LANCASTER
UNIVERSITY
ARCHAEOLOGICAL
UNIT

May 1994

# Langdale Erosion Research Programme

## Project Report

The following project report is commissioned by the National Trust and funded by English Heritage and the National Trust.

# **Langdale Erosion Research Programme**
Project Report

*Edited by J.Quartermaine*

*With contributions by:*
*R.Evans, G. Halliday, D.Higgitt and J.Hooson*

Lancaster University Archaeological Unit
Storey Institute
Meeting House Lane
Lancaster
LA1 1TH

National Trust
Estates Advisory Office
33 Sheep Street
Cirencester
Glos.
GL7 1QW

# CONTENTS

# THE AUTHORS

<u>James</u> <u>Quartermaine</u>

Field Officer with the Lancaster University Archaeology Unit. He has been involved with the Langdale Management project since its conception in 1984. With Philip Claris he was responsible for the survey of the axe factories from around the central massif and has published the results in the Proceedings of the Prehistoric Society (Claris and Quartermaine 1989). He has directed a series of surveys and excavations at sites on the upper glacial bench of Harrison Stickle and Thorn Crag in advance of path repair work. Since 1991 he has undertaken a full level 3 survey of Top Buttress in anticipation of the present management programme.

<u>Robert</u> <u>Evans</u>

Lecturer in the Geography Department at Anglia Polytechnic University

He was the first person in the United Kingdom to demonstrate that overgrazing by sheep could lead to soil erosion and called for schemes to monitor erosion (Evans 1971, 1977). His work led to the Peak Park Joint Planning Board drawing attention to overgrazing in their Structure Plan (1974). This led to some controversy and, along with Derek Yalden's (1979) work which showed that the number of grouse in the Peak District was falling as well as the heather moor was in decline (Anderson and Yalden, 1981), led to the Peak Park Planning Board commissioning a report (Phillips, Yalden and Tallis, 1981) into the impacts of grazing. This confirmed that overgrazing by sheep caused erosion and had also led to the decline of heather moor and hence a reduction in the grouse population. Unless sheep were excluded, bare soil took a long time to become revegetated.

In 1991 he carried out a study which compared grazing intensities on the Armboth Fells, a Site of Special Scientific Interest, with those on adjacent fells to the south and west (Evans, 1992b). South of the Armboth Fells more sheep grazed the land and more bare soil scars (Evans, 1977) had been initiated. Vegetation on peat soils is ten times more vulnerable to overgrazing than that on mineral soils.

He and John Boardman, now of the School of Geography, Oxford University, organised a meeting in November 1988 to discuss the impacts of overgrazing in the Lake District. Two briefing papers were produced for this meeting (Boardman and Evans, 1988; Evans and Boardman, 1988). Among those present were representatives of the Lake District National Park, the National Trust, the National Farmer's Union (NFU), the then Nature Conservancy Council, and other researchers. At this meeting the NFU accepted that there were too many sheep on the Lake District fells and that this had led to a decline in heather moor and the initiation of erosion.

<u>Geoffrey</u> <u>Halliday</u>

Senior lecturer in the Biological Sciences Department at Lancaster University. He is Vice-president of the Botanical Society of the British Isles and the Co-ordinator of the flora of Cumbria Recording Scheme.

<u>David</u> <u>Higgitt</u>

Lecturer in the Geography Department of Lancaster University and, from September 1994, in the Geography Department of the University of Durham. His research interests are concerned with the investigation of geomorphological controls on sediment transfer and in particular in the development of radionuclide tracing techniques. He has undertaken erosion research in the Middle East, China and E.Europe in addition to working on the sensitivity of upland environments to erosion in the UK. He has written a series of reviews on soil erosion and soil problems for the leading journal *Progress in Physical Geography*.

John Hooson

Regional Biologist with the National Trust NW Region since 1990. He is responsible for ensuring that biological interests are taken into full account when management decisions are made relating to National Trust land. The intensity, timing and type of stock grazing is often a critical factor to nature conservation in most upland habitats.

# ACKNOWLEDGEMENTS

The production of this report has been made possible by the work and support of many people who took part in the field work and post-excavation work. Thanks particularly go to all the specialists who have endured the Lake District weather in the course of their site visits.

Thanks also are due to the National Trust path team who undertook the extremely effective repair work on Harrison Stickle.

I must thank Philip Claris of the National Trust for his advice and assistance during the preparation of the project and the editing of the report. I would also like to thank Colin Wells for advice during the early stages of the programme.

*Project Manager*
James Quartermaine

*Survey Assistant*
Patrick Tostevin

*Line Manager and Editor*
Jason Wood

# EXECUTIVE SUMMARY

Severe erosion has been observed at Top Buttress, the most important, surviving Langdale Neolithic axe factory group. The National Trust Langdale Advisory committee considered that it was unwise to proceed with an expensive repair programme before establishing the cause and extent of the erosion. As a consequence, in August 1992, the Lancaster University Archaeological Unit was commissioned by English Heritage and the National Trust to undertake a research programme to establish the factors affecting the ecological equilibrium on Top Buttress, Great Langdale. Four specialists (R.Evans, D.Higgitt, G.Halliday and J.Hooson) were approached to undertake ecological assessments of the area. On the basis of one or two site visits each produced a summary report assessing the causes of the vegetation loss and making recommendations for ecological stabilisation of the area.

The research programme has established that the prime cause of erosion on Top Buttress is the high level of sheep grazing on the fells. Recommendations are proposed below for the control of the sheep in the long term by ESA schemes and in the short term by temporary fencing.

In parallel with the theoretical research, an experiment was undertaken to cover, with turfs, part of a Harrison Stickle site (162) which was comparable to those on Top Buttress. The experiment was successful and will serve as the basis for any repair work undertaken on Top Buttress.

# INTRODUCTION

The Langdale/Scafell Pike axe factories were the source for the most prolific type of Neolithic stone axe (group VI), which has been found in large quantities, scattered over all parts of Britain and even the Continent. Vast quantities of axe production waste, measurable in hundreds of tons, have been found at sites around the Pike of Stickle which is consistent with the wide distribution of group VI products throughout the country. Along with the other large Neolithic axe factory at Grimes Graves they mark the introduction of large scale industry in Britain and are therefore of international importance.

## Threats

Around the central Lakeland massif there are over 580 discrete production sites, which comprise large quantities of worked, waste flakes generally in association with quarries or working floors and have the characteristics of a fine mobile scree. By virtue of the high altitude, soil deposition is low and they are protected by only thin turf cover. They are often on steep (45$^{o}$) slopes and their survival depends upon a fragile ecological equilibrium between soil erosion and deposition. Because of their remote locations, on some of the highest mountains in England, the axe factory sites have until recently been subject to only benign land usage and as a result they are well preserved. However, changing land usage in the last 50 years has seriously disturbed the ecological equilibrium and their survival is now compromised.

**Visitor Pressure**
It is evident that there are a variety of erosive factors affecting the survival of the sites and the purpose of the present programme is to define the scale and extent of these factors. The most clearly definable of these is visitor pressure, which is inevitably channelled along the main access routes to the major peaks and has been evident for the last 20 years. Axe factory sites have been both exposed and severely eroded along the paths on either side of Dungeon Ghyll (Harrison Path and Thorn Crag) but the damage was localised and a significant proportion of these axe factory complexes have not been disturbed. By contrast, at the South Scree gully, the damage has been both more severe and more generalised. Photographs published by Clare Fell in 1948 of the South Scree cave (Fell 1950) show the scree covered by bilberry and heather vegetation (plate 1), but as a result of visitors using the gully the vegetation was disturbed. Flash floods in the early 1950's were channelled by the gully and caused severe damage to the unprotected scree. Subsequent scree running down the gully contributed to the destruction and has resulted in a c.1.5m decrease in the level of scree from around the area of the cave (the main axe production area) since 1950 (plate 2). The material has been redeposited in an artificial tongue near the foot of the hill side which comprises about 3000 metric tons of scree, of which 280 metric tons are Neolithic waste flakes. This, the largest of the axe production groups, is now largely destroyed (plate 3).

## Langdale Axe Factory Management Programme

It was in response to this evident threat that a major management programme was initiated in 1984 by the National Trust (lease holder and land owner) in conjunction with the Lancaster

University Archaeological Unit (formerly the Cumbria and Lancashire Archaeological Unit), and funded by English Heritage and the National Trust. Three stages of the programme have been initiated to date:

**Stage 1 - Identifying the resource**

The first stage of the programme was a topographic survey of all axe factory sites on the Central Lakeland massif in 1984/5, during which over 570 working sites were identified within 35 axe production areas (Claris and Quartermaine 1989). These were generally located in relation to a band of source rock, outcropping between the 2000' and 3200' contours.

Alongside the LUAU / NT management project a research project was undertaken by Prof. Richard Bradley of Reading University (Bradley and Edmonds 1993). Test pits were excavated to determine the extent of the axe working deposits beneath the peat on the plateau behind the Langdale Pikes and small scale excavations were undertaken at some of the quarry sites. Two small rescue excavations were also undertaken on sites threatened by path erosion.

**Stage 2 - Path Repair**

As a preliminary to the instigation of the second stage a National Trust advisory committee was established to provide guidance for the conservation programme. Stage 2 involved the rescue recording and repair of sites under immediate threat from path erosion. Axe factory groups at Harrison Path and Thorn Crag were subject to a detailed level 3 survey. The paths were re-routed to avoid the most sensitive axe factory deposits, which were then protected by overburden; sections of working floors that could not be avoided were excavated in advance of path repair.

A monitoring programme was established in 1987 by the provision of surface photographs for all sites to act as a primary reference to determine subsequent changes in condition of individual sites.

**Stage 3 - Background to the Erosion Research Programme**

This, the third stage of the programme, is concerned with the exceptionally well-preserved axe factory area of Top Buttress, which was the most productive axe working area after the now largely destroyed South Scree. Top Buttress is the south-western face of Pike of Stickle; it has a naturally stepped profile with small benches, formed by more resistant tuffs, which provided both working areas on a series of ledges and adjacent rock faces which could be quarried at their bases (figs. 2 & 4). The area has a sheer crag face above it leading to the summit and a similar sheer crag edge defining the lower edge. It is truncated to the east by the sheer crags of the South Scree gully, and to the west by a lesser but also steep-sided gully; access for both animal and human is severely impeded by the dramatic topography. Most of the protective turf cover over the working sites has been lost and monitoring of the debitage surface since 1989 has shown that there is a general, albeit erratic, slippage of the Neolithic waste material down-slope.

There is an urgent need to protect the sites from the increasing erosion by covering them with compatible turfs; however turfs would have to be imported away from Top Buttress because there is insufficient area of intact turf on this craggy terrain and because the removal of turfs may expose and damage other, presently unknown axe working sites. Because of the remote inaccessible nature of the area this would necessitate the use of a helicopter to import turfs and would have a significant effect on the cost of site repair.

The repair work could also be compromised by the ongoing erosive processes. A significant reduction of vegetation cover over the sites has been observed in the course of the programme and new sites have become exposed as a result of this turf loss (TB 111, 198 & 207). The sites have survived in a good condition for the last 5000 years, so the observed rapid erosion must in part be affected by recent changes in land use; however, the precise mechanics of erosion were not fully understood. Because the factors affecting the loss of vegetation were not adequately researched, the Langdale Advisory Committee decided that expensive repair work should not be undertaken without researching and addressing the problems of erosion in this area. In response the present research programme was established to provide the input of environmental expertise to assess the nature of the erosive forces and to make recommendations for the repair and consolidation of primarily the Top Buttress area, but also other similar exposed site groups (cf. project brief, Appendix 1).

**Research Programme Methodology**

The aim of the programme was to apply specialist ecological experience to the specific problems of the Top Buttress, but without excessive cost and time implications. Specialists from a broad range of environmental subjects were invited to produce a subjective assessment report on the basis of one or two site visits coupled with the use of any other easily accessible, pertinent data source (eg. aerial photography). They were asked to assess the range and effect of various erosion forces and to make recommendations for the repair and conservation of the monuments (Project brief, *Appendix 1*). Because the programme did not allow for more comprehensive experimental work the objectivity of the specialist reports is inevitably restricted; however it is considered that this level of report is adequate for the determination of conservation policy for the sites.

The specialist assessments of the erosion threat depended upon a reliable determination of the scale and localisation of the observed turf loss. This was achieved by comparing recent photographs of Top Buttress with those taken over ten years ago. The most useful reference photographs were taken by Roland Tarver in 1984 from the Band on the opposite side of Mickleden Valley. Recent photography was undertaken as part of the present programme in order to imitate the earlier photographs and so provide a direct comparison of vegetation change. Aerial photographs were also used but were taken from high altitudes and were not as informative.

The feasibility of site repair was tested by covering a site on Harrison Stickle (162) with turfs cut from the locality (fig. 3). This site was chosen because it was comparable in size, form and degree of slope with those on Top Buttress. A full level 3 survey was undertaken of the site in advance of repair. The repair work was undertaken by the National Trust path repair team in September of 1992; turfs were cut from up to 60m away from the sites and were deposited across the upper part of the site (plates 4 & 5). The lower part of the site and the adjacent site 161 were left uncovered as a control. It was anticipated that the greatest potential for erosion would be at the edges of the turf block, so the new turf was set up against either an old turf edge or a more substantial topographic interface such as a crag or boulder. Following the repair, the site has been irregularly monitored and photographed by LUAU personnel to determine how effective the repair was. The results of the experimental programme are described below.

# GEOLOGICAL AND GEOMORPHOLOGICAL BACKGROUND

**D.Higgitt**

The spectacular landscape around Langdale results from the interaction of structural control, weathering and glacial processes. Langdale is formed in rocks of the Borrowdale Volcanic Series, which were erupted as subaqueous and subaerial lavas and tuffs and have a thickness in excess of 5000 m (Moseley, 1978). A fine grained component of the Seathwaite Fell Tuffs (petrographic groups VI, XI & XX) provides the source material for axe production.

Great Langdale is aligned along the axis of an anticline formed in Devonian times. Over time, a considerable thickness of rocks above would have been eroded and the arch of the anticline pierced. Subsequent erosion would have developed the valley from Oxendale to Great Langdale. Other parts of the valley are fault-guided. One fault runs NW to SE along Mickleden and through Blea Tam, whilst a second parallel major fault extends from Stickle Tam to Elterwater and controls the orientation of the lower part of Great Langdale.

These structurally controlled valleys were considerably enlarged and modified by glacial erosion, Great Langdale exhibits the archetypal 'U' shaped cross section in places although the valley alternates between over deepened flat floored basins and narrow gorge sections (as at Chapel Stile). Ice is thought to have covered the Lake District on a number of occasions although the altitude of the District was sufficient to support an outwardly moving ice dome. The thickness of the dome is a matter of speculation but the movement of ice away from the dome would have been essentially radial. In some places (such as Langdale) pre-existing valleys would have discharged ice from the area. At the Last Glacial Maximum, a Langdale valley glacier would have extended into the Windermere basin.

Pollen and geochemical evidence suggests that the Devensian ice had cleared most of the Lake District by about 13000 BP (Pennington, 1978). However, a return to colder periods between 11000 and 10000 BP saw the development of small corrie glaciers in several parts of the Lake District including Mickleden and Oxendale. The timing of glacier renewal corresponds to the Loch Lomond Readvance in Scotland. The limits of Loch Lomond glaciers are marked by characteristic hummocky moraine, formed as the ice stagnated and downwasted. These moraines have been mapped in the Lake District by Sissons (1980). The snout of the Mickleden Glacier would have extended to the base of the Pike of Stickle screes, whilst Langdale Coombe also contained a body of decaying ice.

The scree slopes beneath the buttresses of the Langdale Pikes have thus been exposed for at least 13000 years and possibly considerably longer. Even at the Glacial Maximum it is possible that the steep upper valley slopes were exposed subaerially between plateau ice fields and valley glaciers. The Langdale glacier was sufficiently thick to form a diffluent trough as ice breached the divide at Blea Tarn (Vincent, 1985) but the cliffs of the Langdale Pikes may have been subject to freeze-thaw activity for some of the glacial period.

# ARCHAEOLOGICAL BACKGROUND

## J.Quartermaine

As a result of erosion to the anticline, the main narrow band of fine-grained hornstone tuff, about 15-30m thick, was exposed extending between the peaks of Harrison Stickle, Bowfell, Scafell Pike and Glaramara at altitudes from 1800' to 2900'. A further, higher stratum of fine grained tuff outcrops at altitudes between 2100' and 3100'. Both bands of rock have been exploited as a source material for axes during the Neolithic, however the higher band was only used to a lesser extent (Harrison Combe and Scafell Pike VII).

The great majority of the 570 working sites identified in the area have been found associated with the outcropping source material; the small minority that display no relationship with the source rock (Quartermaine and Claris 1989: Type D) are invariably on the lines of major communication routes and were worked from blocks that were either carried to the sites or were moved by glacial action. The majority of the working floors used naturally detached blocks of source material but these were typically small or medium sized. The largest and by implication the most productive sites were often associated with quarried rock faces and have been found at only a limited number of site groups. The most productive of these were Top Buttress and South Scree, although South Scree has now been largely destroyed.

With the exception of the Bowfell area, axe production has been identified from most localities of the outcropping band of fine-grained tuff; however the scale of working varies enormously throughout. The Scafell Pike and Glaramara areas produced a large quantity of very small working floors, often the result of working individual blocks of tuff. However; the overall quantity of waste material is low, there is no evidence of mass productive quarrying techniques and the evidence suggests that non-intensive, working practices were utilised in these areas (Claris and Quartermaine 1989).

By contrast, around Great Langdale, there is evidence of axe manufacture on a considerably larger scale of production and in some instances this involved quarrying by fire setting. Excavations by Reading University at the Top Buttress site 98 have demonstrated a very deep stratigraphy of axe waste. This revealed two episodes of an axe production sequence which incorporates quarrying, coarse working and fine working (Bradley and Edmonds 1993). The excavation at the adjacent cave site 95 produced carbon dates of 3370-3690 CalBC and 3100-3500 CalBC which would indicate that this intensive working was relatively late within the overall period of group VI axe production. Although no carbon dates are available from the Scafell Pike sites, it has been tentatively suggested that the discrepancy in character of working between the two main regions reflect a chronological development in both production techniques and demand for the axes (Quartermaine and Claris 1989, 19). This is reinforced by excavations undertaken by LUAU at Thorn Crag (Quartermaine & Tostevin 1991) which have revealed a small, single phase working floor which suggests the use of basic knapping techniques to work naturally detached blocks of tuff. In character these practices are reminiscent of those represented at the Scafell Pike sites. The Thorn Crag site produced a carbon date of 3973-3777 calBC (OxA-4212) (Quartermaine forthcoming) which is the earliest from a group VI axe factory site. This date, coupled with that from Top Buttress, would appear to confirm that the Langdale Pikes was exploited for axe material over an extended period and that the variation of technology reflects a chronological development.

In summary the evidence would suggest that the archaeological remains at Great Langdale and Scafell Pike reflect a long period of industrial activity. In the earliest stages manufacture was on a small scale and utilised scattered blocks of tuff, but in the course of time the extractive technology was developed and the scale of working was increased. The Top Buttress site group represents the pinnacle of this technological development in terms of its extensive use of direct quarrying and its enormous scale of production as evidenced by the large tonnage of surviving waste material.

# EVIDENCE OF VEGETATION LOSS ON TOP-BUTTRESS

## Explained Vegetation Loss

Some erosion on Top Buttress is attributable to misguided, amateur 'archaeologists', who in the past have excavated areas of monuments with the aim of finding rough-out axes. Excavations adjacent to the crag face of site 98, were not backfilled and the resultant turf exposures were expanded by natural erosion forces and a limited amount of visitor pressure.

## Unexplained Vegetation Loss

As well as the localised antiquarian disturbance there is evidence of more extensive and expanding erosion around the rest of Top Buttress which is progressively exposing sites and where there is no simple explanation for the primary turf decline. Since the start of the present archaeological recording programme, in 1984, there has been an observed differential decline of the bilberry/heather vegetation concentrated in the lower, south-western parts of the buttress; this has resulted in the exposure of four sites (111, 198, 204 & 207) that were covered at the start of the recording programme (1984). Although there was an observed deterioration of the vegetation cover in specific areas it was not clear of the extent to which the vegetation cover had declined in other areas. A more precise determination of the site condition was possible by commissioning photography of Top Buttress from the Band (opposite side of the Mickleden Valley) to compliment high resolution photographs taken by R.Tarver in 1982 (Prints held by LUAU). The new photography replicated as far as possible the earlier photographs and provides a direct comparison of changing vegetation cover over a twelve year period.

Comparison of the photographs confirm the dramatic vegetation loss in the areas of sites 111, 198, 204 & 207, but also show more subtle variations at the main sites. At site 98 the lower south-western edges have expanded by up to 0.8 metre, and the south-eastern edge has in places expanded by up to 1.2m reflecting the erratic retreat of the vegetation boundary. Significantly the upper part of the site shows relatively little change. At site 94 the top of the site has receded upwards by about a metre and there is patchy erosion at the lower south-western and south-eastern edges. At site 92 there is a marked, albeit erratic decline of vegetation cover throughout the extent of the site. Site 103 displays little change at the top where it is largely constrained by crags, but at the bottom there is a patchy outwards expansion of the exposed scree.

Large boulders and stones within the screes have invariably either moved down slope or disappeared from the later photographs. One particularly large boulder on site 98 has moved up to 7m downslope.

Generally over the Top Buttress area the photographs reveal a considerable increase in the number of sheep trods, the 1982 photograph shows only an occasional sheep trod but the 1994 photograph reveals a considerable number, mainly on the lower benches of the buttress. Where there are large areas of bilberry vegetation visible on the earlier photograph it is thick, uniform and apparently undisturbed; however, the 1994 photograph reveals evidence of disturbance and serious vegetational thinning of the same areas. The areas most subject to this disturbance and decline are again mainly on the lower benches; the highest bench, shows relatively little evidence of vegetational disturbance.

## Monitoring Programme

In 1990 a monitoring programme was initiated in order to assess which sites were deteriorating most rapidly and also the rate of erosion at the main exposed sites on moderate to steep slopes. The latter aim was achieved by placing a line of painted flakes on the scree surface of sites 94 and 98 between two pegs and monitoring the rate at which the flakes move downslope (fig 4). By 1991 the flakes had travelled about two to three metres downslope, although there were a few at the edge that had hardly moved and some in the site centre which had travelled up to five metres. By 1993, there was a dramatically different scene, most of the flakes had been lost, either buried or had moved beyond the visible extent of the site. Those that remained had moved up to 30m down slope, although there were a small number that were still within 5m of the start line. This experimental monitoring has

## Conclusion

The photographic comparison confirms that patchy erosion has taken place across the area of Top Buttress since 1982 and is largely confirmed by the monitoring programme which has demonstrated a considerable, albeit erratic, movement of the site scree surface and that the erosion may significantly disturb the site unless arrested. This erosion does not appear to be attributable to visitor pressure as in other parts of the Langdale Pikes; Top Buttress is fairly inaccessible and in the course of recent surveys (1991/2) only occasional visitors have been observed on it. Although natural and animal erosion forces are evidently now increasing the extent of the turf exposure, the primary cause of the exposure is not apparent.

# EXPERIMENTAL REPAIR PROGRAMME

Before committing considerable resources to the protection of the Top Buttress site by covering them with turf, a number of concerns had to be addressed and could only be answered by localised trial repair work:

What disturbance would occur to other adjacent sites by localised turf cutting?

What disturbance to the sites would occur during the repair work?

How much time and man power are required to cover the sites?

Would the deposited turf hold together and the vegetation become established?

How quickly would the turf stabilise into a cohesive layer?

Would the component species of the imported turfs conform with time to that of the original plant cover?

Site 162 on the western face of Harrison Stickle (fig 3) was selected for the trial because it was the most comparable site with those on Top Buttress, and yet also had an adequate adjacent source turf; it is on a steep 45$^{o}$ slope, it has a high concentration of debitage and it extends up to a quarried crag face. The turf was extracted from a level area about 60m away from the main site (at NY 28220722), which had good turf cover and had no visible sites. Turfs were cut individually from the turf base rather than as larger blocks to improve the recovery rate. 10-15% of these turf cuts exposed worked flakes in varying concentrations and highlights the risk of using local supplies of turf. Unfortunately more remote turf cutting for the Harrison Path repair work also exposed significant concentrations of debitage (sites 247 and 248 at NY 2837107174 and 284147122 respectively) which were up to 90m away from the known Harrison Path sites.

At site 162 the damage to the debitage surface during the repair work was minimal; care was taken not to walk unnecessarily on the site scree and once the first section of turf was laid, the new turfs were always laid from the recently established turf base so that there was little disturbance of the scree surface.

The trial repair of c.25m of site 162, including the cutting, transportation and laying of the turfs, was undertaken by five experienced personnel in three quarters of a working day.

The repair work was undertaken in September before the end of the growing season to allow the turfs to get established before the winter. Subsequent to the repair work the sites were irregularly monitored by LUAU staff, often in conjunction with specialist visits. This has demonstrated that the turfs were able to get established before the winter, following which it was no longer possible to clearly distinguish the edges of the original turfs. One and a half years after the laying of the turfs there is clear evidence of new growth and the turf base has become securely established (plate 6), there are no exposures within the central part of the new turf block and the only evidence of erosion is a very limited amount around the few exposed edges. The botanic make up of the original turf differed from that of the local turf; however the imported turfs have homogenised to a significant extent with that of the original vegetation around the periphery of the repair area and the border between the old and new has become relatively indistinct.

Monitoring will continue on an irregular basis for the next few years. Although in ecological terms it is still too early to confirm the success of the trial, the evidence would appear to suggest that this technique, in the right circumstances and subject to controlling the erosive forces, could be successfully applied to other similar sites.

# REPORT ON REVEGETATING ARCHAEOLOGICAL SITES IN THE LANGDALE PIKES

**Dr G. Halliday**

## The vegetation

Prior to the arrival of man the lower slopes of the Langdale Pikes would have been lightly wooded, probably up to about 450m AOD. The predominant tree at the upper limits would have been rowan (*Sorbus aucuparia*) but oak (*Quercus petraea*), some birch (*Betula pubescens*), ash (*Fraxinus excelsior*), holly (*Ilex aquifolium*) and juniper (*Juniperus communis*) would also have been present. Given particularly favourable situations on steep crags in sheltered gills, such as the upper parts of Dungeon Ghyll, the trees, particularly rowan, would have extended even higher. Below the trees there would have been a fairly continuous cover of dwarf ericaceous shrubs, chiefly heather (*Calluna vulgaris*) and bilberry (*Vaccinium myrtillus*). These would have extended above the tree-line for some distance eventually giving way to montane grassland or the patchy vegetation of screes, rock-ledges and crags.

With the appearance of man the tree-line was progressively lowered. Trees were felled for fuel and building material, and regeneration was prevented by his grazing animals. Gradually the only trees left on the upper fellsides were those rooted in gills or rock outcrops and inaccessible to sheep. The dwarf shrubs were also decimated. Heavy grazing reduces the vigour of the heather and bilberry and consequently, with time, grassland has replaced considerable areas of the fells which were formerly covered by these shrubs.

The lower slopes, above the intake fields, are now covered either with bracken (*Pteridium aquilinum*) or grassland, chiefly of bent (*Agrostis capillaris*) and sheep's fescue (*Festuca ovina*), The grassland, even in winter, is distinctly green and is much sought out by the sheep. As the slope becomes less steep, at about 440m, the grass in winter takes on a paler appearance as the mat-grass (*Nardus stricta*) plays an ever more important role, soon becoming the dominant species over all except the wetter, poorly-drained areas. This is a very tough, fibrous and unpalatable grass and is generally regarded as a clear indicator of over-stocking. Bracken continues up to about 470m. Its rhizomes are sensitive to frost and it is therefore restricted to the deeper, as well as the better-drained, soils. It is fair to say that where bracken grows the soil is deep enough for trees.

On emerging from Dungeon Ghyll into Harrison Combe one encounters a gentler scene. The sides of the basin are still largely covered by mat-grass but the poorly-drained bottom with deep peat is characterised by the creeping common cottongrass (*Eriophorum angustifolium*). Between this and the mat-grass is a zone with varying proportions of mat-grass and the heath rush (*Juncus squarrosus*). The latter too is extremely wiry and unpalatable. It is also very effective at suppressing other species by virtue of its rigid, strongly spreading and almost prostrate leaves. There are also patches of the strongly tussocky hare's-tail cottongrass (*Eriophorum vaginatum*) in the Combe. Both cottongrasses are important peat formers. The common cottongrass is particularly good at colonising bare areas of stable, wet peat.

Below Harrison Stickle and in the Combe the bilberry and heather are largely restricted to rock outcrops. These also feature the local prostrate variety of juniper (*J.communis subsp. nana*).

Isolated and semi-moribund plants of bilberry and heather can of course be found around boulders and patches of scree amongst the mat-grass. There is also clear evidence of the remains of heather roots in the eroding edges by the path at some distance from the nearest living plants. The steep scree slopes below and to the sides of the axe quarrying area below the main crags of Pike of Stickle have in places a complete cover of varying proportions of bilberry and heather, with a certain amount of bent and sheep's fescue and in places a considerable amount of moss. There is very little matgrass. Heather and bilberry are very good at colonising scree provided their vigour is not sapped by grazing.

## Recommendations for specific areas

It will be evident from the foregoing that with a mosaic of vegetation types there can be no one single prescription for the protection of the axe sites. Below Harrison Stickle and in the Combe the prime erosive force must be human. Looking down into the Combe it is only too obvious that there is very little erosion except along the hillside paths and in the lower area where the various paths intersect. Erosion is particularly serious in the deep soft peat of this last area.

**Sites below Harrison Stickle**

These are in gently sloping areas dominated by matgrass. There is no obvious reason why covering the site with turfs of this species should not adequately protect the sites. In all sloping areas some barrier, such as a row of boulders, is necessary along the lower side of the site to arrest further movement and particularly to give protection to the crucial lower edge of the turfed area. The turfs should be removed from an area where removal will not initiate erosion, i.e. from the sides of small hollows. The turfs should be thick enough to minimise the possibility of the grass suffering from water-loss following transplanting. Brief but significant periods of drought must occur on this south-facing slope and transplanting is probably best done at the end of the summer, certainly not in the spring. If the site is large it may be necessary to have more than one row of boulders along the contour but scattering boulders around the site is not recommended as it would provide too many foci for disruption of the turfs.

**Sites in Harrison Combe**

The sites by the path-sides in Harrison Combe north of Middle and West Gullies are in a heavily eroded area and where they abut on to the paths they will need a substantial protective line of boulders along the path in order to contain the sometimes appreciable amount of peat which will be needed to cover the site prior to the planting of turfs. Given the peaty nature of the ground, turfs from the surrounding mixed vegetation of heath rush and mat-grass are recommended. The sites are not wet enough for the use of cottongrasses.

**Sites on Top Buttress**

The situation below the main axe working is quite different to the above. There is no obvious evidence of erosion by humans. The vegetation is very palatable to sheep and there is an abundance of sheep droppings by the workings themselves. Difficult as it may be effectively to protect the area from sheep, this should be given serious consideration as the solution most likely to succeed. It does not take much diminution in vigour on this very exposed site before the heather and bilberry start to die back. It is not feasible to cover the sites with turfs. The areas are too large, the exposed areas are convex rather than concave, and the dominant species are dwarf shrubs, not grasses. Again, a series of substantial barriers along the contours are essential and for permanence would have to be of boulders. Although complete cover by transplanted vegetation is impracticable, it would hasten recolonisation if there was some planting of rooted shoots of bilberry, together with some soil. With its extensive underground rhizomes, bilberry is a much more effective colonist and stabiliser than heather. With diminished grazing the heather would have a chance to flower and seed into the sites.

# EVIDENCE FOR THE OVERGRAZING OF LANGDALE PIKES, WITH PARTICULAR REFERENCE TO THE SOUTH WEST FACING SLOPE OF PIKE OF STICKLE

**Dr. Robert Evans**

## Background

Since the Second War the number of sheep grazing the fells of the United Kingdom has risen markedly. In some localities, the Peak District being an example, the number of sheep began to rise immediately after the 1947 Agricultural Act was passed introducing subsidies for sheep. In other places, the Lake District for instance, the number did not begin to rise rapidly until the United Kingdom joined the European Community so increasing the size of the market for lamb. Farmers received subsidies based on the number of sheep they owned; to increase their income they increased the size of their flocks. As the number of sheep on the fells rose so there was a decline in the extent of heather moor as heather was grazed out, and soil erosion was initiated on grassland containing a high proportion of Wavy Hair Grass.

## The Problem

The brief from the Lancaster Archaeological Unit was to examine the southern and westerly facing slopes of the Langdale Pikes, especially of the Pike of Stickle, for evidence of overgrazing. An explanation was being sought for changes in vegetation cover on these slopes.

Stone Age axe factories on the Pike of Stickle are being exposed as their protective vegetation cover declines. This is an unwanted phenomenon (Appendix 1). "Since the start of the present archaeological recording programme in 1984 there has been a differential decline of the bilberry/heather vegetation. Around the main sites there has been a limited amount of vegetation loss ..... However there has been a dramatic vegetation decrease around periphery areas ...... (Quartermaine and Claris, 1991). Visitor pressure does not appear to be the cause of this vegetation decline, for instance, in the 6 week period around July 1991 only 4 people visited this inaccessible locality (Quartermaine, personal communication).

## Sources of Evidence

1. The slopes of the Langdale Pikes were examined on the 28th of October 1992. There was thin snow cover above about 400m 0.D..

2. Panchromatic aerial photographs of the Langdale Pikes were interpreted. Vertical and oblique photographs were taken on 28 June 1976 by the Cambridge University Collection of Aerial Photography. The ADAS Aerial Photography Unit took vertical photographs on the 10th of August 1983 on behalf of the Lake District Planning Board. The vertical aerial photographs were taken at similar scales; the 1976 ones were 1: 12,600, the 1983 ones 1: 13,100. Unusually, and fortunately, the areas covered by the individual photographs were

very similar, so that the angular relationships between the camera and the ground were very similar. This eased comparisons of the photographs.

There are aerial photographs taken at a later date but their quality is not very good. Besides, there is field evidence from 1984 onwards of the change in ground conditions on the slopes of the Pike of Stickle (Appendix 1).

## The Evidence

**Field evidence**

Ascending from New Dungeon Ghyll Hotel, above the wall delimiting the improved pastures of the valley floor and adjacent lower slopes the *Agrostis-Festuca* sward flanking the path was closely razed with rare flower heads of Wavy Hair Grass (*Deschampsia flexuosa*). Rush (*Juncus SPP.*) was frequently grazed and even the rare small tussocks of mat-grass (*Nardus strict*) were nibbled, a phenomenon not previously seen by the author. Mat-grass is generally considered unpalatable to sheep. With altitude the organic mat on top of the mineral subsoil thickened and mat-grass, frequently grazed, became more common.

The bare soil scars adjacent to the footpath were created by sheep for shelter (Evans, 1977), and strands of wool adhered to the vegetation of their 'polished' backwalls. Sheep dung, much of it fresh, was everywhere on the sward. On the steeper slopes away from the path unpalatable bracken (*Pteridiun aguilinum*) dominated.

Above about 400m AOD mat-grass was dominant, with bilberry (*Vaccinium myrtillus*) where slopes were rocky. The bilberry was severely grazed, and had not flowered and fruited. Just below the axe factory sites on Harrison Stickle, at about 570m AOD, clumps of heather (*Calluna vulgaris*) were found in more protected spots. However, the clumps were contorted, low and tightly grazed, all symptoms of chronic overgrazing (McDonald, 1990).

From the slopes of Harrison Stickle across the peaty valley with its sheep scars, to the east side of the Pike of Stickle, wherever bilberry showed above the snow, its stems were grazed. Heather was always chronically overgrazed.

On the very steep and rocky south west slopes of the Pike of Stickle, at first the bilberry was heavily grazed, and clumps of heather survived only in inaccessible places. However, passing onto the 'front' or 'face' of the Pike, the stems of bilberry became longer, 10-15 cm in length, and more leafy, but most stems had been nibbled. Heather also became more common but was always chronically overgrazed and dying back. On inaccessible terraces heather was 'leggy' and ungrazed. There were more flowering stems of Wavy Hair Grass on these slopes, and sheep droppings were less common than on other slopes. The lower parts of Juniper bushes were grazed. Across the top 5m of the very mobile scree below one of the axe factory sites were five sheep trods.

**From Aerial Photographs**

On the 1976 photographs dark-toned heather occurred intermittently on slopes below Gimmer Crag to about 380m AOD. Heather also occurred to the north-west on the eastern flank of Troughton Beck, between altitudes of about 365-490m. Occasionally patches of heather occurred on slopes north west of Troughton Beck. Heather was not apparent on the 1983 photographs.

Between Troughton Beck and the crags of the Pike of Stickle, the slopes, between 455-610m AOD, were traversed by 11 parallel or sub-parallel paths. On the 1976 photographs there were rare traces of two paths.

Below the crags of the 'fro
nt' of the Pike of Stickle to between 365-425m AOD, as far south east as the scree filled gully, there were two, occasionally three, sub-parallel paths. The paths were more clearly seen on the 1983 than the 1976 photographs.

To the south east of the crags of Pike of Stickle, between 460-520m AOD, were three sub-parallel paths. Another path lay between 335-365m. Only this path linked with what was obviously a footpath which zig-zagged up the slope to the west of an unnamed stream. On the 1983 photographs all the paths were more clearly seen.

The sheep scars in the peaty hollow between Harrison Stickle and the Pike of Stickle were more clearly seen on the 1983 photographs than the 1976 ones.

## Discussion

The impacts of grazing on the vegetation of the slopes of the Langdale Pikes are severe. Probably the most severe seen by the author.

The decline of heather on the south-west facing slopes of the Pike of Stickle and the more numerous and more clearly visible paths in 1983 than in 1976, are the results of sheep grazing the fells. Sub-parallel paths are most unlikely to be created by hikers, especially British ones, who generally take the most direct line to the point they wish to reach, and do not walk along the contour. Besides, walking along the contour is not a comfortable thing for a walker to do.

The decline of heather in the Langdale Valley mirrors that elsewhere in the Lake District (Carr and Evans, unpublished) and Cumbria (NCC, 1987).

The appearance of sheep trods to the north west of the Pike of Stickle and the decline of the heather associated with those paths, suggest that at least some of the sheep invading the 'front' slopes of the Pike of Stickle are arriving from the north west. The scree filled major gully is a major obstacle to sheep travelling north west from the farms of upper Langdale.

The origin of the sheep approaching from the north west can be from two sources. They can travel from the Langdale Valley and attain the 'front' slopes of the Pike of Stickle via the col between Thunacar Knott and Pavey Ark to the north and the Langdale Pikes to the south. Or, they can travel south up the Langstrath from the farms around Stonethwaite and in Borrowdale.

The vegetation on the 'front' of the Pike of Stickle is less heavily grazed than elsewhere and these slopes have been exploited more recently by sheep. These grazings are marginal, and are only being exploited because of the more severe grazing pressure on adjacent slopes. The less competitive family groups of sheep are being forced onto these marginal grazings.

These very steep and rocky slopes of the 'front' of the Pike of Stickle have extremely thin (<5 cm) organic soils. This organic mat has grown since the axe factories were abandoned, a very slow process. This mat is now being disturbed and could disappear rapidly so exposing the underlying very unstable scree, This could be catastrophic.

## Conclusions

The slopes of the Langdale Pikes are severely overgrazed and a reduction in the number of sheep grazing the slopes is needed.

The most vulnerable slopes, those of the Pike of Stickle, are marginal. A reduction in the number of sheep will be most quickly felt here, as the less competitive family groupings of sheep will no longer be forced onto these slopes.

It needs to be known from which direction the sheep are approaching the Pike of Stickle, from Langdale or from Borrowdale?

For regeneration of heather on these slopes, the number of sheep grazing the slopes will have to be cut more severely.

Granting the Lake District the status of an Environmentally Sensitive Area (ESA) could help in reducing the number of sheep on the fells, whilst at the same time safeguarding farmers' incomes. Alternatives to an ESA scheme seem unlikely unless the way farmers are funded to look after the fells is changed radically.

# LANGDALE EROSION PROJECT; GEOMORPHOLOGICAL PERSPECTIVE

**David Higgitt**

## Talus Formation, Equilibrium and Stability

The Langdale Erosion project (Appendix 1) is concerned with the destruction of vegetation cover and the subsequent erosion of scree material below Pike of Sickle. In order to speculate on the likely causes of vegetation destruction and the suitability of remedial action, attention should be given to the processes responsible for the formation of talus slopes.

Debris from rockfalls may accumulate below cliffs to form a talus deposit. Where cliff retreat has been uniform the debris accumulates as a talus slope. However, there is likely to be an area of preferential supply along the cliff line resulting in the development of debris chutes or cones, as is the case at the North and South Screes of Pike of Stickle.

Whilst several attempts have been made to explain talus sheet evolution, the complexity of factors has precluded the acceptance of any general model. Early work on the morphometry of Lake District cliff and talus slopes (Chorley and Kennedy, 1971) indicates a high degree of intercorrelation between geometric and non-geometric variables on Skiddaw Slate slopes but less significant relationships on Borrowdale Volcanic slopes. This, in part, suggests that talus slopes beneath Borrowdale Volcanic Series (BVS) cliffs have not yet reached dynamic equilibrium.

Talus slopes are common features in formerly glaciated valleys where the majority of the deposit must have formed in the last 13000 yrs. During the Holocene, climatic fluctuations and, more recently, human interference will have affected the supply of debris from rockfall and the operation of transport processes on the slopes. Without detailed stratigraphic work on the talus slopes of Langdale it is difficult to establish the sequence of events, but it can be speculated that the slopes have experienced alternations of stability and instability. As the climate ameliorated after deglaciation the debris input to the talus slopes would have gradually declined as freeze-thaw activity decreased and a thin soil and vegetation cover would have established. Subsequently episodes of reactivation may have occurred which relate to climatic and/or anthropogenic disturbance. The possibility should not be discounted that the talus environments are once again tending towards a period of instability.

Little work appears to have been undertaken on Holocene upland erosion dynamics in the Lake District, but some interesting results have been reported from other parts of Britain. Ballantyne (1991), reviewing geomorphological research on upland Britain, has pointed to evidence for enhanced erosion in the Late Holocene and in particular over the last three centuries. One aspect of enhanced erosion of particular relevance on talus slopes is the increased incidence of debris flow activity and debris cone accumulation. In the Forest of Bowland, Harvey and Renwick (1987) carbon-dated peats below debris cones which indicate a period of debris cone accumulation (and hence upstream disturbance) between 5400 BP and 1900 BP, followed by a later pulse of activity around 900 BP. The latter is coincident with an expansion of Viking settlement into the area and has also been reported from the Howgill Fells (Harvey et al., 1981). The earlier phase of erosion coincides with Bronze Age expansion into North-West England, but also overlaps with known climatic deterioration around 2600 BP. Given evidence from neighbouring regions it is likely that the Lake District has also experienced phases of instability. There are "fresh" debris flow tracks on Green Tongue on the southern side of Mickleden. A more detailed investigation of debris fans may yield material which could be dated, so that past phases of geomorphological activity could be placed in the context of human disturbance.

Remobilisation of material on talus slopes is also spatially heterogeneous. Sediment transport will be more frequent at the talus apex and hence any chute or gully funnelling rockfall material to the talus sheet will be more susceptible to disturbance. This is evident at Pike of Stickle where the South Scree has been reactivated (mainly due to recreational pressure) and has become subject to gully erosion. These areas of the talus sheet are particularly susceptible to storm runoff and there are reports of considerable damage occurring after storms in the 1950s. Debris flow activity and other forms of erosional transport on talus slopes will be generated by extreme events, whose distribution in time is essentially random. Slope instability may therefore be a function of the interaction between reduced resilience (caused by human induced degradation of the vegetation cover) and the incidence of extreme rainfall events. Such events may surpass erosional thresholds which leave the slope susceptible to further sediment transport by more moderate events. Examples of the importance of extreme events in surpassing thresholds and initiating slope erosion can be found in North-West England. In the Howgills a 100 year flood event in 1982 reactivated gullies which had been stable since Viking occupation (Harvey, 1986), whilst in the Forest of Bowland many of the degraded headwater slopes are attributed to shallow landsliding following the 1967 Bowland-Pendle flood (Newson and Bathurst, 199 1).

In general, the upper parts of talus slopes will be more sensitive to change. Research in New Zealand (Whitehouse and McSaveney, 1983) and Canada (Gardner, 1983) has demonstrated that talus slope surfaces are diachronous, being less recently disturbed towards the base of the slope. Unfortunately it is the upper and more susceptible parts of the talus slopes in Langdale which are the location of most of the axe sites.

## Talus instability in Langdale: Some possible causes

From the discussion of talus formation and equilibrium it is possible to suggest a number of hypotheses to explain the apparent increase in erosional disturbance encountered in Langdale. It must be stressed that further geomorphological investigation is required to test the hypotheses and the possibilities of more than one factor interacting is not discounted.

**i Recreational damage**

The most obvious damage occurs on South Scree which is the area which has been most greatly disturbed by human activity. Recreational damage, including scree-running, has created a trough which has been subsequently eroded by channelled flow. This, however, does not give a full explanation since much of the erosion on Top Buttress occurs in isolated locations which appear to be seldom visited.

**ii Vegetation loss due to overgrazing**

The consultancy report by Evans (see above) clearly indicates that the vegetation has been degraded by sheep. Furthermore the nibbling of plants which are not the normal preference of sheep highlights the intensity of grazing pressure. Other reports (eg. Boardman, 1992) demonstrate how sheep numbers and erosion damage have increased in the Lake District since the 1970s. It appears that overgrazing is the most plausible explanation for the destruction of vegetation cover and the subsequent disturbance of the talus fabric. However, this does not preclude the interaction of this factor with those listed below.

**iii Vegetation damage related to atmospheric pollution**

In the Scottish Highlands, Innes (1983) has reported increased debris flow activity over the past three hundred years. This may be related to the climatic episode known as the "Little Ice Age", but also corresponds with the onset of industrialisation. In the Peak District, gully erosion of blanket bogs has increased over a similar timescale and is thought to be a consequence of damage to *Sphagnum* by acid precipitation (Tallis, 1985). Although this research related to upland peat bogs, it is possible that atmospheric pollution may have a detrimental effect on the protective properties of other upland vegetation. To my knowledge, these ideas have not been tested on a talus slope environment.

**iv Reactivation of Neolithic erosional forms**

A large portion of the talus material in Langdale is composed of waste associated with stone axe workings. There can be little doubt that the disturbance caused during the period of axe manufacture would have had a direct erosional effect. Some of the rill and gully erosion initiated by Neolithic activity may have ceased with axe production and the talus revegetated as debris supply slowed down. However, these areas of former erosion are likely to be susceptible to reactivation if the protective vegetation cover is disturbed.

**v Natural causes: Increased frequency of erosion events.**

There remains the possibility that the apparent increase in sediment transport in Langdale and other British uplands is attributed to climatic causes. The impact of high magnitude events is an important consideration.

These ideas represent some possible lines of enquiry. Little work has been carried out on either Late Holocene erosion events or the magnitude and extent of contemporary erosion in the Lake District.

# A BRIEF SURVEY OF VEGETATION AND ASSESSMENT OF FACTORS LEADING TO EROSION

**John Hooson**

## Introduction

On 2 August 1993, John Hooson visited a number of axe factory sites on the Langdale Pikes in the company of Jamie Quartermaine. The prime objectives were:

1. to consider the general condition of vegetation found on the Pikes, and in particular that found in close association with the known archaeological sites.

2. to assess the probable contribution of sheep grazing to the apparent degradation of vegetation in certain areas and thus to the consequent erosion of important axe factory remains.

## Vegetation Description

The vegetation, as seen when ascending from New Dungeon Ghyll Hotel through Thorn Crag to Harrison Combe, was accurately described by Dr. Evans in his report, despite his visit being made whilst snow lay on the ground. Field evidence here supports the view that 'ecological over-grazing' has led to the virtual loss of heath species with the simultaneous expansion of unpalatable grassland plants, in particular mat-grass and heath-rush. A picture of what the sward might be expected to be like under a lower grazing pressure can be seen on the steep north/east facing slope above Dungeon Ghyll where vigorous bilberry is abundant.

On the very steep and rocky south-west aspect of Pike of Stickle (Top Buttress) the situation is rather different with widespread healthy heather and bilberry prominent. Sheep grazing pressure here is considerably less than on the more accessible slopes of Harrison Stickle. However, as noted by Evans, there is some impact from stock. Although little actual direct grazing effect (*i.e.* defoliation) was noted there was clear visible damage being caused by regular trampling. A particular area of concern was a steep, heathery slope on Top Buttress where incipient erosion has recently been initiated through sheep following a regular trod. Trampling appears to have killed heather plants and begun to open up the thin peaty soils to the effects of rain. Material subsequently washed downslope then smothers and kills further vegetation. On such steep terrain it is easy to see how quite extensive soil erosion might be the consequence of a well used sheep trod breaking through the vegetation mat, even if stock do little damage by grazing itself.

## Revegetation experiment - Harrison Stickle

A brief visit was made to a badly eroded axe factory site where an attempt to revegetate the slope has been made. Although the work, using turfs cut from nearby, was carried out less than 12 months previously, the site was recovering well. The turfs had all survived and were holding together with obvious new growth (plate 6). The donor site was also inspected. Removal of numerous small turfs has left a curious pattern of square holes in the ground but has not resulted in any serious problems of erosion; these will infill with soil and vegetation in time.

## Discussion

The general conclusion arrived at by Dr. Evans that sheep grazing is the prime cause of vegetation degradation and soil erosion on the Langdale Pikes certainly appears to be the case. Human factors are very much more localised and would not account for the general state of the upland vegetation seen here.

On Top Buttress the impact of defoliation by stock grazing is far less severe and vigorous heather is widespread. However, trampling damage along regular sheep trods is leading to the local loss of vegetation and this appears to instigate more widespread soil erosion on the extreme slopes.

General observation on Top Buttress suggested that sheep are for the most part getting access to the steep heather slopes via an obvious stony gully. If this were the case it may prove possible to discourage sheep damage through erection of a strategic length of fencing.

It may be felt necessary to re-establish vegetation on those axe factory sites where erosion is clearly on-going. The revegetation experiment undertaken on Harrison Stickle appears to have been successful in stabilising the ground. In the situation found on Pike of Stickle the provision of suitable 'heathy' turfs could prove a problem. An appropriate donor location where a secondary erosion situation is unlikely to arise would need to be carefully selected.

It would be useful to find out more about the movement of stock on and off Top Buttress and to gain an indication of numbers and period of use. The tenant may be able to help in this respect.

# RESEARCH PROGRAMME SUMMARY

The research programme has identified that considerable erosion of the Top Buttress area has taken place within the last ten years, there is a general degradation of the vegetation cover over the buttress but the most seriously eroded area is around the main access point onto the buttress (north-western edge of the buttress) (fig 2). Evans and Hooson have identified that the prime cause of the erosion is overgrazing; there is chronic overgrazing on the open fell around Harrison Stickle and there is also evidence of severe overgrazing on Top Buttress. Heather only survives in locations inaccessible to sheep and the more inaccessible terraces contained Wavy Hair Grass which was absent from other parts of Top Buttress; five sheep trods were identified from the top 5m of one of the axe factory sites. The field evidence is confirmed by the aerial photographic evidence which shows that between 1976 and 1983 there was observed a loss of patchy heather and a marked increase of sheep trods.

Unlike other areas of the Langdale Pikes, Top Buttress does not appear to be seriously affected by visitor pressure; however Higgitt has identified that other natural erosive processes may have a significant impact upon the axe factories. The most serious of these is freak storm runoff which could inflict extreme damage to an unprotected site and has already caused considerable damage to South Scree gully (Mck Clough Pers.comm). The destructive effect of such events is enhanced by the reduced resilience of the vegetation cover resulting from sheep erosion, there is therefore an urgent need to protect the sites in advance of such an unpredictable event.

Experimental repair work has been undertaken at a comparable site at Harrison Stickle (site 162) and this has so far been successful; the turfs have become established and they do not appear to have been subject to significant levels of erosion. However the vegetation of the Harrison Stickle is predominantly mat-grass which is in marked contrast to that of Top Buttress which has been identified by Halliday as mainly bilberry with some heather, a certain amount of bent and sheep's fescue and patchy moss; mat-grass is notable by its absence. Because the dominant species are dwarf shrubs rather than grasses it is suggested that the covering of imported alien grass turfs, would conflict with the indigenous vegetation.

Evans has highlighted the fact that on Top Buttress there are extremely thin (<5 cm) organic soils over the axe factory sites and that the growth of this mat is a very slow process. The unaided recovery of the damaged organic mat is therefore likely to be too slow to save the underlying archaeological deposits.

# RECOMMENDATIONS

The programme has established that site repair by turf covering can be effective, subject to addressing sources of erosion. It has also demonstrated that the prime factor altering the ecological equilibrium of Top Buttress is the sheep stocking level. The recommendations need therefore to provide the ecological conditions where the existing vegetation can recover and new vegetation can become established. Long term measures (eg. ESA see below) may be able to restore the equilibrium, however repairs can not be postponed until the successful outcome of these measures because excessive erosion will have severely damaged the sites in the interim. It is therefore proposed that the sites be repaired at the earliest opportunity and short term sheep protection strategies be employed in anticipation of long term, permanent solutions.

The techniques are outlined in detail below.

## Site Repair

Although the returfing experimental work at Harrison Stickle was successful, this entailed the importing of an indigenous vegetation onto sites with similar dominant vegetation. At Top Buttress the dominant species are dwarf shrubs and the transplantation of non-dominant grasses may not be successful (Halliday above). The Harrison Stickle methodology needs therefore to be considered in the light of the dominant bilberry cover. Two repair options are proposed and it may be expedient to apply both as a further stage of experimental work to determine the economy and effectiveness of the techniques.

**a) Transplantation of dominant and non-dominant vegetation**

This involves the application of a similar methodology to that successfully applied to Harrison Stickle 162; however it needs to be varied sufficiently to accommodate the indigenous vegetation of Top Buttress. It is proposed to transplant onto the repair sites appropriate heathy turfs (grass turfs incorporating a significant proportion of heather or bilberry) for the essential soil component with rooted bilberry between the turfs to encourage the establishment of the indigenous Bilberry across the repair site. The transplantation of turfs and bilberry must be from a non-local parent site for turfs to prevent exposing and damaging unknown Top Buttress sites. An appropriate parent site for the 'heathy turfs' and the bilberry needs to be identified which may involve an extensive botanical search of the locality. The turfs and vegetation will then need to be imported to the repair site by helicopter. Once imported it will be possible to place the turfs both quickly and with little anticipated damage to the site. Turf-laying should be undertaken shortly after cutting to prevent drying out of the turfs.

**b) Transplantation of dominant vegetation**

The repair procedure recommended by Dr Halliday is for transplantation of rooted shoots of bilberry into the scree, scattered across the repair site. The method is economical in that it will not require large amounts of bilberry and therefore would not necessitate the use of a helicopter. However during the establishment period, which could be a considerable number of years, the axe factory site will be uncovered and therefore susceptible to continued erosion. It is proposed that the method be applied alongside the alternative method on sites which still contain patchy vegetation cover.

## Short-term Sheep Management

There are two strategies for the temporary reduction of sheep on Top Buttress; fencing off specific sites and fencing of access to Top Buttress.

**Site Fencing**
Following the laying of the imported turfs, any ground disturbance could have a seriously detrimental effect on the establishment of the turf base and there is a risk that the lush grass imported from lower altitudes may be more palatable to sheep than the indigenous grass, resulting in an unrepresentative level of erosion at the repair sites. The short term solution of to this problem is to construct temporary fencing around the extent of a repaired site, to provide a sheep free environment during the establishment of newly deposited turfs. Fencing materials can be transported to the site along with the turfs by the helicopter. The fencing would have an anticipated life-time of only two to three years, so provision will have to be made for the removal of the fencing on completion.

The disadvantage with limited fencing is that it does not exclude sheep from the unrepaired sites and the other areas of Top Buttress which may be subject to greater levels of erosion as sheep will inevitably be channelled between fenced areas and natural topography. Unrepaired sites will become more damaged and new sites will continue to be exposed. The repaired sites will develop lush deep palatable vegetation, because it is not pressured by stock, but on removal of the temporary fencing will be under far greater pressure from stock than adjacent areas.

**Fencing off site access**
Top Buttress is an inaccessible area of the Pike of Stickle, a factor which has encouraged the survival of the axe factory sites and can be exploited to restrict sheep numbers on the sites. It is presently believed that the main access for sheep onto Top Buttress is via the gully on the north-western side of the area, where the worst, recent erosion has been observed. Limited research should be undertaken to confirm that this is the case and that ingress from other access points is not comparable (see monitoring below). It is not possible to completely fence off this access point because ingress could be obtained from more difficult access points and result in small numbers of sheep being trapped on Top Buttress. This would cause considerable amounts of erosion and would restrict the movement of sheep at shearing time. The possible solution is to produce a fencing trap, which would restrict the ingress of sheep but would encourage the outward movement of sheep on a similar principal to that of a lobster trap (see a hypothetical example drawn on the site plan; fig. 4). This would not eliminate sheep from Top Buttress but should significantly reduce the numbers and the erosion of the sites. Again this would only be a temporary option until more long term measures can be introduced.

## Long term sheep management

To aid the ecological recovery of all the axe factories, not just Top Buttress, there is a need to reduce the stocking levels on the fells. The only feasible means of achieving this aim is via the ESA scheme which provides compensation for farmers who abide by a set of environmental guide lines (MAFF 1993). As the Langdale Pikes is a 'Fell without heather' (MAFF 1993, 6) this would restrict sheep levels to between 1.7 to 2 sheep per hectare (Pers. comm M.Edwards, MAFF). At present the stocking levels on Langdale are of the order of 2.5 to 3.0 sheep per hectare, and could result in reductions of c. 56% of the original levels. To date, up to a third of agricultural land within the Lake District has been brought under the scheme; however, only a limited numbers of commons have been brought into the scheme, because of the need to get agreement between all commoners.

Evans (see above) considers that the Top Buttress area is marginal grazing land and that a reduction in the number of sheep will be most quickly felt on this terrain. Thus the reduction to the levels required by the ESA scheme could significantly improve the erosion on Top Buttress.

At present the regulations apply to all land owned or tenanted by the farmer; they restrict the use of pesticides, they dictate building materials and techniques on farm buildings, they restrict new drainage and they limit land improvement. The scheme can therefore have serious implications for the entire working practices of each farm. The scheme is workable for privately owned land but becomes difficult to set up on common land where agreement to join must be unanimous amongst all commoners; however in special circumstances it is possible for MAFF to grant concessions in special instances to allow only the common land of individual farmers to be brought into the scheme.

As a result of recent legislation altering the requisite grazing levels, it is now possible for MAFF to restrict subsidies (Hill Livestock Compensatory Allowance (HLCA)) to farmers who over-graze common land and can be used in exceptional circumstances to encourage farmers to join ESA schemes (M.Edwards pers. comm).

## Monitoring

The monitoring programme will need to be modified to enable the determination of any ecological improvements or changes as a result of the repair work and to provide the information necessary for managing stock on Top Buttress. The first stage is to monitor sheep movement in the locality, secondly to monitor sheep levels following repair and thirdly to monitor the recovery or deterioration of vegetation following the repair work.

**Sheep Movement before repair**

Knowledge of sheep movement is necessary to determine techniques for sheep exclusion on Top Buttress and to serve as a baseline in assessing the effectiveness of the repair programme. Determining the ownership of the sheep is a useful guide in establishing an ESA scheme for the area. Heather and bilberry is most susceptible to sheep grazing during winter months when grass production is very low and dwarf shrubs remain relatively palatable; it is therefore important to determine how stock concentrations vary throughout the year. To determine ownership and sheep numbers on the fell will involve a number of site visits in different seasons; the numbers of sheep on the fell should be recorded and identity marks noted. The attribution of marks with farms can be determined by consultation with the local farmers. To determine the access routes it would be worthwhile to survey or sketch onto existing maps the lines of sheep trods which will converge on the main access points where there will probably be increased erosion.

**Monitoring following repair**

Regular visits to the site will be necessary following the site repair to determine the effectiveness of sheep control and to assess the success of the repair work. During each monitoring visit the numbers of sheep on Top Buttress should be counted and compared with the pre-repair figures. The condition of the repaired sites should be photographed and assessed. A quick reconnaissance over the whole Top Buttress area should be undertaken to ascertain if any new areas of erosion are occurring and to identify any change in the condition of existing erosion scars. Any changes should be recorded photographically.

# BIBLIOGRAPHY

Anderson, P and Yalden, D W 1981 Increased sheep numbers and the loss of heather moorland in the Peak District, England. *Biological Conservation* **20**, 195-213.

Ballantyne, C K 1991 Late Holocene erosion in upland Britain: Climatic deterioration or human influence? *The Holocene*, **1**, 81-85.

Boardman, J and Evans, R 1988 *Overgrazing and Erosion in the Lake District National Park: A discussion document* Unpublished.

Boardman, J 1991 *Environmental aspects of support for hill farming: a consultation document*, Report for Council of National Parks and Council for the Protection of Rural England.

Bradley, R and Edmonds, M 1993 *Interpreting the axe trade, Production and exchange in Neolithic Britain*, Cambridge

Carr, S C 1990 *A Study of Overgrazing and Soil Erosion in the Coledale valley,* Unpublished Dissertation, University of Newcastle Upon Tyne.

Carr, S C and Evans, R 1991 *Overgrazing and Erosion in a Lake District valley,* Unpublished.

Chorley, R J and Kennedy, B A 1971 *Physical Geography: a Systems approach*, Methuen.

Claris, P and Quartermaine, J 1989 The Neolithic Quarries and axe factory sites of Great Langdale and Scafell Pike: A new field survey, *Proc Prehist Soc*, **55**, 1-25

Davis, R V 1984 *Stone implements of Neolithic and Bronze Age from the north-west English highland zone and their origins: an archaeological assessment of recent petrological and experimental work*, M.Phil. thesis, Liverpool University

Evans, R 1971 The need for soil conservation, *Area* **3**, 20-23.

Evans, R 1977 Overgrazing and soil erosion on hill pastures with particular reference to the Peak District, *Journal of the British Grassland Society* **32**, 65-76.

Evans, R 1990 Erosion studies in the Dark Peak, *Proceedings of the North of England Soils Discussion Group* **24**, 39-61.

Evans, R 1992a Erosion of rough grazings in Britain. First ESSC Post-Congress Tour Guide. *European Society for soil conservation, Silsoe*, 18-22.

Evans, R 1992b *Sheep - Their Impacts on Some Central Lake District Fells*, Report to the Friends of the Lake District.

Evans, R and Boardman, J 1988 *Soil Erosion in the Lake District - The Need for its Assessment*, Unpublished.

Fell, C I 1950 The Great Langdale Stone Axe Factory, *Trans. Cumberland Westmorland Antiq Archaeol Soc ns*, **50**, 1-13

Gardner, J S 1983 Accretion rates on some debris slopes in the Mt Rae area, Canadian Rocky mountains, *Earth Surface Processes and landforms*, **8**, 347-355.

Harvey, A M 1986 Geomorphic effects of a 100 year storm in the Howgill fells, Northwest England, *Zeitschrift fur Geomorphologie*, **30**, 71-91.

Harvey, A M, Oldfield, F, Baron, A F and Pearson, G W 1981 Dating of postglacial landforms in the central Howgills, *Earth Surface Processes and Landforms*, **6**, 401-412.

Harvey, A M and Renwick, W 1987 Holocene alluvial fan and terrace formation in the Bowland Fells, Northwest England. *Earth Surface Processes and Landforms*, **12**, 249-257.

Innes, J L 1983 Lichenometric dating of debris flow deposits in the Scottish Highlands, *Earth Surface Processes and landforms*, **8**, 579-588.

MacDonald, A 1990 Heather damage: a guide to types of damage and their causes. Research & Survey in Nature Conservation. *Conservation Management of the Uplands,* **28**, Nature Conservancy Council, Peterborough.

MAFF 1993 *The Lake District Environmentally Sensitive Areas, Guidelines for farmers*.

Moseley, F 1978 The geology of the Lake District: an introductory review. In Moseley, F (ed) The geology of the Lake District, *Yorkshire Geological Society, Occasional Publication* **3**, 1-16.

NCC 1987 Changes in the Cumbrian Countryside, *Research & Survey in Nature Conservation*, **6**, Nature Conservancy council, Peterborough.

Newson, M and Bathurst, J 1991 *Sediment transport in gravel bed rivers*. University of Newcastle upon Tyne, Department of Geography research paper.

Peak Park Joint Planning Board, 1974 *The Peak District National Park Structure Plan, Part 2: Report of Survey 1974,* Peak Park joint Planning Board, Bakewell.

Pennington, W 1978 Quaternary geology, In Moseley, F (ed) *The geology of the Lake District*, Yorkshire Geological Society, Occasional Publication 3

Phillips, J, Yalden, D and Tallis, J (eds.) 1981 *Peak District Moorland Erosion Study, Phase 1*, Peak District National Park Planning Board, Bakewell.

Quartermaine, J and Tostevin, P 1991 *Langdale/Scafell Pike Neolithic Axe Factories Management Project: Interim results of Archaeological Fieldwork 1991/1992*, Unpublished LUAU and NT report.

Quartermaine, J Forthcoming Comment on the C14 accelerator date at Thorn Crag (Site 187), Great Langdale, *Archaeometry*

Sissons, J 1980 The Loch Lomond advance in the Lake District, northern England, *Transactions Royal Society of Edinburgh, Earth Sciences*, **71**, 13-27.

Tallis. J 1985 Erosion of blanket peat bog in the Pennines: New light on an old problem. In: Johnson, R H (ed) *Geomorphology of North West England*, Manchester University Press,

Vincent, P J 1985 Quaternary geomorphology of the southern Lake District and Morecambe Bay area. In: Johnson, R H (ed) *Geomorphology of North West England*, Manchester University Press, 159-177.

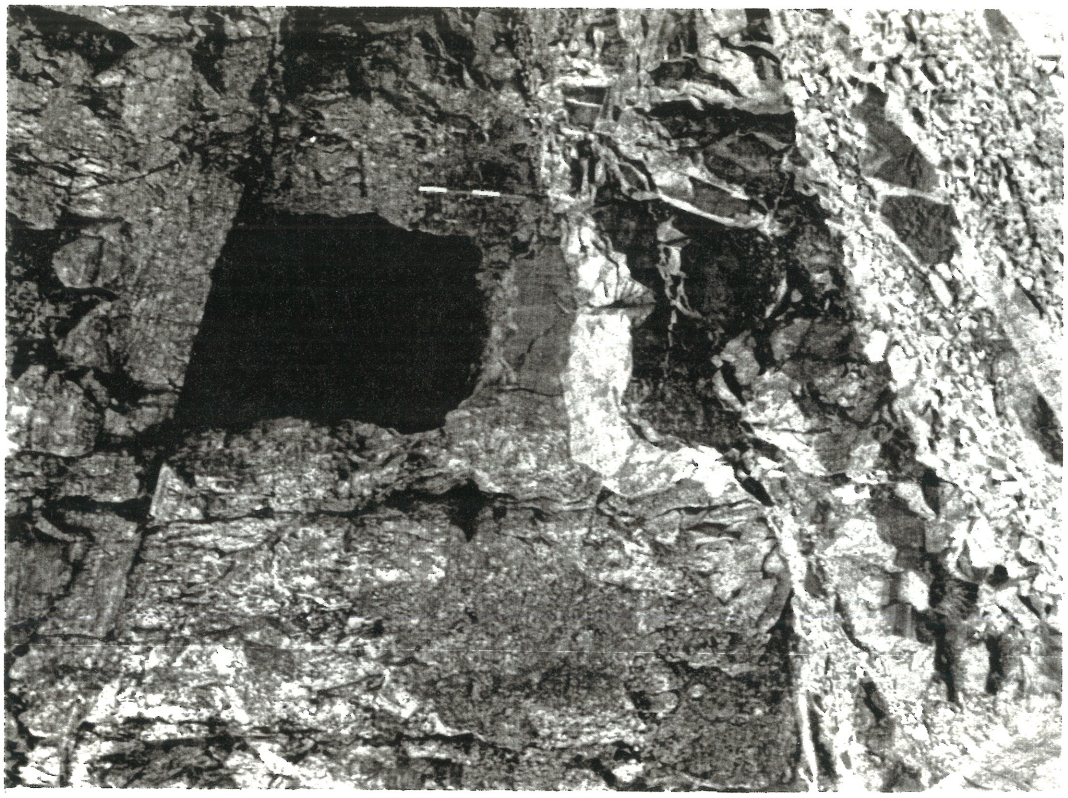
Whitehouse, I E and Mc Saveney, M J 1983 Diachronous talus surfaces in the southern Alps, New Zealand and their implications to talus accumulation, *Arctic and alpine Research*, **15**, 53-64.

Yalden, D W 1979 An estimate of the number of red grouse in the Peak District. *Naturalist* **104**, 5-8

# APPENDIX 1 - PROJECT BRIEF

# ILLUSTRATIONS

Pl.1 Cave site 116
Photographed 1950



Pl.2 Cave site 116
Photographed 1987, showing the result of considerable erosion

Plate 3 Pike of Stickle viewed from the Band

Plate 4 Harrison Stickle site 162 before repair

Plate 5 Harrison Stickle site 162 immediately after repair

Plate 6 Harrison Stickle site 162 one year after repair

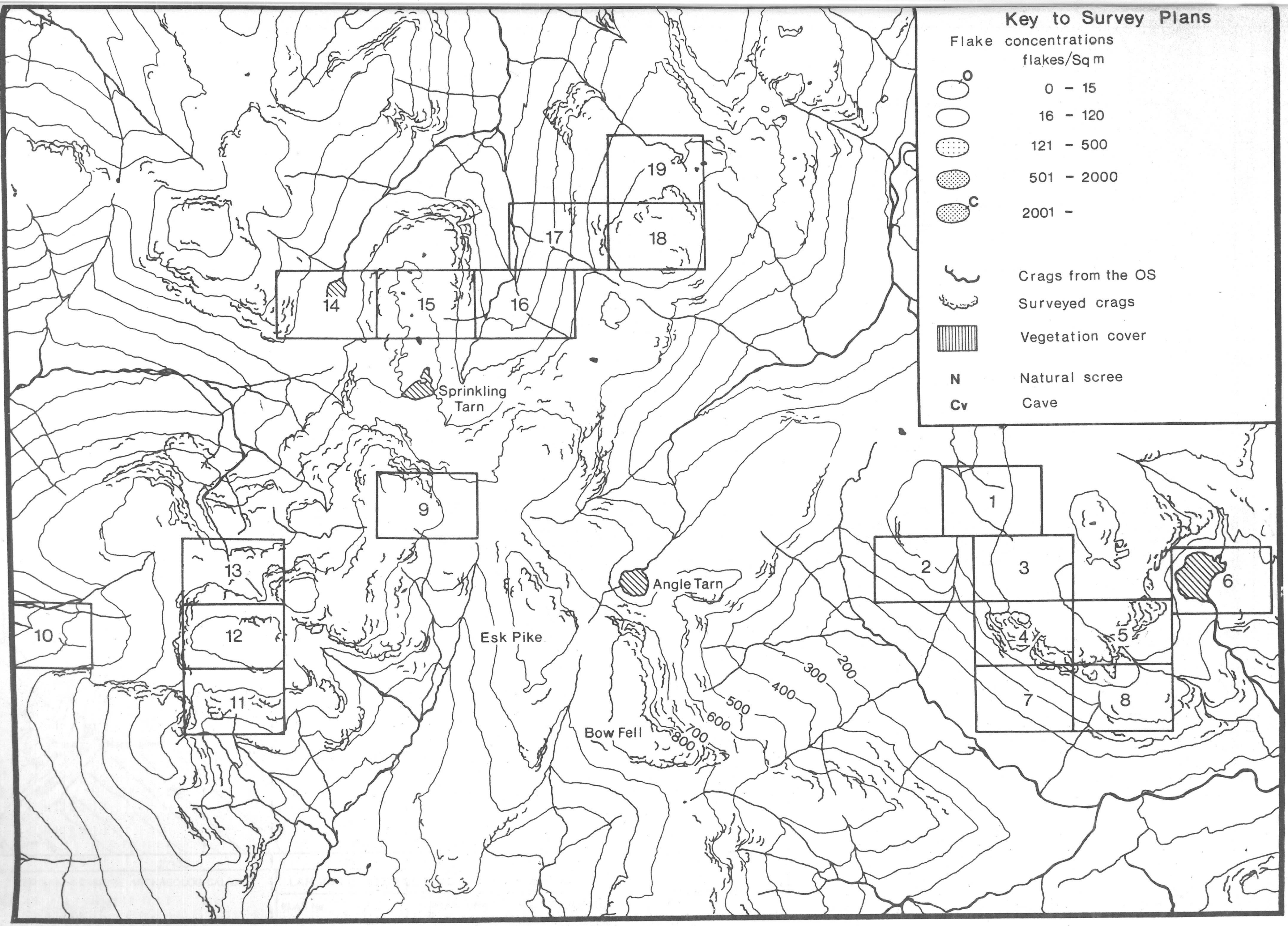
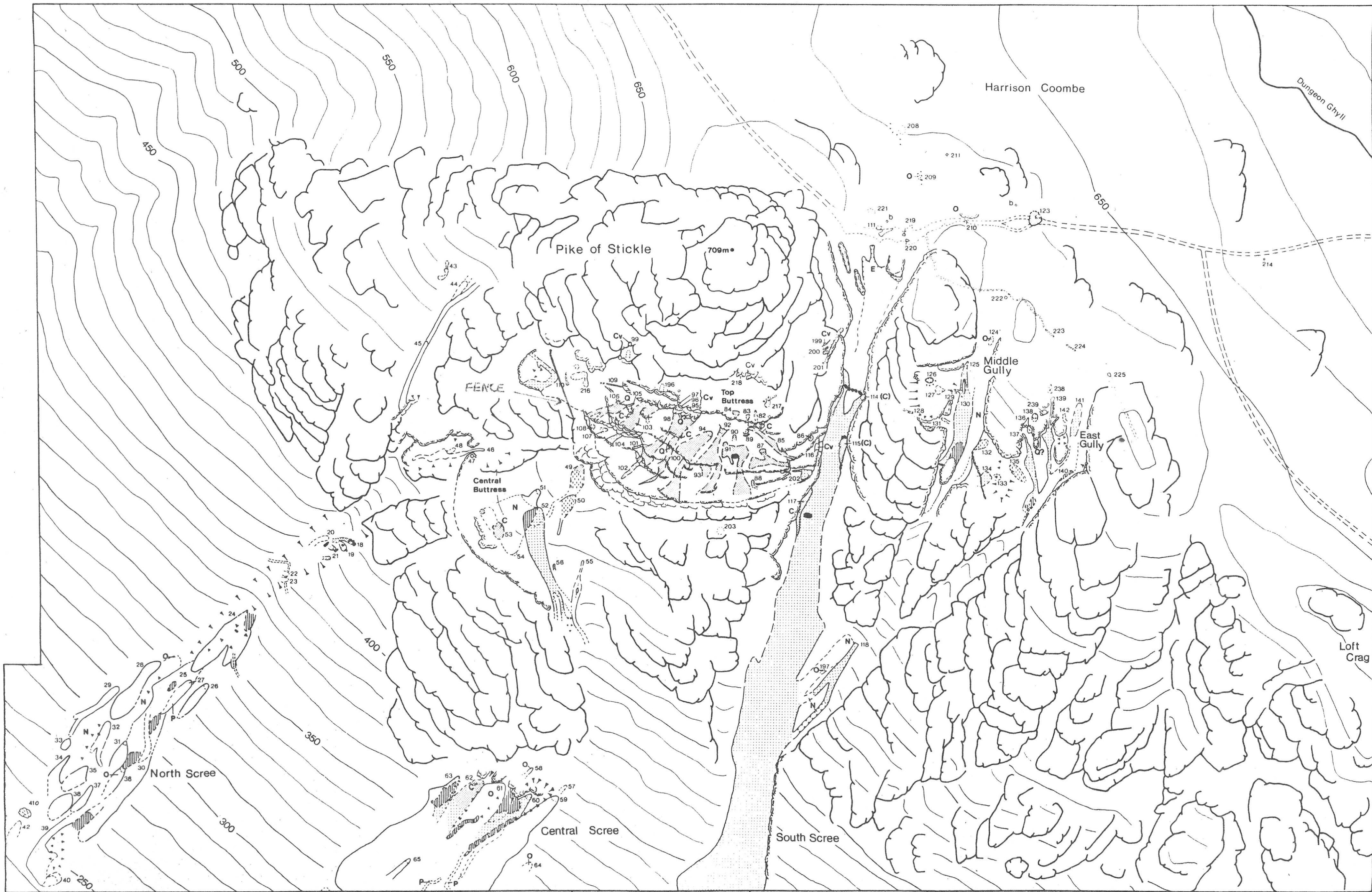



Fig 1 Key to Survey Plans




| | | | |
|---|---|---|---|
| CUMBRIA & LANCASHIRE ARCHAEOLOGICAL UNIT | LANGDALE/SCAFELL PIKE AXE FACTORY SURVEY | 0 50m | |
| THE NATIONAL TRUST | PLAN No. 4 / PLAN NAME PIKE OF STICKLE | | DATE 6 1984 |



Fig 2 Pike of Stickle 1:1000 plan

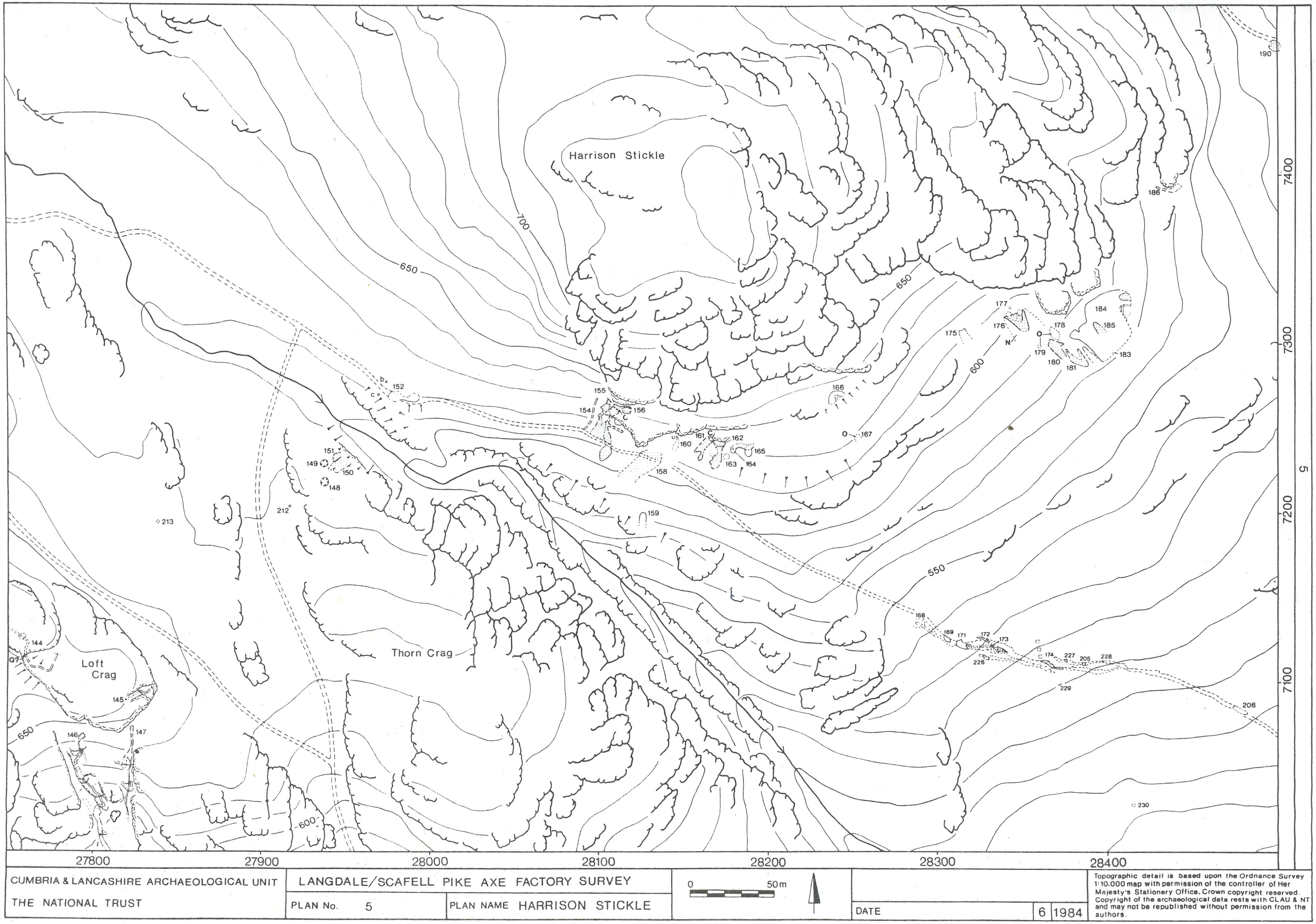



Fig 3 Harrison Stickle 1:1000 plan

No TB 1

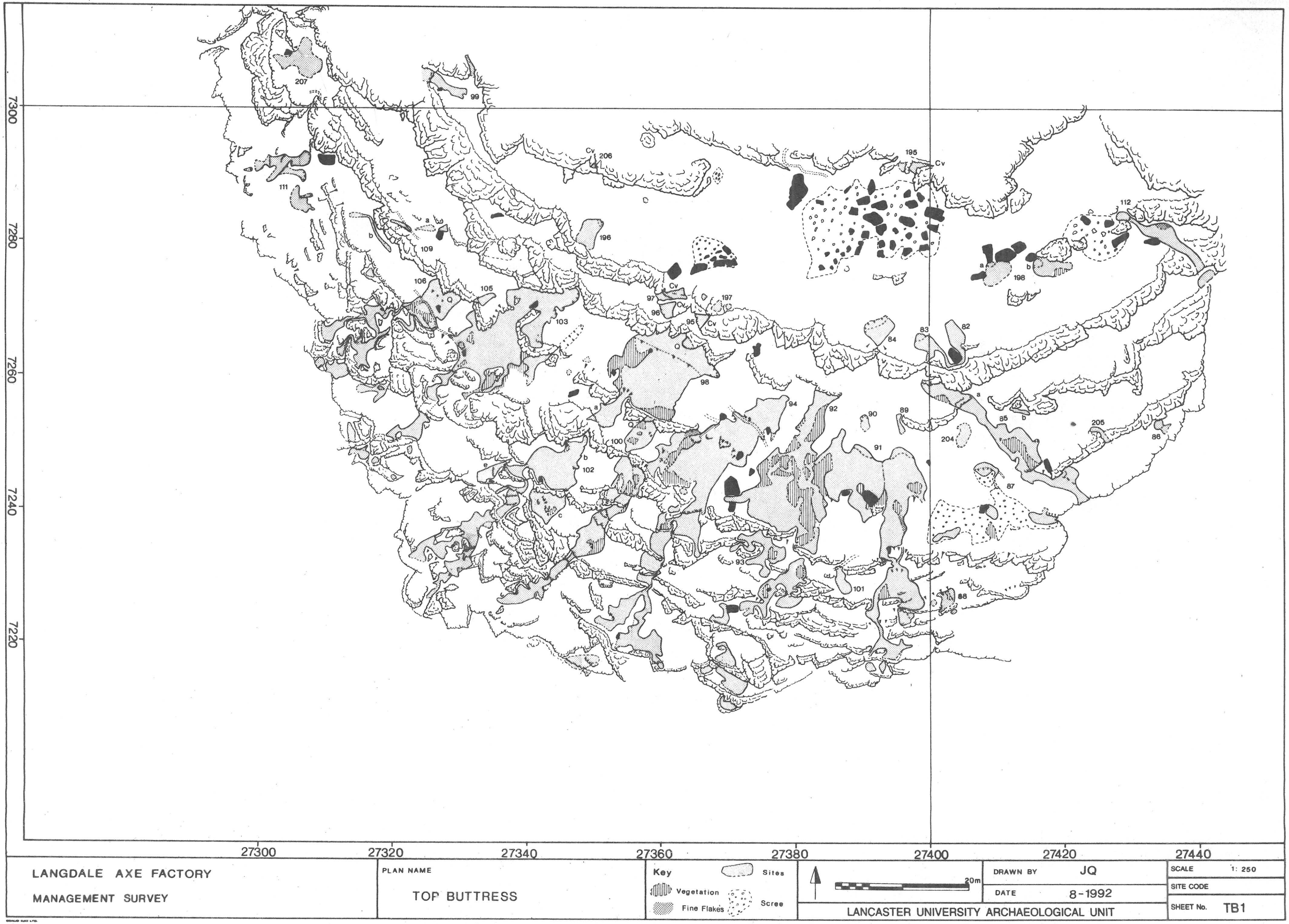



Fig 4 Top Buttress 1:250 plan

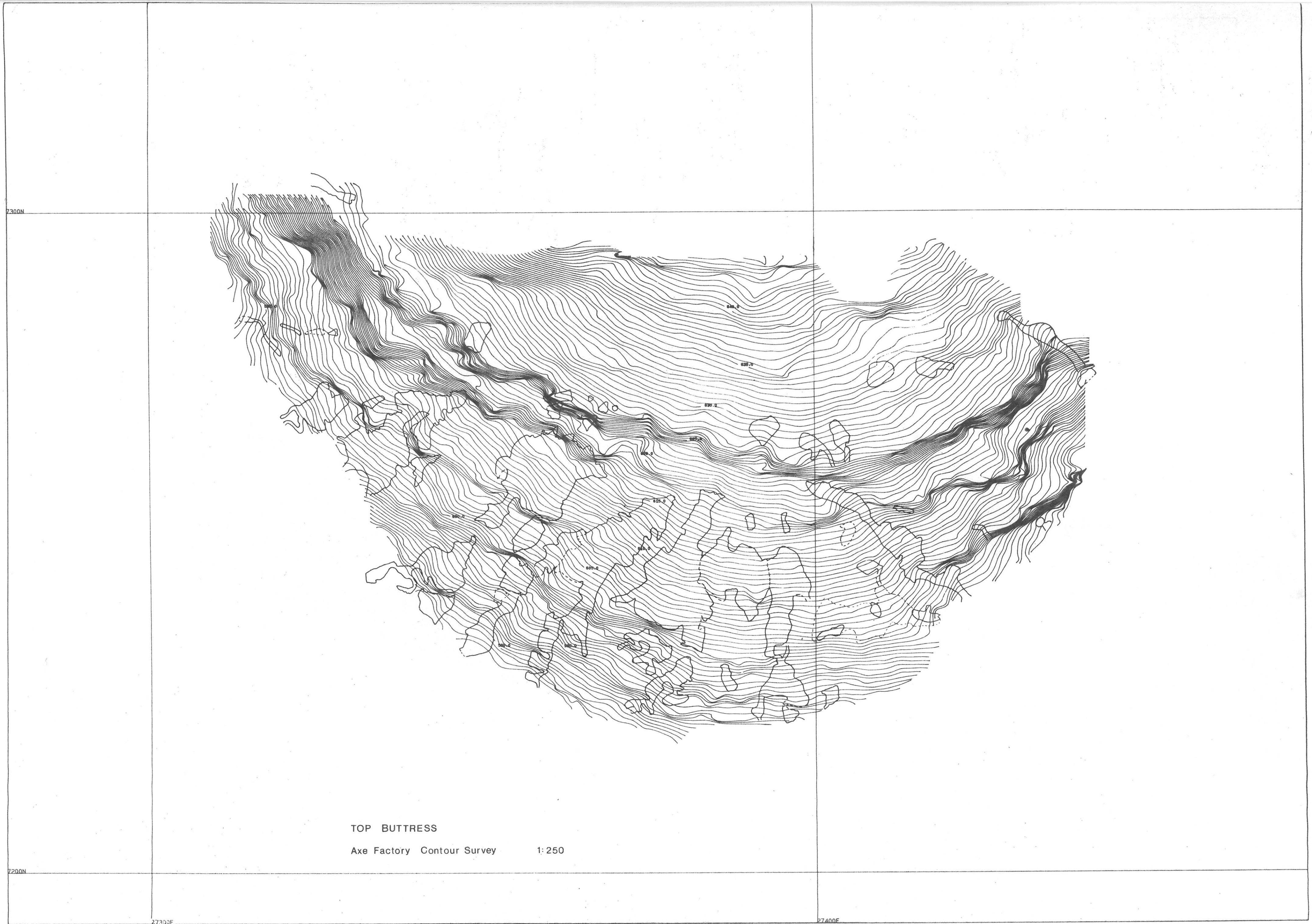



Fig 5 Top Buttress 1:250 contour plan

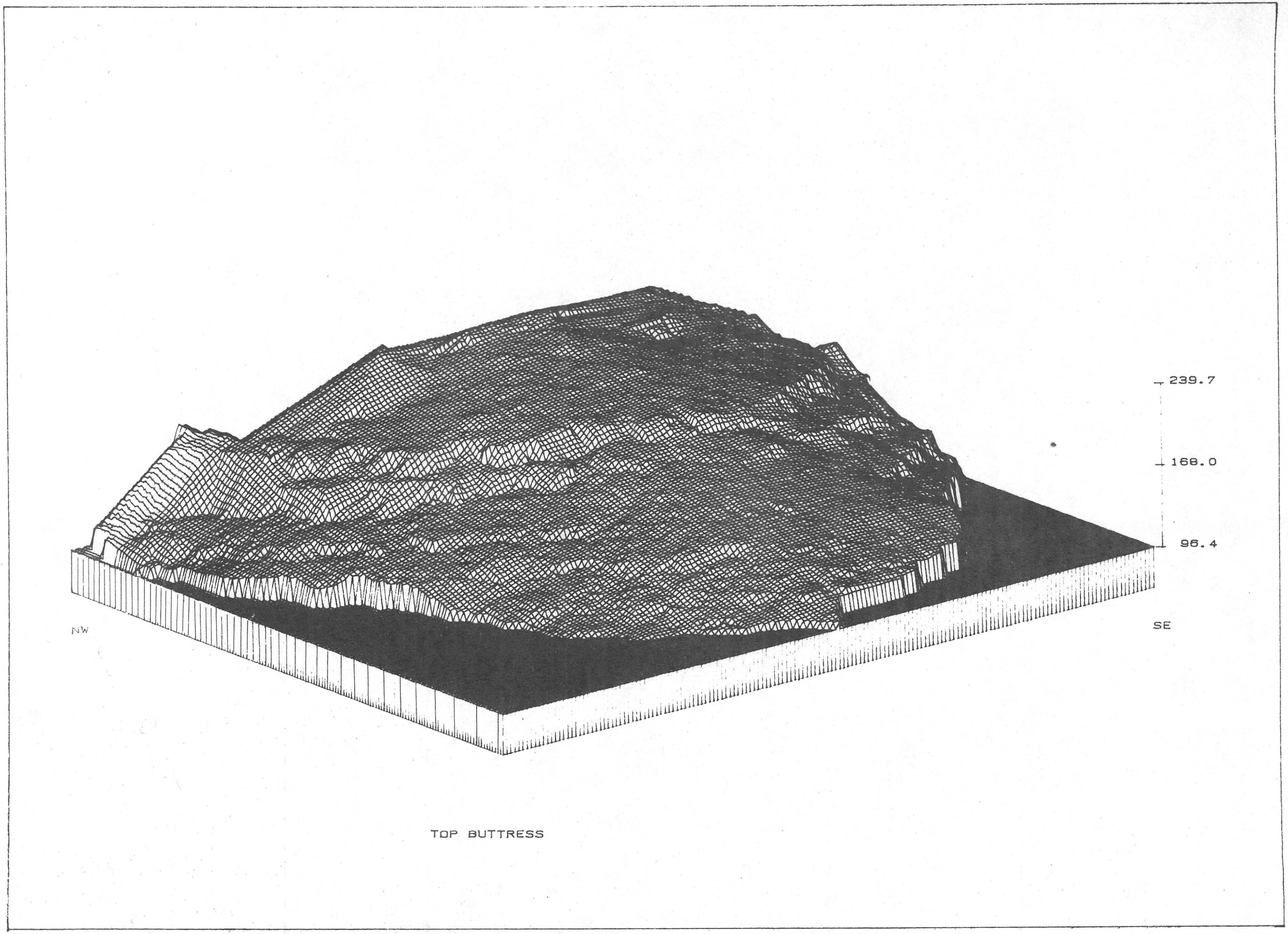



Fig 6 Top Buttress Isometric view