QUATERNARY GEOLOGY OF UPPER SWALEDALE AND ADJOINING REGIONS: FIELD MEETING REPORT

Leaders: J. Rose
W.A. Mitchell

May 27–30th 1988

Introduction

A party of 20 members gathered at the Kearton Guest House, in Thwaite, Swaledale, on the evening of Friday 27th May, to review briefly the field programme for the coming three days. The leaders reported that different themes would be illustrated in different areas, and that examination of the sites would involve a fair amount of walking. Time would be available on the Saturday and Sunday evenings to discuss the general context of the days' observations. The evidence studied in the field would consider all the main aspects of the Quaternary Geology of this part of the Pennine region.

The main elements are summarized, from the oldest to the youngest, in the following list. The location of the sites given in this list is shown on Fig. 1.

i) Pre-Devensian organic deposits—

Scandal Beck, near Ravenstonedale, Cumbria.

ii) Tills and glacier bedforms formed during the Dimlington Stadial (26–13,000 ^{14}C yrs BP)—

Scandal Beck, near Ravenstonedale, Cumbria.
Widdale, south of Hawes, North Yorkshire.
Grisedale, near Garsdale Head, Cumbria.

iii) Glaciofluvial Landforms and sediments formed during the wastage of the Dimlington Stadial icesheet in the Pennines—

Skeb Skeugh and Keld Side, Swaledale, North Yorkshire.
Swale valley between Keld and Hartlakes, North Yorkshire.
Stockdale between Muker and Thwaite, North Yorkshire.

iv) Moraine ridge formed by a corrie glacier in the Loch Lomond Stadial (11–10,000 ^{14}C yrs BP)—

Swarth Fell, west of Mallerstang, North Yorkshire.
Cautley Crag, Rawthey valley, Cumbria.

v) Mass movement landforms, including block glides, large and small debris flows, deep rotational slides, block flows) formed during Late Devenian and Flandrian time (c. 15,000 ^{14}C yrs BP–present day)—

Kisdon Hill, Swaledale, North Yorkshire.
Swarth Fell, west of Mallerstang, North Yorkshire.
Wild Boar Fell, west of Mallerstang, North Yorkshire.

vi) River Terraces formed during Devensian Lateglacial and Flandrian time (c. 15,000 ^{14}C yrs BP–present day).

Swale valley between Keld and Muker, North Yorkshire.
Stockdale between Muker and Thwaite, North Yorkshire.

(vii) Lake sediments and peat bogs formed from the Devensian Lateglacial (c. 15,000 ^{14}C yrs BP) to the present time.

Skeb Skeugh, Swaledale, North Yorkshire.

Mercian Geologist, vol. 11, no. 4,
1989, pp. 275–283.

In many respects the sites visited are typical of much of the upland parts of the Northern Pennines. They are described further in Wilson *et al* (1978), Rose (1980, 1981), Letzer (1981), Pounder and Rose (1981), Riley (1987), and are the subject of unpublished work currently being carried out as part of a University of London PhD thesis by W.A. Mitchell. Raistrick (1926) and King (1976) provide a general review of elements of the glaciation of the region, but many of the statements made in these publications reflect earlier interpretative models and invoke explanations that are not supported by new evidence described on this field excursion.

Saturday 28th May—the area around Kisdon Hill, upper Swaledale

The whole of this day's investigation took place on foot, beginning, both for good geological reasons and for the practicality of obtaining a pub lunch, at Keld village where cars were parked. Mr. Rose outlined the day's programme and indicated that all the evidence to be studied was in the valleys around Kisdon Hill, and on Keld Side, southwest of Keld Village. The main topics to be examined were the origin of Kisdon Hill, the pattern of glaciation and ice wastage, the forms and origins of river terraces and the nature of mass movement on the hillside slopes.

The first stop began at the north end of Skeb Skeugh, just east of Keld Village (NY 894 012). Attention was drawn to the large size of the Skeb Skeugh valley and the absence of any stream. The position of the River Swale was also noted trending east-west across the head of the north-south dry Skeb Skeugh, and incised into a gorge cut through limestones and shales.

This gorge could be seen more clearly at the bridge across the River Swale (NY 895 011) and attention was drawn to the fact that along this section of the river, terraces consist of a thin veneer of rounded river boulders, cobbles and gravel on a rock-cut platform. Usually this rock is a hard limestone band, which can be traced upstream to a waterfall in the river bed, where the fossil terrace becomes the contemporary floodplain. It was suggested that these river terraces are formed by the headward retreat of hard rock bands and are related to the general incision by the River Swale in this region. Each terrace is short in length and can only be correlated within a very small area, having no regional significance.

Similar terraces are associated with East Gill and were discussed at the bridge over this stream (NY 896 012). In the angle between the East Gill and the Swale, high level terrace fragments of this type could be seen where the two rivers converged before incision. The section of East Gill north of the bridge was referred to as an example of what the valleys were like before incision took place and the gorge was formed. The equivalent head of incision on the River Swale is Wain Wath Force (NY 877 016). It was also noted that the north-south alignment of East Gill also coincides with the alignment of Skeb Skeugh suggesting that they were once part of the same valley, along with the upper Swale which flowed southwards down Skeb Skeugh (Fig. 2).

At NY 897 011 it was possible to obtain a magnificent view of the main gorge of the River Swale between Keld and Hartlakes. This gorge is of a much larger scale than that associated with the river terraces, which occupy the lower part of the large feature. Mr. Rose suggested that this gorge was initiated by glacial erosion during the later part of the Dimlington Stadial and was adopted as a route for the River Swale following sub-glacial meltwater drainage. Prior to this the Swale valley had followed the route down Skeb Skeugh on the west side of Kisdon Hill and the section between Keld and Hartlakes had been the site of a col between the Swale and Swinner Gill valleys (Fig. 2). Only when this col had been eroded to a low level did diversion occur and the Swale adopt its present route. He explained that evidence in support of this interpretation would be examined on Keld Side, later in the day.

Attention was also drawn to a massive block glide that also appears to be associated with the gorge (NY 898 009). Mass movement at this locality is attributed to failure along an incompetent shale band within the limestones into the space provided by the newly eroded gorge. Above the block glide the party were able to see the lower parts of an even more massive debris-flow that appears to have stabilized on the upper part of the hillside. Mr. Rose commented that evidence to show that this feature developed during the Loch Lomond Stadial would be provided from lake sediments on the final day.

The party then continued along the footpath through the gorge, examining en route, the old lead level below Stony Hill. A good example of the river terrace composed of bedrock with a veneer of gravel and cobbles was seen below the level (NY 904 007) where it was also possible to see a poor, but convincing, exposure of the river sediments.

The area around Hartlakes (NY 908 004) provided the best examples of conspicuous fossil river terraces in the region. In this region, all the terraces are formed of river sediments, and can be related either to the Swale or to Swinner Gill. The highest of the terraces related to the main river could be seen on both sides of the present channel sloping at an angle far in excess of that of the present stream. Mr. Rose suggested that these terraces

were formed as fans at the mouth of the Swale gorge having been dissected as a response to the progressive incision of the gorge. As with the rock-cut terraces upstream, these depositional features are of local significance only. A similar explanation was suggested for the massive, and most impressive terrace fragment at the mouth of Swinner Gill. The surface gradient and imbrication of the boulders that comprise much of this feature indicate formation by the tributary stream rather than the Swale, but the party were able to see that a far more complex history is indicated by the sediments exposed in the feature at NY 908 005. Deposits revealed at this section include well sorted fine sands, laminated sands and silts, diamicton units, as well as a bouldery, cobbley gravel which forms the uppermost part of the section. It was considered by the party that these deposits suggest that debris-flow and lacustrine processes were involved in the sedimentation, in addition to high energy river activity.

After Mr. Mitchell had discussed the debris-flow tracks and deposits on the hillside of Ivelet Moor (NY 911 004), the party headed south along the path to Muker. This section of the Swale valley shows well developed low level terraces on which channels and bars can cleary be discerned. Some of these features have formed as a response to lead-mine debris being added to the rivers in the area, and others, such as that at SD 908 988 are currently in the process of formation. Mr. Rose emphasised that, irrespective of their age, all these terraces are the product of reworking existing boulder- and cobble-size river sediments, by a powerful River Swale. Because of the coarse-grained nature of the sediment, individual terrace fragments show a wide range of relief which means that as the terraces are dissected fragments survive at different altitudes above the present river level. Mr. Rose emphasised that as with the terraces already studied these features have only local significance and cannot form the basis of any widescale correlation.

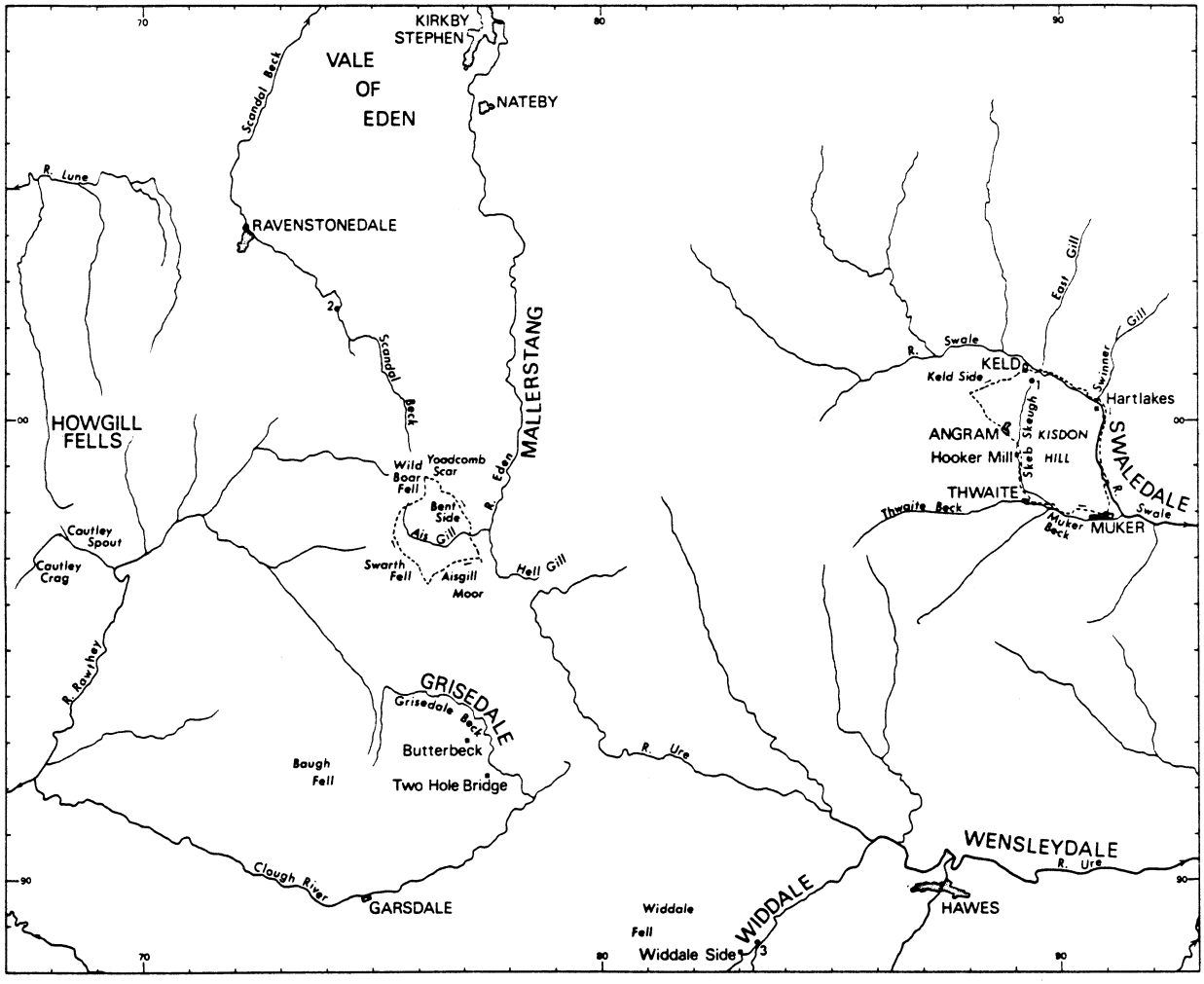

Fig. 1. Localities visited during field meeting. The dashed lines in the area of Kisdon Hill and Ais Gill show the routes taken on the first and second days respectively. The black dots show particular sites visited: 1 = the point of the borehole in Skeb Skeugh; 2 = the site of the organic deposit at Scandal Beck; 3 = the site of the drumlin at Widdale Side. The scale and orientation is shown by 1 km interval National Grid coordinates marked around the margin of the map. The number of each 10 km coordinate is given.

After a pub lunch at the Farmers Arms the party continued their walk westwards over a high terrace (about 9 m above the present stream). Mr. Rose pointed out that this feature is anomalous in that it has a very low gradient and has an isolated location at the confluence of the Stockdale and Swale valleys. He suggested that it had formed as a kame terrace, probably in a lake between an ice tongues filling the Swale east of Muker and the valley west of Muker (Fig. 2). He indicated that if this interpretation is correct then it provides evidence for the position of ice margins at the later stages of ice wastage in the area showing that the main ice-stream down the main Swale valley was more extensive than ice-stream from the west which had already begun to retreat back up the tributary valley.

After descending from the kame terrace (SD 904 981) the party were able to look eastwards and see a shallow staircase of river terraces formed where the Muker Beck has dissected the sediments in the ice-tongue hollow, and westwards to the impressive debris-flow at Usha Gap which extends part-way across the valley bottom. Continuing west along the footpath on the terraces of the Muker Beck, Mr. Rose attempted to demonstrate a site where a terrace with an elevation of about 3 m above the river continued upstream to become a floodplain terrace only 1 m above the same river. He suggested that the point where this change takes place fulfilled the criteria of a 'knickpoint' formed at the limit of incision by the present stream. In this case incision is attributed to river adjustment to valley bottom slopes created by Devensian glacial activity in the area, and is of local significance only.

Following the footpath to Skeb Skeugh, the party continued across depositional river landforms. Initially, in the area around Thwaite they crossed the fan of Thwaite Beck (SD 895 882) which is currently being dissected by the present stream, then in the area around Dirty Piece (SD 892 985) they were able to observe that the diminutive Skeb Skeugh was flowing in a channel with banks at a higher elevation than the adjacent floodplain. This phenomenon was described as typical of an aggrading stream, and in this locality was shown to be due to local erosion of landslip material by Skeb Skeugh. Also in this area, the party were able to observe a series of small hills and a ridge composed of sand and gravel, which are considered respectively to be kames and an esker formed by glacial meltwater during ice wastage.

At Hooker Mill (SD 892 994) the party were able to study the largest of all the landslips in the area—a deep rotational slip extending into bedrock. The backwall of the slip was observed at Hooker Mill Scar, and the toe could be seen in the bottom of Skeb Skeugh where it completely blocked the valley, although it has since been dissected by the present stream which forms a narrow gorge. Mr. Rose reported that boreholes drilled in the valley bottom, upstream of the landslip, indicated that a lake had once existed in the area, and that pollen analysis from the basal lake sediments showed that the slip probably occurred early in the Flandrian Interglacial. He also reported that detailed levelling had shown that the dam caused by the landslip would have been large enough to flood the whole of the valley upstream of Hooker Mill, although it is probable that such a lake was short-lived due to the rapid erosion of the gorge through the landslip sediments.

After leaving the landslip the party headed out of Skeb Skeugh to the hamlet of Angram and onto the hillside known as Black Hill/Keld Side. En route to Black Hill (NY 882 006) the path crossed a series of dry channels, the largest of which (about 15 m deep, 12 m wide at the base) separates Black Hill from Clumpstone Hill. The party stopped to discuss these features at the point where this channel crosses the watershed between the Swale and Skeb Skeugh (NY 882 005). Mr. Rose pointed out that these dry channels are part of a series located on the hillside between Angram Pasture and the River Swale. All are aligned and slope west-east, most have a position on the hillside independent of the present gradient (ie parallel to the contours), all exist without a catchment to provide runoff for their formation and several have a position that crosses the interfluve.

Raistrick (1926) had noted some of these features, and suggested that they were formed as proglacial lake overflow channels. However, Mr. Rose informed members that there was no sedimentary evidence in support of this hypothesis despite detailed field mapping in the area where this lake had been postulated. Alternatively, he suggested that the abrupt origin of certain channels, the anastamosing patterns of some of the channel systems, and the up-and-down long profile of the lowest channels indicated that they had formed by sub-glacial meltwater rivers with a direction of flow controlled by the hydrostatic head of water within a glacier, which in this case was derived from an ice body flowing from the west to the east along the upper Swale valley.

Mr. Rose also pointed out that these channels are important in terms of the regional history of the area and the origin of Skeb Skeugh, because: i) they show a sequential pattern of dissection whereby the higher, southerly channels were eroded and abandoned before the lower and more northerly features and: ii) the southern group of channels show a trend indicating meltwater drainage towards Skeb Skeugh, whereas the most northerly group of channels show a trend indicating drainage into the Swale valley between Keld and Hartlakes. The party were able

to examine the point where this divergence of drainage takes place (SY 889 009) and consider the implications for the abandonment of Skeb Skeugh, and the initiation of drainage by the River Swale north of Kisdon Hill. Following this line of argument, Mr. Rose suggested that these channels provide the evidence for the change of drainage from Skeb Skeugh to the present route now followed by the River Swale and indicate that this change took place during the later part of the Dimlington Stadial as the icesheet over this part of the Pennines began to thin and waste back to its source areas. In this case the diversion of the River Swale, the abandonment of Skeb Skeugh and the formation of Kisdon Hill also took place some time around 15,000 years ago.

To conclude the investigation the party returned to Keld village and to the first site of the day (NY 894 012). Here Mr. Rose drew attention to a rather poor exposure of limestone, soft sandstone and shale boulders by the side of the track and suggested that this material represents some of the deposits eroded by the meltwater rivers that drained beneath the glacier across the lower slopes of Keld Side to the west.

Sunday 29th May—Widdale, Grisedale, Swarth Fell and Wild Boar Fell.

A number of sites were visted in the area of upper Wensleydale to examine the evidence for ice movement directions, glacier behaviour, local corrie glaciation and large-scale slope failures. The first site visited was in Widdale (SD 83 88), a southern tributary valley of Wensleydale (Fig. 1). Mr. Mitchell outlined the main geomorphological features of the area and explained his techniques of detailed geomorphological mapping. He pointed out that drumlins are the most distinctive landform in the region and that they are more variable in form than those in adjacent areas such as the Vale of Eden (Letzer, 1981). In addition, he drew attention to the fact that many of the drumlins show evidence of post formational modification in the form of erosion or slope failure in response to river action along their flanks.

Attention was then directed to the ice movement directions indicated by the orientation of the glacial bedforms (drumlins). Mr. Mitchell reported that the regional pattern within the Wensleydale catchment shows a down-valley ice-flow (Fig. 3) with small ice-streams from the tributary valleys coalescing to form a major flow down Wensleydale. Within the region around Widdale drumlins were noted both in the valley and on the interfluve area of Widdale Fell (SD 79 87). This evidence is interpreted as indicating that Widdale and the adjacent fells were overridden by ice flowing from an ice-shed to the south and southwest rather than an ice-centre to the north west over Wild Boar and Baugh Fells as suggested by Raistrick (1926), Clayton (1966) and King (1976).

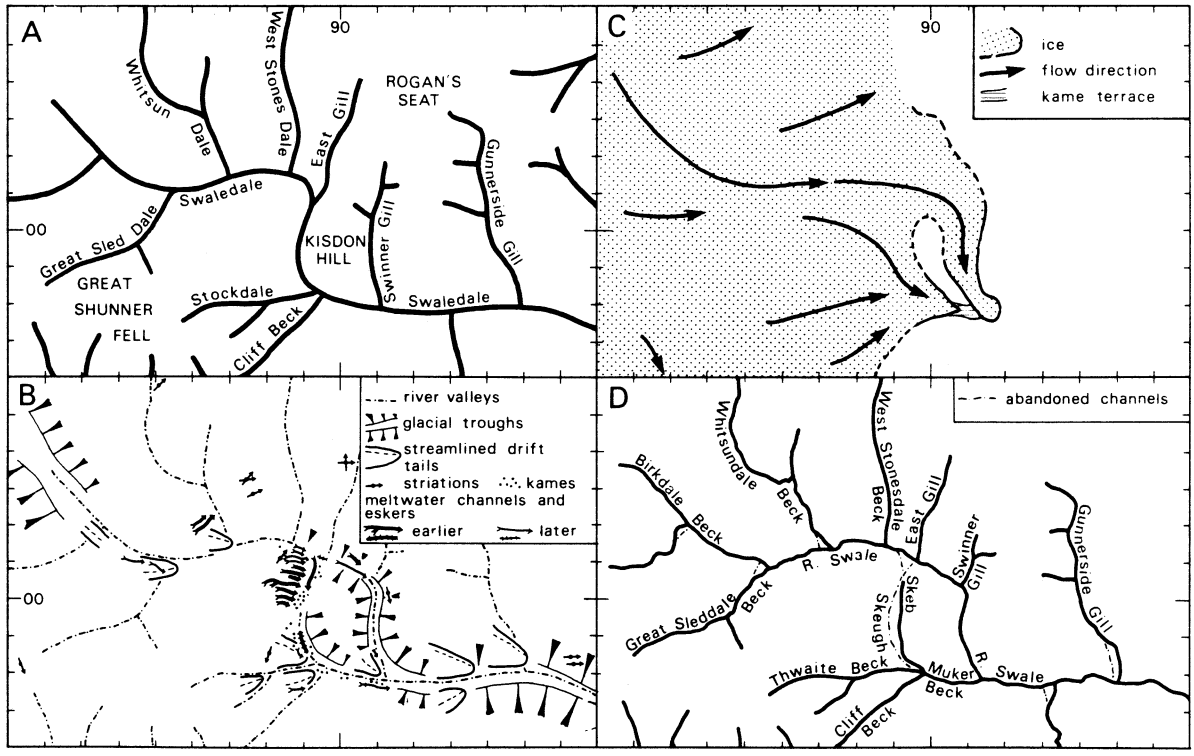

Fig. 2. Possible development of the river pattern and glaciation around Kisdon Hill, upper Swaledale, North Yorkshire. A = inferred original valley pattern; B = glacial landforms; C = inferred ice marginal positions and glacier flow paths at the time of formation of the kame terrace at Muker; D = present river pattern with position of abandoned (buried) river channels.

The party then examined a section cut in the stoss end of one of the drumlins at Widdale Side (SD 834 886). The sediment in this drumlin comprises a diamicton including stratified units of sand, gravel and diamicton. Mr. Rose pointed out some of the characteristics of the sediments, noting that the lower part of the diamicton contained a larger proportion of limestone clasts and a clast fabric with, in the majority of cases, a preferred orientation parallel with the drumlin crestline. This was compared with the upper part of the diamicton which has a sandier matrix and a higher proportion of sandstone clasts. These units are considered to be tills laid down either at the base (the lower part of the diamicton) of the glacier or from material transported on the glacier surface (the upper part of the diamicton). The presence of sorted sediments and interbedded diamicton units within the larger sediment body was considered to be evidence that running water was present during the formation of at least part of these deposits. A lively debate then followed on the significance of the internal sediments to the formation of drumlins. Various interpretations of the sediments were proposed, illustrating the many different ideas on drumlin formation. These ranged from lodgement to subglacial deformation of the bed (Boulton, 1987), flow separation by high magnitude meltwater events (Shaw, 1986) and sedimentation in leeside cavities (Dardis *et al.*, 1984).

A short drive up Wensleydale to Garsdale brought the party to the next site in the area of the confluence between Grisedale and Garsdale (Fig. 1). On a rain swept drumlin near Two Hole Bridge (SD 775 923), Mr. Mitchell pointed out a complex drumlin pattern. In the main, drumlins indicate an ice-flow from the west and southwest from Garsdale towards Wensleydale and the Mallerstang. However, detailed mapping in Grisedale has shown that the drumlins at Butterbeck (SD 77 93) have smaller forms superimposed on them and that the final ice-flow was down valley towards the southeast. It was suggested that this pattern indicated changes in the location of the ice divide due to mass balance variations during glaciation. The attention of the party was also drawn to the large channel of Grisedale Beck cut in bedrock just upstream of its confluence with the River Clough (SD 779 922). It was suggested that this had originated as a subglacial meltwater channel.

After lunch at the Moorcock Inn the party drove north to Aisgill Moor and parked in an abandoned quarry near the Settle to Carlisle Railway (SD 774 969). Because of its importance to mass movement processes in the region Mr. Mitchell first outlined the pre-Quaternary geology of the area pointing out that the quarry was located in the Main Limestone which marks the beginning of the Namurian in this area.

The party walked towards Swarth Fell (Fig. 1) to examine a moraine ridge associated with a small local glacier which developed on the steep, east facing slope of this hill. On the walk up to the moraine the party were able to observe the drumlins on Aisgill Moor (SD 766 968) and south of Hell Gill (SD 78 96). The former could be seen to trend northeast-southwest parallel with those in Grisedale and related to regional ice-movement independent of the local topography, whereas those around Hell Gill and along the adjacent valley bottom show a north-south trend associated with ice flow down Wensleydale (Fig. 3).

The moraine ridge was reached at the point where it is breached by Low Soursike (SD 762 966). Although the glacial origin of this feature had previously been recognised by Rowell and Turner (1953), Mr. Mitchell showed that its form was more complex than previously realised, consisting in place of several individual ridges, and with the northern part having developed on a pre-existing landslide. The party were able to observe the variations in the form of the moraine ridge: being indistinct just north of the stream that flows from Flue Scarth Nick (SD 761 961), consisting of two ridges just south of Windy Hills (SD 761 968), and comprising three ridges northwest of Windy Hills. In places the inner most ridge is buried by peat. Much discussion was generated regarding the origin of the ridges. Small exposures in the side of Low Soursike (SD 762 965) were examined showing till and shale. Attention was also drawn to the various mass movement landforms on the steep east facing slope of Swarth Fell. These include debris flows, boulder lobes, rotated bedrock blocks (SD 756 968), and a protalus rampart.

Discussion on the age of the moraine ridge was based on correlation with similar sites elsewhere in the northern Pennines and the Lake District (Gunson, 1966; Pennington, 1978). Mr. Mitchell reported that similar small moraine ridges have also been mapped on Whernside, Great Coum, Combe Scar, and Cautley Crags. At Combe Scar in Dentdale, Gunson (1966) had taken a core from a basin behind the moraine and found only a Flandrian pollen spectrum. On the basis of this type of evidence it was suggested that these moraine ridges were formed by corrie glaciers developed during the Loch Lomond Stadial. However, it was agreed by all that the basin deposits within the moraine ridge at Swarth Fell would justify further study, and that the relatively low elevation of the ridge at 530 m O.D. poses a problem that would also deserve further attention.

From Swarth Fell a walk north along the hillside took the party to the summit of Wild Boar Fell (SD 75 98) where panoramic views of northern England in late afternoon sunshine were appreciated by all. The purpose of visiting the eastern part of this mountain was to examine the impressive mass movement features on High White Scar (SD 761 983). Mr. Mitchell pointed out some of the major forms that have been identified as a result of very large scale mapping. He commented on the role of lithology in determining the type of slope failure. Most of the mountain is composed of thick shales and occasional sandstones with a massive gritstone caprock. This latter was shown to be important as a reservoir rock and in introducing blocks and boulders into the failures.

The style of failure could be seen to vary from south to north along this edge of the mountain. At Bent Side (SD 765 976) the failures only occur in thick shales which have broken down along a complex pattern of vertical tension gashes to form small 'terraces' that show little sign of rotation. The lower part of this slope shows a number of discrete rotational slides or flows which even extend down to the Aisgill valley (SD 762 973).

Under High White Scar the gritstones provide a debris input. A series of ridges occur at right angles to the cliff edge and have been interpreted as lateral moraine ridges (Rowell and Turner, 1953). Mr. Mitchell pointed out that the mapping had shown that in terms of form, size and position these features were better explained as large debris flows or rock glaciers with marginal levées. He also pointed out that in places these features lie on top of older and more extensive failures that extend across much of the hillside, even as far as the outcrop of the Main Limestone.

The party then descended at Yoadcomb Scar, noting the steepness of the backslope of the large rotational failure to the north. This group of failures differ from those further south in being covered with extensive spreads of boulders (SD 765 984). However, like those failures further south these features rest on more extensive massive landslips. Mr. Mitchell informed the party that Rowell and Turner (1953) have recorded a Flandrian pollen spectra in sediments from a small tarn impounded by a rotational block on the other side of the Mallerstang. He suggested, therefore that the youngest mass movement features may have formed during the Loch Lomond Stadial, whereas the more extensive earlier features may have formed during the later part of the Dimlington Stadial.

The route back followed Yoadcomb Sike where sections in the various failures were examined only briefly due to lack of time. These sections recorded such features as clay-rich diamicton with shale clasts, deformed shale units and a buried palaeosol. The party then returned to the cars and the hotel at Thwaite.

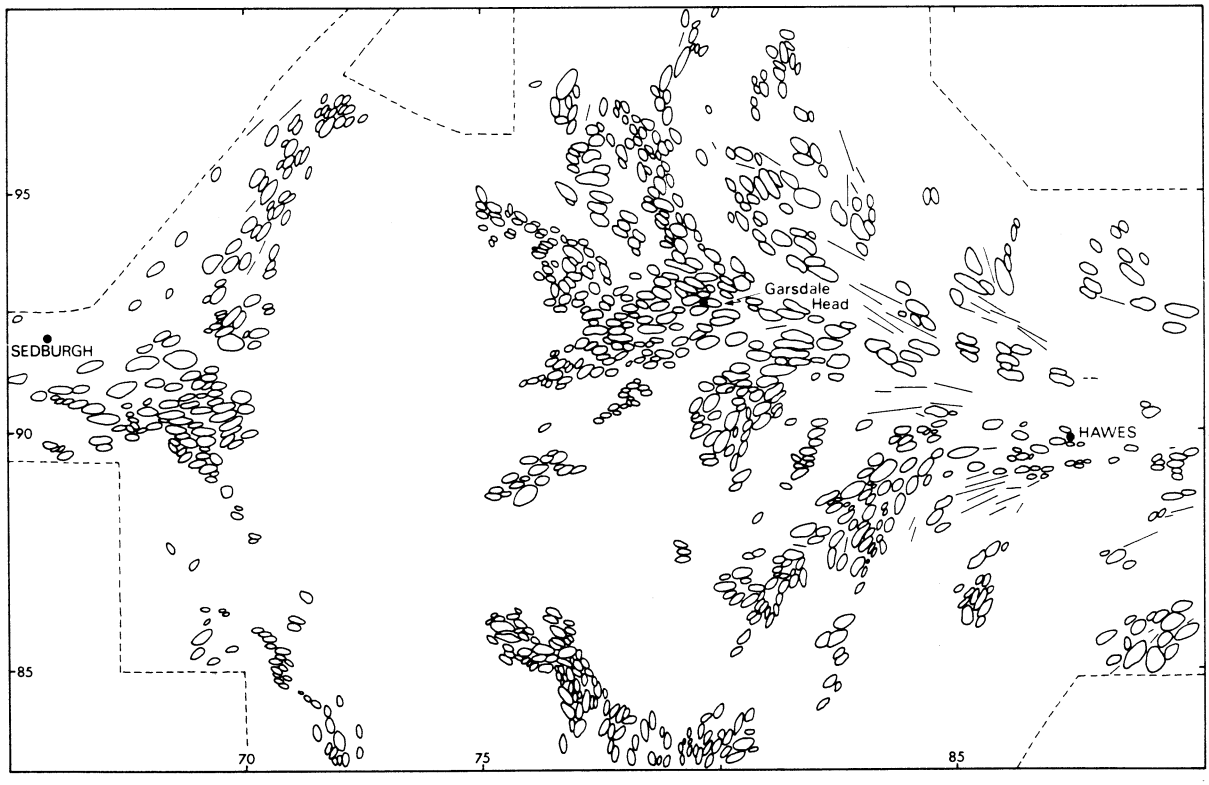

Fig. 3. Patterns of drumlins and streamlined drift tails in upper Wensleydale and adjoining areas. Each glacially streamlined landform is shown by the outline planform. Scale and orientation is shown by 10 km National Grid coordinates.

Monday 30th May—Keld, Upper Swaledale; Scandal Beck, Vale of Eden and Cautley Crag, Howgill Fells.

This day's investigation began by returning to Keld to take a core from the lake sediments at the base of Skeb Skeugh (NY 894 009) in order to examine evidence for the depositional history of this valley bottom location since deglaciation (see Rose 1980, Fig. 5 for a full description of the succession). Drilling was carried out with a Russian Corer with a 0.5 m barrel, using labour provided by the male members of the party.

A core of about 5.8 m long was taken and laid out adjacent to the borehole. Members were able to see quite clearly the main elements of the lithostratigraphy, and Mr. Rose added details of the biostratigraphy that had been carried out by Drs. R.L. Jones and D.H. Keen both of the Geography Department, Coventry Polytechnic.

From the base upwards, the succession consisted of a pale brown and grey laminated marl, a dark grey clay, a second pale brown and grey laminated marl and peat. On examination of the units, members discovered gastropod and bivalve shells and a rodent's tooth from the marls, and a section through a tree trunk in the peat. Samples were taken from the core by Mrs. Mulholland. Subsequent analysis by Mr. R.C. Alvey, who has kindly communicated his results, indicates the presence of Chara oospores, species of ostracod, and the following freshwater mollusca: *Pisidium obtusala* Pfeiffer, *Planorbis corneus* (L), *Lymnaea peregra* Muller, *Armiger obtusale* Pfeiffer, and *Sphaerium corneum* (L). Mr. Rose indicated that laboratory analyses had shown that the lower marl had formed in a sediment-free lake during the Windermere Interstadial (13,000–11,000 ^{14}C yrs BP), that the dark grey clay (which often includes fresh rock fragments, although none were seen on this occasion) was formed during the Loch Lomond Stadial (11,000–10,000 ^{14}C yrs BP) and that the upper marl and peat were formed during the Flandrian Interglacial (10,000 ^{14}C yrs BP to the present day). He suggested that the change of lithology during the Flandrian was due to the infill of the lake and the change of base status of the hillside soils, so that a clean-water, base-rich water-body in which the Chara oospores were deposited, was replaced by an acidic bog progressively infilled with organic detritus. Mr. Rose suggested that the rock fragments usually associated with the dark clay are likely to be associated with the formation of the debris flow on the hillside above the site (see page 276).

After further discussion of the environmental significance of this site, and the possible relationship with the lake formed by the Hooker Mill landslip, the auger was cleaned in a nearby pool, and the party returned to their cars at Keld, then made their way to Nateby for lunch.

For most of the party, the final site of the excursion was at Scandal Beck (NY 743 025) near Ravenstonedale in the Vale of Eden. This site is located in the Vale of Eden drumlin field (Riley 1987) and is famous as being one of the few sites in the north of England with organic material preserved beneath *in situ* glaciogenic sediments, and is particularly important in that these organic sediments contain a pollen spectra that indicates a temperate vegetational assemblage that has been ascribed, tentatively, to the Ipswichian Interglacial (Carter *et al.* 1978, Letzer 1981).

At the time of the visit the section was quite badly degraded, but the leaders were able to dig out a small section where the organic sediments could be seen bedded with yellow sands and grey clays, and overlain by two matrix-rich tills distinguished on the basis of the relative frequencies of limestone and sandstone clasts. Members were able to examine the sheared nature of the organic sediments and the hard compresed natured of the wood fragments, and discussed the implications of this evidence in terms of: i) the small lake that was filled with organic detritus during the Ipswichian Interglacial between about 132,000 and 122,000 yrs ago, and: ii) the glaciers that over-rode this site at least once during the Devensian Glaciation. Current interpretations of the Quaternary sediments and landforms in the region confirms that glaciation occurred during the Dimlington Stadial between about 25,000 and 15,000 ^{15}C yrs BP (Riley 1987), but the possibility of an Early Devensian Glaciation between around 80,000 and 50,000 yrs ago was also considered in view of the two tills above the organic sediments.

At this stage a vote of thanks was given by Dr. A.C. Benfield and the majority of the party dispersed for home. However, those who were able followed Mr. Mitchell to Cautley Crags where they were able to examine the glacial features in the valley bottom below Cautley Spout (SD 684 975). Mr. Mitchell pointed out the general features in the area noting that the scenery reflected a change in lithology relative to that in the Pennines on the other side of the Dent Fault. Cautley Crags are developed on Silurian mudstones and sandstones. Mr. Mitchell indicated that Cautley Crags are the one feature in the area visited on the field meeting which have the form of a corrie, and a large mound of drift in the valley bottom in front of the crags has the appearance of a moraine ridge. However, detailed mapping of the area had shown that a distinct moraine ridge could be identified only in the position of the corrie lip, and the large mass of drift is of indeterminate form worthy of further study. The discovery by Dr. Benfield of clasts of Carboniferous origin from this body of sediment added further complications to a deposit that had previously been considered to have been derived from the Howgill Fells, and provided an intriguing problem with which to bring the field meeting to a close.

Acknowledgements

Grateful thanks are expressed to Mr. John Ruken for permission to put down the core in Skeb Skeugh and to Mrs. Nancy Mulholland for supplying the list of fossils identified from the Skeb Skeugh core by Mr. R.C. Alvey. Thanks are also expressed to the management of the Kearton Guest house in Thwaite for making the party so welcome, and to Mrs. Madge Wright and Dr. Ian Sutton for organising the meeting and Mr. Jack Fryer for so successfully carrying out administration during the excursion.

References

Boulton, G.S., 1987. A theory of drumlin formation by subglacial sediment deformation. In *Drumlin Symposium*, J. Menzies and J. Rose (eds) 25–80. Balkema.

Carter, R.A., Johnson, G.A.L., and Turner, J., 1978. An interglacial deposit at Scandal Beck, northwest England. *New Phytol.*, 81, 785–790.

Clayton, K.M., 1966. The origin of landforms of the Malham area. *Field Studies*, 2, 359–84.

Dardis, G., McCabe, A.M. and Mitchell, W.I., 1984. Characteristics and origin of lee-side stratification sequences in late-Pleistocene drumlins, Northern Ireland. *Earth. Surf. Proc. and Landf.* 9, 409–424.

Gunson, A.R., 1966. *Some aspects of the Lateglacial Period in the Western Pennines area.* M.A. Thesis, Univ. Lancaster.

King, C.A.M., 1976. *The Geomorphology of the British Isles: Northern England.* Methuen, 213pp.

Letzer, J.M., 1981. The upper Eden valley. In *Field Guide to eastern Cumbria*, J. Boardman (ed.) 43–61. Quaternary Research Association.

Pennington, W., 1978. Quaternary Geology. In *The Geology of the Lake District*, F. Moseley (ed.), 207–225. Yorkshire Geological Society.

Pounder, E.J., and Rose, J., 1981. River terraces of upper Swaledale. In *Field Guide to eastern Cumbria*, J. Boardman (ed.) 70–75. Quaternary Research Association.

Raistrick, A., 1926. The glaciation of Wensleydale, Swaledale and the adjoining parts of the Pennines. *Proc. Yorks. Geol. Soc.*, 20, 366–410.

Riley, J.M. (née Letzer), 1987. Drumlins of the southern Vale of Eden, Cumbria, England. In *Drumlin Symposium*, J. Menzies and J. Rose (eds.) 323–333. Balkema.

Rose, J., 1980. Landform development around Kisdon, upper Swaledale, Yorkshire, *Proc. Yorks. Geol. Soc.*, 43, 201–219.

Rose, J., 1981. Upper Swaledale. In *Field Guide to eastern Cumbria*, J. Boardman (ed.), 61–69. Quaternary Research Association.

Rowell, A.J. and Turner, J.S., 1953. Corrie glaciation in the upper Eden valley. *Liv. and Man. Geol. J.*, 1, 200–7.

Shaw, J., 1986. Subglacial and ice marginal environments. In *Glacial Sedimentary Environments*, G. Ashley, J. Shaw and N.D. Smith (eds.) 7–76. Soc. Econ. Pal. Min.

Wilson, A.A., Dunham, K.C., Rose, J., Rodgers, P.J. and Small, A.T., 1978. Field Meeting, North Swaledale-Arkengarthdale mineral belt, North Yorkshire. *Proc. Yorks. Geol. Soc.* 42, 188–191.

J. Rose,
Department of Geography,
Birkbeck College,
University of London,
7–15 Gresse St.,
London W1P 1PA.

W.A. Mitchell,
Faculty of Applied Science,
Luton College of Higher Education,
Park Sq.,
Luton, LU1 3JU.