Black Mountain Scarp, Carmarthenshire

[SN 810 220]

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Highlights

Debris flows occur on high-gradient, high sediment supply mountain streams, and the Black Mountain has some of the best examples in Wales and the best documented to date. Relationships between debris flow activity, surface conditions and climatic factors have been studied in some detail for the site.

Introduction

The northern-facing Old Red Sandstone escarpment of the Black Mountain (Carmarthenshire) provides the best examples of debris flows in Wales (Figure 3.37). The escarpment has deep gullies as well as minor mass movement scars. Three such gullies have been extensively studied by Statham (1976), who mapped the dimensions of each of the gullies, together with the extent of debris flow trails downslope of each gully and subsequent debris flow cones. There are well defined levels at the base of the gullies, and it was suggested that debris flow movements tended to be concentrated along similar pathlines, creating well-defined cones of deposition. The gullies have cut into bedrock in the upper parts such that much of the flows consist of bouldery debris. Such flows actively move in response to heavy rainfall events but, it was suggested, only if there is sufficient material within the gullies (Statham, 1976). The sedimentological properties of the flows as well as the yields of such gullies were also studied, and it was suggested that since the gullies were approximately 700 years old, they developed as a response to an environmental change, possibly sheep grazing.

Description

The Black Mountain forms part of the north-facing of scarp structure of which has been discussed in great detail by North (1955). The escarpment in this locality is determined by Plateau Beds (conglomerates and sandstones) which overlie Brownstones, up to 450 m thick in places, consisting of red marls, brown sandstones and conglomerates. Locally, the junction between the two beds is marked by a visible discordance in dip (Davies, 1967). At the base of such slopes, scree deposits have built up, it is suggested, through post-glacial erosion processes such as freeze-thaw activity (National Museum of Wales, 1979). Such deposits consist of coarse sandstone material interspersed with finer material (Statham, 1976); in places they are vegetated. The deposits in turn have been cut through by deep gullies, which have reached bedrock in the headwall regions. These gullies have been identified in the Fforest Fawr area of the Brecon Beacons (in some form) in 80% of the area above 450 m (Thomas, 1956). On the slopes of Bannau Sir Gaer, however, debris flows are taking place within the gullies, incorporating bedrock materials together with fines washed down from the gulley sides, leading to the formation of debris flow cones at their bases (Figure 3.38).

Three gullies were studied in great detail by Statham (1976), who examined the form of debris flow trails as well as the active input to such flows from the gullies themselves. It was suggested that debris flows were initiated in the gully system where the angle of the slope ranged from 27 to 37° (Figure 3.39). A survey of one gully profile showed that the slope varied from 40° (where the lowest bedrock layers were present within the gully) to 8° where the debris cones levelled out upslope of a morainic ridge which farther west 'dams' Llyn y Fan Fach (Davies, 1967). This ridge has been 'overtopped' by those deposits from gully C (Figure 3.38) which stem from more recent rainfall events, such that coarse deposits up to 30 cm in diameter lie on the north-facing slopes of the ridge. There is evidence to suggest, therefore, that material is advancing further than those trails plotted by Statham for the early 1970s. There is also evidence that new gullies are being initiated on the slopes to the west of those studied by Statham, and that a gully with an associated debris cone has formed since Statham's work. This would tend to oppose his view that the gullies were all in a similar stage of development. In addition, a number of the gullies do not exhibit debris flows along their courses, suggesting the importance of an optimum slope angle for such features, and the significance of regolith stability and the rates of sediment supply. Thus, for example, Statham suggested that such factors as the stability of the gully sides are important — there is a maximum stable angle of 43.5° when slopes are dry.

Statham also suggested that there was a critical angle which determines whether features of debris trails were governed by erosional or depositional processes, evidenced by levees. Levees were deposited, it was suggested, when the slope fell below 16° at which point the nature of the debris trails changes from erosional to depositional. Thus … 16 degrees is the transit slope for these flows' (Statham, 1976).

In addition, the input of sediment from the gully sides was measured by traps for gully B in (Figure 3.38), and total sediment yields calculated. This amounted to 8.436 111^3 in the year from September 1971 to September 1972, with an estimated 81% of this being eroded from the west-facing slopes (Table 3.3); this fact was attributed to the prevailing rainfall from westerly winds, which leads to asymmetrical cross-sections with steeper, less stable westerly slopes. An estimation of the amount of material moved in a debris flow (9.8 m^3) showed a good correlation with that estimated from gully erosion, such that the 'input of sediment to the gully is balanced by output of debris flows, implying that sediment movement by other processes such as streamflow is negligible' (Statham, 1976). However, it was stressed that the observation period (of one year) would need to be extended before such conclusions could be verified. In the upper parts of the gully system, resistant beds of sandstone are evident, although there are suggestions that these are gradually being eroded to add a coarser element to the debris flows. Vegetated areas of scree show evidence of downslope creep of the regolith, especially in gully C. Adjacent slopes show similar features.

Statham also analysed the response of the debris flows to individual rainfall events in the study period and found that a debris flow resulted from a daily rainfall of 54 mm (20 November 1971) but that no flows occurred on those 15 other occasions in the year when rainfall exceeded 30 mm. An analysis of the daily record at Waun Sychlwch [SN 804 220] for the period 1971–86 (unpublished) revealed that this event was ranked 103rd in those falls above a 50 mm threshold and had a return period of 1.15 years. This would tend to confirm Statham's hypothesis that … the debris flow process is controlled by the rate of accumulation of loose sediment in the gully bottom and is not specifically a result of high rainfall intensity' (Statham, 1976). However, rainfall is likely to influence slope instability indirectly through its effect on pore-water conditions in the slope material. Thus the regolith has to be considered in terms of its susceptibility to flow activity and erosivity, particularly with reference to the rainfall regime. Such factors may explain the lack of well-developed flows to the east of those studied by Statham, in particular mid-slope gullies where there is no headwall erosion and where the majority of the sediment is derived from gully sides. There are also small erosion scars along the deposits of Bannau Sir Gaer to Bwich Blaen Twrch with smaller debris flows, some of which are relict features.

Interpretation

The scarp slopes of the Black Mountain provide excellent examples of debris flows originating from gullies developed in scree deposits which, in turn, were eroded from Old Red Sandstone rocks. These have varying degrees of activity, and are seen to be controlled by the supply of sediment, although trigger storms are needed to initiate such flows (Statham, 1976).

(Table 3.3) Input and output of sediment from debris-flow gullies. Yearly sediment derived from sides of gully B, 30 September 1971–29 September 1972.

	Western-facing side		Eastern-facing side		
	1	2	3	4	
Trap sediment yield	0.0128	0.0184	0.0039	0.0028	$m^3 m^{-2} yr^{-1}$
Mean sediment yield	0.0156		0.0033		$m^3 m^{-2} yr^{-1}$

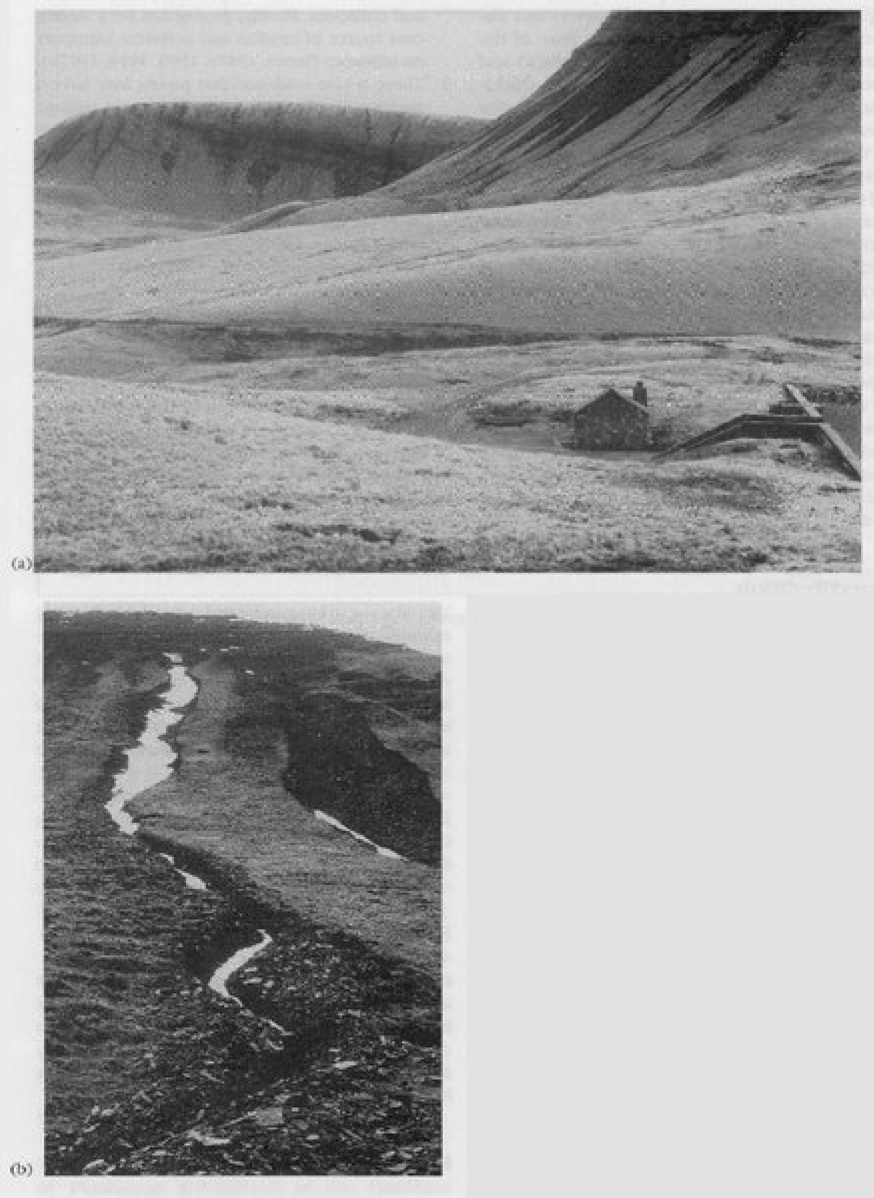
Gully side area	435.6				497.3	m^2
Total sediment yield	6.795				1.641	$m^3 yr^{-1}$
Total sediment derived from gully sides = 8.436 m^3 in one year						
Volume of debris flow removal from gullies						
Gully	A	A	B	C		
	11.5 m^3	11.5 m^3	9.8 m^3	8.3 m^3	In observation year	
				9.1 m^3	Outside observation year	

There are well-developed levees, some of which have been vegetated, suggesting that the flows have periodically switched channels. The debris flow material is mainly derived from the gully-side slopes; these features are tentatively dated at 540–700 years old (based on a constant annual loss rate) and probably originated as a response to an environmental change, possibly sheep grazing in the area. However, recently, newer gullies have been initiated, which suggests that the picture is more complex than previously thought, and that more work needs to be done, particularly with regard to the thresholds of regolith stability and the rates of sediment supply in relation to heavy rainfall events.

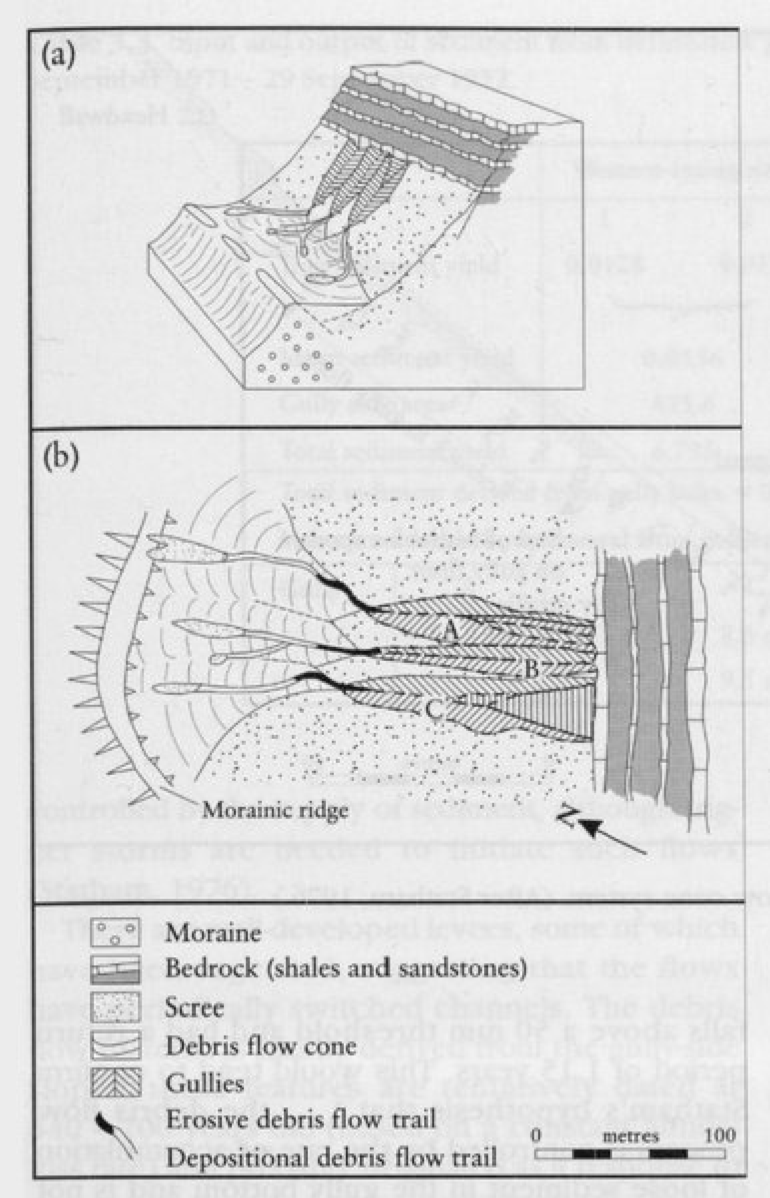
Conclusion

The debris flows of the Black Mountain escarpment are the best documented features of their kind in Wales. The presence of recent erosion scars may suggest that the processes initiating such features are still continuing. Therefore, more work may be needed to establish, for example, how and why such flows are initiated, and also the conditions under which they are activated, such as the importance of antecedent rainfall.

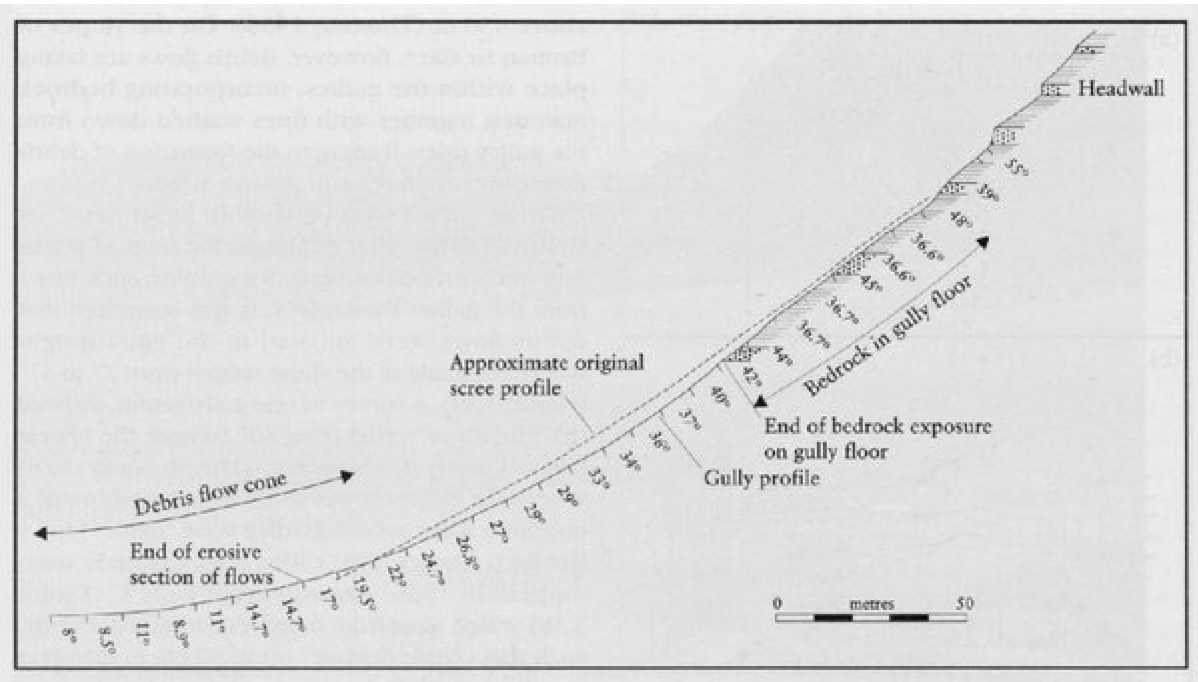
References



(Figure 3.37) Mynydd Du (Black Mountain): (a) Location; (b) scars. (Photos: S. Campbell.) escarpment of Old Red Sandstone, the geological



(Figure 3.38) Black Mountain: (a) a block diagram of the scarp; (b) a plane table survey of three debris-flow gullies. (After Statham, 1976.)



(Figure 3.39) Black Mountain: a profile of a typical gully-flow cone system. (After Statham, 1976.)

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