# Man as geological agent

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*A Yorkshire landslide has been reactivated by man's activities.*

Early in 1999, a country backroad on the northern slopes of the North Yorkshire Moors was broken by a landslide that left a step over a metre high right across the road (Fig. 1 and front cover). Hardly a major event; but the Ainthorpe slide has proved to be a classic example of the role man plays as an agent of geomorphological process. That is how the geologist views it; to the civil engineer, it is yet another example of how destructive 'natural' events are so commonly unnatural, and are triggered by man's own activities.

**Fig. 1.** Renewed movement on the landslide head scarp that has cut the road from Ainthorpe; the displacement of the road represents the downward movement of the graben across the head of the slide. (Photos by George Dowson and the authors.)

## Geology of the landslide

The Ainthorpe landslide lies on the western slope of The Coombs, a small valley draining north off the Moors, just south of Ainthorpe village and 19 km west of Whitby. The landslide is small – less than 200 m wide and long (Fig. 2), with a fall of about 40 m from head to toe. It is formed within the Whitby Mudstone Formation (of the Jurassic Lias Group) that comprises mainly shales with interbedded sandstones. This sequence dips gently north, which is obliquely downslope at the landslide site. The near-surface material is weathered and is partly covered by head; there is glacial till on the valley floor.

The slide's most conspicuous feature is a splendid graben (Fig. 3) against the head scarp; this forms the western edge of the slide and crosses the road near its northern and lower end.

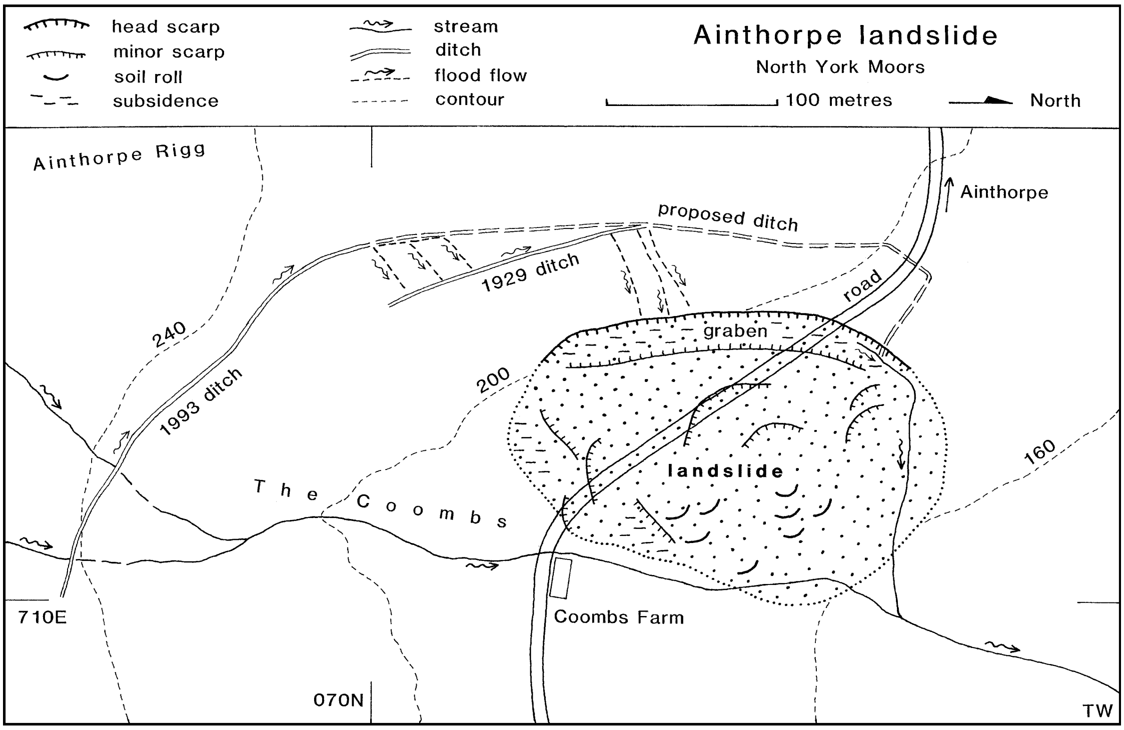


**Fig. 2.** Sketch map of the main features of the Ainthorpe landslide.

**Fig. 3.** (left) The graben across the road, with its higher margin on the left forming the landslide head scarp. The main slide mass on the right is moving downslope and away to the right.

**Fig. 4.** (below left) A dry stone wall stretched across the shear zone on the edge of the landslide. Coombs Farm is in the distance.

The southern margin of the landslide is poorly defined along a zone of subsidence and *en echelon* shears that have displaced and stretched some dry stone walls (Fig. 4). In the toe area of the slide, towards the north-east, a complex of compressional ridges, rolls and bulges has developed, suggesting the presence of overriding soil nappes. Within the slide mass, subsidiary slumps have created various head scarps, regressive failures and small grabens, some of which break the road tarmac (Fig. 5). The main graben and most of the head of the landslide are in unimproved moorland with an extensive cover of bracken, while the toe of the slide below the road is grazed pasture.

The horizontal component of landslide movement during the 1999 event was over a metre in the toe area, and the wedge of ground in the graben dropped by about a metre behind the main mass. There is no clear indication of rotation of the main slide mass, and the graben is evidence of translational movement. The depth to the basal shear is uncertain, because the whole site is covered by soil and vegetation with rock exposures only in the main and subsidiary head scarps of the landslide, but it could lie along gently dipping bedding planes that emerge to daylight in the toe of the slope (Fig. 6).

The Ainthorpe landslide is clearly an ancient feature. Its graben is degraded, with a thick plant cover, and appears on the 6″ scale base map of the Geological Survey field slip of 1879, but it was not the practice at that time for the geologists to map minor landslides. In common with many other quasi-stable slopes in Britain, the initial movements of the landslide may well date back to wetter climatic phases within the mid-Holocene; other degraded landslides can be seen along the hillside to the east. The recent reactivation of slope movement appears to be the culmination of a chain of events related to the drainage basin of The Coombs.

## Timetable of events

It is known that the slide moved in 1889, when a step about 250 mm high formed in the road where it crosses the upper edge of the graben. Similar movement occurred in 1929. Soon afterwards, a ditch (Fig. 2) was dug by hand across the moor to keep surface drainage away from the slide; this continued as far as the road, but its lower half is now choked and untraceable.

In the early 1980s, motorbike trials on the moors of The Coombs basin damaged some of the vegetation cover and caused some increase in storm runoff. In 1989, the bracken in the same area was reduced by spraying. Subsequently, erosion gullies developed on the moorland, and flood flows increased until they reached the capacity of the culvert beneath the road beside the farm.

Heavy rain on 14 November 1993 created a high-magnitude flood down The Coombs valley that significantly exceeded the capacity of the culvert beneath the road. Excess water poured from the hill onto the road, where the natural slope took it into the front door of the house at Coombs Farm. The farmer awoke during the night, found water flowing through his hallway, and then saw his front and back doors torn from their hinges as water a metre deep cascaded

**Fig. 5.** Subsidiary movement within the landslide mass has created small steps in the road surface; a miniature graben has formed just below the head scarp.

through. In six hours the flood pulse was over; the 236-year-old farmhouse was still structurally sound, but there was extensive superficial damage. The flood came from the natural drainage basin of The Coombs, which extends way up onto the moor just south of the landslide. In its area of 25 hectares, runoff at 30% of heavy rainfall at about 50 mm/hour creates a flow of around 1 cubic metre per second, which matches an estimate of the flood through the farm.

The next month, an unlined ditch (Fig. 2) was dug to divert some of the surface flow away from The Coombs above the farm. Unfortunately, this carries the water across the hillside just above the landslide. Furthermore, the new ditch ends on the hillside directly above the landslide (Fig. 7); the ditch's water is allowed to flow down the hillside to the ditch that was dug after the 1929 slide movements. This old ditch is also unlined and has not been maintained, and any flood flow poured into it now continues down the hill into the landslide.

The new ditch could carry about 300 litres/second of floodwater onto the hill directly above the old landslide; this was potentially disastrous. That copious water followed the ditch during and after various storm events is demonstrated by the fan deposits of coarse sediment at its lower end. The first really wet winter after the ditch's construction was 1998/9, and there was a week of heavy rain in late February and early March. On 5 March, the postman on his evening collection found a step in the road 100 mm high. The slide moved steadily over the next few days, until the scarp on the upper side of the graben created a step about a metre high across the road. After a week the movement ceased, and subsequent ground disturbance has been restricted to subsidiary slumping within and just above the slide mass.

A storm flood on 10 June of the same year filled the drainage ditches, from where about 100 litres/second of water poured down the active head scarp into the graben (Fig. 8). All this water sank into the landslide, and re-emerged from fissures in the landslide toe below the road. But the generally dry state of the ground in summer ensured that this water input did not reactivate the landslide.

## Cause and effect

It is safe to predict that the Ainthorpe landslide will move again when an adequately high storm-flood event occurs in an adequately wet winter when groundwater levels are already high. The threshold levels are not known, but the slide's limited history suggests that such an event has a return period of over 50 years. However, the new ditch increases the flow into the critical area of the hillside, and has greatly increased the probability of landslide activity; movements that render the road unusable may now be expected to recur within 10 years or less.

The landslide does appear to have reached a (temporarily) stable state, and there are plans to repair and re-open the road. Filling in the graben would impose load on the head of the

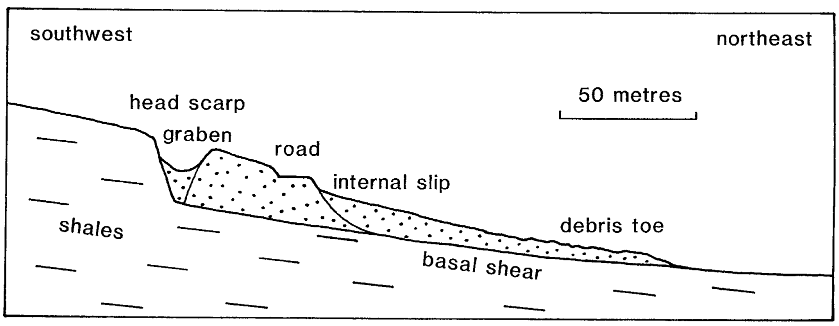


**Fig. 6.** Diagrammatic section through the Ainthorpe landslide; the depth of the basal shear is interpreted and not measured.

**Fig. 7.** (left) Water pours from the end of the 1993 ditch in the June 1999 flood event; it continues as surface flow over the moor down to the 1929 ditch.

**Fig. 8.** (below left) Water cascades over the landslide head scarp during the June 1999 flood; it came from the open end of the 1929 ditch on the moor just above.

slide, and is to be avoided; instead, the road will be lowered on either side of the graben. The water problem is also recognized. Option A is to abandon, fill and seal the ditches, and enlarge the culvert under the road beside the farm and down through the fields. Option B is to improve the ditches and continue them even further north until they can link to another old ditch and pass under the road north of the landslide. Short-term budgets and environmental factors favour the second option, but leave a hazardous situation with a watercourse across the head of an active landslide. A fully engineered interceptor drain can be a good means of stabilizing a landslide; but an unlined drain may create its own problems, where any maintenance deficiencies could prove very expensive, and ditch leakage can never be totally controllable. A third option of improving plant cover (and water retention) on the catchment slopes would take some years to achieve effect and may prove inadequate with the climatic changes that are current.

The future of the Ainthorpe landslide will prove to be an interesting example of geomorphological process in action. It appears to be a classic case of man creating his own disasters, albeit on a modest scale. Modern man, in the form of the civil engineer, is very capable of controlling a landslide of this scale, but the costs may be significant or even prohibitive. Administrative structures do not always help; those who work on the land understand the processes behind this type of small slope failure, but decisions are so often taken in remote offices by accountants with no feel for geomorphology. The proper management of water is critical, and the old saying certainly holds true: 'it all comes down to the drains'.

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**Depressing geology**: 'We read with alarm of the effect which our illustrious counterpart *The National Geographic Magazine* is having on the north American continent … the weight of accumulated copies of NGM will eventually depress the American surface by up to 100 metres. Furthermore it is likely that the NGMs stored in subscribers' homes in California will one day trigger activity on the San Andreas Fault … Isostatic rebound is a fact. What happens, for instance, when the centre of London is invaded daily by commuters[?] Imagine 1,020,000 people weighing on average 70 kgs, plus 130,000 cars at an average 1671 kgs. That's a total of 288,633 tonnes. Does London go down by day and up again at night?.' – *The Geographical Magazine*, v.54, p.661, 1992.

**Who he? (ed)**: 'Of course, wall space [in the National Portrait Gallery] is limited, but see who gets in – Grant Whyte Melville, Lady Duff Gordon, Sir Angus Wall Calcott, Brian Proctor, Sir Roderick Impey Murchison (who are *they*?).' – Gavin Stamp, *The Sunday Telegraph*, 22 September 1996.