

# Examples of recent rockfalls from basalt cliffs in Northern Ireland

**Peter Wilson and Alana Cunningham**

*School of Environmental Sciences, University of Ulster at Coleraine*

## ABSTRACT

Two examples of recent rockfalls from basalt cliffs in Northern Ireland are described and some trigger mechanisms suggested. The Downhill rockfall of June 2002 resulted in derailment of the Londonderry-Belfast train and occurred following two months of above average rainfall. The Trostan rockfall(s) has (have) resulted in basalt boulders accumulating on the track bed of a late nineteenth century mineral railway, the track having been removed by 1900. Rockfall timing(s) and cause(s) are not known with certainty but the possibility of distant seismic activity acting as a trigger mechanism is introduced. Both examples exceed in magnitude rockfall events recorded elsewhere on the Ulster basalts, and demonstrate the unstable nature of basalt cliffs and the hazards posed to transport routes engineered along their base.

**Key index words:** Rockfalls, basalt, Northern Ireland.

## Introduction

The Tertiary basalts of Northern Ireland form escarpments of precipitous cliffs around much of their margins. Away from the margins, cliffs exist where glacial erosion and/or faulting have created major 'steps' in the landscape. A consequence of these landscapes and the structural/lithological characteristics of the basalts is the widespread evidence for past and present rock-slope instability (e.g. Prior *et al.*, 1971; Douglas, 1980; Clark, 1984; McKenna *et al.*, 1992; Smith and Ferris, 1997). Such has been the magnitude and frequency of rock-slope failure that the Antrim basalts are cited in general geomorphological texts as examples of rock types that are particularly susceptible to this type of slope process (e.g. Whittow, 1975; Davies and Stephens, 1978).

It is probably true that many contemporary small rockfalls go unreported, although some of these events and their products may have been observed. Larger rockfall events that produce significant quantities of coarse debris and impinge on human activities frequently make the news headlines, although it is usually the impact of an event rather than the event itself that captures media interest. During the 1990s concerns about the likely results of contemporary and potential future rockfall activity at two sites on basalt cliffs on the north coast of Northern Ireland prompted action from the National Trust. At the Giant's Causeway, co. Antrim, a 2 km long footpath that traversed the 90-100 m high cliffs at mid-height was closed because of repeated damage to the path and its retaining fence by rockfalls and other mass movements, particularly during winter (Smith and Ferris, 1997). At Downhill, o Londonderry, major cliff stabilisation work was undertaken to prevent the Mussenden Temple (a late-eighteenth century structure on the edge of 50 m high cliffs) from falling into the sea. In the first of these cases public safety was of paramount importance; in the second, work was designed to safeguard a part of the built heritage. In both cases it was the susceptibility of the basalts to failure that necessitated action.

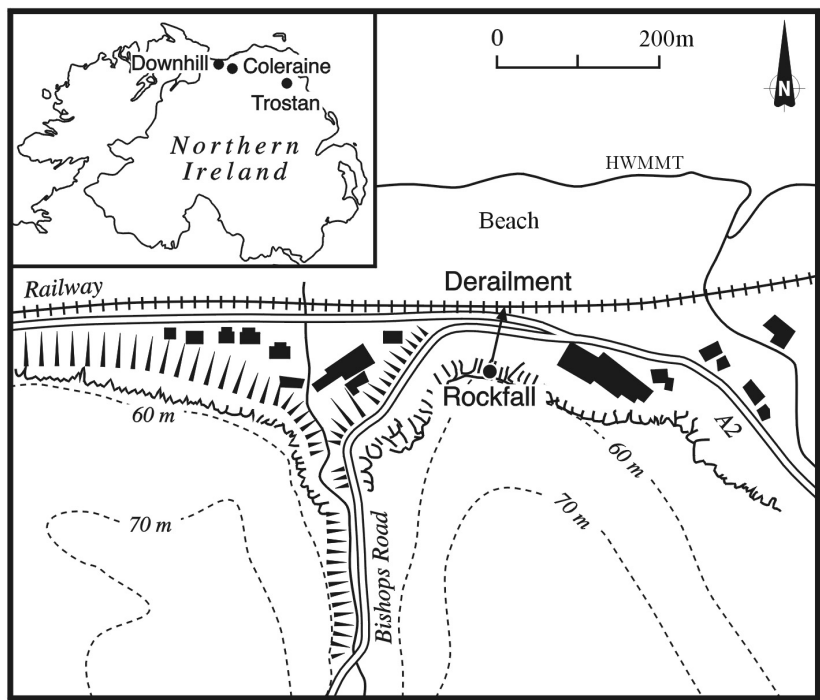


Figure 1: Downhill, co. Londonderry. Rockfall site and derailment point are indicated.



Figure 2: View of the derailment site from the east showing the relationship between cliff, roads and railway. The upper arrow indicates the rockfall site, the lower arrow marks where the train hit the boulder.

This short paper reports two examples of rockfall activity from basalt cliffs in Northern Ireland. Both examples are associated with railways and demonstrate the potential hazard posed by basalt scarps to transport routes engineered along their base.

### The Downhill rockfall of June 2002

At Downhill, co. Londonderry (Grid Ref. C 75 36), the Belfast-Londonderry railway and A2 road (Seacoast Road) run parallel along a narrow strip of ground between the beach and basalt cliffs that here rise to 60 m OD. A minor road (the Bishops Road) branches from the A2 and ascends a steep and narrow valley that breaches the cliff line (Figure 1). On Tuesday, 4<sup>th</sup> June 2002 the 12.50 Londonderry to Belfast train was derailed at Downhill after hitting a boulder that had come to rest on the track following a small rockfall from the adjacent cliff (Figure 2). Although described in some newspapers as a landslide, the slope failure was in fact a combination of rockfall from a free face and soil fall from a vegetated area on the cliff. Inspection of the site (from below) revealed fresh rockfall scars, from where boulders had fallen, just below the crest of the cliff, and at approximately mid-height a grassy ramp whose vegetation and thin soil cover had been disrupted. It seems that boulders falling from high on the cliff had hit the ramp rupturing the vegetation and displacing some soil. Most of the fallen debris lodged behind a grass-covered bank (possibly the stabilised accumulations of earlier rock-slope failures) alongside the road at the base of the cliff, but some boulders (up to 1 m in length) passed the eastern end of the bank and reached the road. A number of fresh depressions in the asphalt of the Bishops Road indicated that some boulders had hit the road.

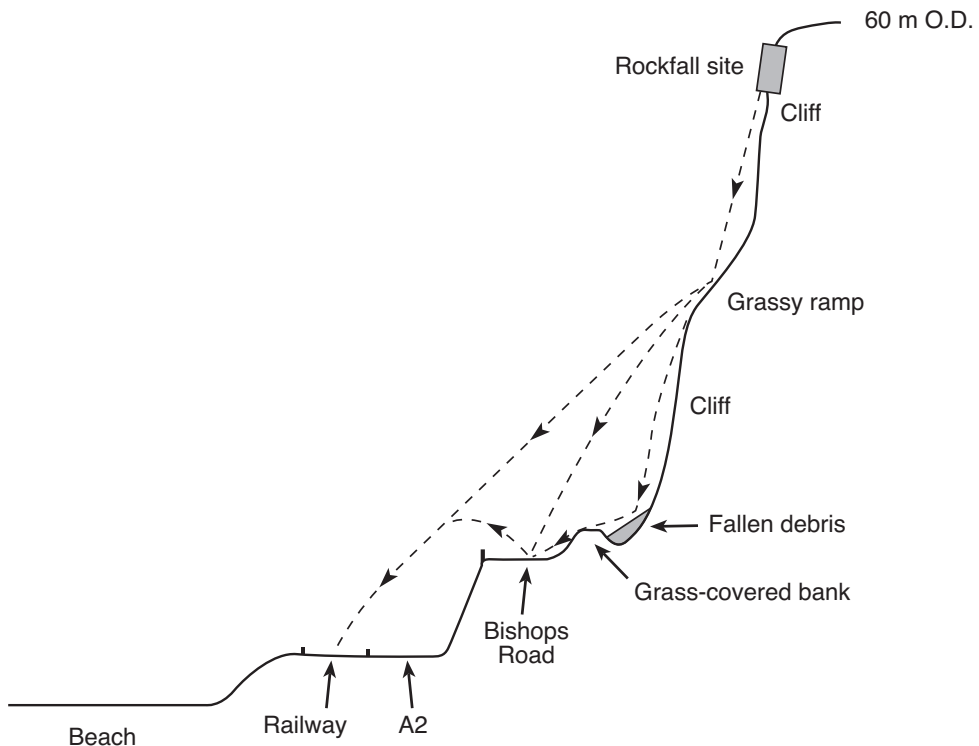


Figure 3: Pathways of debris movement at Downhill. Not to scale.

with considerable force. The largest of these depressions was 12x7x5 cm. At least one boulder, of unknown size, either hit the ramp and then the Bishops Road with sufficient force that it bounced over the A2 and ended up on the railway line or, after hitting the ramp, the trajectory of the boulder carried it across both the Bishops Road and the A2 onto the railway line (Figure 3).

The three-coach diesel unit was reported to have been travelling at 60-70 mph (c. 95-110 kph) when it struck the boulder. It then travelled for a further 100-150 m before one coach came to rest on the grassy bank between railway line and beach and another straddled the bank between the line and a roadside parking area adjacent to the beach access point. Twelve of the 21 passengers on the train were taken to hospital with serious, but not life-threatening, injuries. Fortunately, no cars were damaged or beach users injured. The Downhill beach is usually a very popular location but in spite of it being a Bank Holiday there were very few people on the beach because of the inclement weather.

It is not known what volume of debris fell from the cliff, but it was small and that which reached the Bishops Road was quickly cleared away. Numerous small rockfalls from the Downhill cliffs have been noted previously: McKenna *et al.* (1992) list three such occurrences, November 1987, January 1991 and October 1992. On the latter occasion debris reached and blocked the A2. Other evidence for previous rockfall activity at Downhill can be seen to the west of the current site where the cliffs are fronted by aeolian sand ramps. Some ramps have a partial cover of basalt boulders, and ramp exposures show interbedding of sand and basalt debris. Therefore the rockfall of June 2002 must be viewed in the context of continuing but intermittent rock-slope failure.

Rockfall events on basalt cliffs in Northern Ireland have previously been linked to either freeze-thaw activity (Prior *et al.*, 1971; Douglas, 1980) or heavy rainfall (McKenna *et al.*, 1992). The Downhill 2002 rockfall is likely to have been triggered by heavy rainfall. At Coleraine, 10km east of Downhill, the long-term (1970-99) average rainfalls for April and May were 59 mm and 57 mm respectively. In 2002, 111 mm and 90 mm were recorded for these months. The April rainfall total had not previously been exceeded, the May total had been exceeded five times in the 30-year record. These amounts in 2002 probably served to increase cleft-water pressures in the basalt and promote failure. However, the role of freeze-thaw cannot be excluded entirely as, in the long term, this may have facilitated localised and progressive joint widening. Furthermore, the vibrations generated by passing road and rail traffic may have also played a part in weakening rock structure.

### **The Trostan rockfall(s)**

Trostan (Grid Ref. D 17/18 23; 550m OD) is the highest hill in co. Antrim. Around its eastern and northern flanks at c. 400-430m OD an interbasaltic bed crops out. This bed was mined for iron ore in the 1870s and for bauxite in the 1890s, and to facilitate transport of ores to the nearby road a mineral railway was constructed (Patterson, 1968; Hammond, 1991). Following the demise of mining on Trostan, the track was lifted: probably by 1900 (K. O'Hagan *pers. comm.*).

For a distance of c. 650m on the east side of Trostan the line of the former railway is overlooked by basalt cliffs (Figure 4), and the track bed and adjacent hillslopes are partly covered by basalt boulders (Figure 5). It is clear that the boulders on the line of the former

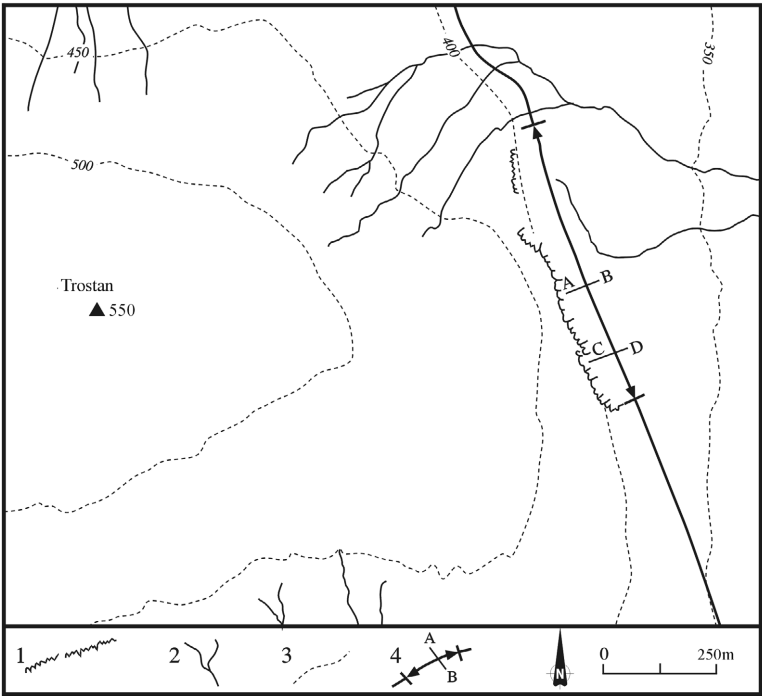


Figure 4: Line of former railway and rockfall site on east side of Trostan, co. Antrim. Location of Trostan in Northern Ireland is shown on Figure 1 inset. 1, cliffs; 2, watercourses; 3, contours in metres; 4, former railway with profile locations and zone with track bed boulders indicated.



Figure 5: Basalt boulders on the track bed of the former railway.

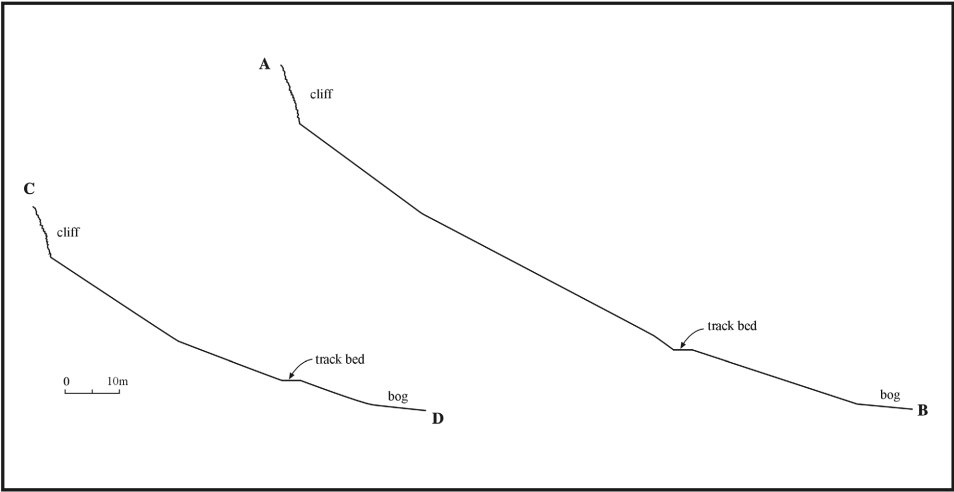


Figure 6: Surveyed profiles across the track bed and adjacent hillslopes. Profile locations are shown on Figure 4.



Figure 7: Debris from cliff collapse on hillslope above track bed of former railway.

railway post-date removal of the track and therefore represent the products of rockfall events during the twentieth century. The boulders on hillslopes adjacent to the track bed are likely to be of the same age.

Two profiles surveyed across the hillslopes and track bed to the base of the cliffs (Figure 4) indicate the form and relationships of these morphological components (Figure 6). Downslope of the track bed, hillslope gradients are 14–19°; those upslope are within the range 20–36°. The vertical drop from cliff base to track bed is 22–41 m. The cliffs above both profiles occur as tiers separated by steep grassy slopes. On profile A-B the lowermost cliff tier is 10 m high and on profile C-D it is 15–20 m high.

The largest boulder on the track bed measures 1.8 m x 1.7 m x 1 m. This occurs immediately north of profile A-B and is part of the debris of a substantial cliff collapse (Figure 7). Maximum boulder size in the debris above the track bed is 4.9 m x 2.5 m x 2 m and below the track bed the largest boulder is 3.5 m x 3 m x 1.8 m. Numerous boulders have a *b* axis in excess of 1 m.

Boulders at all points on the track bed display lichen and moss-covered faces, suggesting a prolonged period of stability. Cliff faces are similarly colonised. At two points, small (few m<sup>2</sup>) fresh rockfall scars occur on the cliffs. Boulders from one of these have lodged at cliff base; from the other boulders (*b* axes <0.5 m) with ‘clean’ faces and fresh impact fractures have descended the hillslope but have not reached the track bed. The inference is that these rock-slope failures are very recent, perhaps within the last 2–3 years. Thus, rockfall activity of the last few years does not match in magnitude with those events that produced the boulders now found on the track bed.

The cause(s) of rock-slope failure on Trostan may be similar to some of those mentioned above in connection with the Downhill rockfall, in particular frost-related processes and high cleft-water pressures associated with periods of above average rainfall. Observations of basalt cliff rockfalls in Northern Ireland from 1968 until 1972 have demonstrated maxima in February–March and November–December, and continuous small-scale activity throughout the year (Douglas, 1980). The size range of material collected in box traps was 2–200 mm and a relationship between frost processes and rockfall was suggested. However, the boulder sizes associated with the cliff collapse adjacent to profile A-B on Trostan suggest frost processes are unlikely to have been the only ones involved. Over time frost action could have reduced rock mass strength by expanding joints and fractures but the trigger for failure may have been something quite different.

In the Lake District of north-west England some rockfall events within the past few centuries have been associated with seismic activity emanating from both in and around that region (Melville, 1986; Wilson, 2003). Although Ireland has had very few earthquakes during the last century, it has on occasions felt the effects of seismic shocks centred in Great Britain (Musson, 1994; Walker, 2003). A recent example was the Carlisle earthquake of December 1979. This had a magnitude of 4.7 ML (Richter Local Magnitude) and was one of the most significant British earthquakes of the second half of the twentieth century. In addition to being felt throughout southern Scotland and northern England, it was also felt in Belfast, Donaghadee, Newtownards, Larne, Portrush and Limavady although there are no reports of damage to property in Northern Ireland (Musson and Henni, 2002). However, given the occurrence of rockfalls associated with this and earlier earthquakes elsewhere in the United Kingdom, it is an intriguing speculation that some rockfalls in Northern Ireland may have also been a consequence of seismic activity.

## Conclusions

Two examples of recent rock-slope failure in Northern Ireland demonstrate the unstable nature of basalt cliffs. The cause(s) of these rockfalls are not known with certainty although above average rainfall, frost-related processes, and the vibrations generated by passing traffic and distant seismic activity may have contributed. Although the magnitude of these failures has not been quantified it is clear that they exceed the magnitude of rockfall events documented elsewhere on the Ulster basalts by Douglas (1980), and indicate the potential hazard posed by basalt cliffs to adjacent transport routes.

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