British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Summary report on the Arthur's Seat rockfall, Edinburgh, February 2007

Physical Hazards Programme

Internal Report IR/07/033

BRITISH GEOLOGICAL SURVEY

PHYSICAL HAZARDS PROGRAMME

INTERNAL REPORT IR/07/033

Summary report on the Arthur's Seat rockfall, Edinburgh, February 2007

N R Golledge

Keywords

Arthur's Seat; Edinburgh; Scotland; rockfall; natural hazard; mass movement; slope failure.

Bibliographical reference

N R GOLLEDGE. 2007. Summary report on the Arthur's Seat rockfall, Edinburgh, February 2007. *British Geological Survey Internal Report*, IR/07/033. 13pp.

Keyworth, Nottingham British Geological Survey 2007

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 a short study by the British Geological Survey (BGS) of the rockfall that occurred from cliffs on the south side of Arthur's Seat, Edinburgh, in the early hours of 28th February 2007. The report is based on data collected during a one hour investigation of the site, as well as an assessment of existing data held in BGS archives. The site and its surrounding area is covered by 1:50 000 scale Geological Sheet 32E (Edinburgh), published in 2006 from resurvey between 1981 - 2000. This report does not include any assessment of geotechnical properties of the failed material, and should not be used in place of a full geotechnical review.

Acknowledgements

BGS acknowledge with thanks the assistance and cooperation of Holyrood Park Ranger Service. All photographs were taken by Fergus MacTaggart, BGS Photographic Services.

Contents

FIGURES

Summary

This report describes the geological context of a small rockfall event from exposed bedrock faces on the southern side of Arthur's Seat, near the locality known as Samson's Ribs approximately two kilometres southeast of Edinburgh city centre. Rockfall from the cliffs resulted in debris lying in the road and some minor damage to a stone wall. Consequently the road was closed until the debris could be removed and an inspection of the slope carried out. The rockfall probably occurred as a result of prolonged and intensive rainfall, combined with strong winds.

Date of event: 28th February 2007

Location: Arthur's Seat, Edinburgh, central Scotland

Type of failure: rockfall from exposed face

BGS landslide ID: 15636

---

1 Introduction

High winds and heavy rain during the night of 27-28th February led to the failure of a small part of the cliff immediately east of 'Samson's Ribs', on the southern flank of Arthur's Seat (Fig. 1). Debris fall onto the road, and minor damage to the road, footpath and adjacent stone wall rendered the road unsafe and prompted its immediate closure. The following was posted on the BBC News website, 28th February 2007:

> **Road closed after large rock fall**.
>
> *A road through the Queen's park in Edinburgh has been shut following a large rock fall during the night.*
>
> *Traffic through part of Holyrood Park, on the south-east side of the city centre, is being diverted away from what is normally a busy commuter route.*
>
> *Heavy rain and strong winds are being blamed, initially, for the incident, but a full inspection of the area at Park Road is being carried out.*
>
> *The incident happened at 0415 GMT. No-one was injured.*
>
> Rock face inspection
>
> *The low road leading to Duddingston was closed immediately and will remain shut until inspection of the rock face and removal of materials has been completed.*
>
> *A Historic Scotland spokeswoman said: "The persistent heavy rain and high winds overnight caused a sizeable amount of rock debris to fall from Arthur's Seat onto the low road.*
>
> *"The area was closed immediately, and our staff have been on site since early this morning analysing the cliff face.*
>
> *"We hope to re-open the road on Thursday, once we are assured the area is completely safe and secure.'*
>
> [http://news.bbc.co.uk/1/hi/scotland/edinburgh_and_east/6403571.stm]

A visit to the site by a BGS team of geologist and photographer was arranged on 1st March 2007 through Mr. Graham Checkley (Park Ranger, Holyrood Park Ranger Service).

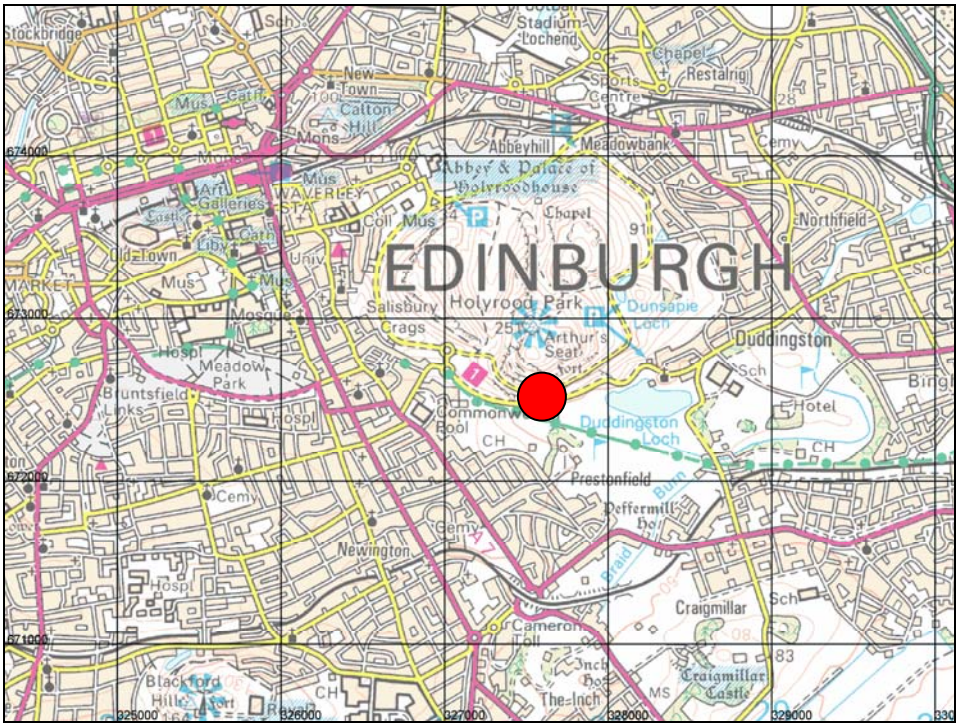

Figure 1. Location of site in relation to wider area. Spot shows failure site illustrated in Fig. 2.

1.1 FAILURE LOCATION

The failure took place at [NT 27520 72471], on the southern flanks of Arthur's Seat, a 250 m high hill in Holyrood Park. The rockfall occurred from crags between an upper road (Queen's Drive) and a lower road leading to Duddingston. Approximately the top half of this slope is near-vertical cliffs, whilst the lower portion is a steep grassy bank (Fig. 2).

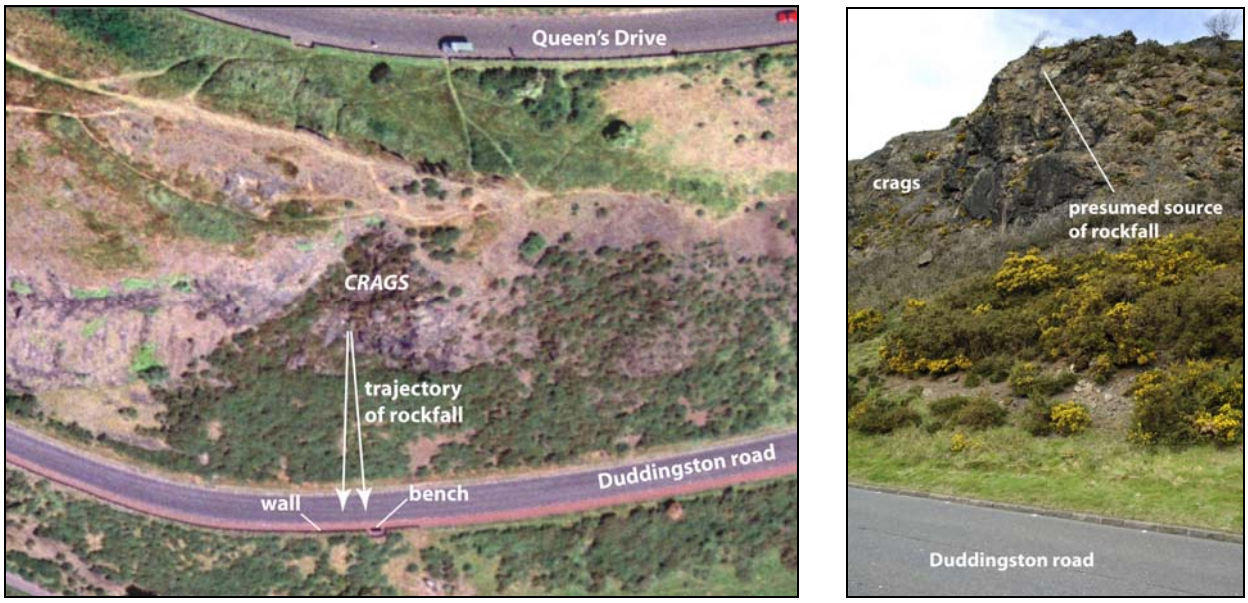

Figure 2. Detail of landslip site. Lefthand image from Getmapping high-resolution aerial photography. Righthand image shows context of the rockfall, looking northwest.

1.2 GEOLOGICAL CONTEXT

The Arthur's Seat massif is composed of a variety of igneous and sedimentary lithologies (Fig. 3). The extrusive igneous rocks forming the majority of Arthur's Seat are principally Carboniferous micro- to macro-porphyritic olivine-basalt of Jedburgh and Markle types respectively. Intrusive rocks (sills) are typically olivine-basalt and olivine-dolerite of Dunsapie type, or Teschenite. Close to the failure site the bedrock is vent agglomerate, presumably of similar chemistry to the other igneous units but lacking their structure or coherence. Sedimentary rocks in the area are mainly shallowly-inclined (10-20°) approximately eastward-dipping Lower Carboniferous calciferous sandstones.

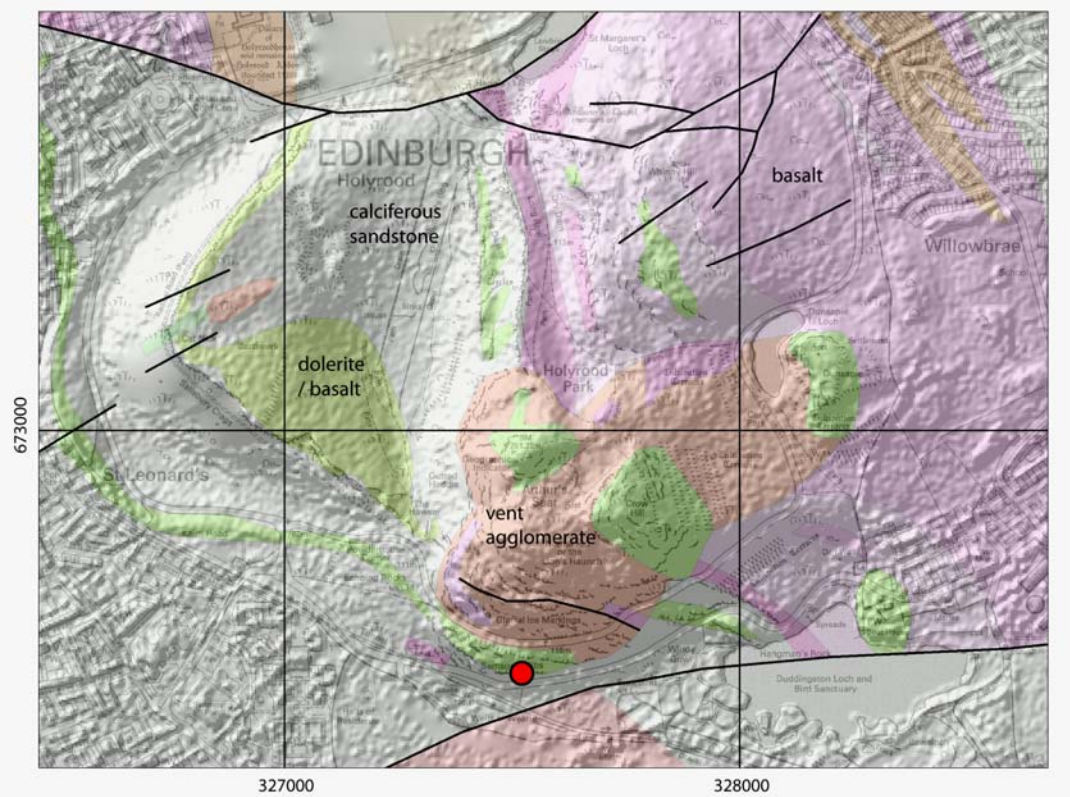

Figure 3. Geological map of the area surrounding the failure site (red spot), draped on NEXTmap Digital Surface Model (DSM). Black lines denote unclassified normal faults. Geology derived from BGS 1:50 000 scale DigMap digital data and BGS (2006) Scotland Sheet 32E (Edinburgh), Bedrock and Superficial Deposits.

2 Description of failure

2.1 SITE

The rockfall occurred during the early hours of 28th February 2007, and was assessed on the morning of 1st March, by which time all the fallen debris had, unfortunately, been removed from the road. The road and pavement directly beneath the site showed decimetre-scale abrasions consistent with recent rockfall impact, the largest up to approximately 20 mm deep (Fig. 4). The pavement is bounded on its southern side by a low, mortared stone wall that had been struck by the rockfall debris. The wall was intact but showed signs of some limited fracturing. The base of the wall had separated from the adjacent tarmac of the pavement, and the freshness of this approximately 10 mm wide fissure indicated its probable origin due to debris impacting the wall (Fig. 4). Some edge-chipping had been sustained by the concrete base of a nearby bench, but no

further damage could be seen. Whilst boulders and smaller rock debris were present on the slopes below, they did not appear fresh, and their intimate association with the wild vegetation indicated that they were not derived from the recent rockfall event but nonetheless attest to the relative frequency of such falls.

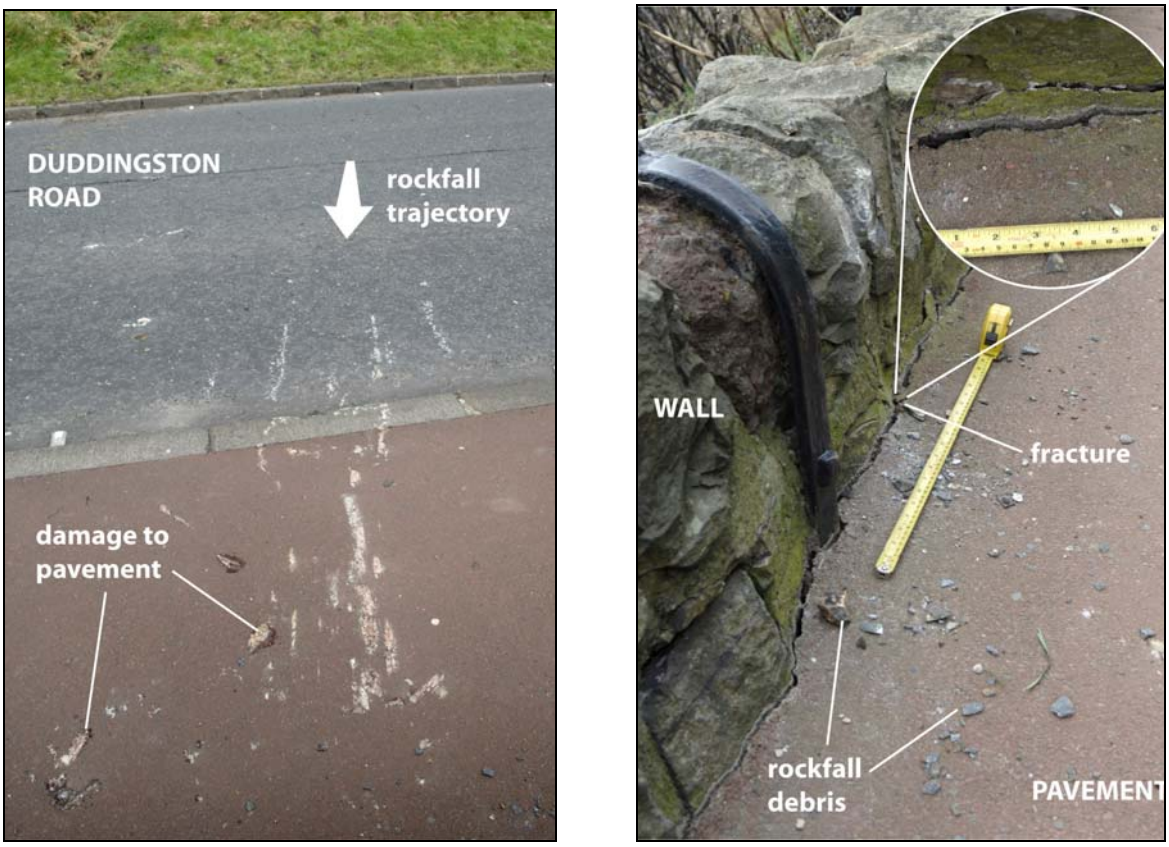

Figure 4: Damage to road , pavement and wall resulting from rockfall

2.2 MORPHOLOGY

Close examination of the crags was not possible, due to the steepness of the face and the presence of loose material below it. Consequently the face could only be assessed through binoculars from the road. The dark, basaltic crags appeared to reveal lighter areas of rock, presumed to be failure planes of the fallen material. These lighter surfaces were estimated to account for a surface area of < 2 m^2 (Fig. 5). The slope from the road at the base of the bank to the failed face on the crags was measured by Abney level as 51° (Fig. 6).

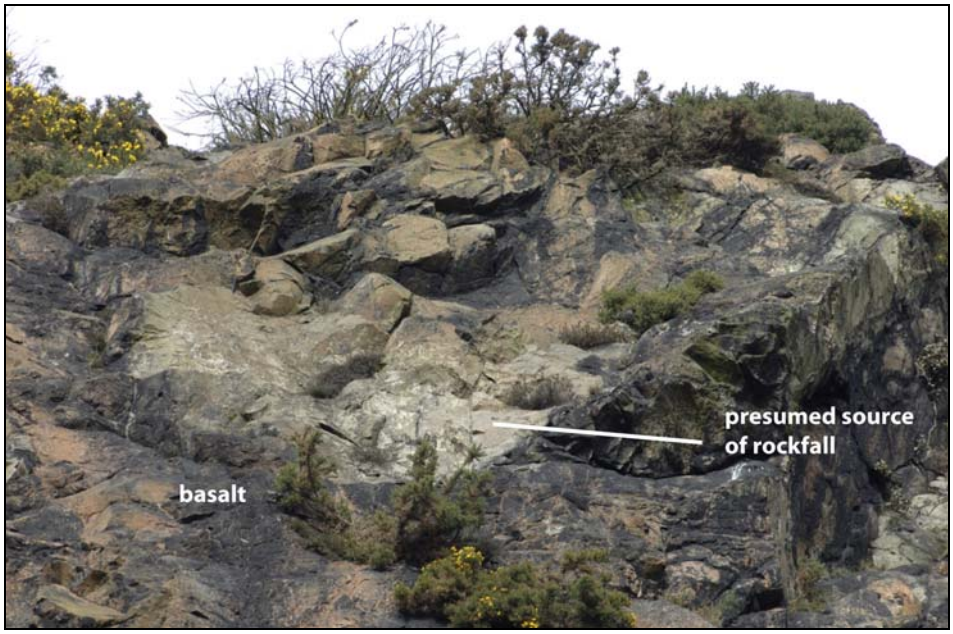

Figure 5: Presumed source area for the rockfall, near the top of the basaltic crags.

The bedrock composing the crags exhibited a nodular surface weathered to a dark grey, and supported vegetation in some places. It was assumed that the pseudo-spheroidal / reniform surface reflected curvilinear joint sets within the rock, representing post-emplacement cooling and contraction. These structural discontinuities were considered to correspond to potentially weaker zones that may have been more susceptible to fluid ingress during heavy rainfall.

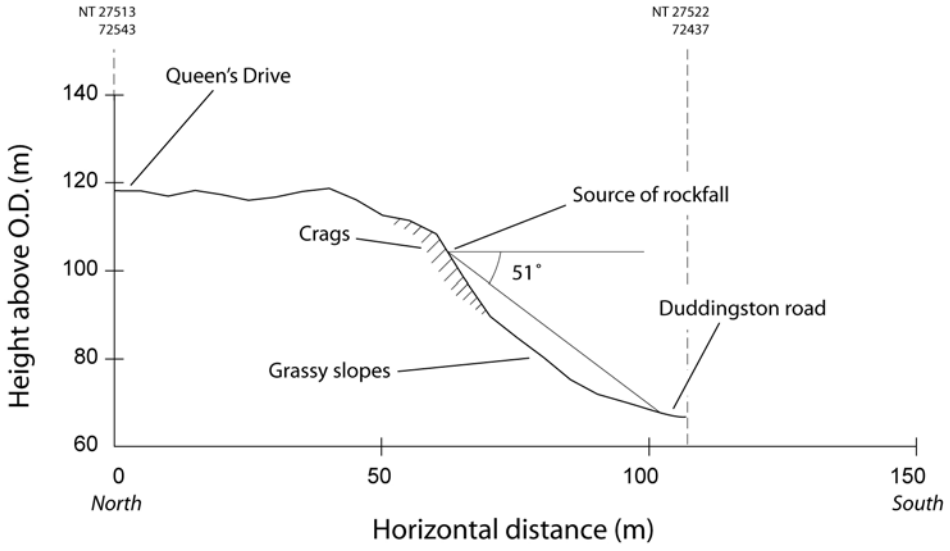

Figure 6. Slope profile of the failure site derived from NEXTmap digital elevation data, showing mean slope angle from road to rockfall scar.

2.3 GEOLOGY

The crags from which the rockfall occurred are thought to be olivine-basalt and olivine-dolerite of Dunsapie type, but are immediately overlain by the agglomerate. Hand specimens of rock were collected from what little debris could still be found on the road, and has been identified as basalt.

2.4 CLASSIFICATION

BGS adopt the classification scheme for landslides suggested by the World Landslide Inventory, largely based upon Varnes (1978) and Cruden & Varnes (1996). This is a morpho-genetic scheme – classifying according to material, failure morphology and (often inferred) mechanism. Failures may occur within rock, debris or earth, and may be composite in form. This scheme allows for over 20 categories of failure to be recorded. The Arthur's Seat event is classified as a rockfall.

2.5 TRIGGERS OF SLOPE FAILURE

On the basis of the brief site examination, and the geological inferences above, it was concluded that the poor weather conditions (high winds and heavy rainfall) caused a failure within an already weakened rock mass. It is highly likely that thermal weathering (differential expansion and contraction - freeze-thaw) during the preceding winter months weakened the rock and led to gelifraction. This, coupled with invasive root systems of vegetation on the slope, will have resulted in opening of joints and a degradation of joint infill. Over time, the strength of the rock mass will have decreased to a point where a triggering event, in this case a period of poor weather, caused the mass the fail.

3 Impacts

The road was considered unsafe after the event, due to the likelihood of further rockfall, and was temporarily closed. Slopes in the immediate vicinity of the fall may have been affected by the event, and should be treated with caution.

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.

CRUDEN, D. M. AND VARNES, D. J. 1996. Landslide types and processes. In *Special Report 247: Landslides: Investigation and Mitigation*, Transportation Research Board, Washington, D.C.

VARNES, D. J. 1978. Slope movement types and processes. In *Special Report 176: Landslides: Analysis and Control*, Transportation Research Board, Washington, D.C.

BRITISH GEOLOGICAL SURVEY. 2006. Edinburgh. Scotland Sheet 32E. Bedrock and Superficial Deposits. 1:50 000 Geology Series. (Keyworth, Nottingham: British Geological Survey.)