

REPORT

**Landslide movement at Mam Tor**

The Mam Tor landslide is just one of the features that make the Castleton area of the Peak District a popular destination for geologists. Initial failure of the shale and sandstone slope occurred over 4000 years ago as a rotational landslide that developed into a large debris flow at its toe. The road that was built across it nearly 200 years ago (and was closed in 1979) provides graphic evidence of movement of the slide mass, and the site is now a classic for teaching slope processes and engineering geology.

Surveying students in the Civil Engineering Department of Nottingham Trent University used the site as a class exercise for eight years. They established a series of over 50 fixed stations that were resurveyed each year, and the results have provided a record of the slide's movement, as told in a paper just published (Waltham, A.C. & Dixon, N, 2000. Movement of the Mam Tor landslide, Derbyshire. *Quarterly Journal of Engineering Geology and Hydrogeology*, **33**, 105-123).

The active landslide contains over 3.2M m<sup>3</sup> of slipped material. It is 1000 m long, with a fall of 270 m below a head scar 70 m high, and three structural zones have now been recognised within the slide mass. The upper part (above the upper road) is a series of rock slices that were produced by the rotational failure of the original slope, and most of these slices have little movement today. The lower part (crossed by the lower road) is a debris flow of broken slide material that continues to slide over a basal shear surface. Between these, a central zone is an unstable complex of blocks and slices that overlie the steepest part of the landslide's basal shear and are disintegrating into debris as they are deformed; this part of the slide has the most rapid movement. The upper road is broken where it crosses the head scars of these active slide blocks, while the lower road is merely deformed into waves by the plastic movement of its underlying debris flow.

Figure 1 shows the different rates of movement across the landslide; the length of each arrow is drawn to the map scale to indicate 100 years of movement (details on derivation of the data are in the QJEGH paper). The current mean annual movement is up to 0.25 m, but this is not at a steady rate. Nearly all the movement occurs through the winter months, and is significantly increased in wet years. Movements do not increase in proportion to rainfalls and consequent groundwater levels, but instead increase dramatically when threshold levels are exceeded. When rainfall in a winter month exceeds 210 mm after at least 750 mm of rain in the preceding six months, parts of the slide move more than half a metre (mostly within the wet month), but drier years have only 10% of the wet year movement. These rainfall thresholds are exceeded once in every four years, and movement predictions can now be made. Trent University's work at Mam

Tor finished in 1998, but monitoring is being continued by Manchester University; they had already started with two dry and unexciting winters, but 1998/9 was wet - when they recorded their first large movements, in line with predictions.

Recognition of the patterns of movement at Mam Tor has improved understanding of the landslide's evolution. Figure 2a shows the original slope where an unbuttressed wedge of shale stood in front of a mass of sandstone; this probably failed (Fig. 2b) as a precursor to the main slide event. The main rotational landslide is likely to have been a single large event (Fig. 2c), when a mass of rock moved rapidly over a new slip surface along which strength was reduced as it sheared. From the initial rotational failure, the toe of the landslide blocks has broken into a debris mass that has continued to flow down the slope (Fig. 2d). Renewed failure of the head scar will occur when the existing slide blocks have slumped and been eroded enough to reduce support at the foot of the shale slope (Fig. 2e); the almost stable nature of the upper blocks implies that this is not imminent.

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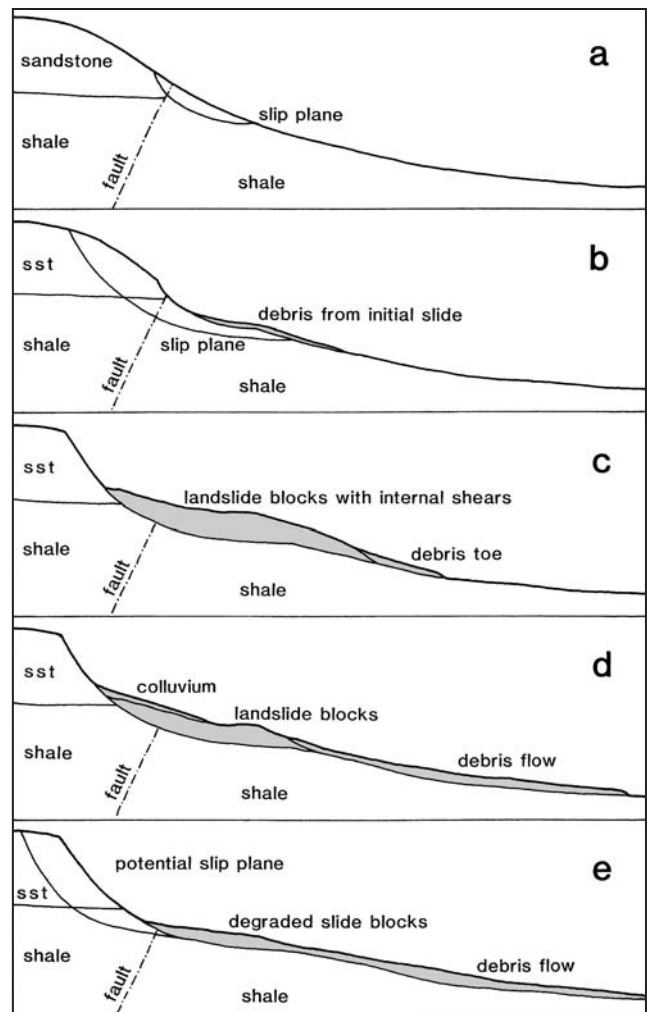


Figure 2. Evolution stages of the Mam Tor landslide.

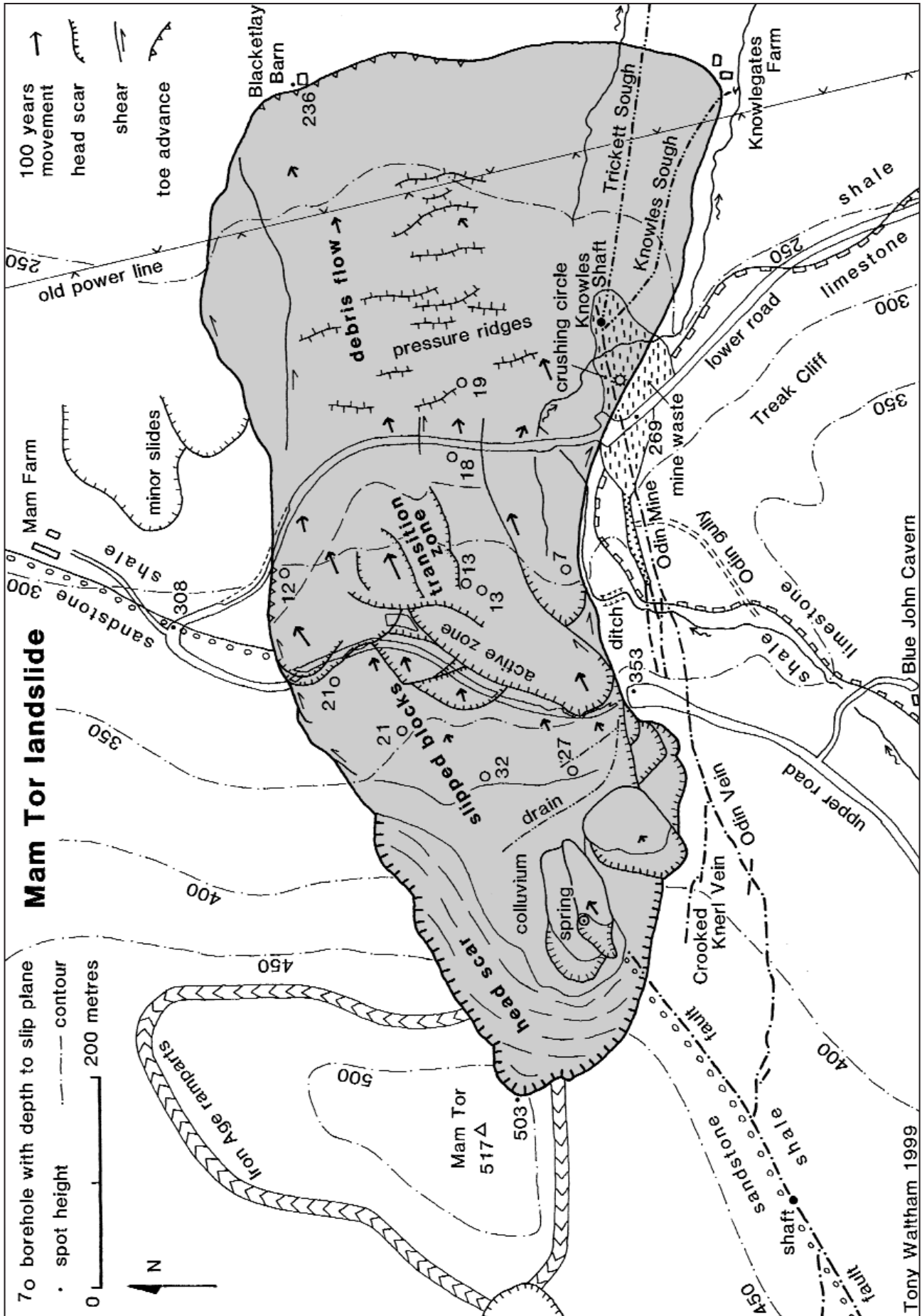


Figure 1. Map of the Mam Tor landslide with arrows drawn to lengths that represent 100 years of ground movement on the map scale.