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Walkover survey of a landslide on the A57 (Snake Pass) road at Cowms Moor, Derbyshire in January 2008.

Land Use and Development

Open Report OR/08/006

BRITISH GEOLOGICAL SURVEY

LAND USE AND DEVELOPMENT PROGRAMME

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Keywords

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Front cover

The A57 road closed for over a month in January 2008 due to subsidence caused by a landslide at Cowms Moor, Derbyshire. Photo looking east from [SK 12935 89480].

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Foreword

This report describes a walkover survey carried out by the British Geological Survey to inspect the damage caused by a landslide that affected a section of the A57 (Snake Pass) road between Glossop and the Ladybower Reservoir, on the 23rd January 2008.

Acknowledgements

The authors would like to thank the following BGS staff: A Gibson, M G Culshaw, D Entwisle, P Hobbs, and C Foster for their advice during this study.

The authors would also like to thank Mr B Martin, Chief Structural Engineer for Derbyshire County Council (DCC), for providing information about this landslide and for his donation of DCC data for the National Landslide Database project. We would also like to thank Mr A Byford, resident of Wood Cottage, for escorting us around his and the surrounding land and for sharing his wealth of historical information about the site.

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Summary

A walkover survey was carried out on the 23rd January 2008 to inspect damage caused by a landslide at Cowms Moor, [SK 12875, 89480]. The subsidence caused by associated ground movement caused the closure (for over a month) of the A57 (Snake Pass) between Glossop and the A6013 junction at Ladybower Reservoir, Peak District National Park, Derbyshire, UK. The recent event affected a 90 m section of the A57 (Snake Pass) carriageway. Evidence for associated recent ground movements was observed up to 100 m above and below the A57 road.

The reported landslide is classified as a non-circular rotational failure in a mixture of bedrock, debris, and artificial fill, composed of mudstone, siltstone and sandstone material. The slip is likely to be a reactivation of a pre-existing landslide at the toe of a large deep-seated landslide complex, the Cowms Rocks Landslide, comprising multiple rotations and mudflows. The landslide complex is shown on the published 1:50 000 geological map, Sheet 99. The landslide is developed in a south facing slope formed in gently south-dipping bedrock of interbedded thin to thick-bedded mudstones, siltstones and sandstones of the Shale Grit Formation and Mam Tor Beds of the Namurian Millstone Grit Group.

The cause of the slope failure is due to a combination of driving forces including excessive water ingress after prolonged rainfall, and removal of mass from the toe by river erosion. The slope has a history of instability affecting the road and private property. It has been subject to previous remediation attempts, probably involving redistribution of rock material and installation of drainage. The current condition of the installed drainage system within the slope is contributing to current slope instability. Relaying the road adds mass or load to the head of the landslide.

Further detailed assessment, including geomorphological mapping, is required to properly understand the nature of this landslide and the hazards posed to the A57, Wood Cottage, and Ladybower Reservoir. Any future planning decisions and/or engineering activity should consider the potential impact of the Cowms Rocks landslide complex.

1 Introduction

BACKGROUND

On 23rd January 2008, the BGS landslide response team were informed that a landslide had caused the closure of a stretch of the A57 trunk road (locally known as Snake Pass), between the Glossop and the Ladybower Reservoir (between the A57/A624 junction, and the A57/A6013 junction), Derbyshire. On the 24th January a team comprising David Boon (Engineering Geologist) and Hannah Evans (Geomorphologist) visited the site to collect photographic evidence and record physical damage caused by the event for entry into the BGS National Landslide Database. All fieldwork was carried out in accordance with the British Geological Surveys' Health and Safety Guidelines.

On site, the team met Mr A Byford, the owner and occupier of Wood Cottage, a residence located above the road. Mr Byford, who has lived in the house for over 50 years, stated that the stretch of road below his property had a long history of subsidence and had undergone some remedial activity in the 1970s. Later telephone communications with Mr Brian Martin, Chief Council Engineer for Derbyshire County Council, who are responsible for maintaining the road, confirmed that the County Council holds records of road closures at the site dating back to the 1930's. The engineer stated that the usual course of action involved temporary road closure until movement ceases, after which a temporary speed restriction will be enforced until the ground 'dried out' and the road will then be resurfaced and reinstated. The road subsequently re-opened under traffic lights, single lane traffic, and speed restrictions on the 15th February 2008, with long-term repair scheduled for later in the year.

LOCATION

The section of the A57 road affected by the landslide is shown in Figure 1. The damaged road is located at [SK 12875 89480] below Cowms Moor on the northern part of the Woodlands Valley, part of the Ashop River Valley, approximately 10 km southeast of the town of Glossop. Derbyshire County Council maintains the A57 road, which transects the Peak District National Park.

Note: Grid References referred to in the text and captions are given as five-figure National Grid References, except figures on map ticks, which are given as full six-figure National Grid References.

TOPOGRAPHY AND LAND USE

The area is mostly undulating steep moorland used for grazing with small isolated small woods scattered along the valley bottom. Peat forms on the hill tops and in low lying areas over the slope. A Roman road crosses Cowms Moor and may have been affected by historical slope movements. A search of the archaeological literature may yield further information on historic land use.

The aerial photograph shown in Figure 2 shows the undulating ground surface in the area of the mapped landslide. In Figure 2, several distinct morphological zones can be identified. The far west of the landslide is characterised by narrow lobes (possibly mudflows), the central area has a more uniform smooth surface and is mapped as an insitu block of bedrock. The north eastern area has linear degraded scarps and bench features with either brown peat formed in the mini basins or ponding of water. The central eastern area has fresher, narrower, scarps and benches than in the north, and the south and south eastern area has subdued and isolated scar and bench features including degraded scarps. The steep sided river valley, gentle slopes and some flat toped terraces characterise the base of the valley.

The Next Map^{TM} Digital Terrain Model (DTM) shown in Figure 3 shows the position of the landslide affecting the A57 and shows the wider scale features associated with the Cowms Rocks landslide complex.

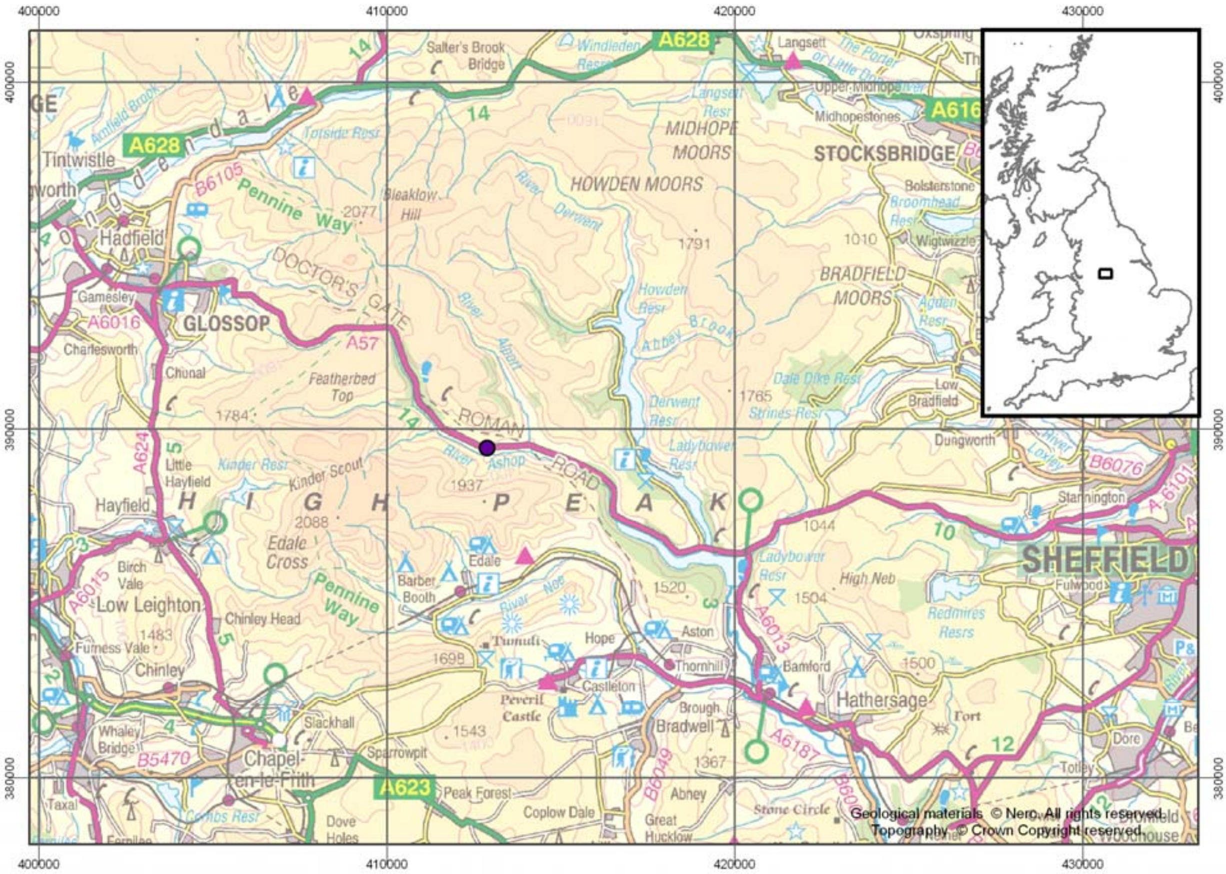

Figure 1 Ordnance Survey map showing the location of the landslide event along the A57, Derbyshire.

Figure 2 Air Photograph (c. 2000) of Cowms Rocks landslide complex, Derbyshire. White point (bottom, right) marks the location of new landslide event detailed in this report. The white point (top, left) indicates the existing database point [ID 5470] for the Cowms Rocks Landslide held in the BGS National Landslide Database. The outer black boundary marks the extent of the mapped Cowms Rocks landslide (see Mass Movement).

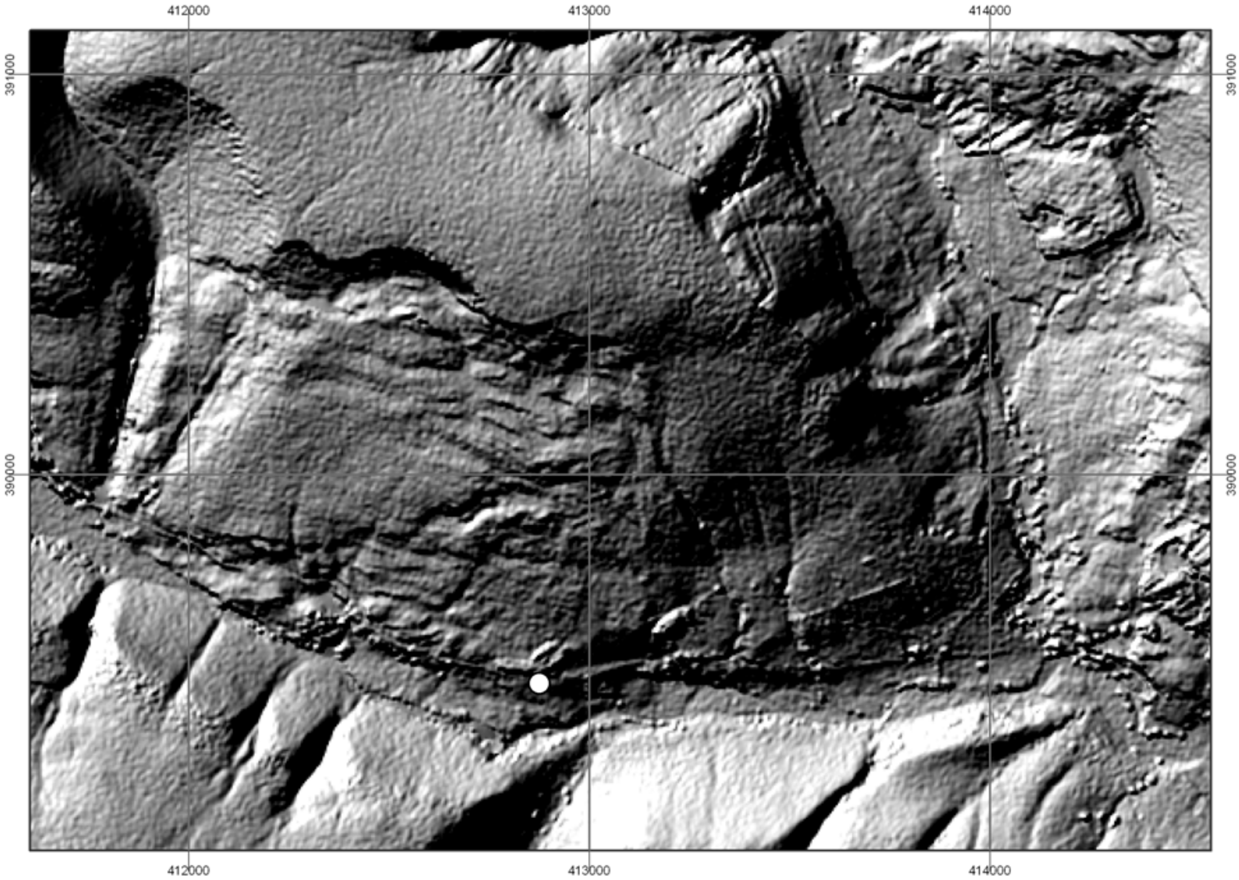

Figure 3 NextMap50 Digital Terrain Model showing the northern side of the Ashop valley. The white point (bottom, centre) marks the location of the reported landslide.

2 Geological Background

A geological map of the study area is given in Figure 4. The area lies within the British Geological Survey 1:50 000 map sheet 99, Chapel en le Firth, and BGS 1:10 560 maps SK18NW (1961), and SK19SW (1960). The original one inch geological sheet 99 is detailed in the 1971 sheet explanation by Stevenson & Gaunt. The geological descriptions given below conform to British Standard 5930 (1999).

BEDROCK

The upper valley slopes comprise Shale Grit, a formation of the Namurian Millstone Grit Group deposited some 320 million years ago. This is underlain by the Mam Tor Beds, which are in turn underlain by the Bowland Shale Formation (previously Edale Shales).

In the Ashop valley the Shale Grit is an approximately 180 m thick sequence of sandstones, primarily composed of jointed, strong, often massive, sometimes laminated or flaggy, coarse-grained quartzitic sandstone (often containing mudstone rip up clasts), with rare weak to moderately weak laminated mudstone partings. The upper boundary of the Mam Tor Beds has been mapped where the thick massive sandstone beds become less well developed. The Mam Tor Beds are well exposed along the southern Ashop valley in river cut cliffs [SK 12840 89325]. The deposits comprise around 60 metres of alternating strong, massive and laminated sandstone, laminated siltstones, and weak to moderately strong mudstones deposited by turbidite flows and background fallout. The sandstone beds increase in thickness within discrete packages indicating cyclic sedimentation and pulsed depositional events. Bed thicknesses may vary laterally. The underlying Bowland Shale Formation (previously referred to as the Edale Shales, locally) is generally around 240 m thick in the area but is reported to be up to around 370 m thick in the nearby Alport Borehole (Stevenson & Gaunt, 1971). It is generally a very weak pyritic mudstone with moderate interbeds of strong quartzitic sandstone and rare beds of bentonite rich clay.

The two 1:10 560 geological maps that cover the study area record regional dips between 2 and 4 degrees, dipping to the south-west. Bedding planes and other older structural discontinuities may have been locally altered by a range of structural and mass movement processes.

SUPERFICIAL

There are no glacial deposits mapped within the valley. The area is located just outside the southern limit of the Devensian glaciation and a periglacial processes were probably active throughout the late Devensian in the Ashop valley. Mapped ‘head’ deposits including solifluction deposits, are known to mantle slopes in this area. ‘Head’ deposits can be up two metres in thickness, being thicker towards the base the valley, and are generally silty gravels but the composition depends on source lithology. Clay rich soliflucted deposits may contain relict shear surfaces. Head deposits are not consistently mapped in the valley but can be seen in the top soil horizons in river bank exposures throughout the valley. Cryoturbation structures are also recorded in the area and are discussed in the 1971 sheet explanation. Recent river alluvium and river terrace deposits occur along the Ashop River.

MASS MOVEMENT

The road crosses the lower portion of a previously recorded and mapped landslide complex, shown in Figure 2, Figure 4, and Figure 5, called the Cowms Rocks Landslide (BGS National

Landslide Database, ID 5470). This landslide is described in the 1971 geological sheet explanation by Stevenson & Gaunt: "Compound landslips are present along about half of the northern side of the Ashop valley, where the southerly dip has facilitated large-scale down-dip sliding. At Cowms Moor an area of ground in the middle of the slip appears either not to have moved or to have slipped without breaking up. Periodic recent movements have necessitated repeated road repairs in the Ashop valley". Examples of valley-bulge structures are also known in the Ashop as described in the sheet explanation: "Sharp, symmetrical, straight-limbed folds are also present in lower Mam Tor Beds and upper Edale Shales (now Bowland Shale) in the lower Alport valley and adjacent parts of the Ashop valley…".

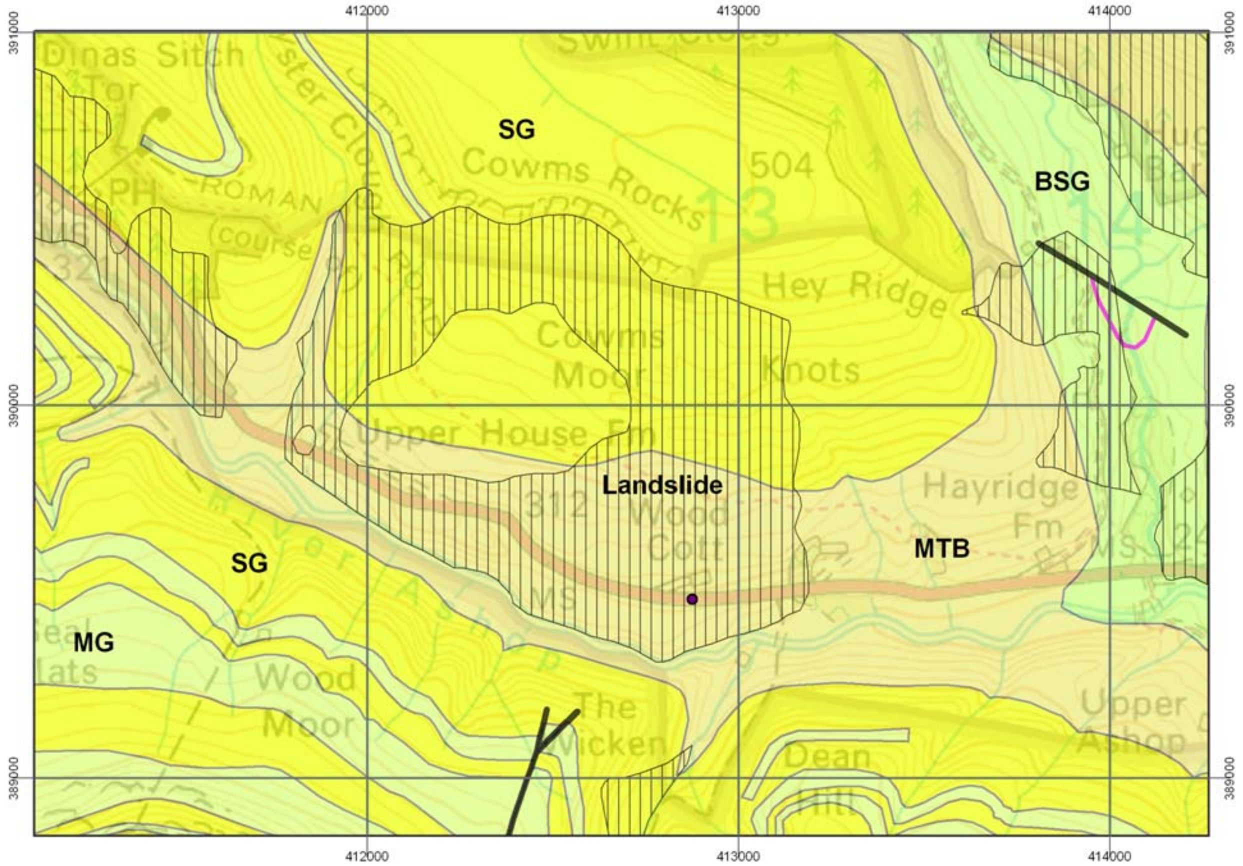

Figure 4 Extract from 1:50 000 digital geological map (DigMapGB50, Version 4, 2007) showing bedrock and mass movement deposits (hatched). Bedrock Legend: BSG, Bowland Shale Group (mudstone); MTB, Mam Tor Beds (sandstone, siltstone, and mudstone); SG, (sandstone); MG, Shale Grit Formation (mudstone rich). The black dot shows the location of the reported landslide.

3 Field Observations

During a rapid walkover survey the following field observations were made. Observation numbers relate to the locality numbers on the map given in Figure 5. Additional information, including anecdotal evidence, is summarised separately under Additional Information.

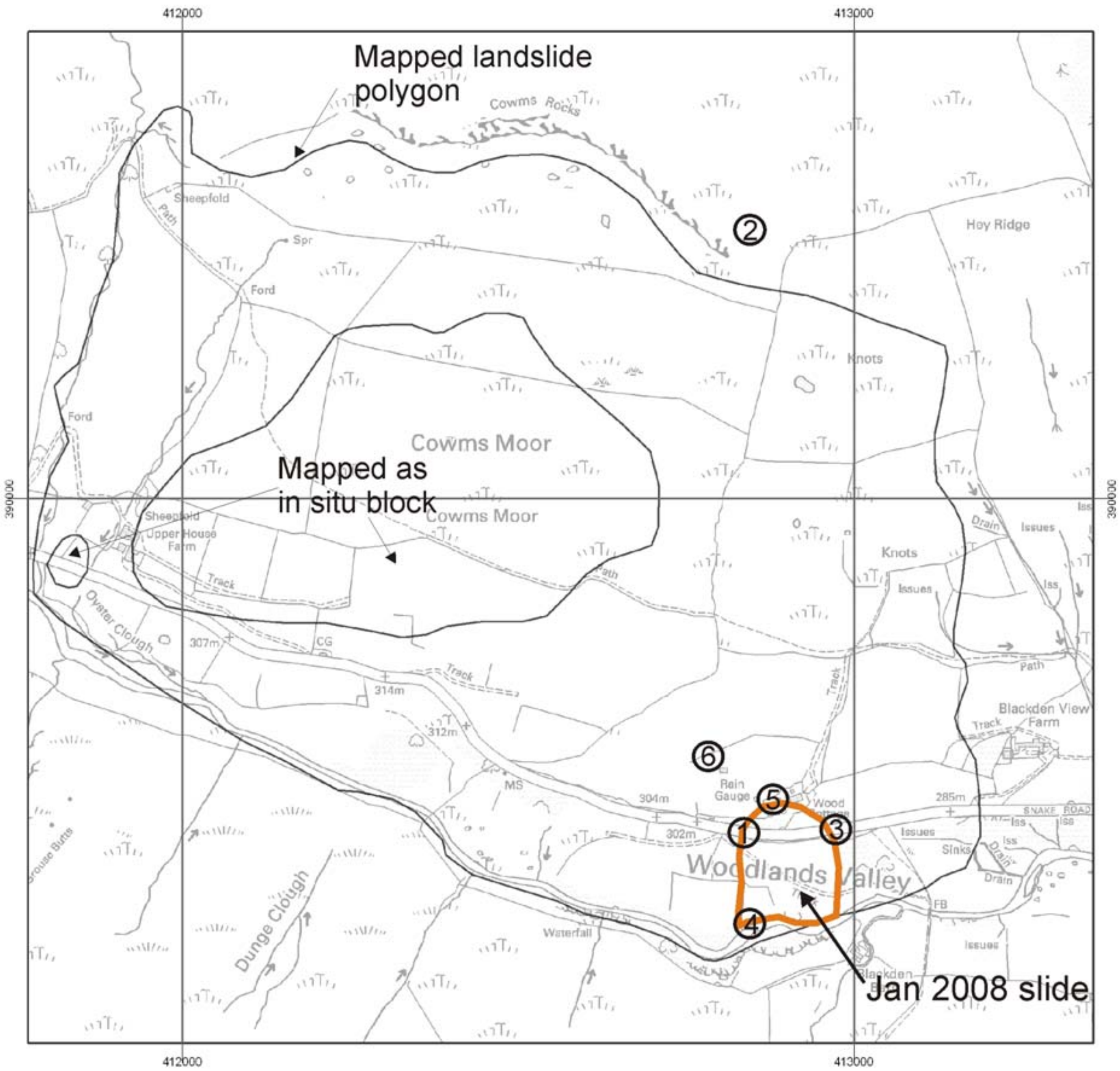

Figure 5 Location map showing locality numbers, extent of the reported January 2008 landslide event (red outline), and the BGS mapped landslide (black outline).

LOCALITY 1

Observation

1. The section of slope affected by recent movement is approximately 150 m long and 90 m wide. The average slope gradient is approximately 17º, with the surrounding natural slope closer to 14º.
2. The road surface was deformed with fresh cracks in the tar macadam surface. At the edges of the deformed roadway, tarmac was buckled indicating compression and cracks showed a sense of shear displacement. Open tension cracks aligned parallel with the road were also noted. The cracks were up to 5 meters in length and at least 0.5 meters deep, as shown in Figure 6.
3. The road marking shown in Figure 6 was displaced horizontally by 150 mm and vertically by at least 400 mm. The road surface was back rotated by 2 or 3 degrees producing a camber on the failed section, (see cover image). Several survey pins had been installed (presumably by DCC) across most cracks in the road top.
4. A linear scarp feature, shown in Figure 7, marks the western extent of the right flank of the landslide.
5. Ponding of water was observed below the road (visible in Figure 7).
6. Artesian groundwater flow conditions were noted at the concave break in slope, at the elevation of the pond (see Figure 7).

Figure 6 Photograph showing crown crack (0.4 m deep) above the right flank of the landslide. The offset of the road markings indicates a dextral sense of slip. Taken at [SK 12845 89498].

Figure 7 Photograph showing western side scarp. Taken from [SK 12845 89495] facing south. This feature crosses the road surface. Artesian water pressure was observed above the pond (middle, left).

Additional Information

The Chief Structural Engineer, Mr B Martin, commented that Derbyshire County Council have records of ground movements at the site dating back to the 1930's.

According to Mr Byford, the ground immediately below the road is composed of locally derived rock fill removed from above the road during a 1970s remediation effort. Mr Byford also described that the ground level immediately east of Wood Cottage had risen in recent years.

LOCALITY 2

The recent failure reported here lies within the toe area of a previously mapped landslide complex which affects much of the northern side of the Ashop valley at Cowms Moor. The main back scar has formed the steep edge called Cowms Rocks. The eastern side of the mapped Cowms Rocks landslide was traversed during the walkover survey to look for signs of recent movement in the upper part of the valley slope.

Observation

1. Discrete bench features, hummocky ground, and ponding are present across the Northern Ashop valley slope. These features are visible in Figure 8, taken from the left edge of the Cowms Rocks landslide crown looking south across the valley.
2. No fresh signs of movement were identified, although the not all the ground was covered.
3. However, a shallow peat slide was noted just below Locality 2 on the eastern part of the degraded backscarp and a 2 m high exposure of peat was noted over the brow of the hill which may be of significant.
4. A surface drain was identified crossing the upper section of slope. It is constructed as a 0.4 metre wide concave strip of concrete and was in a degraded, cracked condition.

Figure 8 Elongated ridges or bench features are probably formed by rotation of resistant sandstone beds in the Shale Grit. Photograph taken looking south from Location 2 at [SK 13113, 90318] on the crown of the Cowms Rocks landslide complex.

LOCALITY 3

Observation

1. The old (disused) road surface and retaining wall is off-set at several points recording down slope translation and rotation of the ground.
2. The material involved in the A57 slide was not well exposed.
3. Alternating layers of road base and tarmac (Figure 9) were revealed on the faces of minor scarps below the road indicating a long history of resurfacing.
4. The material below the road may consist of made ground (artificial placed fill), slipped bedrock and soliflucted ‘head’, a mixed material moved down slope by freeze-thaw action and gravity in a largely periglacial environment.
5. Compression deformation of a recently erected fence above the road 50 m east of Wood Cottage does indeed suggest compression above the road.

Additional Information

The county council engineer, Mr Brian Martin, remarked that the slip generally moves every one to two years usually after snowmelt or prolonged rainfall.

Mr Byford, resident of Wood Cottage, described a spring line flowing from above Wood Cottage. The water is diverted into a chamber for domestic water and the overflow is reportedly diverted under the road and through an area of made ground below the road via a clay pipe.

Figure 9 Photograph showing a displaced and rotated retaining wall and disused section of road at the eastern edge of the recent landslide. This cross cutting relationship is evidence for historical down slope movements. Taken from [SK 12935 89480] looking NE.

LOCALITY 4

Observation

1. Firm grey sandy clay with weak to strong sub-angular sandstone and siltstone gravel, cobbles and boulders exposed in the Ashop riverbank, shown in Figure 10.
2. Large volumes of water were observed issuing out of the slope from several partially blocked and broken clay pipes 20 metres north of Location 4.
3. Recent debris slide has de-vegetated the river back.

Additional Information

Large amounts of rainfall that had fallen in the area during the two weeks leading up to the event and so is likely that the material was in a saturated condition when it failed.

Figure 10 Recent debris slide on riverbank. The failure has de-vegetated the bank. Surface water emanating from springs and pipes was flowing down the bank. Photograph taken looking east from Location 4 [SK 12845 89376].

LOCALITY 5

Observation

1. Fresh linear shears were found cutting across the access track to Wood Cottage.
2. Vertical tension cracks were recorded along the concave break along the driveway of Wood Cottage, shown in Figure 11.

Figure 11 Photograph showing fresh tension cracks along the degraded scarp directly below Wood Cottage. The presence of cracking at [SK 12895 89545] provides evidence for recent reactivation of a landslide mass upslope of the A57.

LOCALITY 6

Observation

1. Abandoned, sub-vertical metal tubes were found protruding from the ground set out in a line up slope from the Met Office Rain Gauge (see Figure 5). These are probably old extensometers that are used to establish the depth of slip surfaces in landslide investigations.
2. The ground surface is scarred by many degraded sharp linear bench features separated by areas of hummocky ground.
3. A line of telegraph poles has been displaced and some are tilted showing differential translational movements of the ground.

Additional Information

The National Geoscience Records Centre based at BGS Keyworth, does not hold any site investigation data or reports detailing investigations at this site. The county council or national trust may hold or know of some records but this search has not been investigated fully due to time restraints. The Met Office weather station on site has a Rain Gauge. Rainfall information should be acquired and compared with slip events.

Figure 12 Degraded features and hummocky ground scar the land surface around Wood Cottage. Note also that the line of telegraph poles in far ground have been offset and tilted. Photograph taken looking east from [SK 12841 89570].

4 Interpretation

A record of historical instability of this slope has been preserved by several physical features. These features include morphological evidence and damage to man made structures, described in the previous Section (see Field Observations). The interpretation of this evidence within the context of the existing mapped landslide enables the following interpretations to be made:

- The landslide event of January 2008 is the reactivation of an existing shallow non-circular rotational failure developed in bedrock, superficial and made ground deposits.
- The slip moved out in a southerly direction, with rotational and downward movement at the backscarp which caused subsidence over a 90 m section of the A57 carriageway.
- The curved shear cracks found in the road top are interpreted as crown cracks which mark the lateral extent of the failure. The straight cracks are interpreted as transverse cracks.
- The off-set of road markings along cracks indicates a downward and outward movement of soil and rock.
- The fresh cracks near Wood Cottage suggest the rear scarp of the landslide is located above the main road placing the road on the 'head' area of the landslide.
- The scale of displacement across the old retaining wall indicates several meters of down slope movement since the retaining wall was constructed.
- The presence of nearly two metres of alternating layers of asphalt and road sub-base material and various isolated patches of tarmac suggest the road top has been resurfaced many times.
- The occurrence of newly formed springs near the pond area indicates ground water was very high around the time of the failure and may be hydrogeologically confined by the fill material.
- Some drain outfalls located below the road were not flowing indicating the current drainage system is not performing sufficiently.
- Anecdotal information suggests there is a water pipe serving from the cistern above the road. This pipe runs through the slipped mass and is likely to have been damaged by recent movement. If so, the pipe may be supplying water directly into the slope. Any ground water, spring lines or surface water drainage sinking into the ground may decrease the stability of the slope.
- Degraded surface features and hummocky ground above and below the road indicate that several other potentially unstable remnant landslide blocks exist along the route of the road.
- The anecdotal report that Wood Cottage has moved recently may be explained by a relative movement due to a combination of downward movement of Wood Cottage and bulging of adjacent ground. The warping of the new fence above Locality 3 does indeed suggest the slope above the road is actively deforming.
- The surface drain described in 'Locality 2' may have been installed in an attempt to drain a large pond at the head of the main landslide. A curved v-shaped drainage channel may have been artificially cut to allow surface water to drain off the upper slope.

5 Conclusions

A walkover survey of a section of the A57 (Snake Pass road) [SK 12875 89480] was conducted following reports of a landslide causing a road closure on the 13th January 2008. The landslide had caused unacceptable ground deformation to the carriageway after a period of prolonged and intense rainfall.

CLASSIFICATION

The landslide event documented here has been entered into the BGS National Landslide Database as ‘Cowms Rocks 2’ (Landslide ID 15929).

The landslide is classified as a reactivation of a non-circular rotational failure in a mixture of pre slipped bedrock, debris and artificial fill material. The landslide lies within a previously mapped landslide complex recorded in the National Landslide Database as Cowms Rocks (Landslide ID5470). The recent event is one of a cluster of a large, degraded, deep-seated multiple rotations in weathered mudstone, siltstone and sandstone bedrock. These landslides probably formed during or just after the last ice age under periglacial conditions.

The presence of different morphological zones or sets of characteristics across the Cowms Rocks landslide area suggests that this landslide complex has undergone several phases of activity.

MECHANISM

The cause of the recent failure is likely to have been due to a combination of factors:

A period of heavy and prolonged rainfall two weeks prior to the event probably saturated the slope materials and led to an increased in pore water pressures along the existing basal shear surface. This will have lowered the effective stress along the slip plane, significantly reducing its shear strength and hence the soils ability to resist the downward forces applied by the slope.

Recent removal of material from the river bank has probably removed critical mass from the ‘toe’ area of the landslide, further reducing normal forces (frictional resistance) along the slip plane.

Relaying the road also adds mass or load at the head of the landslide. Earthworks to redistribute weight over the slope and improve subsurface drainage and the presence of abandoned instrumentation and anecdotal accounts suggest the slope has been remediated in the past. The existing subsurface drainage system may have been damaged by the ground deformations. The result of this will have been to increase the amount of water entering the slope which will have had an adverse affect on its stability.

Any movement of a singular part of this interconnected ground system will change the distribution of forces acting on the slope. The impacts of changing the equilibrium of the slope are currently not well understood.

FUTURE WORK

This report has established that the recent landslide event is just one singular element forming part of a much larger and more complex landslide system.

It is therefore suggested that a more detailed geomorphological investigation and ground investigation should be carried out to identify and better understand the landslide system. Monitoring of the landslide could be undertaken to provide data in order to understand the physical and hydrogeological processes acting on the system.

Rainfall data from the Rain Gauge on the site should be acquired and considered against known landslide failure events.

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