CARSTAIRS KAMES

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OS Grid Reference: NS937467

Highlights

Carstairs Kames is one of the best examples of an esker system in Britain. The landforms and deposits provide important morphological and sedimentological evidence for interpreting the processes of glacial drainage development.

Introduction

Carstairs Kames is one of the most famous geomorphological sites in Britain for an assemblage of glaciofluvial landforms. Although the features, which extend over a distance of *c.* 5.5 km (between NS 937467 and NS 981497), 8 km east of Lanark, have been described in the scientific literature for almost 150 years, their mode of origin is still a source of debate. The main explanations are that they are either sub-glacial eskers or a form of ice-marginal deposit. The site has been described by Chambers (1848), Geikie (1863a, 1874, 1901), Milne Home (1871, 1881c), Dougall (1868), Jamieson (1874), Ramsay (1878), Smith (1901), Gregory (1912, 1913, 1915a, 1915b, 1915c, 1926), Charlesworth (1926b), Macgregor (1927), Sissons (1961c, 1967a), Goodlet (1964), McLellan (1967a, 1967b, 1969), Boulton (1972b), Jardine and Dickson (1980), Laxton and Nickless (1980) and Jenkins (1991).

Description

The Carstairs Kames consist largely of sand and gravel and comprise a series of anastomosing, sub-parallel ridges and mounds interspersed with kettle holes (Figures16.3 and 16.4) (Geikie, 1874; Gregory, 1913 and 1915a; Goodlet, 1964). They formerly extended over a distance of about 7 km, running west-south-west to east-north-east from Newmill (NS 920455) to Woodend Moss (NS 980495) but have been extensively quarried, and the GCR site is restricted to the most impressive remnants north-east of Carstairs village where the ridges attain heights of 25 m above the adjacent peat bogs. On its northern side, the ridge complex presents a relatively steep face to the flat peat bogs, but on the opposite side glaciofluvial deposits continue southwards in a zone of low, undistinguished mounds. Over a wider area, the Carstairs Kames form part of an extensive belt of glaciofluvial deposits extending south-west to north-east along the valley of the Douglas Water to the Carstairs area (Sissons, 1967a; Goodlet, 1970; Cameron *et al.*, 1977) and north-east from there towards the Edinburgh area (Sutherland, 1984a, 1991a; Jenkins, 1991). Many workers have mentioned in passing the composition of the kames. More detailed accounts have been given by Gregory (1913 and 1915a) and particularly Goodlet (1964), McLellan (1969) and Laxton and Nickless (1980). Gregory described bedded gravels with layers of coarse pebbly sand resting upon boulder clay. Gravel was most prevalent and coarsest on the north side of the kames. Goodlet, who monitored the changing faces in working pits over a period of several years, established a three-fold stratigraphic succession for the Carstairs area:

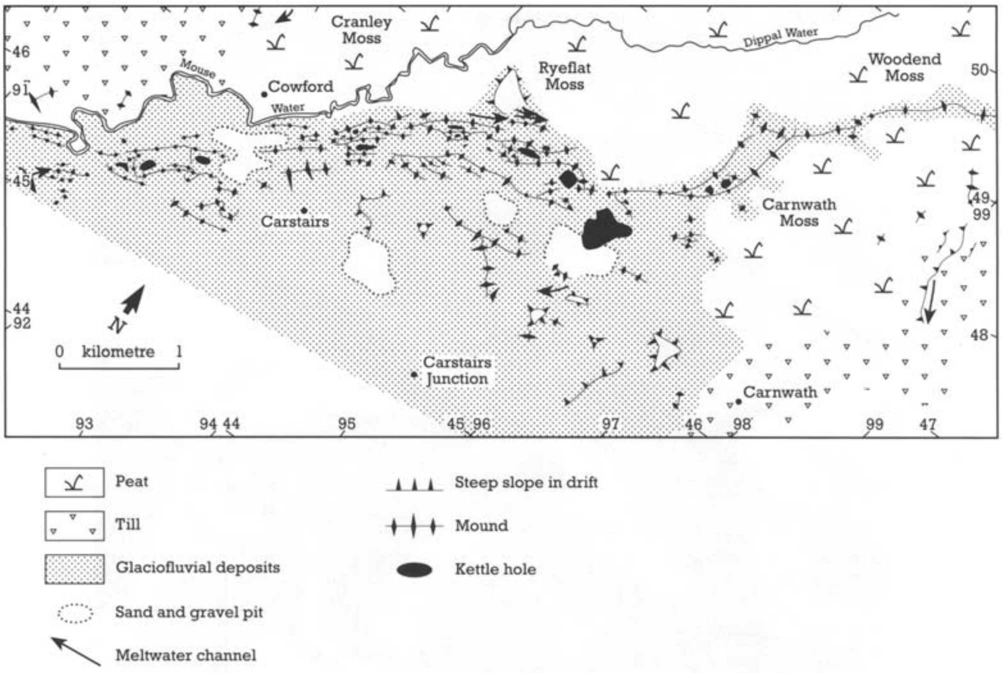

Figure 16.3: Geomorphology of the Carstairs area (from McLellan, 1969).

Figure 16.4: Carstairs Kames showing the interlinked form of the ridges and mounds, with intervening kettle holes. (British Crown copyright 1992/MOD reproduced with the permission of the Controller of Her Britannic Majesty's Stationery Office.)

3.	Later Beds:	peat sand gravel
2.	Middle Beds:	Carstairs Station Sands
1.	Earlier Beds:	Upper Gravels Main Sands Lower Gravels Boulder Drift

The kames consisted of the lowest member (1) which he sub-divided into the four units listed. The Boulder Drift had an extremely variable matrix ranging from fine to coarse, clayey sand, with embedded boulders up to 1–2 m in size. The Lower Gravels consisted of clasts 0.07–0.1 m in size and larger stones in a sandy matrix. Sometimes poorly defined bedding was present. The Main Sands, a unit of relatively pure sand with a few bands of gravel, were up to 12–15 m thick and showed clear current bedding with palaeocurrents directed to the east and north-east. They were interdigitated with the poorly bedded Upper Gravels, or separated from them by a thin clay layer. Goodlet also described extensive folding and faulting in the deposits. McLellan (1967a, 1967b, 1969) later recorded decreasing grain size of materials and an increasing proportion of sand in an easterly direction along the kames.

Laxton and Nickless (1980) investigated the sediments of the kames both in sections and from boreholes. They concluded that although Goodlet's stratigraphic framework was valid for the pits which he examined, it was not substantiated over a wider area where their own results suggested a complex variation of facies through time. The ridges largely comprise what they term "glacial sands and gravels', a poorly sorted cobble and boulder gravel with a clayey, sandy matrix. The ridges are underlain by well-bedded glaciofluvial sand and gravel rapidly grading laterally into glaciolacustrine deposits, noted earlier byGregory (1915a). In some of the boreholes till occurs below the glaciofluvial deposits. In the north-east part of the site the mounds consist of glaciolacustrine deposits – laminated clays, silts and fine sand.

Jenkins (1991) distinguished two types of landforms on the basis of morphology and sedimentary characteristics. The first type are the esker-like ridges composed of coarse boulder gravel in a matrix of poorly sorted finer gravel, sand and silt. These deposits are sometimes covered in finer gravel and draped by laminated, fine-to-medium sand, in places with trough cross bedding. The second type are elongate mounds, up to 20 m high and several hundreds of metres long. They mainly comprise medium-coarse sand with trough cross bedding and channel scours. The mounds are often capped by massive or trough cross-bedded gravel up to 3 m thick and are interspersed with kettle holes.

The lithological composition of the kames is predominantly of materials from sources to the south and south-west, with only a very few rocks of Highland origin present (Gregory, 1912, 1915c; Goodlet, 1964; McLellan, 1969). This agrees with the general pattern established for the drift over a wider area on the northern side of the Southern Uplands (Stark, 1902; Gregory, 1915c; McCall and Goodlet, 1952).

Interpretation

In view of their striking landscape form theCarstairs Kames have long attracted the attention of geomorphologists and geologists. They have been referred to in many textbooks and papers, including the several geological guides to the Glasgow region (McCallien, 1938; Bassett, 1958; Jardine, 1980a). Considerable debate has centred on the origin of the features (Sissons, 1976b) and their implications for the pattern of glacial events in the area. In an early reference, Chambers (1848 p. 213) noted a range of sandhills at Carstairs which he believed were the remains of former marine plains. Later, Geikie (1863a) lyrically described their form and composition. He acknowledged that their origin was probably complex and suggested water currents in association with ice as a possible mechanism, probably operating also with marine processes and drift ice. Milne Home (1871, 1881c) advocated a marine origin for the kames. He interpreted stratified sand and gravel layers overlying boulder clay as submarine banks or deposits formed by the action of marine currents (Milne Home, 1881c). The ridges were formed by water currents. Dougall (1868), too, favoured marine processes and referred to the "beach' at Carstairs.

Jamieson (1874), however, dismissed the marine hypothesis and proposed that eskers and kames such as those seen at Carstairs were formed by meltwaters along the margins of the later glaciers which covered the area.

Geikie (1874) provided a systematic description of the morphology and sediments of the kames, noting in particular their variable composition, the stratification and dip of the sands and gravels and the occasionally contorted nature of the beds. He concluded that the kames had not been formed through erosion of a pre-existing deposit by rain or rivers, but he did not speculate on their origin.

Ramsay (1878 p. 386) referred to the "beautiful' examples of kames at Carstairs and other localities in Scotland, including them in the assemblage of landforms and deposits of the glacial epoch. Somewhat surprisingly, he later described kames or eskers as marine gravelly mounds (p. 430).

Geikie (1901) described the characteristics of the Carstairs Kames, noting that kames and eskers in general were "a fruitful source of wonder and legend to the people'. After paying due respect to several mythological theories, he stated that no satisfactory explanation so far accounted for them. They were superficial deposits overlying the till and formed during the closing stages of the glacial period. Lacking the characteristics of moraines in the normal sense, they seemed to be associated with meltwater. Smith (1901), however, was rather more specific, suggesting that the Carstairs Kames and related features were the product of fluvial and subaerial denudation of a large delta of drift.

In a series of papers on kames Gregory (1912, 1913, 1915a, 1915c, 1926) described and discussed many of the characteristics of the Carstairs features. He considered them to be the most famous and typical representative of the Scottish kames (Gregory, 1913). They were glaciofluvial deposits derived mainly from the south and laid down as a marginal formation along the front of a receding glacier. Although they shared similarities in form with eskers, they were not eskers in the true sense, that is deposited on the beds of glacial rivers, since they lacked the seasonal bedding characteristic of these features seen in Sweden and Ireland. Moreover, unlike typical eskers they were aligned across the inferred former direction of glacial drainage in the area.

Macgregor (1927) proposed another mode of origin for the kames. He believed that they were either deposited against a remnant of stagnant ice in the low ground to the north of Carstairs by meltwaters issuing from the glaciers of the Clyde and Douglas valleys, or else they were deposited in a narrow, ice-walled channel between stagnant ice to the north and still active ice to the south in the Southern Uplands.

Despite the predominantly southern provenance of the constituents, Charlesworth (1926b) argued in the face of previous opinion that the kames were formed by northern ice originating in the Highlands. In his view they were ice marginal features associated with drainage off a wasting ice sheet receding from the maximum of the Lammermuir-Stranraer glacial "stage', supposedly a readvance of the last ice sheet. In support he pointed to their apparent continuity with deposits both to the north-east and south-west, which he argued were associated with the northern ice of the readvance. He also argued that the steep north face of the kames represented an ice-contact slope (see Charlesworth, 1957, plate 15B). Several factors could explain the high content of southern erratics: they could have been deposits of southern ice reworked and incorporated during the readvance from the north or during fluctuations in the zone of convergence of northern and southern ice at the time of the ice maximum, or even brought to the area by river transport from the south.

Subsequently, Linton (1933) supported Charlesworth's views. However, from a re-assessment of the field evidence, Sissons (1961c) showed that in its central and eastern areas the supposed moraine almost everywhere consisted of glaciofluvial "dead'-ice deposits. Furthermore, over much of the area the last ice came from the Southern Uplands, not the Highlands as Charlesworth had suggested. The Carstairs Kames and their predominantly southern lithologies were associated with this southern ice which probably advanced over some older Highland till, as happened farther east (Eckford, 1952; McCall and Goodlet, 1952). On morphological grounds Sissons argued that the kames were typical of subglacially formed eskers, and the whole system related to a complex meltwater drainage network under the Southern Uplands ice. The trend of this drainage system accorded with the direction of movement of the last ice sheet (Sissons, 1967a) and was associated with the supposed Perth Readvance (Sissons, 1963a, 1964).

From his detailed studies of the sediments and structures in the ridges, Goodlet (1964) concluded that the Carstairs Kames were part of a complex terminal moraine formed during a halt stage in the retreat of Southern Uplands ice which had readvanced northwards over a wide area (see McCall and Goodlet, 1952) after Highland ice had withdrawn. The Boulder Drift ridges were deposited partly as ice-cored moraines, and as the ice receded, the Lower Gravels and Main Sands were superimposed as outwash deposits. During the later melting of the buried ice, these sediments were modified by erosion and subsidence. Goodlet argued that the deposits were laid down transverse to the last ice movement which, together with their internal composition, made it improbable that they were eskers as Sissons had suggested.

McLellan (1967a, 1967b, and 1969) interpreted the available exposures at Carstairs to indicate that the deposits were entirely water-laid and in his conclusions he fully supported Sissons' view that the kames were part of a subglacial esker system. In McLellan's opinion the Boulder Drift material simply represented coarse proximal sediments which became finer in a downstream direction. However, Boulton (1972b) has shown that there is support from modern glacial environments for the type of interpretation proposed by Goodlet. Boulton argued that the morphology, sediments and internal structure of the kames were unlike those of any known subglacial features, but were identical to those of many supraglacial fluvial deposits accumulated in association with ice-cored moraines. If the analogy is valid, the Carstairs Kames are neither moraines nor eskers, but glaciofluvial deposits originally laid down between ice-cored moraine ridges which blocked and controlled the supraglacial and proglacial drainage. Upon melting of the buried ice in the moraine ridges, inversion of relief gave topographic prominence to the glaciofluvial sediments. Boulton also suggested that many other Pleistocene stratified ice-contact deposits, such as the Bar Hill-Wrexham moraine (Boulton and Worsley, 1965; Yates and Moseley, 1967) and the Escrick moraine (Gaunt, 1970), may have formed in a similar fashion.

Laxton and Nickless (1980) emphasised the complex variation of facies within the whole suite of deposits in the Carstairs area in which they distinguished glacial sand and gravel, glaciofluvial sand and gravel and glaciolacustrine deposits. They envisaged an integrated assemblage of subglacial and proglacial depositional environments in which subglacial streams formed the ridges, then discharged from below the ice. The ridges showed strong similarities with the Guelph Esker in Ontario (Saunderson, 1977) which comprises poorly sorted and bedded material, becoming more graded distally. As suggested by Saunderson (1977) such deposits could have been laid down under sliding bed conditions during high velocity flow in subglacial tunnels. The underlying glaciofluvial deposits could reflect earlier subglacial deposition under lower velocity in less physically constrained conditions. Laxton and Nickless (1980) therefore supported the esker hypothesis for the origin of the Carstairs Kames. However, they did not consider the origin of the folding and faulting recorded by Goodlet (1964).

More recently, Jenkins (1991) has developed these ideas, drawing analogies with the formation of meltwater drainage systems in modern glacier environments. From the geomorphology and sediments he inferred that the overall environment of deposition at Carstairs was one of englacial or supraglacial streams "feeding' a subaerial fan overlying buried ice. The ridges of boulder gravel were formed by high-energy flows in englacial tunnels or supraglacial channels near to the ice margin. The sandy mounds were formed by lower-energy, braided streams that fanned out across a surface of buried ice. The laminated finer sand was probably deposited by shallow sheet floods, whereas the capping gravels represented high-energy floods. Subsequent melting of the buried ice, indicated by the presence of kettle holes and faulting in the sediments, resulted in topographic inversion, with the areas of greatest sediment thickness in the channels now forming upstanding ridges and mounds (*cf.* Boulton, 1972b).

Jenkins (1991) also considered the deposits at Carstairs in their wider regional context, particularly in relation to the style of deglaciation. He showed that the Carstairs features form part of a sequence of ice-marginal landform and sediment associations that together indicate continuous recession of the last ice sheet on the south side of the Pentland Hills from the southern outskirts of Edinburgh towards the south-west, accompanied in places by the development of zones of partly buried, stagnant ice. Such a pattern accords with the interpretation of Sutherland (1984a).

In terms of their size, extent and morphology, the Carstairs Kames is one of the most striking assemblages of glaciofluvial landforms in Britain. In terms of their braided morphology, the Carstairs Kames resemble most closely the Kildrummie Kames near Nairn (see above) but differ from a number of large single ridge features that are typical subglacial eskers, for example at Bedshiel (Stevenson, 1868; McGregor, 1974), Torvean (see above) and Littlemill (see above). Although they are frequently acknowledged to be classic examples of kames or eskers, the precise origin of the Carstairs Kames has been disputed among geomorphologists and geologists for almost 150 years. The most recent studies suggest that they are either subglacial eskers or eskers formed in an englacial or supraglacial position in association with proglacial outwash fans that later became topographically inverted. A key feature to emerge from these studies is that the ridges do not exist in isolation, but are part of a complex and integrated suite of glacial, glaciofluvial and glaciolacustrine deposits in the Carstairs area. To approach a fuller understanding of their formation, they need to be viewed in this wider context. The site clearly has further important research potential in the field of glacial sedimentology and its application to the interpretation and reconstruction of Pleistocene glacial environments and hydrothermal processes (*cf.* Kildrummie Kames). Carstairs is a particularly appropriate site for such work because of the existing body of information on the sediments.

Conclusions

Carstairs Kames is a classic site, long renowned for its glacial landforms. These comprise a series of esker ridges, kames and kettle holes, one of the best such assemblages in Britain formed by the meltwater (rivers) of the last ice sheet as it decayed approximately 13,000 years ago. The site has a long history of research and has featured in many publications. Although the precise origin of the landforms has been much debated, the site is unquestionably of the highest value for studies of meltwater drainage development, processes of meltwater sedimentation and patterns of glaciofluvial landscape development.

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