Fort Augustus

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Highlights

The landforms and deposits at Fort Augustus include kame and kettle topography, glacier flood deposits and lake shorelines. They provide important information for interpreting the geomorphological changes that occurred in the landscape during the Loch Lomond Stadial. Particularly significant is the evidence for re-depression of the Earth's crust by the build-up of glaciers in the west Highlands during the stadial.

Introduction

The site at Fort Augustus consists of three areas at Borlum [NH 383 084], the north shore of Loch Ness [NH 386 105] and Auchteraw [NH 366 090]. These demonstrate an assemblage of landforms and deposits including drift limits, outwash gravels and raised shoreline fragments. The interpretation of these features has varied considerably between authors. Charlesworth (1956) and J. S. Smith (1968) proposed that the drift limits represented a stillstand in the decay of the Late Devensian ice-sheet, and Synge (1977b) and Smith (1977) suggested that the highest shoreline terraces were marine. In contrast, Sissons (1979b, 1979c) and Firth (1984, 1986) proposed that all the features were of Loch Lomond Stadial age and that all the shoreline terraces were lacustrine. Sissons (1979c, 1981c) also suggested that the extensive outwash terrace in the area was *a jökulhlaup* deposit formed by the drainage of the former ice-dammed lake in Glen Spean. Firth (1986) largely agreed with this interpretation and further proposed that the morphological evidence indicated glacio-isostatic depression of the Earth's crust during the Loch Lomond Stadial.

Description

The low ground at the southern end of Loch Ness and the surrounding slopes of the Great Glen are mantled by extensive glacial and glaciofluvial deposits (Figure 7.18). On the eastern side of the Great Glen above Fort Augustus, Charlesworth (1956) and Synge (1977b) recorded a lateral moraine which rose from the shores of Loch Ness along the Allt an Dubhair to an altitude of 100 m OD. Firth (1984) has indicated that there is no true lateral moraine at this site, only a drift limit. A similar drift limit has been identified by Sissons (1979b) on the western side of the valley.

At Borlum, inside the drift limit on the eastern side of the valley, a number of Late Devensian features are present. To the east of the River Tarff an area of ice-decay topography (Figure 7.18) consists of kame terraces in the south, which lead into a meltwater channel through kame and kettle topography. The channel descends to an outwash terrace, which in turn grades to a shoreline fragment at 32.4 m OD. Synge (1977b) and Smith (1977) proposed that this shoreline is of marine origin. However, Sissons (1979b, 1979c) and Firth (1984, 1986) maintained that it was a lacustrine feature.

The ice-decay topography is truncated to the north and west by an erosional bluff, which is fronted by a series of terraces. Synge and Smith (1980) suggested that both the bluff and the terraces were of fluvial origin. In contrast, Sissons (1979c) and Firth (1986) have proposed that the terraces and bluff to the east are fluvial in origin, but that the bluff to the north was produced by lacustrine processes, forming a raised shoreline fragment at 22.4 m OD. Further north, directly adjacent to the shore of Loch Ness, is a raised shingle ridge at 17.9–18.8 m OD, also interpreted as a lacustrine feature.

On the lower slopes of the Great Glen, above the northern shores of Loch Ness, there is a distinctive bench at 29.0–29.5 m OD (Figure 7.18). It is up to 10 m wide, and stream sections indicate that it is an erosional feature formed in both bedrock and drift deposits. In places the bench is backed by degraded cliffs cut in bedrock. Firth (1984, 1986) recorded the bench on both sides of the glen but only outside the limit of the Loch Lomond Readvance glacier at Fort Augustus.

The area between Auchteraw and the River Oich contains glaciofluvial outwash deposits (Figure 7.18). To the south of Auchteraw there is an extensive area of kame and kettle topography which is continued to the north by a large outwash terrace. Sissons (1979b, 1979c) believed that these features were associated with an ice margin that lay 4 km inside the Loch Lomond Readvance limit in the area. Deposits in sections [NH 073 355] exposed in the terrace comprise poorly sorted materials ranging in size from sand to boulders. The nature of the deposits and the absence of major erosional contacts appears to be consistent with high-energy fluvial deposition, and they have been tentatively interpreted as *jökulhlaup* (large flood) deposits (A. J. Russell, unpublished data): given the probable deltaic depositional environment, the deposits may be related to below-peak flows.

Interpretation

The drift limits identified on the slopes of the Great Glen were initially considered to mark a halt in the retreat of the Late Devensian ice-sheet (Charlesworth, 1956; J. S. Smith, 1968). Mapping by Synge (1977b), Sissons (1979b) and Firth (1984) and palaeoenvironmental evidence from Loch Tarff [NH 425 100] and Loch Oich [NH 330 020] by Pennington *et al.* (1972) implied that the drift limits were deposited during the Loch Lomond Readvance. The limits mark the northernmost extent of readvance ice in the Great Glen and as such are important in the reconstruction of ice coverage during this glacial phase.

Synge (1977b) and Synge and Smith (1980) proposed that the shoreline bench at 29.0–29.5 m OD was a marine feature formed during the decay of the Late Devensian ice-sheet, when the sea penetrated into Loch Ness around 12,800 BP. They considered that marine terraces occurred throughout the River Ness valley, near Inverness, providing a former link between Loch Ness and the sea. However, Firth (1984) reinterpreted the landforms in the Ness valley and concluded that there was no evidence there to support a marine incursion into Loch Ness (see Torvean). Instead he suggested that all the terraces around the shores of the loch were lacustrine in origin. He argued that the erosional feature at Fort Augustus would not have formed in an area of such limited fetch during the period of deglaciation (Firth, 1984, 1986) and proposed that it could only have been produced by periglacial processes during the Loch Lomond Stadial. As such, it is a lacustrine feature and thus comparable to the Parallel Roads of Glen Roy. Dawson *et al* (1987b) have indicated that such features could easily have formed in an area of limited fetch under periglacial conditions. Firth used the bench to reconstruct the Loch Lomond Stadial lake-level changes of Loch Ness, and it provided important evidence for his idea that the Earth's crust was glacio-isostatically re-depressed at this time (Firth 1986, 1989c). In particular, it demonstrated a rise in loch level from 29 m to 32 m OD between the formation of the erosional terraces at Fort Augustus and the high-level delta at Borlum. Such a rise is present only at the south-west end of the loch and not at the north-east end (see Dores). According to Firth, the simplest explanation of these observations is that the build-up of glaciers in the western Highlands during the stadial was sufficient to re-depress the crust in the area at the south-west end of the loch, resulting in a lake transgression there.

Sissons (1979b, 1979c, 1981c, 1981d) suggested that many of the glaciofluvial features within the Loch Lomond Readvance limits were produced by the catastrophic drainage of the ice-dammed lake in Glen Roy and Glen Spean. He ascribed the outwash terrace at Auchteraw to such an origin and also proposed that it formed part of a more extensive surface including the terrace at 32 m OD at Borlum. Sissons (1981c) suggested that the flood of water into Loch Ness during the *jökulhlaup* was so great that the water level of the loch was temporarily raised by 8.5 m from 22.5 to 31 m OD. He suggested that the loch level then fell to its *pre jökulhlaup* level. Firth (1984, 1986) agreed that the Auch-teraw terrace was the product of a Loch Lomond Stadial *jökulhlaup* but proposed that it descended towards the north-east to grade into a raised shoreline fragment at 36.0–36.1 m OD, and was not associated with the terrace at Borlum. Alternatively, he suggested that the latter was formed during the initial retreat of the Loch Lomond Readvance glacier and thus is distinct from the terraces south-west of Fort Augustus. Firth (1984) interpreted the terrace at Borlum as a delta associated with the 32 m OD loch level and, as a result, he suggested that the *jökulhlaup* flood temporarily raised the loch level by only 4 m from 32 m to 36 m OD.

The field evidence in the Fort Augustus area therefore suggests a sequence of events which spans the period of the Loch Lomond Stadial (Firth, 1984, 1986). During the early part of the stadial, loch level stood at 29 m OD and the erosional benches were formed. The Loch Lomond Readvance then reached its maximum extent; during the initial retreat, loch level stood at 32 m OD. After the ice-front had retreated 4 km, the ice-dammed lake in Glen Spean drained catastrophically to produce a large outwash spread related to a temporarily high loch level at 36 m OD. Subsequently, the level of the loch fell to 22.5 m OD in response to erosion of the outlet of Loch Ness produced by the floodwaters.

The Quaternary landforms and deposits in the Fort Augustus area are important in a number of respects. The features at Borlum are important in determining the Late Devensian and early Holocene evolution of Loch Ness. Synge (1977b) and Synge and Smith (1980) interpreted the 32.4 m OD feature as a marine terrace. In contrast, Sissons (1979c) suggested that it represented a fragment of *the jökulhlaup* deposit. More recently, Firth (1984, 1986), has proposed that the terrace formed during the Loch Lomond Stadial prior to the *jökulhlaup* and thus provides key evidence for the level of Loch Ness before the event. Firth (1984, 1986, 1989c) also used the features in this area to identify re-depression of the Earth's crust during the Loch Lomond Stadial. The evidence from Fort Augustus, together with that from other sites along the Great Glen (see Dores), is therefore important in reconstructing variations in the regional pattern of isostatic uplift in northern Scotland.

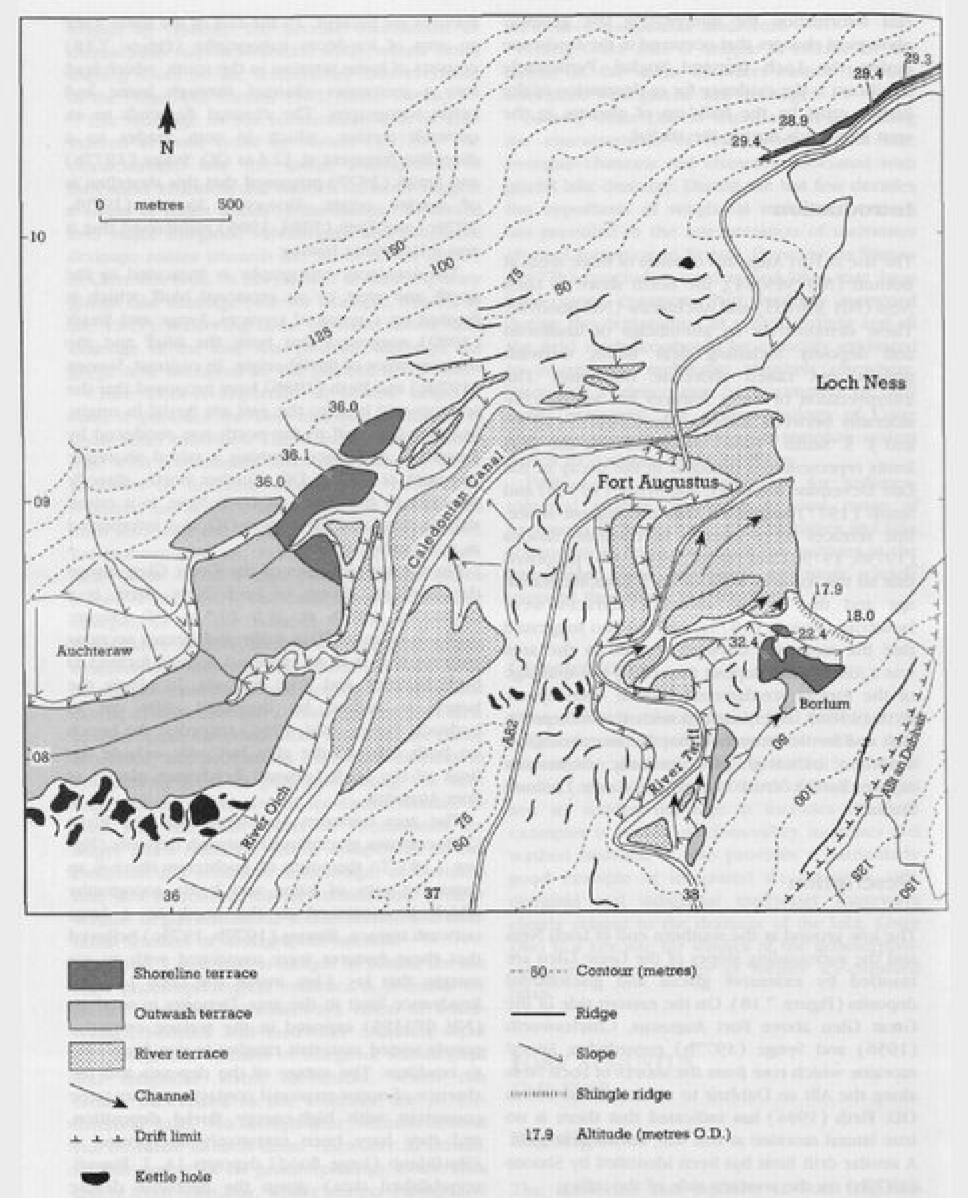
The features at Auchteraw represent the first *jökulhlaup* deposit identified in Great Britian (Sissons, 1979c, 1981d). The evidence indicates that the floods had a considerable impact on Loch Ness, being of sufficient volume to temporarily raise the level of the loch by 4 m and of sufficient erosive power eventually to lower the loch exit by 9.5 m (Firth, 1984). The landforms at Auch-teraw also demonstrate the nature of early deglaciation of the Loch Lomond Readvance glacier at Fort Augustus, indicating active retreat over a distance of 4 km before the *jökulhlaup* event.

The erosive benches on the north side of Loch Ness are important in the context of the Late Devensian evolution of the area: they provide one of the key lines of evidence relating to changes in water level. They also represent an erosive feature formed by periglacial lacustrine processes at low altitude and thus complement the higher altitude shorelines of Glen Roy and the low altitude marine features of the Main Rock Platform of western Scotland.

Conclusion

The assemblage of landforms and deposits at Fort Augustus provides evidence for a range of geomorphological processes in the Loch Ness area during the Loch Lomond Stadial (about 11,000–10,000 years ago). They include deposits that indicate the drainage pathway of the melt-waters from the Glen Roy ice-dammed lakes and a series of benches and terraces that show the changes in level of Loch Ness and how the buildup of the Loch Lomond Readvance glaciers in the western Highlands was sufficient to affect the isostatic recovery of the Earth's crust (the weight of the ice on the land had depressed the level of the ground surface) following the melting of the Late Devensian ice-sheet (approximately 14,000–13,000 years ago). Together, the features at Fort Augustus contribute significantly to the understanding of key events and changes in the landscape that occurred during the stadial.

References



(Figure 7.18) Geomorphology of the Fort Augustus area (from Firth, 1984).