The Allt Dubhaig, Perthshire and Kinross

[NN 635 740]

A. Werritty

Highlights

The Allt Dubhaig provides a superb example of a small gravel-bed stream in which the very rapid downstream fining of bed material can unequivocally be attributed to selective transport.

Introduction

The site comprises a 3.2 km long reach of the Allt Dubhaig, a gravel-bed stream occupying part of the Pass of Drumochter, whence it flows southwards into Loch Garry and ultimately into the River Tay (Figure 2.30). The stream is notable for its highly concave long profile caused by the locally imposed base level produced by the alluvial fan adjacent to the outflow of Loch Garry. This rapid decrease in channel gradient has, in turn, generated a dramatic decrease in the size of the bed material and progressive changes in channel planform from near braided, through meandering to stable sinuous channel types. During its 3.2 km length the channel receives minimal additional discharge from tributaries and no lateral inputs of sediment (Ferguson and Ashworth, 1991).

The site has been selected as a suitable location for examining the role of selective transport in the downstream fining of bed material independent of the process of abrasion. The site has also been used to calibrate and verify a numerical sediment routing model which successfully simulates the field results (Hoey and Ferguson, 1994). The empirical results from a two-year programme of tracers (1460 tracer pebbles in six sub-reaches) plus bedload data collected from a bedload trap have demonstrated slightly size-selective transport (Wathen *et al.,* 1995). The upper part of the Allt Dubhaig has also been the subject of a detailed tracer-based investigation of downstream sediment fluxes and local vertical exchanges of sediment (Drew, 1992). More recently, two sub-reaches have been intensively analysed using precise and highly detailed topographic survey and a large-scale tracer study. This has enabled sediment budgets and sediment response times to be derived for these two contrasting sub-reaches comprising active braids and stable alternate bars (Wathen, 1995). The stable sinuous reaches located in the lower part of the site have also been used to examine the processes which generate a rapid transition from gravel to sand-sized bed material (Sambrook-Smith and Ferguson, 1995).

Description

The Allt Dubhaig is an alluvial channel which rises in Dalnaspidal Forest close to the main divide (> 1000 m) which separates the north-flowing tributaries of the River Spey from the south-flowing tributaries of the River Tay. The study reach is located in the Pass of Drumochter, a NW–SE aligned glacially eroded trough on a valley floor 410–440 m above sea level. The alluvial reach starts at the point at which a mountain torrent (the Allt Coire Dhomhain) emerges from an area of hummocky drift on to the main valley floor and crosses several rocky sills, all distances quoted below being downstream of this point. Local base-level control is exerted by an alluvial fan at 3.2 km near the outflow of Loch Garry, causing the channel gradient to decline from 0.02 at 0 km (where the channel is 20 m above base level) to less than 0.003 at 2.5 km, and then abruptly to 0.0002 after the bed changes from gravel at 2.7 km to sand at 2.9 km (Sambrook-Smith and Ferguson, 1995).

Associated with this decline in gradient are progressive changes in channel pattern in a downstream sequence: (1) near-braided; (2) meandering with active point bars; (3) meandering with active outer-bank talweg; (4) stable, sinuous equi-width; and (5) stable, sinuous with levees and flood basins (Ferguson and Ashworth, 1991). These transitions in channel pattern generate only a slight increase in bankfull depth; thus mean bed shear stress only decreases from *c.* 100

to < 30 Pa along the gravel-bed reach and then to < 2 Pa at the gravel-sand transition (Ferguson *et al.,* 1996). The final channel pattern (stable, sinuous with levees and flood basins) is probably of recent origin following a hydroelectric diversion sluice built in 1935 at the downvalley end of the fan (3.9 km). This has raised water levels by up to 1 m, causing backswamp flooding for much of the year behind the low levees which flank the lower part of the channel (Figure 2.31).

Outlet glaciers from the nearby Gaick Plateau ice cap occupied the valley during the Loch Lomond Stadial (Sissons, 1974a; Walker, 1975) 11 000–10 000 BP, with remnants of the associated hummocky drift still being located marginal to the valley. Bank erosion rates exceeding 1 m per year have been recorded in the upper part of the valley, and readily identified palaeochannels have been attributed to a major avulsion between 1860 and 1930 (Ferguson *et al.,* 1996). Beyond 2 km most of the valley floor is marshy and coring has revealed deep silty sands and peat, with gravel only occurring within 20 m of the modern channel. It is inferred that the lower course of the Allt Dubhaig has been laterally stable and has prograded over a fine valley fill, possibly an ice-dammed lake. The evidence of proximal avulsion and distal aggrada- tion suggests that the channel as a whole has been aggrading as a result of base-level control and continues to do so, as expected on such a concave long profile.

The bulk of the water and sediment enters the alluvial reach of the Allt Dubhaig from upstream. Given the small catchment area (13 km^2 upstream and 16 km^2 downstream), the runoff regime is very flashy, with heavy rainfall or rain on snow generating a bankfull discharge of about 11 $m^3 s^{-1}$ several times a year (Black and Werritty, 1993). Lateral inputs of sediment are also negligible with minimal coupling of the modern channel and the hillsides. The bedload of the river is thus derived from reworking its alluvial floodplain and by transporting the wide range of sizes released from the hummocky moraines adjacent to the Allt Coire Dhomhain upstream of the alluvial reach. The bed material comprises late Precambrian psammitic schists with some granitic clasts of glacial erratic origin. Laboratory abrasion tests undertaken by P. Brewer and J. Lewin (University of Wales, Aberystwyth) recorded weight losses of < 0.3% per 2.5 km of simulated transport, thus excluding abrasion as a significant process contributing to downstream fining (Ferguson *et al., 1996*).

Interpretation

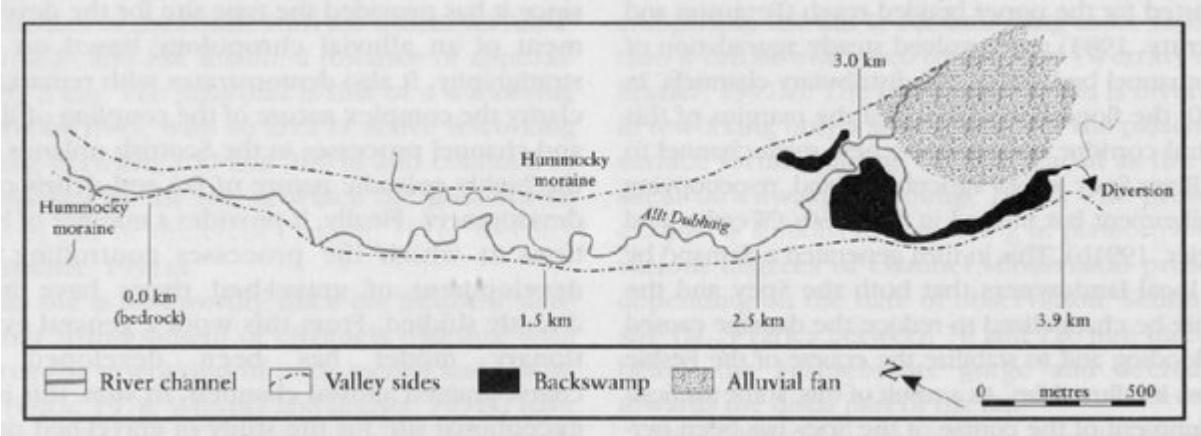
Detailed investigations at this site have produced much field evidence in support of selective transport as the mechanism for generating the downstream fining. Thus pebble counts at 120 sites, backed up by large bulk samples at 11 sites, show an 80% reduction in D_{50} (Figure 2.32) orders of magnitude greater than the 0.1% reduction inferred from laboratory abrasion tests of the same sediment (Ferguson *et al.,* 1996). The tracer programme revealed a clear pattern of travel distances decreasing downstream, with the coarser tracers moving less far. The data from the bedload trap showed size-selective transport across the full range of flows. The field-based analyses from this site have also been successfully integrated with both flume-based studies and numerical modelling to produce a general and robust model of downstream fining (Hoey and Ferguson, 1994).

The rapid change in channel and sediment characteristics and the lack of inputs within this short reach make the site an exceptional natural laboratory for fluvial studies. Several major projects have now enhanced the scientific value of this site.

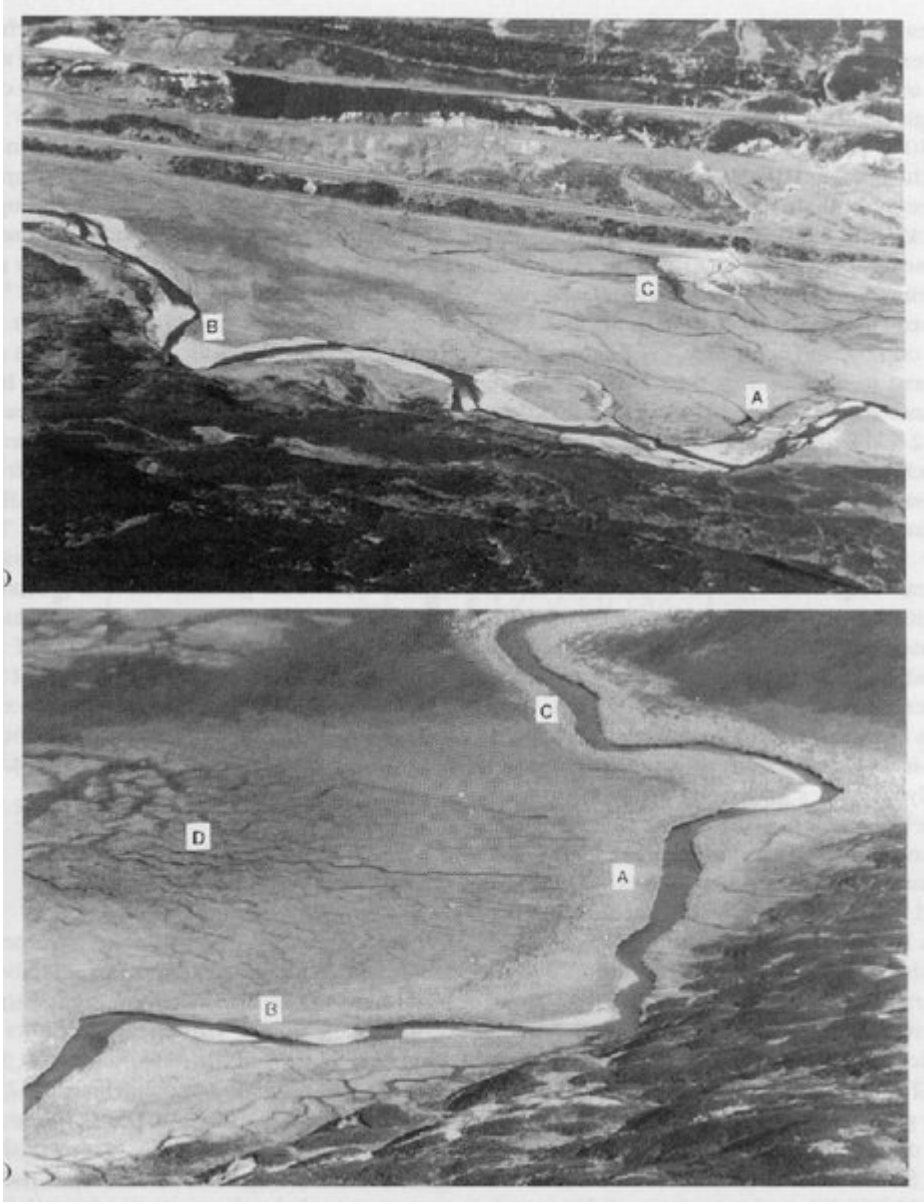
Conclusion

The Allt Dubhaig offers a superb site within which to examine the relative roles of selective transport and abrasion as the processes responsible for the downstream fining of bed material found in many rivers. The combination of a highly concave long profile, coupled with the absence of significant lateral inputs of either water or sediment into the 3.2 km reach and the minimal role played by abrasion, make this an ideal field site for isolating the role of selective transport. Independent field evidence based on tracers and bedload trap data unequivocally confirm that the rapid downstream fining found at this site can be attributed to size-selective transport. The recent work undertaken at this site has produced a significant contribution to the age-old debate as to how and why river-bed material fines downstream.

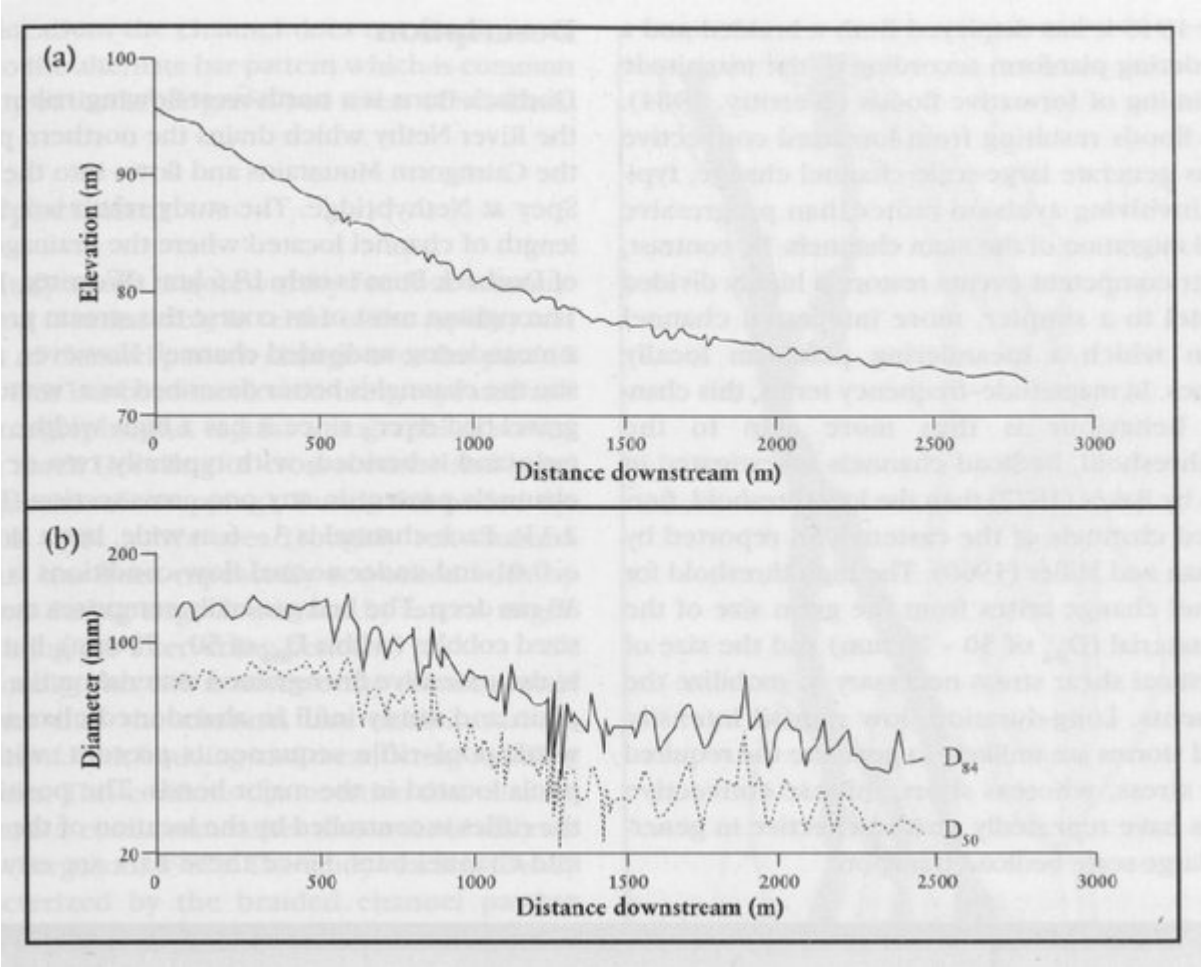
References



(Figure 2.30) Allt Dubhaig from its emergence from hummocky moraine to its diversion into Loch Garry. The distances recorded provide reference points for features reported in the text. (After Ferguson et al., 1996.)



(Figure 2.31) (a) Upper Allt Dubhaig, illustrating the character of the near-braided channel (A), a meandering channel with active point bars (B) and palaeochannels on the adjacent floodplain (C). (b) Lower Allt Dubhaig, illustrating the character of the stable sinuous channel (A) with fixed point bars (B), levees (C) and flood basins (D). (Photos: A. Werritty.)



(Figure 2.32) (a) Long profile of Allt Dubhaig. (b) Downstream fining on the Allt Dubhaig for D_{50} and D_{84}.