NORTH ESK AND WEST WATER GLACIOFLUVIAL LANDFORMS

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Highlights

The assemblage of outwash and river terraces at this site illustrates the range of geomorphological processes that accompanied the decay of the Late Devensian ice-sheet in the Eastern Highland Boundary area. The site is particularly noted for its palaeochannels which have allowed changing discharge patterns to be reconstructed since the time of deglaciation.

Introduction

This site comprises two areas in Strathmore located at the Highland edge near Edzell. The larger (c.2.5 km^2) lies to the west of the village between NO 565695 and NO 597679; the smaller (*c.* 0.6 km^2) to the south-east between NO 614686 and NO 620673. Together these areas are important for an assemblage of glaciofluvial landforms and deposits. These comprise an extensive spread of outwash (palaeosandur) deposits built out eastwards across Strathmore during the wastage of Late Devensian glaciers in the adjacent glens of the West Water and River North Esk (Synge, 1956; Sissons, 1967a; Maizels, 1976). In the former case the sandur deposits are associated with an ice-marginal position marked by a distinctive area of kame and kettle topography and meltwater channels.

The palaeosandur deposits associated with the North Esk and its tributary, the West Water, extend for 10 km downstream from the Highland Boundary Fault zone. They provide an excellent example of Late Devensian outwash deposits which have been dissected to form four main terrace systems. The terraces display systems of palaeochannels which have been mapped in detail by Maizels (1976, 1983a, 1983b), and used in palaeohydrological reconstructions and modelling (Maizels, 1983a, 1983b, 1983c, 1986; Maizels and Aitken, 1991).

Description

In the valley of the West Water, 3 km west of Edzell, an area of hummocky kame and kettle topography and ice-contact slopes marks the position of a former glacier margin. A section at NO 567688 shows that, at least in part, the landforms are developed in sand and gravel. Although formerly ascribed to readvances of the last ice sheet (Synge, 1956; Sissons, 1967a), these deposits probably reflect either a local halt, or change in glacier dynamics and sedimentation as the Late Devensian ice wasted back from Strathmore into the confined Angus glens, probably between 14,000–13,000 BP (Sutherland, 1984a). The former ice margin is not marked by an end moraine in the classic sense, but rather by a landform assemblage typical of modern glacier environments dominated by glaciofluvial activity and kame and kettle topography (Price, 1973; Boulton and Paul, 1976).

Meltwater channels are associated with the icefront and they also occur in a proglacial location, for example, at Edzell Castle (NO 585692). Outwash terraces lead away from the former icefront and extend out across Strathmore, and also from adjacent glens (Buckland, 1841a; Lyell, 1841a; Howden, 1868; Synge, 1956; Sissons, 1967a, 1976b; Crofts, 1974). In Glen Esk, outwash terraces extend from north-west of The Burn (Sissons, 1967a). As deglaciation progressed, the outwash deposits and stream channels would have continued to adjust to changes in water discharge and sediment supply. During and following deglaciation, the area also underwent isostatic uplift, with consequent changes in base level.

The sandur deposits are up to 6 m in depth and are characterized as "massive, coarse, poorly-sorted, imbricated gravels and cobbles, with isolated lenses of cross-bedded and plane-bedded coarse and medium sands, characteristic of Miall's (1978) Gm gravel lithofacies type, and similar "to Scott outwash sediments (facies assemblage GII ofRust, 1978) comprising over

90% gravel content' (Maizels, 1983b, p. 256). The sedimentary characteristics of the sediments indicate deposition in an aggrading, proglacial, braided river environment (Maizels, 1983a).

The four main terraces, associated with both the North Esk and the West Water, have been mapped by Maizels (1983a, 1983b) (Figure 14.8). The upper two terraces (T1 and T2) are evident only as isolated fragments; the lower two (T3 and T4) are much more extensive (Figure 14.8). Study has focused on the nature, direction and magnitude of change within this terrace sequence (Maizels, 1983a, 1983b, 1983c, 1986; Maizels and Aitken, 1991). For example, large-scale changes in channel pattern and morphology have been identified between terrace fragments and attributed to a decline in the amounts of meltwater discharge and sediment supplied during and after deglaciation. The resulting palaeoforms thus reflect channel adjustment from a proglacial environment to present-day fluvial controls. They also demonstrate a south-eastward migration of the North Esk/West Water confluence by 2.8 km; a shift that was clearly accompanied by periods of aggradation and incision.

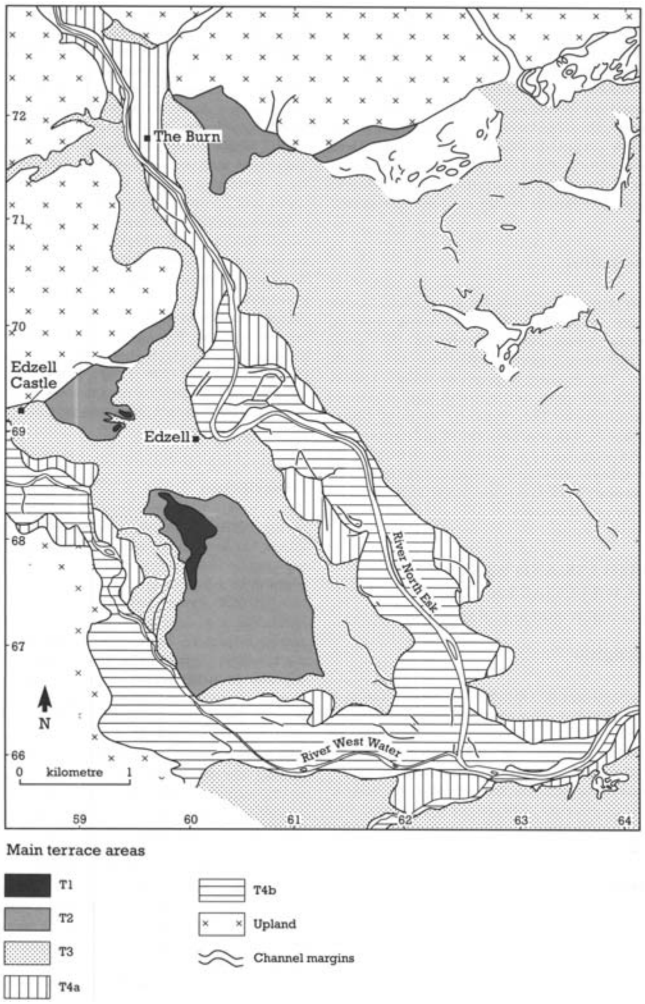

Figure 14.8: Terraces of the River North Esk and West Water in the Edzell area (from Maizels, 1983a).

As well as macro-scale change, more intricate localised channel incision and minor terrace fragments have been mapped. Three different types of palaeochannel have been identified, each type associated with different rates of discharge and sediment availability (Maizels, 1983a). These include complex braided systems (Type A), deeper wider channels (Type B) and deeply incised and relatively localised meander scars (Type C). In terms of inter-terrace variation in palaeochannel type, the two upper terraces have been identified as having more braided (Type A) and periglacial (Type B) channel systems, whereas the lower terraces have more sinuous (Type C) channels, although all terraces exhibit complex braided palaeochannels to a certain degree. The lower terraces (T3 and T4) are characterized by multiple channel networks, longitudinal bars, high width-to-depth ratios and low sinuosities. The lower terrace surfaces are also locally incised by relatively well-defined, deep, low-gradient, sinuous channels and many of the adjacent terrace bluffs possess major meander scars. The number of sinuous channels increases from the highest terrace (T1) to the lowest (T4), whereas the degree of braiding declines. Mean width-to-depth ratios decline from about 108 to about 40 between T1 and T4 (Maizels, 1983a).

Interpretation

Maizels (1983a, 1983b) concluded that the deep, sinuous channels (Type C) were responsible for terrace formation and that each phase of terrace formation involved a change from straight, multiple channels to single-thread channels in response to threshold changes in meltwater and sediment discharges which could relate to glacier fluctuations or episodic flood events. Base-level variations appear to have had only a minor effect on the channel adjustments.

As well as inter-terrace variation in palaeochannel type, both lateral and downstream intra-terrace changes have been identified. It is important to note, however, that many of the palaeochannel features are of low amplitude; the palaeochannel patterns are better viewed from the air, and are especially highlighted on infra-red aerial photographs. This site, with its extensive suite of palaeochannels in the terrace surfaces, thus provides a marked contrast to the well-defined suite of terraces with steep "risers' along the River Findhorn (see above).

The present channel discharges are small compared to estimated palaeodischarges, and Maizels (1983a, 1983b, 1986; Maizels and Aitken, 1991) estimated order-of-magnitude velocities and discharges for particular palaeochannels, using empirical formulae (*cf.* Church, 1978: Ryder and Church, 1986). Peak flows calculated for the terrace sequence decreased from a maximum of *c.* 18,000 m3s-1 on the highest terrace to *c.* 1,300 m3s-1 on the lowest. The decline in peak discharge to the present day value of *c.* 330 m3s-1 is thus as much as fifty times. At best, these values provide only order-of-magnitude estimates (*cf.* Maizels and Aitken, 1991)

The River North Esk and West Water site is significant in several respects. First, it provides a good illustration of a suite of glaciofluvial landforms which are characteristic of the Highland margin in Strathmore, where extensive spreads of outwash have built out from the mouths of the Highland glens (Sissons, 1967a, 1976b; Paterson, 1974; Insch, 1976). Second, it provides a good illustration of a former glacier-margin landform assemblage dominated by glaciofluvial activity and the close association of ice-contact and proglacial meltwater features. In this respect the site bears comparison with, for example, Muir of Dinnet, Glen Feshie and Almondbank, and with the Loch Lomond Readvance sites at Moss of Achnacree and the Western Forth Valley. Third, the River North Esk and West Water site demonstrates the effects of topographic controls on deglaciation. As the Late Devensian ice receded from the open, piedmont area of Strathmore, the tributary glacier fronts in the narrow Highland glens may have become temporarily stabilized in the lower reaches of the valleys as their ablation areas changed configuration. Fourth, the site is significant for the development of palaeochannels on the terrace surfaces. These features are among the best preserved of their type studied in Scotland and have allowed significant insights into the controls and thresholds governing channel change during and since deglaciation, particularly in relation to discharge and sediment supply. It is an important research site for assessing the extent of adjustments within the fluvial system since the Late Devensian in a lowland area with upland headwaters. Although Late Devensian palaeochannels are known to exist on terrace surfaces at other locations in Scotland; for example, along the River Dee (Maizels, 1985) and River Don ()Maizels and Aitken, 1991), in Glen Feshie (Robertson-Rintoul, 1986a) and in the area south of Fraserburgh (BGS 1:50,000 Sheet 97) these are generally less extensive and have not been studied in comparable detail to the North Esk and West Water features.

Conclusions

This site is important for understanding the geomorphological changes that occurred in the landscape during and following deglaciation of the Lte Devensian ice sheet (approximately 14,000–13,000 years ago) when large volumes of meltwaters were released from the decaying ice. It shows an excellent assemblage of landforms characteristic of the eastern Highland boundary area. These include outwash and river terraces formed as the ice melted and wasted back into the Highland glens. The higher terraces contain kettle holes indicating the former presence of the glacier, whereas the lower terraces are most notable for particularly good examples of fossil river channels. The latter provide valuable evidence for reconstructing the changes that occurred in river characteristics and behaviour during and following the period of ice melting.

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