3 Quaternary geology and geomorphology of the area around Kisdon, upper Swaledale

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Purpose

To examine landforms and sediments in the valleys and on the valley-side slopes around Kisdon, upper Swaledale, to demonstrate the effects of: (i) glaciation and glacier wastage during the Dimlington Stadial of the Late Devensian (ii) paraglacial readjustment of the glacial landscape by fluvial and slope-forming processes during the Devensian Lateglacial and Holocene and (iii) the effects of 9th-century mining activity.

Logistics

This full-day excursion uses a circular route mainly on well-defined footpaths. The route begins at Keld (limited parking at [NY 893 013]), with Muker as an ideal venue for lunch (Figure 3.1). The area is an S.S.S.I. and is located in the Yorkshire Dales National Park.

Maps

O.S. 1:50 000 Sheets 91 Appleby-in-Westmorland and 98 Wensleydale & Upper Wharfedale; O.S. 1:25 000 Outdoor Leisure Sheet 30 Yorkshire Dales, North and Central Areas (shows public footpaths very clearly).

Geological and geomorphological background

Bedrock in the area is upper Dinantian limestones, sandstones and shales ('Yoredale Series') with lower Namurian sandstones (Millstone Grit) capping the highest interfluves. A sandy diarnicton with blocks of sandstone and shale (probably till, but free of far-travelled erratics) and blanket peat covers much of the fells. The steeper valley sides are relatively free of superficial deposits, although locally there are patches of till and landslide sediments. Most of the valley bottoms contain thick deposits of glacial and debris-flow diamictons, glaciofluvial sand and gravel and coarse-grained river gravels, although in the upper part of Skeb Skeugh fine-grained lake petits, gyttja and marls fill the valley bottom. In some places the valley bottoms are undergoing active incision and waterfalls reflect the differences in rock hardness.

The large-scale landforms of the area are visually impressive and geomorphologically intriguing. The Swale valley crosses the region from northwest to southeast, but takes a sharp right-angle bend at Hartlakes. However a valley of a similar size to the Swale, but with a tiny stream called Skeb Skeugh, extends south of Keld towards Thwaite, then bends sharply towards the east to rejoin the valley of the Swale just beyond Muker. Between these valleys, Kisdon forms an isolated hill some 200 m above the valley bottoms. The origin of Kisdon hill, the changing direction of the Swale valley and the virtually dry valley of Skeb Skeugh have long been a topic of debate.

Many of the small-scale landforms are classical for their type and provide detailed evidence of the direction of ice movement across the region, the pattern of ice wastage, the response of rivers and oversteepened slopes to changes of climate over the past c. 15 000 years and the effects of human activity on river processes. Glaciofluvial landforms include a variety of glacial meltwater channels southwest of Keld, kames and kettle holes around Angram and Thwaite and kame terraces west of Muker. Evidence for climatically driven changes of river activity include a debris flow fan at Hartlakes, and river terraces along the Swale upstream of West Stonesdale Beck. Landforms produced by slope failure include a deep rotational slip at Hooker Mill, a massive debris slide on the northwest side of Kisdon, a massive debris flow at Usha Gap and a block glide at Birk Hill. In the upper part of Skeb Skeugh fine-grained lake sediments below the valley bottom preserve the record of Devensian Lateglacial and Holocene vegetational change, soil development and slope stability. In addition, river landforms show the effects of rock control, of human activity in determining sediment loads, and intrinsic

within-channel processes resulting in the formation of large-scale boulder bedforms. The river terraces upstream of Kisdon Force have an extent and elevation determined by rock hardness. Those around Thwaite show the effects of reduced discharge of the present rivers relative to the discharges of the rivers that formed the main valley bottom floodplain slopes, while the impressive array of valley bottom terraces south of Hartlakes are the product of within-channel processes enhanced by sediment yield from the local lead mines.

Meltwater channels, drift tails, drumlins and striations provide the main evidence that glaciation of the region was from the west, and an explanation for the anomalous valley pattern of the Swale and Skeb Skeugh and the origin of Kisdon hill. Meltwater channels indicate that prior to the final melting of this ice sheet, drainage was through Skeb Skeugh and the area between Keld and Hartlakes was an interfluve between the Swale and Swinner Gill. The present valley between these points is ascribed to glacial erosion in response to structural weakness and relatively high glacier energy determined by a steep ice-surface gradient. The kame terraces at Muker indicate a temporary ice-dammed lake between an ice lobe in the Swale valley and a lobe in the Muker Beck valley, and dead ice topography around Angram indicates local ice stagnation. This episode of glaciation was during the Dimlington Stadial (26 000–13 000 ^{14}C yrs BP) of the Late Devensian Glaciation and ice wastage across the region occurred about 14 000 ^{14}C yrs BP.

Pollen from the lake sediments in the upper section of Skeb Skeugh indicates that tundra vegetation colonized the region during the Windermere Interstadial (13 000–11 000 ^{14}C yrs BP), but that this vegetation broke down during the severe climate of the Loch Lomond Stadial (11 000–10 000^{14}C yrs BP). The mineral content of these lake sediments indicates that accelerated mass movement took place on the slopes during the Loch Lomond Stadial, resulting in the formation of the debris slide on the northwest side of Kisdon. It is probable that the debris flow at Usha Gap and the high fan at the mouth of Swinner Gill also formed at this time.

During the Holocene (10 000 ^{14}C yrs BP to present) vegetation cover returned including extensive woodland, and the rate and magnitude of geomorphological processes was reduced. However, thick glaciogenic sediments and steep valley-side and valley-bottom slopes maintained a paraglacial regime, and relatively high levels of river and slope activity resulted in the formation of important and distinctive landforms. Hooker Mill rotational slip occurred during the early Holocene damming a long narrow lake in the upper part of Skeb Skeugh, and the block glide at Birk Hill continues to move in response to river erosion. River activity has resulted in incision and the formation of river terraces of a variety of origins in different parts of the region, but most significantly, the introduction of mining waste during the 19th century increased the scale and rate of development of these landforms in the section of the Swale downstream of Hartlakes.

For further details see Rose (1980), Rose & Pounder in Boardman (1981, 1985), Rose & Mitchell (1989) and Pounder (1989).

Excursion details

Locality 1. Take the track from the centre of Keld [NY 8930 0115] to the footbridge across the River Swale [NY 8960 0105]

A poor exposure at [NY 8935 0115] shows rounded boulders in a glaciofluvial ridge formed by meltwater deposition during final stages of ice wastage. The view south across the head of Skeb Skeugh [NY 8940 0110] indicates a virtually dry valley. A thick sequence of lake sediments underlies this valley bottom. The lake formed in depressions at the base of a subglacial meltwater channel that took the last main drainage down Skeb Skeugh. The view from the footbridge across the Swale shows the gorge which has formed since ice wastage.

Locality 2. Continue along the track and cross the bridge over East Gill as far as the junction with the track to Crackpot Hall [NY 9045 0085]

From the bridge over East Gill [NY 8965 0115] river terraces can be observed both adjacent to the Swale and to East Gill at levels controlled by hard rock outcrops. Prior to the diversion of the Swale along its present route to the east, East Gill drained southwards and joined the Swale which then flowed down Skeb Skeugh. At [NY 9035 0095] the track crosses the

lower end of the Beldi Hill glacial meltwater channel. The sides of this feature are much modified by mining.

Locality 3. Proceed along the track to the footbridge over Swinner Gill [NY 9090 0050]

Below Crackpot Hall [NY 907 007] the track crosses an active landslip. Crackpot Hall was built on this landslip and is currently disintegrating in response to this mass movement. In the area around the bridge over Swinner Gill it is possible to examine: (i) the high terrace at the mouth of Swinner Gill; (ii) a river-cut exposure that shows this terrace to be formed of interbedded boulder and cobble beds, sandy diamicton, fine sands, and laminated sands and silts. The slope of the terrace and the clast fabric of the sediments show that the feature was formed by Swinner Gill rather than the Swale, and indicate very high sediment loads typical of debris flow processes; (iii) Low terraces formed by Swinner Gill and the Swale in response to high yields of readily available, unconsolidated sediment.

Locality 4. Continue along the track to Ramps Holme Bridge across the River Swale [SD 9105 9860]

Well-developed river terraces can be seen adjacent to both the east [SD 9100 9995]–[SD 9090 9965] and west [SD 9065 9945]–[SD 9085 9935] banks of the Swale sloping at an angle steeper than that of the present river. Several poor sections show that these are formed of rounded boulders in a gravel and sand matrix. These terraces formed as fans at the mouth of the Swale gorge but have been dissected as the river eroded upstream as far as Kisdon Force. A small fan is developed at [SD 908 992] where Am Gill changes gradient from the steep hillside to the low angle valley bottom. The river between Hartlakes and Ramps Holme Bridge shows well-developed active braiding and adjacent low terraces. These very coarse-grained bedforms have developed here due to the introduction of mining waste into the river. Progressive formation and dissection of these features results in small terraces, which like all the other terraces in the region are of local significance only.

Locality 5. Take the footpath to Muker [SD 9100 9790]

This path crosses well-developed low terraces and river channels that were probably formed as a classical paraglacial response to the transportation of large volumes of sediment during the Lateglacial. Nearer the confluence with Muker Beck the terraces reflect the interaction of the two channels.

Locality 6. Take the footpath to Thwaite [SD 8930 9820] via a short section of road at Usha Gap [SD 902 979]

Part of Muker and the eastern section of the path are on a kame terrace [SD 9090 9790]–[SD 9050 9800] which was formed when a lake was dammed between ice lobes in the Swale and Muker Beck valleys. The gradient of this terrace is less than the adjacent rivers reflecting sediment supply from both ice sources. While the kame terrace formed, Kisdon acted as a nunatak. West and south of the kame terrace the land is at a lower level, originating as an ice-tongue hollow (around [SD 904 979]).

This is now infilled with low-level river terraces formed in response to high flood events, such as that of 1883, when the Swale reached a level of 9.4 m at Keld. At Usha Gap the nose of the massive debris flow extends across the north side of the valley (around [SD 901 981]), having originated from a scar just below Kisdon Farm (around [SD 902 984])

Between Usha Gap and Thwaite the footpath passes a classic nickpoint [SD 8985 9815] formed at the limit of incision by Skeb Skeugh into the fan of Thwaite Beck. At this point the active floodplain of Skeb Skeugh becomes a fossil terrace. At the south side of Thwaite Beck small kames can be seen surrounded by river gravels (around [SD 896 980])

These kames must have been formed in the valley bottom during ice stagnation, then, following ice-wastage they have been almost buried by river sedimentation.

Locality 7. Continue along the footpath through Skeb Skeugh to the road at [SD 8890 9940], then along the road to Angram [SD 8875 9975]

Thwaite and the first section of path (around [SD 893 983]) are on the fan of Thwaite Beck. Around Dirty Piece [SD 8915 9860] the path crosses several small gravel hills and a short north–south trending ridge which are interpreted, respectively, as kames and an esker formed beneath the glacier by meltwater draining southward down Skeb Skeugh. The slopes of Kisdon show the effects of mass movement in the form of scree and shallow landslips around [SD 893 988], and the massive Hooker Mill rotational slip around [SD 891 994]

The latter was sufficiently big to block the valley and form a lake. The lake has drained because Skeb Skeugh has now dissected the toe of this landslip [SD 8910 9950]–[SD 8905 9925], but in this section the stream flows in a narrow gorge, in contrast with the open valley to the north and south.

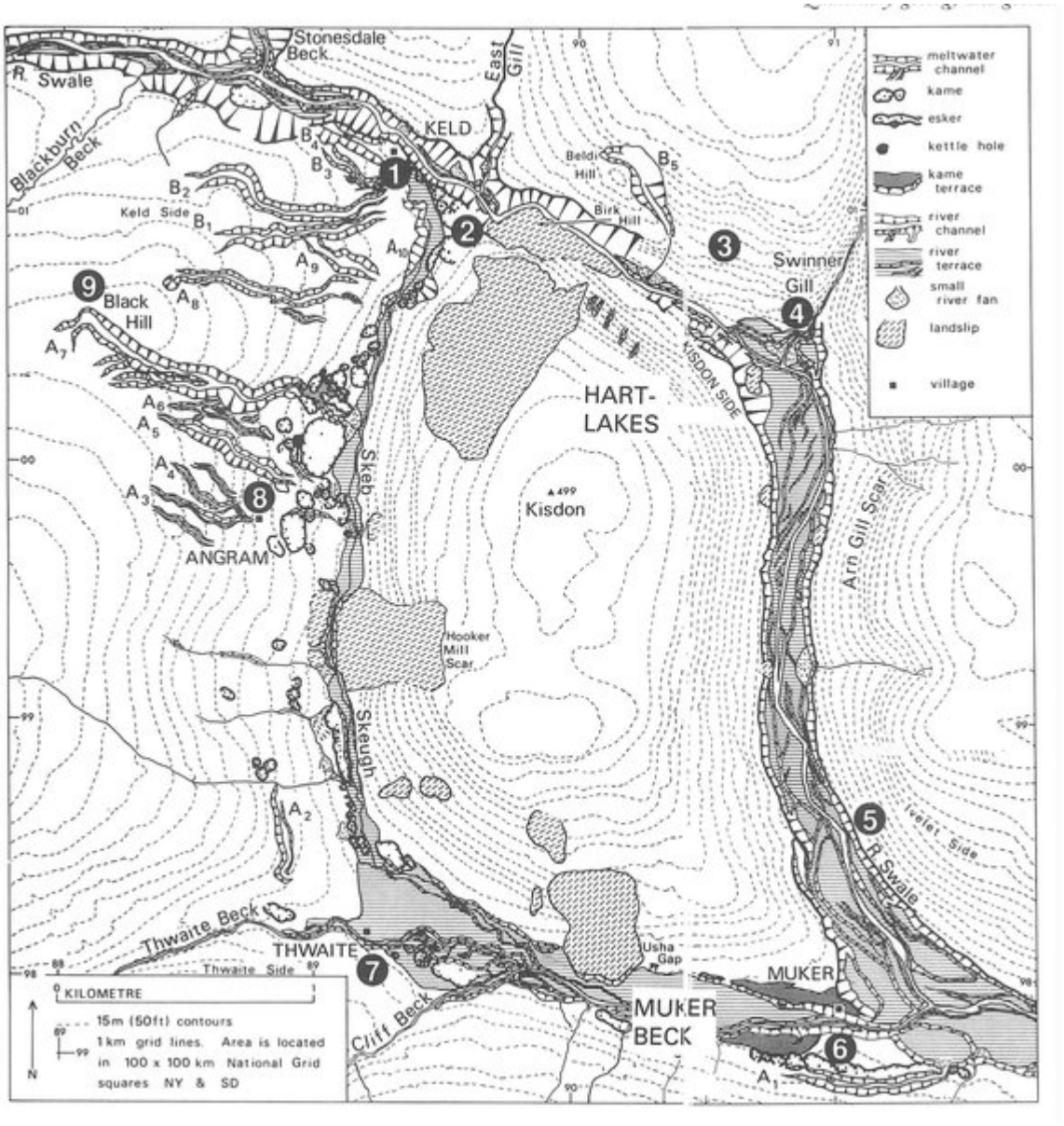
Locality 8. Take the footpath to Black Hill [NY 8815 0055]

This path crosses a series of meltwater channels formed by rivers flowing westward beneath the ice across the Black Hill into Skeb Skeugh. Kames developed in the fields east of the road, just north of Angram around [NY 889 000], are composed of sediment transported by these rivers. The meltwater channels dissect one another(i.e. [NY 884 003], providing evidence for their sequence of development, and indicating that channels become progressively younger towards the north. The subglacial origin of the channels can be demonstrated clearly by number A7 on (Figure 3.1) [NY 881 005], because the topography at the head of this feature does not support a catchment and the channel at Black Hill crosses a watershed with what must initially have been an up-and-down long profile. Such a channel form could only have eroded by confined drainage under hydrostatic pressure.

Locality 9. Walk north along the wall to [NY 8820 0090], then east across the fell to the track [NY 8895 0090] which joins the road at Keld Youth Hostel [NY 8917 0097]

From here follow the road to the village centre. Gullying is developed at the east side of the wall that runs north across Keld Side in response to improved field drainage. Small exposures show a sandy diamicton with boulders and cobbles of sandstone and shale. Although far-travelled erratics and striated stones have not been observed, this is interpreted as a till deposited by ice that has moved to the region at a relatively high level in the glacier and only intersected the bed in the region of the Swaledale fells. The route eastward across the fell intersects meltwater channel B1 (Figure 3.1), then continues along this channel as far as the road. Channel A, can be seen to diverge to the southeast. To the north, Channel B2 can be seen to run parallel with Bi. Like Channel A7 these formed without a catchment and are routed across the local watershed. However, these channels drain towards the route of the River Swale from Keld to Hartlakes, indicating that they formed after Skeb Skeugh had been abandoned and meltwater drainage had adopted the course presently used by the Swale. The critical change of direction can be seen at [NY 8888 0088] where Channel A, heads southeast, and is dissected by Channel B1 which heads northwest.

Bibliography



(Figure 3.1) Landforms around Kisdon, upper Swaledale, North Yorkshire. Published originally in Rose (1980) and reproduced by permission of Yorkshire Geological Society.