
COIRE DHO

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OS Grid Reference: NH193142

Highlights

The assemblage of landforms and deposits at Coire Dho provides an excellent illustration of the development and sudden drainage of an ice-dammed lake during the Loch Lomond Stadial. The cross-valley moraines and bedrock surfaces washed by meltwater floods are the most outstanding examples of these features in Britain.

Introduction

Coire Dho (NH 193142) is a *c.* 10 km² area located in upper Glen Moriston, 55 km south-west of Inverness. It provides an excellent assemblage of glacial, glaciofluvial and glaciolacustrine landforms and sediments and is particularly noted for the best example in Britain of cross-valley moraines. The landform assemblage is associated with a Loch Lomond Readvance glacier that impounded a lake in the upper part of the valley. The former presence of the lake is also recorded by shorelines, lacustrine sediments, overspill channels and areas of washed bedrock where the water drained in a succession of floods. The geomorphology of the site was noted briefly by Milne Home (1878) and has been investigated in detail by Sissons (1977b) and also summarized by him (Sissons 1977d).

Description

Although in an early account Milne Home (1878) reported the presence of "remarkable terraces" and sand and gravel deposits in Coire Dho, the site subsequently attracted little attention until the work of Sissons (1977b). Sissons produced a comprehensive description and interpretation of the geomorphology of Coire Dho and the wider assemblage of landforms extending a further 15 km to the east in Glen Moriston. During the Loch Lomond Readvance, a glacier flowed eastwards along the Cluanie Valley and down Glen Moriston to a limit several kilometres east of Dundreggan (Peacock, 1975a; Sissons, 1977b). The glacier transported distinctive erratics from the Cluanie granodiorite intrusion into Coire Dho, a tributary of Glen Moriston. As a lobe of ice extended up Coire Dho, it dammed a lake in the upper part of the valley. The formation of this lake and its subsequent periodic drainage, together with a fluctuating ice margin, produced a remarkable and varied assemblage of landforms and sediments in a relatively small area.

The limit of the ice in Coire Dho is marked by a low end moraine which merges upslope with a large lateral moraine (Figure 7.17). Inside the end moraine and extending downvalley for a distance of 3 km is a sequence of at least 30 cross-valley moraines with individual ridges up to 7–8 m high and 20–40 m wide. They run more or less straight down the valley sides and in some cases across the valley floor. The composition of the ridges varies from boulders and unstratified sand to till comprised of grit, sand and stones. In places the ridges consist of lake-floor sediments with coarser material deposited on top.

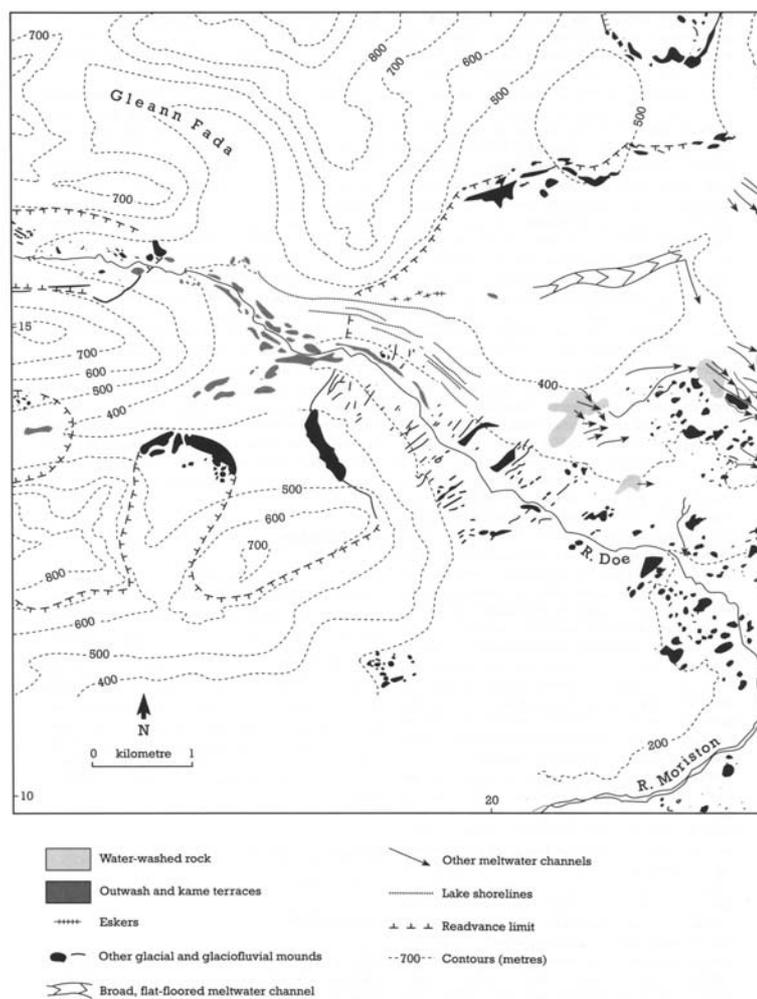


Figure 7.17: Geomorphology of Coire Dho showing landforms associated with the former ice-dammed lake (from Sissons, 1977b).

Although not included in the GCR site, two of the tributary valleys at the head of Coire Dho were also occupied by Loch Lomond Readvance glaciers, which produced end moraines and hummocky moraines.

Glaciolacustrine and glaciofluvial interests include lake shorelines, lake sediments, washed bedrock, meltwater channels and river terraces. Up to seven former lake shorelines have been identified on the north-east side of Coire Dho (Sissons, 1977b). Like similar shorelines in Glen Roy they are partly erosional and partly depositional features. The highest shoreline at 406 m OD is the clearest and most extensively developed, reaching a maximum width of 15–20 m and extending over a distance of 2.6 km (Figure 7.17). It is associated with a col at 407 m OD, suggesting topographic control on the lake level. Several of the lower shorelines are also at the same altitudes as adjacent cols, indicating that drainage through these cols controlled the level of the corresponding ice-dammed lake.

Lake-floor deposits occur extensively in Coire Dho. Sissons (1977b) recorded several sections which show bedded sands overlying laminated silts, sands and clays. Drop stones are locally present, while penecontemporaneous slumping is indicated by low-angle normal faults and contorted bedding. In places the lacustrine sediments have been incorporated into cross-valley moraine ridges (Sissons, 1977b). They extend up to an altitude of 450 m OD, implying lake levels well above the highest shoreline. At the head of Coire Dho the lake sediments have been gullied by water erosion and now take the form of ridges.

Two suites of terraces are present in Coire Dho. Those at higher levels are formed in lake deposits and are erosional features associated with falling lake levels. The lower terraces comprise coarse-gravel aggradational features unrelated to lake levels. These terraces were probably formed by outwash from the Loch Lomond Readvance glaciers at the head of Coire

Dho.

An important and unusual interest in Coire Dho and eastwards into Glen Moriston is the presence of extensive areas of water-washed bedrock. The individual areas of washed bedrock are up to 1.5 km long and up to 0.4 km wide. Together with interconnecting meltwater channels they form two distinct belts over 9 km long. Sissons (1977b, 1977d) considered the water-washed bedrock to be associated with sudden drainage of the ice-dammed lake. Such drainage stripped away the former drift cover, often leaving a well-defined washing limit. Bedrock erosional marks comparable to those ascribed to subglacial floods by Shaw (1988) and Sharpe and Shaw (1989) have not been recorded at Coire Dho. The meltwater channels associated with the washed bedrock occur as two main types. The first occupy pre-existing valleys or depressions and have flat floors up to 0.35 km wide, infilled with glaciofluvial sediments which sometimes demonstrate braided channel surfaces or terraces. These channels are associated with catastrophic lake drainage. The second are smaller, narrower channels typical of subglacial meltwater erosion.

Interpretation

There is a considerable body of literature on the geomorphology of moraines that lie transverse to ice flow (*cf.* Sugden and John, 1976). Sissons (1977b) considered the Coire Dho features to be sublacustrine cross-valley moraines as described by Andrews (1963a, 1963b) from Baffin Island. Various processes have been proposed to explain the formation of such moraines, including the squeezing of material into basal crevasses (Andrews, 1963b), squeezing or pushing of debris at the ice front (Andrews and Smithson, 1966) and accumulation at the grounding margin of floating ice ramps (Holdsworth, 1973; Barnett and Holdsworth, 1974). Sissons (1977b) favoured an ice-marginal origin for the Coire Dho ridges, arguing that their bouldery composition and close spacing were incompatible with squeezing of material into subglacial crevasses. However, as acknowledged by Sissons, the precise mechanism or mechanisms requires detailed study, which could usefully focus on the sedimentary characteristics of the ridges (*cf.* Dardis, 1985; Benn, 1989a).

The drainage of the ice-dammed lake is considered in some detail by Sissons (1977b). The characteristics and the spatial arrangement of meltwater channels and washed bedrock suggest a series of major floods (*jökulhlaups*) following two major marginal, submarginal and subglacial drainage routes towards the snout of the glacier in Glen Moriston, in the manner of contemporary glacial lake drainage (see for example, Sugden *et al.*, 1985). Following these periodic floods, final drainage of the lake was probably through the gorge now occupied by the present River Doe.

Coire Dho is important in several respects. First, it provides the best example in Britain of cross-valley moraines. These are normally associated with ice-dammed lakes and the only other localities in Scotland where they have been reported are at Glen Spean (Sissons, 1979c; see Glen Roy and the Parallel Roads of Lochaber), Achnasheen (Sissons, 1982a; Benn, 1989a), Gartness (Rose 1980e) and possibly Loch Muick (Lowe *et al.*, 1991). The Coire Dho moraines are exceptional for the number of ridges present, their clarity of development and the clear spatial relationships between the moraines, lake sediments, shorelines and lake drainage features that can be demonstrated in a relatively compact area. In Glen Spean the cross-valley moraines are partly afforested, but provide an important element in interpreting ice-front positions during the later stages of the sequence of ice-dammed lakes in Glen Roy and Glen Spean. At Achnasheen the ridges are a relatively minor component in the landform and sediment assemblage; at Gartness they are associated with a considerably greater volume of glaciolacustrine sedimentation and additional features of stratigraphic interest.

Second, Coire Dho is unique in Britain for the clear geomorphological evidence it provides for glacial lake drainage routeways. Areas of water-washed bedrock and meltwater channels show two integrated systems of marginal, submarginal and subglacial water movement, which can clearly be related to the evidence for an ice-dammed lake. No comparable reconstructions can be made in such detail elsewhere in Britain. In this aspect of its geomorphology Coire Dho differs from Glen Roy, where steeper topography confined lake drainage to the subglacial valley floors and hence restricted the development and survival of comparable landforms.

Third, Coire Dho is unique in Britain for the extent of the areas of water-washed bedrock associated with glacial lake drainage.

Fourth, Coire Dho is important in illustrating the characteristics of unequivocal glacial lake overspill channels and channels associated with glacial lake drainage. During the last few decades the hypothesis of subglacial meltwater erosion has prevailed in the interpretation of meltwater channel formation in Britain. However, as Sissons (1977b) concludes, ice-dammed lakes may have been more common than recently supposed during the deglaciation of upland Britain and all the field evidence should be critically evaluated in interpreting meltwater channels elsewhere. Since this evidence may be incomplete or only partly preserved, the geomorphology of Coire Dho may provide an invaluable template against which to compare other locations.

Fifth, Coire Dho is important for sedimentological studies, providing a good range of exposures in both cross-valley moraines and lake sediments. In some examples the sections in the fine-grained lake sediments are more clearly exposed than those in Glen Roy.

Conclusions

Coire Dho is exceptional for its range of landforms and deposits associated with a lake dammed by glacier ice during the Loch Lomond Stadial (approximately 11,000–10,000 years ago) and its sudden drainage. It includes the best examples in Britain of cross-valley moraines and washed bedrock. It also provides a particularly good example of integrated ice marginal, submarginal and subglacial meltwater routeways clearly related to the drainage of the lake. Coire Dho is a key site for studies of the geomorphology and sedimentology of former ice-dammed lakes.

Reference list

- Andrews, J.T. (1963a) Cross-valley moraines of the Rimrock and Isortoq River valleys, Baffin Island, N.W.T. – a descriptive analysis. *Geographical Bulletin*, **19**, 49–77.
- Andrews, J.T. (1963b) The cross-valley moraines of north-central Baffin Island: a quantitative analysis. *Geographical Bulletin*, **20**, 82–129.
- Andrews, J.T. and Smithson, B.B. (1966) Till fabrics of the cross-valley moraines of north-central Baffin Island, Northwest Territories, Canada. *Bulletin of the Geological Society of America*, **77**, 271–90.
- Barnett, D.M. and Holdsworth, G. (1974) Origin, morphology and chronology of sublacustrine moraines, Generator Lake, Baffin Island, Northwest Territories, Canada. *Canadian Journal of Earth Sciences*, **11**, 380–408.
- Benn, D.I. (1989a) Controls in sedimentation in a late Devensian ice-dammed lake, Achnasheen, Scotland. *Boreas*, **18**, 31–42.
- Dardis, G.F. (1985) Genesis of Late Pleistocene cross-valley moraine ridges, south-central Ulster, Northern Ireland. *Earth Surface Processes and Landforms*, **10**, 483–95.
- Holdsworth, G. (1973) Ice deformation and moraine formation at the margin of an ice cap adjacent to a proglacial lake. In *Research in Polar and Alpine Geomorphology* (eds B.D. Fahey and R.D. Thompson). Norwich, Geo Abstracts, 187–99.
- Lowe, P.A., Duck, R.W. and McManus, J. (1991) A bathymetric reappraisal of Loch Muick, Aberdeenshire. *Scottish Geographical Magazine*, **107**, 110–5.
- Milne Home, D. (1878) Fourth report of Boulder Committee. *Proceedings of the Royal Society of Edinburgh*, **9**, 660–706.
- Peacock, J.D. (1975a) Palaeoclimatic significance of ice-movement directions of Loch Lomond Readvance glaciers in the Glen Moriston and Glen Affric areas, northern Scotland. *Bulletin of the Geological Survey of Great Britain*, **49**, 39–42.
- Sharpe, D.R. and Shaw, J. (1989) Erosion of bedrock by subglacial meltwater, Cantley, Quebec. *Geological Society of America Bulletin*, **101**, 1011–20.
- Shaw, J. (1988) Subglacial erosional marks, Wilton Creek, Ontario. *Canadian Journal of Earth Sciences*, **25**, 1256–67.
- Sissons, J.B. (1977b) Former ice-dammed lakes in Glen Moriston, Inverness-shire, and their significance in upland Britain. *Transactions of the Institute of British Geographers*, NS **2**, 224–42.

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- Sissons, J.B. (1979c) Catastrophic lake drainage in Glen Spean and the Great Glen, Scotland. *Journal of the Geological Society of London*, **136**, 215–24.
- Sissons, J.B. (1982a) A former ice-dammed lake and associated glacier limits in the Achnasheen area, central Ross-shire. *Transactions of the Institute of British Geographers*, NS **7**, 98–116.
- Sugden, D.E. and John, B.S. (1976) *Glaciers and landscape*. London, Edward Arnold, 376pp.
- Sugden, D.E., Clapperton, C.M. and Knight, P.G. (1985) A jökulhlaup near S@1ndre Str@1mfjord, West Greenland, and some effects on the ice-sheet margin. *Journal of Glaciology*, **31**, 366–8.