British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

A short report on a landslide survey in the Sheffield Area

Physical Hazards Programme

Internal Report OR/08/020

BRITISH GEOLOGICAL SURVEY

PHYSICAL HAZARDS PROGRAMME

OPEN REPORT OR/08/020

A short report on a landslide survey in the Sheffield Area

C Foster

Keywords

Sheffield, Landslide.

Front cover

View from the Deer Park of Chatsworth House across the Millstone Grit scenery.

Bibliographical reference

FOSTER, C. 2008. A short report on a landslide survey in the Sheffield Area. . *British Geological Survey Open Report*, OR/08/020 17pp.

Keyworth, Nottingham British Geological Survey 2008

BRITISH GEOLOGICAL SURVEY

The full range of Survey publications is available from the BGS Sales Desks at Nottingham, Edinburgh and London; see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications including maps for consultation.

The Survey publishes an annual catalogue of its maps and other publications; this catalogue is available from any of the BGS Sales Desks.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Department for International Development and other agencies.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey offices

Keyworth, Nottingham NG12 5GG

☎ 0115-936 3241 Fax 0115-936 3488
e-mail: sales@bgs.ac.uk
www.bgs.ac.uk
Shop online at: www.geologyshop.com

Murchison House, West Mains Road, Edinburgh EH9 3LA

☎ 0131-667 1000 Fax 0131-668 2683
e-mail: scotsales@bgs.ac.uk

London Information Office at the Natural History Museum (Earth Galleries), Exhibition Road, South Kensington, London SW7 2DE

☎ 020-7589 4090 Fax 020-7584 8270
☎ 020-7942 5344/45 email: bgslondon@bgs.ac.uk

Forde House, Park Five Business Centre, Harrier Way, Sowton, Exeter, Devon EX2 7HU

☎ 01392-445271 Fax 01392-445371

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF

☎ 028-9038 8462 Fax 028-9038 8461

Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB

☎ 01491-838800 Fax 01491-692345

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff, CF15 7NE

☎ 029–2052 1962 Fax 029–2052 1963

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU

☎ 01793-411500 Fax 01793-411501
www.nerc.ac.uk

Foreword

This report is the published product of an investigation into the distribution and nature of landslides on the Sheffield Sheet, undertaken as part of the East Midland regional remapping project.

Contents

FIGURES

TABLES

Summary

This report describes the results of aerial photograph interpretation and fieldwork that was undertaken to assess the extent and nature of landsliding on the Sheffield Sheet. The first part of the report introduces the project and the context of this particular bit of work.

1 Introduction

This report focuses on the findings of an investigation into landsliding in the Sheffield area, undertaken as part of the remapping of the geological map for this area. It follows on from a report which covered the aerial photograph interpretation (API) of the area (IR/06/00).

1.1 STUDY AREA

The geology of the Sheffield sheet is dominated by Upper Carboniferous Formations of the Millstone Grit and Pennine Coal Measures with some limited extent of Permo-Triassic material. The Millstone Grit Group contains fine-very course sandstones and is interbedded with siltstones and mudstones. The Pennine Coal Measures are a series of interbedded mudstones, siltstones and sandstones. The Cadeby Formation, a dolostone with subordinate mudstone, dolomitic siltstone and sandstone, dominates the Permo-Triassic sequences.

In valleys and mantling some slopes there are deposits of Head, a deposit of Late Devensian age formed outside of the glacial maximum within a periglacial climate. The Head accumulated through downslope movement (solifluction) and is generally an unsorted, heterogeneous mixture of clay, silt, sand and gravel.

The geomorphology of the area expresses the differences in the geology. The Millstone Grit Group forms steep Grit edges and deeply incised valleys. The Pennine coal measures have a more subdued topography of lower and more rounded sandstone escarpments with valleys formed in the weaker mudstones. The Permo-Triassic Formations are dominantly planar and the landscape is flat with little topography. Reference is made to Foster 2008 for further discussion of the geology and form of the area.

1.2 METHOD OF INVESTIGATION

Areas of landsliding were identified during the aerial photograph interpretation, which then formed the focus of fieldwork. Areas visited included Curbar Edge, Hallam Moor, Sheffield and Dronfield areas. The main fieldwork took place over a two week period in July when the majority of field visits took place.

2 Landslides in Sheffield

Prior to this investigation the BGS National Landslide Database for the Sheffield sheet contained 70 recorded landslides, of these 23 were removed because they could not be verified through field checking or aerial photograph interpretation. A further 25 landslides were added as a result of this investigation.

2.1 DISTRIBUTION OF LANDSLIDES

The total number of landslides on the Sheffield sheet is 72 with the majority of these landslides concentrated in the far west of the area. The Millstone Grit and Pennine Coal Measures dominate the landsliding within the Sheffield Sheet with around 92% of the total number of landslides (Figure 1).

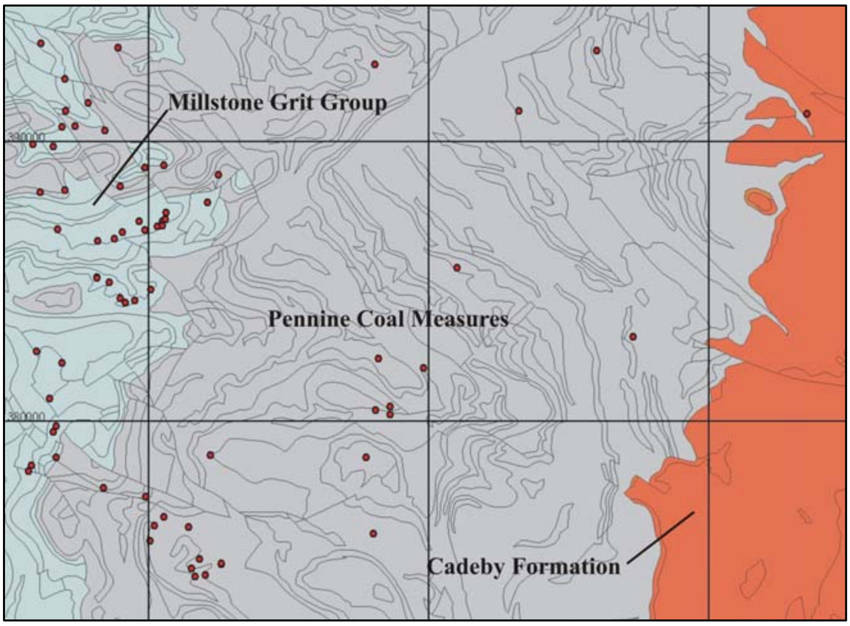

Figure 1: Distribution of landslides on the Sheffield Sheet

Many of the landslides are shallow in nature and therefore the materials involved are likely to be a mixture of Head (if present), soil and weathered bedrock. A large proportion of landslides in this study (88%) have developed on slopes over mudstone (Figure 2) which is likely to relate to the weakening effect of weathering on mudstones and other similar lithologies (Waters *et al*., 1996). Failures in slopes of sandstone occur within the Millstone Grit and Pennine Lower Coal Measures present across the sheet.

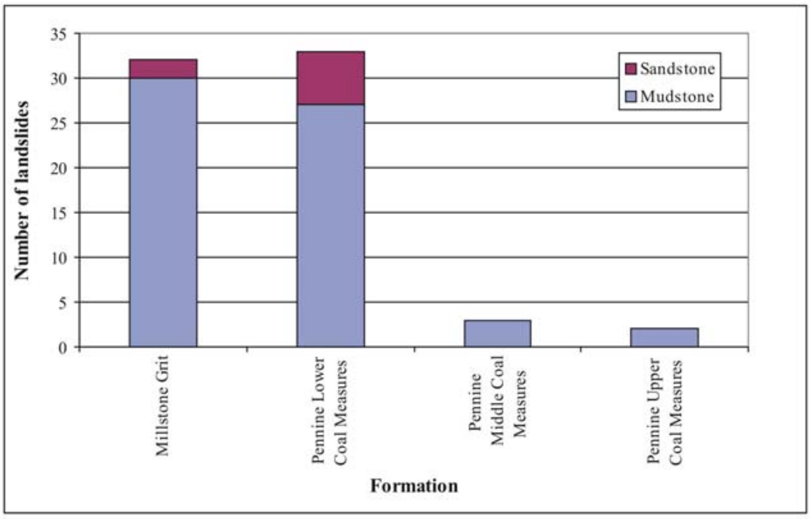

Figure 2: Frequency of landslides in sandstone and mudstone for formations on the Sheffield Sheet.

2.2 LANDSLIDE MECHANISMS

The dominant mechanism for landsliding is sliding of both a rotational and translational style (Table 1), predominantly in mudstone (Table 2). Flows are the third most dominant mechanism of landsliding, which is unsurprising given the age and strength of material that is present. Analysis of slope angles for landslides on the Sheffield Sheet showed that most of the landslides occurred on slopes of between 7-19^{o}. Geological mapping in Bradford, that included the Millstone Grit and Coal Measures, indicated landsliding was commonplace on slopes of between 11-18^{o} (Waters *et al*., 1996).

Landslide Mechanism	Number of landslides
Fall	1
Flow	11
Spread	1
Translational Slide	18
Rotational Slide	21
Grand Total	**52**

Table 1: Landslide mechanisms recorded on the Sheffield Sheet

	Slide Lithology	
Mechanism	Mudstone	Sandstone
Fall		1
Spread	1	
Flow	10	1
Translational	17	1
Rotational	17	4
Grand total	**45**	**7**

Table 2: Mechanisms of landsliding and lithology involved.

3 Landslide Characteristics

3.1 MILLSTONE GRIT GROUP

Within the area covered by the Sheffield sheet there are 32 landslides that occur on the Millstone Grit Group, which also includes the Rough Rock Formation and Chatsworth Grit Formations. The Group contains both a sandstone and a Mudstone component. There are three main types of failure occurring on the Millstone Grit.

3.1.1 Landslides at the junction between a Sandstone unit and a Mudstone unit.

Landslides on the Millstone Grit Mudstone occur predominantly where a sandstone bench has formed a plateau whilst the mudstones below form slopes that dip relatively steeply from the scarp edge into the valleys. The sandstone acts as a permeable cap rock that is able to supply water into the impermeable mudstone below. Springs and seepage lines occur at the sandstone/mudstone interface and can lead to failures within the weaker mudstone. In Rivelin, just outside Sheffield there are a cluster of landslides that have occurred in this type of situation. Figure 3 shows the location of landslides in the Rivelin valley in association with the Millstone Grit sandstone and mudstone, there is also a mapped covering of Head in the east of this valley. In Figure 4 the topography created by the more resistant sandstone and weaker mudstone is shown along with the position of the landslides. Landslides within the Rivelin valley are dominantly shallow translational earth slides with some element of flow being visible. Examples of the landslides present are shown in Figures 5 and 6. During the aerial photograph interpretation the landslides in Figures 5 and 6 were much more pronounced and their morphology more recognisable. The air photographs were flown in 1997 and since then the landslides have degraded somewhat so their morphology and shape is no longer as pronounced.

Figure 7 shows another example of a shallow translational earth slide occurring near Bradfield on the Millstone Grit mudstone.

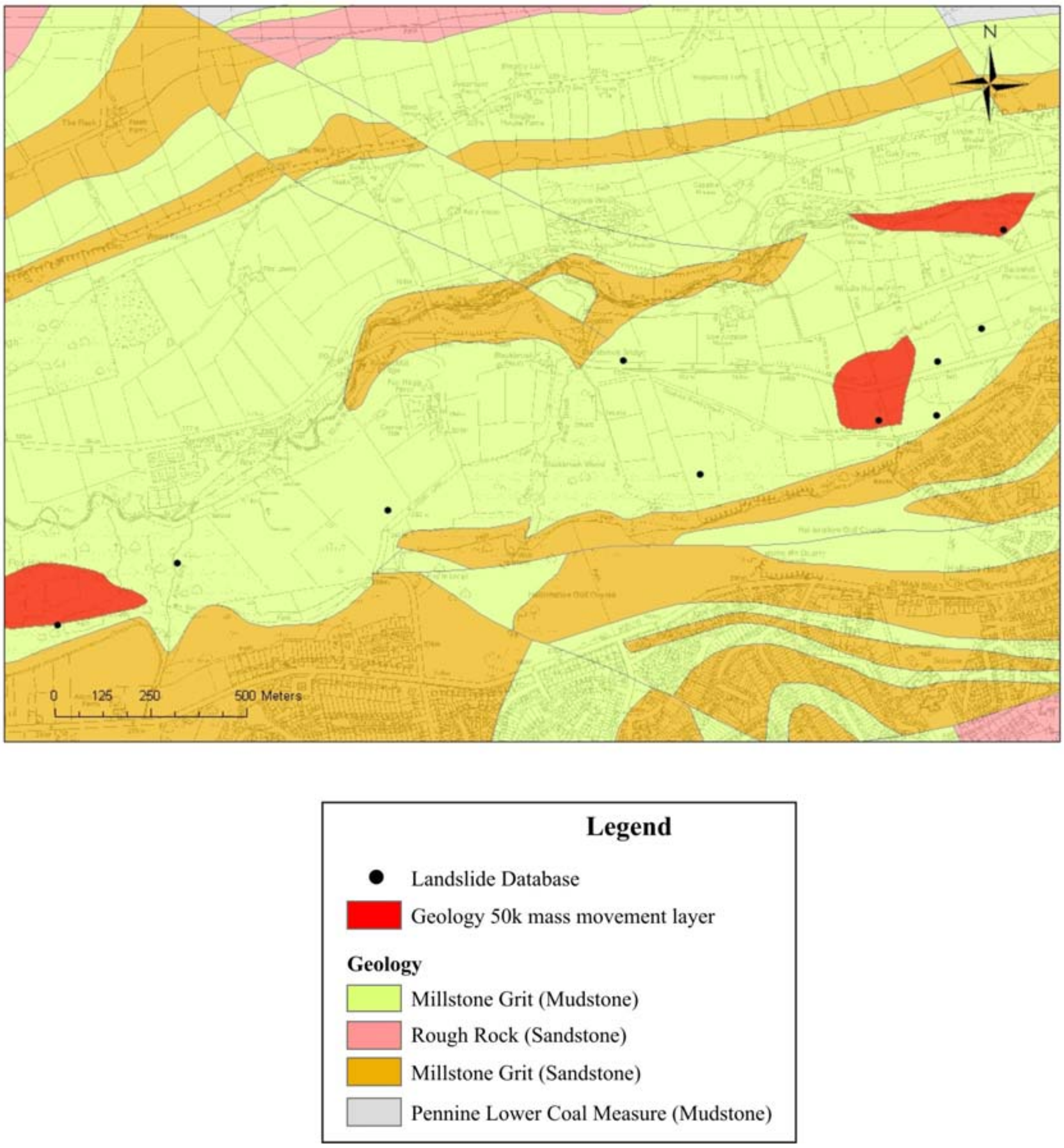

Figure 3: Distribution of landslides within the Rivelin Valley showing the relationship to lithology.

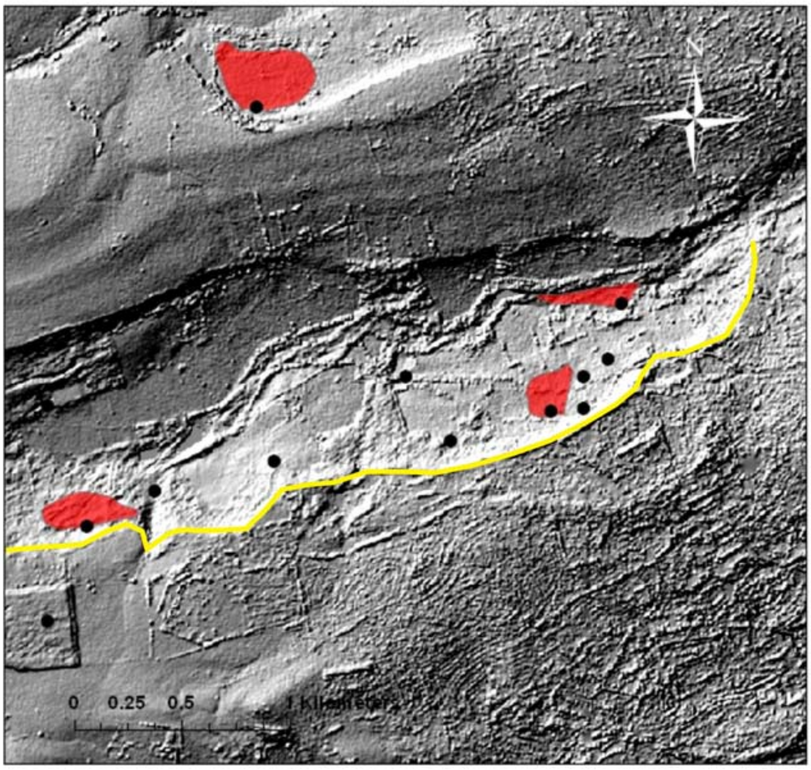

Figure 4: NextMap image showing the topography of Rivelin Valley and the distribution of landslides (Black dots/Red polygons). The yellow line highlights the sandstone escarpment edge.

Figure 5: Shallow earth slide failure at SK290867. This failure occurs next to a more degraded, larger slide that is obscured by the trees. (Photograph taken from 429600 387831).

Figure 6: Shallow earth slide at SK306872, one of several on this section of slope. (Photograph taken from 429600 387831).

3.1.2 Rotational failures relating to river erosion

Other types of failure within the Millstone Grit included small scale rotational landslides, commonly associated with river erosion at the base of a slope (Figure 7). This type of failure is not particularly large. The landslide in Figure 7 is approximately 100 m by 50 m, but the morphology is obvious enough to be able to map these features both in the field and through API.

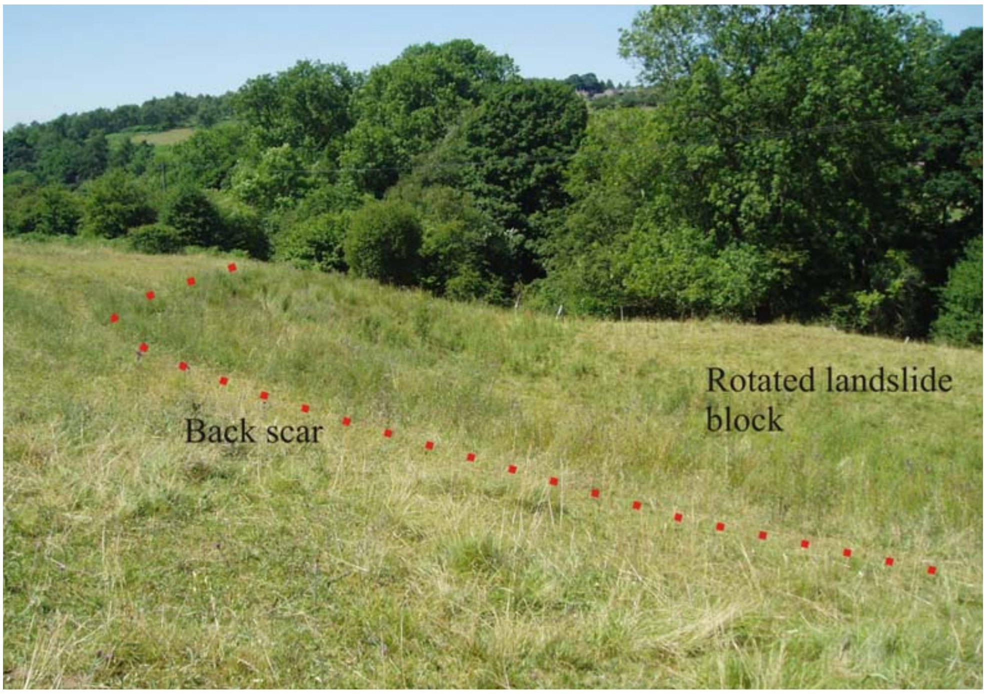

Figure 7: Rotational landslide probably caused by river incision in Millstone Grit mudstone (SK).

3.1.3 Large-scale rotational landslides

There was one instance recorded during this study of a large scale landslide involving the sandstone units of the Millstone Grit. This was at Chatsworth House where a large scale backscar was visible in the woods behind the Deer Park. The polygon is around 2.5 km long but only 100 m wide; with an area of 0.3 km^2 (Figure 8). The width of the landslide may be thinner than expected due to landscaping in the grounds which may removed the surface expression of the landslide toe. The landslide itself involves both the mudstone and sandstone parts of the Millstone Grit with the backscar being within the harder sandstone section. In the area around Chatsworth the Millstone Grit sandstones form benches with the weaker mudstones in-between; this benched topography is visible in Figure 9. The base of the landslide was mapped along a line of hummocky ground which could clearly be distinguished from the landscaped grounds of the park (Figure 10).

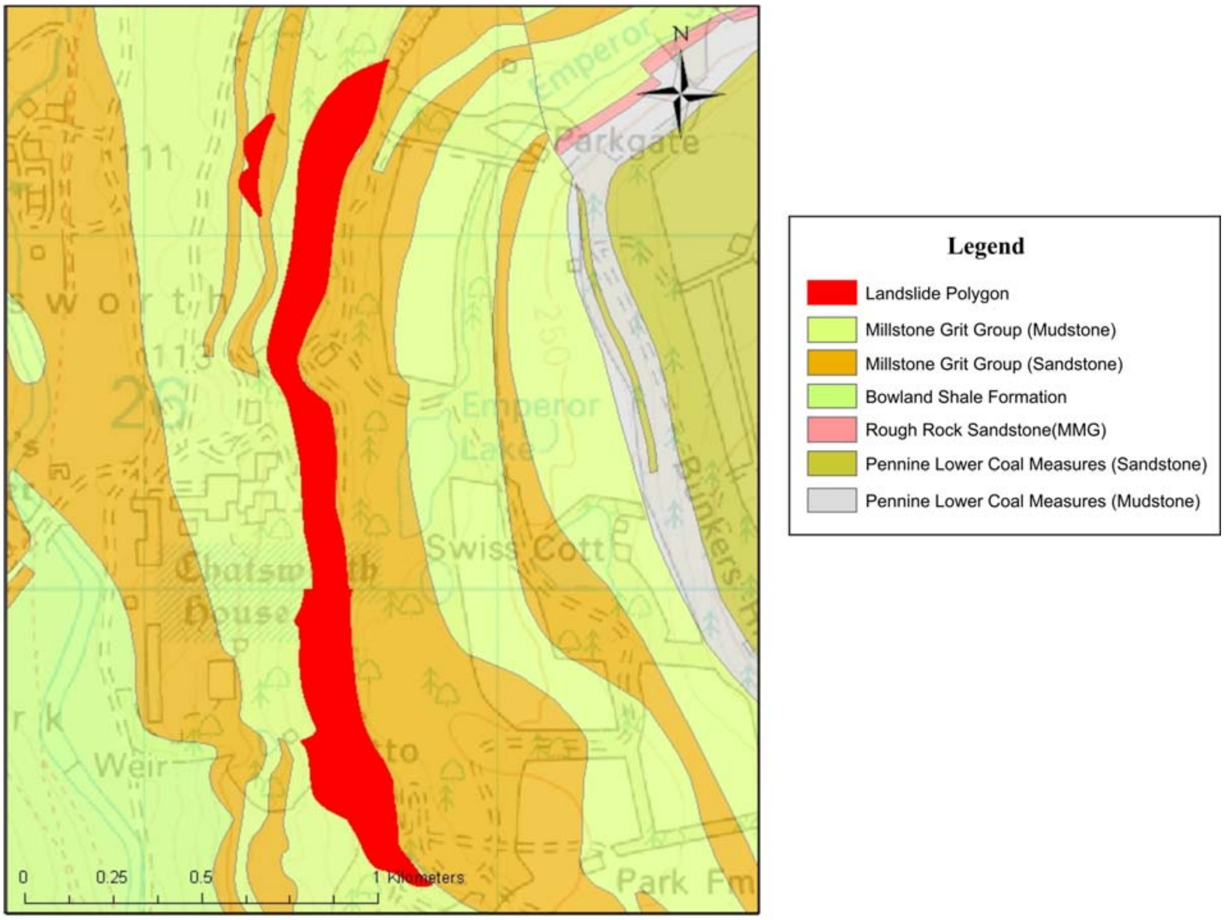

Figure 8: Geology of Chatsworth House with mapped landslide polygons

Figure 9: 3D image of the northern section of Chatsworth Deer Park showing the topography of the area.

Figure 10: Hummocky ground in Chatsworth Deer Park

3.1.4 Degradation of the Grit Edges by rock fall.

The harder sandstone lithologies of the Millstone Grit Group are susceptible to rockfalls when they are exposed (Figure 11). However, these types of failures are not recorded as a landslide which lead to an underestimation of the level of activity at these grit 'edges'. Whilst substantial debris is accumulated at the base of the grit 'edges' and it was decided that this represents a continual erosion of the sandstone by ravelling and no one single rockfall event could be identified of a scale or magnitude that would be recorded in the database.

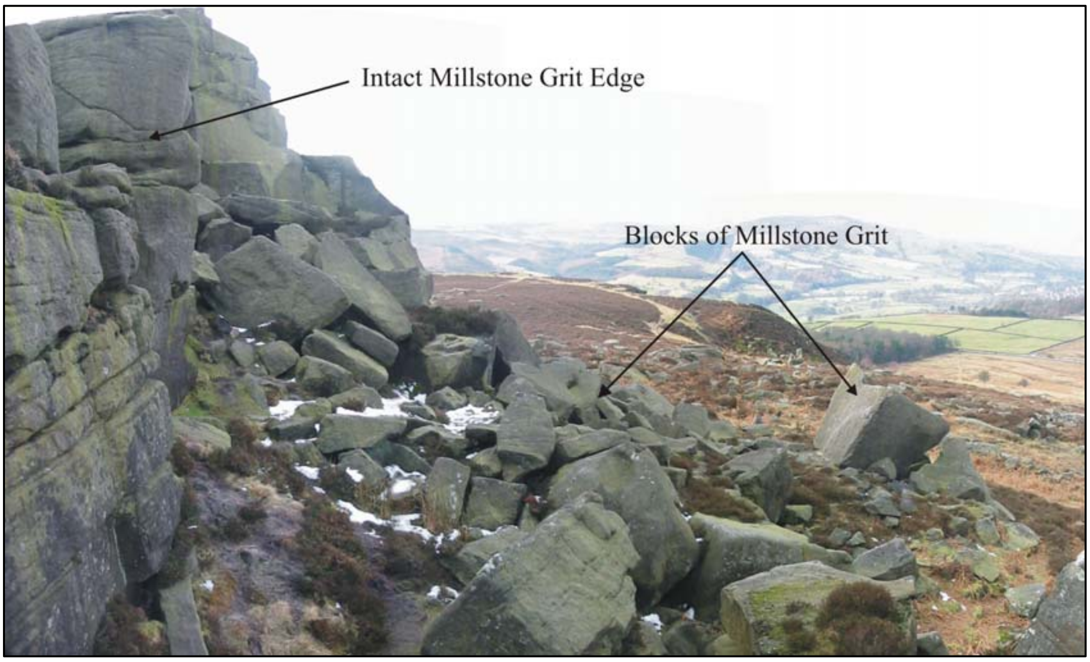

Figure 11: Degradation of the Millstone Grit Edges near Owler Tor (Photograph taken looking SW from around SK 251807).

3.2 PENNINE COAL MEASURES

Of the 38 landslides that occur on the Pennine Coal Measures Group the majority of these are within the Pennine Lower Coal Measures (84%). Many of the landslides occur in association with a boundary between the sandstone and mudstone units. Most of the landslides on the Pennine Coal Measures occur over the mudstone sections and are predominantly slides of both rotational and translational nature with a few flows. Figure 12 shows the distribution of four landslides that were mapped around Crowhole Reservoir in the south of the Sheet. There were a total of five landslides in this area, with all but one slide occurring in the mudstone bands of the Pennine Lower Coal Measures. All of the landslides were shallow translational slides. Landslides in the Pennine Lower Coal Measures tend to be shallow in nature and this can lead to a subdued hummocky topography which is difficult to identify without stereo aerial photographs (Figure 13).

Figure 12: Distribution of shallow slides around Crowhole Reservoir on mudstones slopes of the Pennine Coal Measures (SK 319746).

Figure 13: Subdued landslide topography of the Pennine Lower Coal Measures Mudstone lithologies (SK298890).

4 Conclusions

Aerial photograph interpretation was a successful mechanism for identifying landslides on the Sheffield Sheet, leading to the addition of 25 landslides into the Landslide Database. Two geological formations dominate the Sheet, The Millstone Grit Group and the Pennine Coal

Measures Group. Of these the Millstone Grit and the Pennine Lower Coal Measures are the dominant formations involved in landsliding. Most of the landslides occur within the mudstones of these Formations (88%). Sliding is the dominant form of failure and these are occurring on slopes of between 7-19°. Within the Sheffield Sheet there are four types of landslide environments, which are geomorphologically and geologically similar. These environments are

- Slopes between 7-19° which are formed in mudstone lithologies and are susceptible to sliding of a rotational and translational nature (Crowhole Reservoir).
- Near vertical gritstones edges formed in Millstone Grit Group sandstone lithologies which are susceptible to falling and deterioration by blocky failure, not of a significant scale or magnitude to record in the landslide database (Curbar Edge).
- Valley sides where a hard sandstone cap rock is positioned above weaker mudstone valley sides. Water flowing through the aquifer (sandstone) is unable to flow into the aquiclude layer (mudstone) and seepage occurs at the interface. Raised pore pressures at this location can lead to failures. (Rivelin Valley)
- Steep slopes formed by Millstone Grit Group sandstone benches which have failed through deep seated rotational landslides. These landslides are much older, probably Devensian, and include a steep back scar with hummocky ground in front representing degraded rotated blocks and landslide toe (Chatsworth House).

References

Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

FOSTER, C.2008. *Aerial photograph interpretation of landslides on the Sheffield Sheet.* British Geological Survey Report OR/08/019

WATERS, C. N., NORTHMORE, K., PRINCE, G. AND MARKER, B.R. (eds) 1996. a geological background for planning and development in the city of Bradford metropolitan area. Volume 2: *A technical guide to ground conditions. British Geological Survey Technical Report, No. WA/96/1.*