Glen Feshie

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Highlights

The landforms and deposits at Glen Feshie include outwash and river terraces, alluvial fans, palaeochannels and debris cones. This assemblage of features provides an outstanding record of valley-floor and valley-slope development during the Lateglacial and Holocene.

Introduction

The River Feshie is a right-bank tributary of the River Spey, draining a catchment area of 240 km^2 in the western Cairngorms. It is one of the most important sites in Britain for fluvial and Holocene geomorphology. As one of the most active gravel-bed rivers in the country it has attracted considerable research interest, particularly during the 1970s and 1980s (Young, 1976; Buck, 1978; Werritty and Ferguson, 1980; Ferguson, 1981; Ferguson and Werritty, 1983; McEwen, 1986; Robertson-Rintoul, 1986a, 1986b; Brazier, 1987; Brazier and Ballantyne, 1989; Werritty and Brazier, 1991). The River Feshie and the glen it occupies are particularly important in three respects: first, for the unique opportunity they provide for the study of present-day river processes and rates of channel and landform change in a large, highly active, gravel-bed river; second, for the record of such changes in the past, which are represented in documentary, geomorphological and stratigraphic evidence; third, for the unrivalled opportunity they allow to set the present-day river dynamics into a long-term perspective of geomorphological changes during the Lateglacial and Holocene. In scientific terms, these three aspects are closely interlinked, and it is the combination of all three, as well as each individual interest, which distinguishes the site. In this report, the emphasis is placed on Lateglacial and Holocene geomorphology and palaeohydrology, whereas the historical and present-day river dynamics and landforms are to be reviewed in the *Fluvial Geomorphology* volume of the Geological Conservation Review.

Three parts of the glen are important for Lateglacial and Holocene geomorphology and palaeohydrology: (1) a 3.3 km long reach extending from Allt Garbhlach [NN 850 952] to north of Achlean [NN 850 986]; (2) the Allt Lorgaidh fan ([NN 842 908] to [NN 846 918]); and (3) an area of debris cones extending over a distance of *c.* 0.8 km below Creag na Caillich [NN 853 903].

Description

Most of the drainage basin lying between 700 m and 1000 m OD is underlain by Moine schist, but to the north-east the ground rises to 1265 m OD on the Cairngorm granite batholith. The basin is dissected by a steep-sided glacial trough (Linton, 1949a) through which the River Feshie flows westwards before turning north at about 400 m OD into the wider, lower valley cut into glacial tills and outwash, these glacigenic deposits being restricted to the valley floor and lower slopes. Bedrock on the plateau (600–800 m OD) is mantled by blanket peat; at the highest levels bare, frost-shattered regolith occurs. The lower course of the river is confined locally by bedrock outcrops, and more extensively by Lateglacial and Holocene terraces, but in three reaches (upper Glen Feshie, Lagganlia and at the confluence with the River Spey) the river is free to migrate laterally and is actively reworking its floodplain.

The geomorphological impact of Late Devensian ice-sheet wastage in lower Glen Feshie has been discussed in detail by Young (1975a). During the Loch Lomond Readvance, outlet glaciers descended from the Gaick ice-cap northwards into the upper valleys of the Feshie (Sissons, 1974b) and small glaciers occurred in the Cairngorms massif to the east (Sissons,1979). Glaciofluvial landforms are abundant in the lower part of the catchment and local accumulations of outwash materials are remarkably thick Young (1976) identified three stages of terrace development, but more recently five terraces levels have been described in the lower part of the valley by Robertson-Rintoul (1986b). During the Holocene in certain parts of the valley the river has trimmed the distal margins of fans and cones (Brazier, 1987). Rates

of channel change, which have resulted in extensive reworking of the floodplain over the past 200 years, are remarkably high for the British uplands (Werritty and Ferguson, 1980; McEwen, 1986).

Terraces and alluvial fans

Glen Feshie is typical of valleys in upland Scotland in containing large accumulations of glaciofluvial and fluvial sediments deposited as valley fills. The particular valley fill in Glen Feshie was created towards the end of the Late Devensian as the ice-sheet in the valley downwasted in *situ* (Young, 1975a). Three groups of landforms comprise the major geomorphological features of this valley fill:

1. kame and kettle landforms and an extensive associated palaeosandur;
2. an extensive suite of terraces;
3. tributary valley alluvial fans.

All of these features are extremely well exhibited in the reach from the Allt Garbhlach to north of Achlean. The dominant landform assemblage within this reach is the Allt Garbhlach fan and dissected palaeosandur (Figure 9.16). The latter is pitted with kettleholes, between which former braided channel networks can be traced. Partially buried by fan deposits, but projecting above the level of the fan are several kames. The fan deposits have also buried the ice-contact slopes between the sandur and the kame and kettle deposits upstream. The fan was probably built during the later phases of late Devensian ice-sheet deglaciation about 13,000 BP (Robertson-Rintoul, 1986a).

Within this area lying some metres below the level of the 13,000 BP pitted outwash terrace, there is a group of three low-level terraces. The highest of the terraces, dated by soil stratigraphic methods at 10,000 BP, is about 5 m above present river level (Robertson-Rintoul, 1986b). The middle terrace, about 3 m above the present river, has been dated to 3600 BP; the lowest terrace, about 1.5 m above the present river, has been dated to approximately 1,000 BP. All of the more extensive terrace fragments possess well developed, braided palaeochannel networks on the terrace surfaces. A fifth terrace (late 19th century) is not represented within this site.

In this reach north of the Allt Garbhlach, discharges of the prior River Feshie around 13,000 BP were about 520% higher than present discharges. This earlier river was also considerably more braided and had much higher sediment transport rates than those of the present river. The 3,600 BP terrace surface was formed by a river which had discharges 100–120% greater than those of today (Robertson-Rintoul, 1986a). Again the stream was more braided and probably had higher rates of sediment transport than the present-day river. Discharges for the 1000 BP channel were about 8–34% higher than the present-day mean annual flood (estimated at 70–80 $m^3 s^{-1}$).

The river terraces in Glen Feshie are the product of temporal changes in the balance between fluvial transport capacity and sediment supply. The patterns of runoff and sediment production have fluctuated throughout the Holocene in response to climatic change and vegetational disturbance. This has resulted in at least five phases of incision within the main valley floor since 13,000 BP, locally these phases being accompanied by aggradation.

Allt Lorgaidh fan

In the upper braided reach of the River Feshie (*c.* [NN 847 917] to [NN 845 937]), where the valley floor is almost 0.7 km wide, the terrace fragments become laterally very extensive. The high dissected palaeosandur is not represented in this reach, and the terraces comprise the three low-level late Holocene surfaces discussed above. At the upstream end of the upper braided reach is the tributary valley of the Allt Lorgaidh, which terminates in a complex alluvial fan. This fan probably owes its dimensions to debris provided by meltwaters from a tongue of the Gaick ice-cap which descended into Glen Feshie during the Loch Lomond Readvance (Sissons, 1974b). The eastern side of this fan comprises three units which correlate with the three low-level Holocene terraces in the upper braided reach. On the western side of the Allt Lorgaidh stream the low angle fan has been subjected to cut-and-fill processes. Local trenching of the fan by the stream has exposed a buried podsol for which a radiocarbon date of 3620 ± 50 BP (Har–4535) has been obtained on charcoal found in the organic-rich layer. This podsol is buried beneath fluvial gravels which comprise the present upper surface of the fan, the latter forming the upper terrace surface in the tributary valley. The buried soil is traceable for some distance

upstream in the Allt Lorgaidh and occurs in exposures on both banks of the tributary valley. The date of 3600 BP thus gives an approximate age for the initiation of a phase of late Holocene sediment aggradation in the tributary valley.

In the area of confluence between the River Feshie and River Spey the present alluvial fan is actively reworking a small part of a much larger fan formed during the Lateglacial. On this larger palaeofan a dendritic palaeochannel network can be identified from aerial photographs.

Glen Feshie debris cones

Three coalescing debris cones have built out from the steep gullied walls of the glacial trough in upper Glen Feshie at a mean altitude of 390 m OD. These gullies are cut into the Moine schist of Creag na Caillich from which sediment has been readily supplied into a set of coalescing cones. Basal erosion of these cones by the River Feshie has resulted in the exposure of an extensive section over 60 m long and in places up to 10 m high (Figure 9.17). The exposure consists almost entirely of coarse debris-flow deposits, with poorly sorted and dominantly angular clasts embedded in a coarse sandy matrix. The deposits extend down to the level of the river, with the exception of the northernmost cone which has buried a low river terrace. Stratification is largely absent, although when the section was freshly exposed in 1984 there were linear discontinuities that marked the boundaries between individual debris-flow units (Brazier, 1987). The flow units revealed comprise broad sheets of debris up to 1 m in thickness, which contrasts with open hillslope flows where the forms are narrower and delimited by levees (see the Cairngorms).

Radiocarbon dating of organic material (mainly woody roots) has been undertaken at four of the cones (Figure 9.17) in order to establish the timing of debris cone initiation and the subsequent periodicity in debris-flow activity at the site (Brazier and Ballantyne, 1989). The oldest age of 2090 ± 50 BP (SRR–2877) is from the base of the centre of cone 3. The other dates (320 ± 50 BP (SRR–2880) to 'modern' (SRR–2873, SRR–2874, SRR–2875 and SRR–2879) are too similar to permit any meaningful analysis of the periodicity of debris flows on the cones. It is, however, clear that the three upper debris-flow units have been deposited within the last 300 years. A minimum age for the river terrace buried by cone 1 is 270 ± 50 BP (SRR–2881).

Brazier and Ballantyne (1989) concluded that the aggradation of these debris cones in upper Glen Feshie was initiated by approximately 2000 BP. The site may then have remained stable for about 1700 years until, within the last 300 years, rapid and episodic debris-flow aggradation formed the bulk of the deposits visible in the stream-cut exposure.

It is also important to note the relationship between river undercutting and the source of the debris-flow sediments. The abundance of palaeochannels and the well-defined terraces preserved on the valley floor opposite the cones indicates that the formerly braided River Feshie has repeatedly migrated across the valley floor episodically reworking this area of the valley fill. Prior to 2000 BP the river may have eroded earlier slope deposits at the site currently occupied by the debris cones. Thus the stratigraphy of the present cones only provides evidence for debris-cone activity at this site for a maximum timespan of 2000 years (Brazier, 1987).

Debris flows and cones are a characteristic feature of the Holocene geomorphology of upland Britain (see Eas na Broige and the Cairngorms; Harvey *et al.,* 1981; Innes, 1983b, 1989; Ballantyne, 1986d; Brazier, 1987; Brazier *et al.,* 1988) and recent debris-flow events in these areas have all been triggered by heavy rainstorms (Common, 1954a; Baird and Lewis, 1957; Harvey, 1986; Carling, 1987; Jenkins *et al.,* 1988). Brazier and Ballantyne (1989) considered three possible hypotheses to explain the episodic nature of the Glen Feshie features and the marked increase in activity within the last few hundred years. First, as suggested by Innes (1983b), they may relate to changes in estate management practices and the introduction of systematic burning or overgrazing. Second, they may relate to secular climatic change and the known incidence of increased storminess during the period *c.* 2950–2250 BP and the Little Ice Age of the 16th–19th centuries. Third, they may be controlled by the dynamics of the River Feshie, debris cone formation occurring only when the river followed a course on the opposite side of its floodplain. Brazier and Ballantyne rejected the first hypothesis partly because the very steep and rocky nature of the source area would probably have precluded systematic forest clearance, and partly because of the absence of charcoal fragments in the sediments. Although the general coincidence in timing of debris-flow activity and known periods of climatic instability was notable, direct relationships were likely to be modulated by other variables. The major control was therefore attributed to the lateral migration of the river channel, although

exceptional rainstorms were still required to trigger individual debris flows or periods of increased debris-flow activity.

In relating the Glen Feshie debris cones to natural processes, Brazier and Ballantyne (1989) also highlighted the contrast with debris cones elsewhere where anthropogenic effects had been significant in cone development (see Eas na Broige; Harvey *et al.,* 1981; Innes, 1983b; Brazier *et al.,* 1988). In terms of their more recent activity, the Glen Feshie cones also offer a further contrast with Eas na Broige, where the important control on debris cone formation is exercised by the inherited sediment supply. The geomorphological importance of debris-flow processes in upper Glen Feshie is indicated by the volume of material transported, which, when averaged over the last 300 years, represents an annual accumulation of about 50–60 m^3.

Interpretation

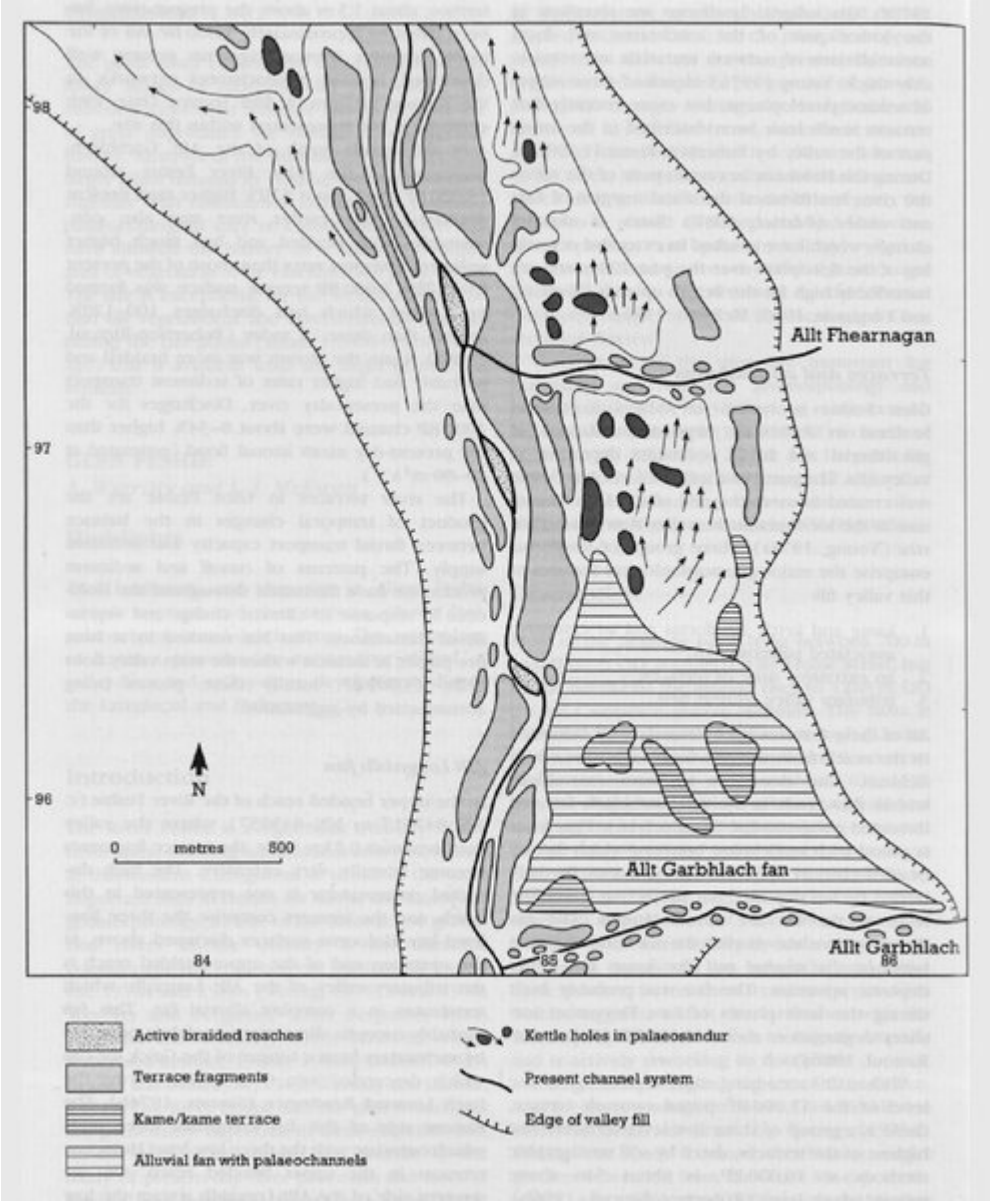
The geomorphological features in Glen Feshie described above are significant in a number of respects.

1. They provide a particularly good assemblage of fluvial and slope landforms and deposits, encompassing outwash and river terraces, alluvial fans, braided palaeochannels and debris cones.
2. Together these features provide one of the most detailed records of valley-floor development in Scotland during the Lateglacial and Holocene. Following deglaciation during the Late Devensian a pitted sandur surface was formed, inset within which a series of alluvial terraces developed during the Holocene. Large alluvial fans formed on the main valley floor at the confluence with tributary valleys. These formed in response to episodic release of large quantities of sediment from the steeper tributary streams. At other sites where slope processes have constructed debris cones directly on to low terraces and the adjacent floodplain, substantial debris-flow activity is reported over the last 300 years. Within the same time-scale, in response to a flashy runoff regime and a steep slope, the River Feshie has extensively reworked its valley floor in three major reaches.
3. The geomorphological and stratigraphic record provides a firm basis for setting the present-day river processes and geomorphological changes into a longer-term perspective.
4. The landforms and deposits in Glen Feshie demonstrate with remarkable clarity the complex nature of the coupling of slope and channel processes in the Scottish uplands and the highly episodic nature of fan and debris cone development.

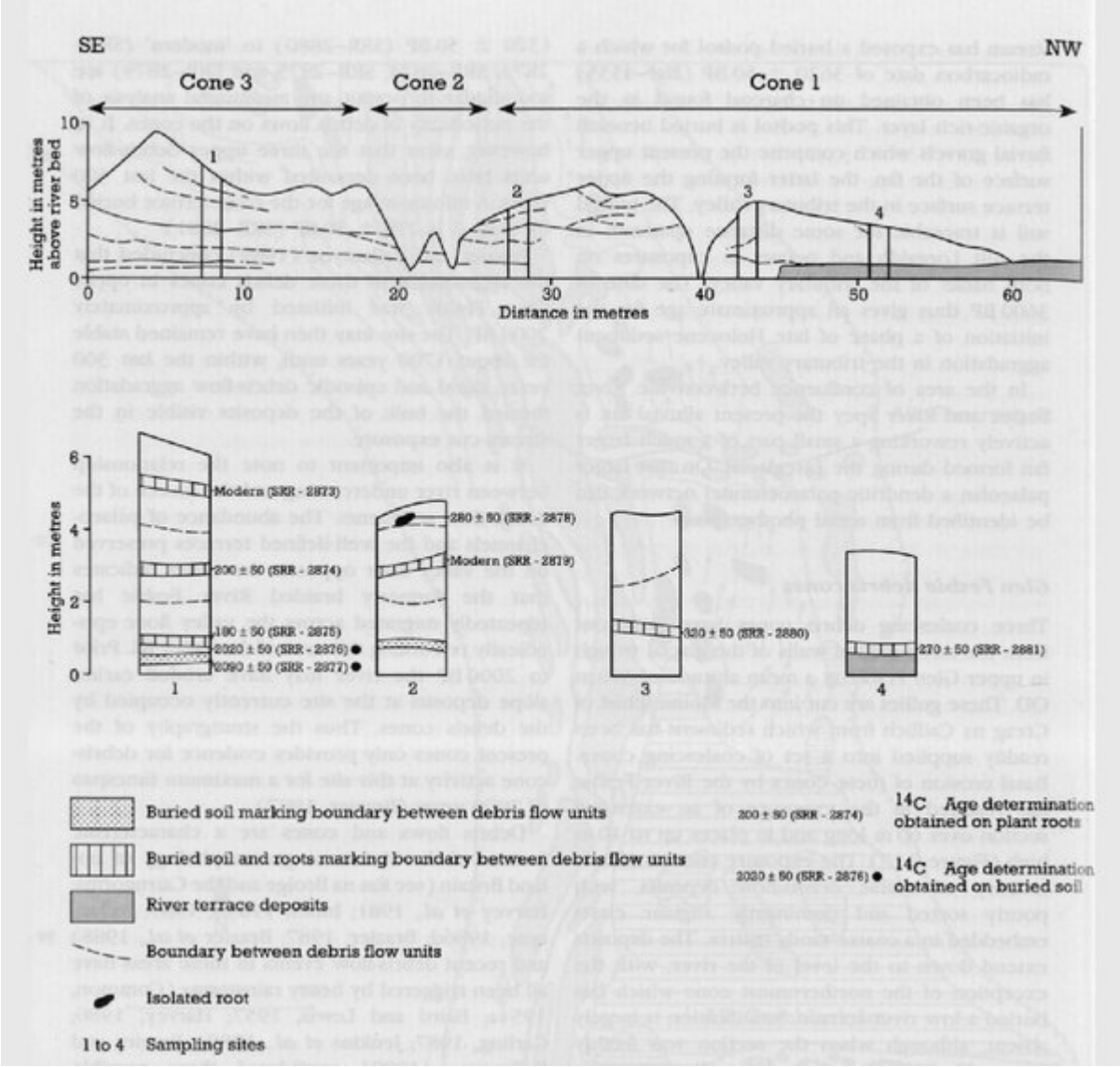
Conclusion

Glen Feshie is outstanding for an assemblage of landforms and deposits that record the processes and patterns of valley-floor and valley-slope development during Lateglacial and Holocene times (approximately the last 13,000 years). Not only are the individual features particularly well developed, but also the total assemblage is one of the best of its kind in Scotland for the range of evidence provided and the detail of the record. This record is also fundamental to an understanding of the evolution of the present River Feshie, which is a key site for studies of active river processes.

References



(Figure 9.16) Geomorphology of the Allt Garbhlach–Allt Fhearnagan area of Glen Feshie (from Robertson–Rintoul, 1986a; Werritty and Brazier, 1991).



(Figure 9.17) Top: surveyed section across the base of the Glen Feshie debris cones showing boundaries between individual debris-flow units. Bottom: detailed sections at sampling sites 1–4 (from Brazier and Ballantyne, 1989).