The Bradford Kames

[NU 162 320]

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Introduction

The Bradford kames form the northern termination of a marked linear sand and gravel zone running south-east from Budle Bay to Preston, a distance of about 13 km (Figure 5.42). It is an important site for glacial geomorphology because the assemblage of mounds and ridges provides an excellent example of the complex landform and sediment association that developed during the decay of the last ice-sheet in northern England. It also illustrates the difficulty in interpreting this type of landform where there is virtually no sediment exposure.

Description

The kames were first discussed by Gunn (1900), Smythe (1912) and Gregory (1922) and described more fully by Dinham in Carruthers *et al.* (1927) and Carruthers *et al.* (1930). Much later, Parsons (1966) placed the Bradford Kame Complex in a wider consideration of the de-glaciation of this part of Northumberland. The Bradford Kame Complex is composed of a series of elongate mounds of sand and silt associated with locally sinuous, esker-like ridges composed of silt, sand and gravel (Figure 5.43). The latter have steep sides and undulating crests and their origin must be associated with that of the silt and sand mounds with which they are physically linked, as the ridges commonly terminate abruptly against the sand and silt mounds. This suggested to Parsons (1966) that they were the casts of feeder meltwater streams, which formed as subglacial or englacial eskers and that the linear silt and sand deposits formed in crevasses. Accumulation within an open crevasse was suggested originally by Dinham (in Carruthers *et al.,* 1927) to account for the formation of the esker ridge between Spindlestone (see (Figure 5.42)) and Hoppen and was thought to coincide with the junction between active ice advancing through the Waren Gap (see (Figure 5.42)) and stagnant ice lying to the east. Occasionally, as at Hoppen and Burton Goldenhill, the sand and silt mounds are at right angles to that of much of the complex.

In the northern complex on the leeward side of the Whin Sill, banked against a till rise, are sands and silts in terrace-like form that feather out against the till. Irregular mounds of gravel that rise some 6 m above the surface of the sands and silts were interpreted as moulin kames located along a zone of weakness in the stagnant ice (Parsons, 1966). Near Lidderton Hill, the sands and silts become of increasing topographical importance and to the south the deposits form the steep-sided and broad-crested Bradford Goldenhill ridge, the most northerly of the linear sand and silt mounds. The upper surface is broad and gently undulating, and falls gently from 60 m to 53.8 m at the summit of Cockle Hill. Parsons (1966) thought it was deposited by meltwater within a crevasse, probably subject to continual widening during the advanced stages of deglaciation. The linear Burton Goldenhill is at right angles to the general trend and is at a similar altitude to Bradford Goldenhill. It appears to be an ice-frontal deposit, although Parsons (1966) suggests it was formed as a crevasse filling.

To the west of Lidderton Hill, and associated with these sand and silt deposits, is the pronounced, sinuous ridge (30–50 m wide and 6–15 m high) of 'earthy' gravel, composed of local lithologies, including sandstones, shales, and Oxford and Chesterhill Dean limestones, although quartz dolerite is rare (Carruthers *et al.,* 1927). The ridge is distinguished from the surrounding land by rough scrub vegetation along the southern half and by the Long Barracks plantation in the northern part. Although there are no sections in the ridge today, arch-bedding in gravels was exposed near Goldenhill Farm (see (Figure 5.42)) as reported by Garwood (1893). Angular to subangular boulders, up to 1 m in diameter, are common on the crests and sides of the ridges, frequently of the locally outcropping Oxford Limestone (George *et al.,* 1976). The smaller pebbles in the gravel are generally fairly well rounded, although there are larger clasts of unabraded shale, which suggests minimal sediment transport. To back this up, striated and faceted stones have been found (Gregory, 1922; Carruthers *et al.,* 1927), which indicates subglacial sediment and little transport.

This ridge has been interpreted as an esker by Parsons (1966) and he linked it with a shallow channel, the long profile of which rises to the south-east and is incised into the till immediately south of the Whin Sill outcrop. This ridge terminates in the sand and silt deposits of Pigdon Hill. Occasionally, as at the northern end of Bradford Goldenhill and to the south-east of Spindlestone, the gravels appear to be banked against the west side of the main sand and silt deposits. This results in the more characteristic ridge morphology being divided into a series of sections generally separated from the silt and sand deposits to the east by poorly drained hollows, once occupied by small lakes. Near Hoppen (Figure 5.42) the finer-grained deposits form a steep-sided, gently undulating, broad-topped mound, (56 m OD maximum). It has a deltaic appearance and from the south-east end of this mound a broad-topped, steep-sided ridge of silt and sand extends SSE as far as Newham. At its northern end it is 60.9 m at Ell Hill, where gravel is banked against and overlies fine-grained sediments, although the upper surface of the rest of the deposit undulates between 46.15 m and 3.8 m. South of Newham the deposits extend south-eastwards at about 30 m OD, as a sinuous and broken, irregular, esker-like ridge, composed mainly of gravel in the northern part (Gunn, 1900; Carruthers *et al.,* 1927), resting on till. The deposits rise to a maximum of 46.15 m OD at the steep-sided Horse Hill, where it is composed of sand and silt. The sand and silt deposits at Preston form a steep-sided and linear, broad-topped mound as far as Doxford Hall (see (Figure 5.42)), and towards and beyond Falloden Hall the deposits form a kame terrace. These deposits are not traceable beyond Christon Bank, which is thought to mark the end of the Bradford Kame Complex, al though meltwater from this zone may have eroded channels at, and to the south of, Embleton.

Auguring of the sediments (Figure 5.44), reported by Parsons (1966), revealed extensive deposits of silt, laminated clay and fine-grained sand in many of the glaciofluvial deposits away from the main esker ridge and Carruthers *et al.* (1927) reported sands and clays in occasional borehole records, such as the 18.5 m of clay reported in a well at Hoppen. The auguring has been important, since much of the area underlain by these deposits was reported to be covered by boulder clay by Carruthers *et al.* (1927).

Interpretation

Gregory (1913, 1922) suggested that this kame, and kames in general, were laid down pro-glacially along the margin of the glacier. However, Dinham (in Carruthers *et al.,* 1927) thought that the greater part of the deposit suggested accumulation in a crevasse as an open channel, within a mass of clean, wasting ice and locally near its margin, although this site may have marked the site of an earlier subglacial stream. The bank on the west side of Crook Hill–Cockle Ridge followed by the kame was supposed to mark a sudden rise of 15–27 m in the subglacial surface and a corresponding change in the ice thickness. The boundary between active and stagnant ice would be fixed and maintained along this bank for a period during which the ice margin could fluctuate and eventually retreat a considerable horizontal distance over the gradual slopes on the other side of the valley. The tensions of differential flow to be expected near such a boundary would coincide for a long time with the bank and a more or less permanent marginal crevasse might be developed here. The site of the kame was sheltered by Spindlestone Heughs on the Whin Sill ridge from the direct southerly pressure of the ice behind them and therefore deposits or crevasses would stand a better chance of preservation here. Sediment incorporated in the ice as englacial debris was released into the crevasse.

The problem with this explanation for the kame is that it does not explain the relationship with finer-grained glaciofluvial sediments, especially the laminated clays and silts, or landforms to the south and east of the main Bradford kame ridge and the fact that this type of sinuous ridge is duplicated to the south. The transition from active to stagnant ice noted above at Cockle Ridge is difficult to explain physically too, although undoubtedly the shelter of the Whin Sill ridge might be an important locating factor. Parsons (1966) interpreted the ridge system as a subglacial esker feeding meltwater and sediment into a reticulate, open crevasse system and therefore the glaciofluvial sediments were suggested to be a series of eskers and crevasse fillings in an extensive, terminal zone within decaying ice. During deglaciation Parsons (1966) believed that the ice in the northern part of this area had thinned sufficiently for the crevasse system to have penetrated to the underlying till. In parts he considered that the evidence suggests that deposition began in the south and progressed northwards, but this was believed to be a local phenomenon and that the deposits were broadly contemporaneous, probably accumulating within a decaying, terminal zone. A series of eskers and crevasse fillings extended SSE from the Whin Sill outcrop as far as Doxford Hall (see (Figure 5.42)). They appear to continue as a kame terrace leading south-east towards Falloden Hall, but beyond this, extensive glaciofluvial deposits are absent and the meltwater was believed to have eroded several SE-trending channels in the till west of Craster (Parsons, 1966). Douglas (1991) thought that these eskers of sand and gravel were aligned in the direction of ice flow and represented subglacial channels draining the Devensian ice sheet.

However, there recently has been renewed interest in the origin and depositional environments associated with these types of kames and eskers, and several models of sedimentation have been proposed (e.g. Brennand, 1994; Warren and Ashley, 1994; Huddart and Bennett, 1997; Thomas and Montague, 1997; Huddart, 1999; Thomas *et al.,* in press). One of these models includes sedimentation from subglacial channels into a pro-glacial lake during active ice retreat, which gives a distinctive landform and sediment association (Thomas *et at,* in press). This model has been proposed for the Newbigging esker system in the South Medwin valley (Lanarkshire), whereas the nearby Carstairs kames have been explained by Huddart and Bennett (1997) as deposition within a supraglacial topography of ice-cored ridges, which gave a diverse range of depositional environments and a number of distinct glaciofluvial systems. Adjacent to the main ridges at Carstairs, mounds composed mainly of sand show evidence of fluvial channel systems and glacio-lacustrine, ice-contact environments, con sistent with supraglacial kames. From the landform morphology and the limited sedimentary records proved by Parsons (1966), it is suggested that the Bradford Kame Complex developed in a similar series of environments to those in Lanarkshire.

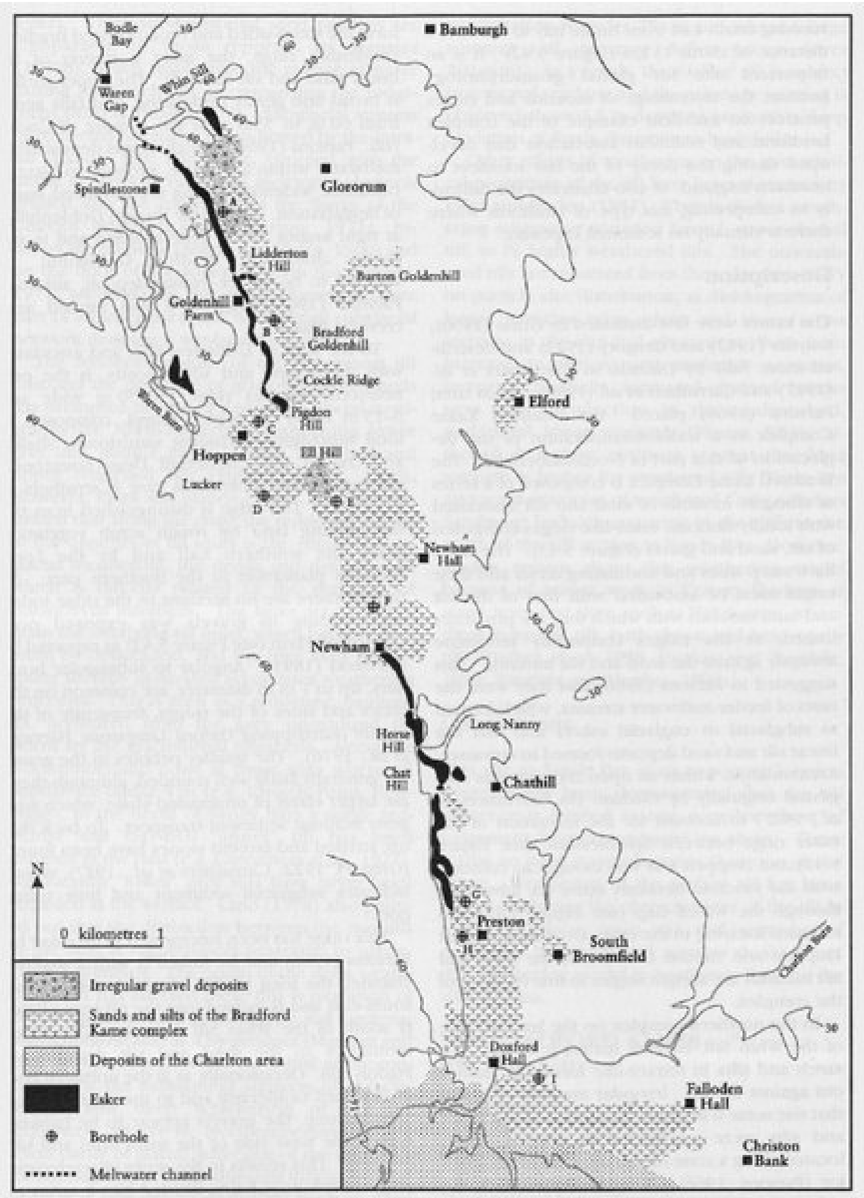
1. Subglacial eskers. These occur in the Bradford kame proper between Spindlestone and Pigdon Hill and again between Newham and north of Preston. They are composed of gravel but with surface angular boulders on their crests and sides derived from supraglacial sources as the ice melted. The arch-bedding seen by Garwood (1893) is indicative of a sub-glacial system, although it is conceivable that these deposits could be supraglacial eskers (Huddart and Bennett, 1997).
2. Pro-glacial, glacio-lacustrine deltas. The much bulkier deposits at Burton Goldenhill, Cockle Ridge, Hoppen, Ell Hill and near Preston are steep-sided, undulating to flat-topped mounds with a gradient to the south-east. They are composed largely of sands and silts, although gravels are located at their northern, up-ice ends at the ice-contact face. They are interpreted as pro-glacial deltas that prograded into lakes as the ice retreated actively to the north. There are three such suites of landforms.
3. Other landforms. The roughly elongate sand and silt mounds best developed between north of Lidderton Hill and Cockle Ridge are thought to represent either finer-grained glaciofluvial sequences that built up as fans into the lake as breakouts from the main sub-glacial esker, or as a series of supraglacial kames. The finer-grained sands–silt landforms could be developed in supraglacial lakes bottomed on till.

This model invokes active retreat to the north, although between Pigdon Hill and Spindlestone in the lee of the Whin Sill there could have been stagnant ice and supraglacial environments at a late stage in deglaciation in this area. There is evidence for glaciofluvial sediment and erosion landforms in the North and South Charlton areas to the south-west of the Bradford Kame Complex, which resulted in thick sequences of glacio-lacustrine and glaciofluvial sediments in the Lower Aln valley (Parsons, 1966). To deposit such sequences of glacio-lacustrine sediments associated with the Bradford Kame there must have been a continuous ice dam to the northeast as ice retreated actively to the north. This means that the meltwater channels between Embleton and Craster, thought to be eroded by meltwater from the Bradford Kame Complex by Parsons (1966), must have been independent from that series of deposits and probably cut by subglacial erosion. It is possible that Carruthers *et al.* (1930) were correct in linking the Bradford deposits with the North and South Charlton deposits and it is considered that all these deposits and landforms best fit into a model of active ice retreat, punctuated by stillstands to build up sediments in fronting, pro-glacial lakes in topographically deeper valleys. This means that the model of crevasse fillings in an extensive, terminal zone within decaying ice, supported by Parsons (1966), is likely to be wrong for the whole complex, although a supraglacial series of landforms and deposits could be argued for the northern section close to the Whin Sill. However, although it forms a complex landform and sediment assemblage and is one of the best examples of glaciofluvial–glacio-lacustrine sedimentation in northern England, its exact mode of origin still remains to be explained completely, simply because the sediment exposure is so limited. To obtain the precision in interpretation for the depositional environments provided by Huddart and Bennett (1997), Thomas and Montague (1997) and Thomas *et al.* (in press), good sediment exposure is essential. Nevertheless, the model suggested, where the landforms are associated with an active ice retreat and subglacial meltwater inputs into pro-glacial lakes, is thought to be the most likely depositional model.

Conclusions

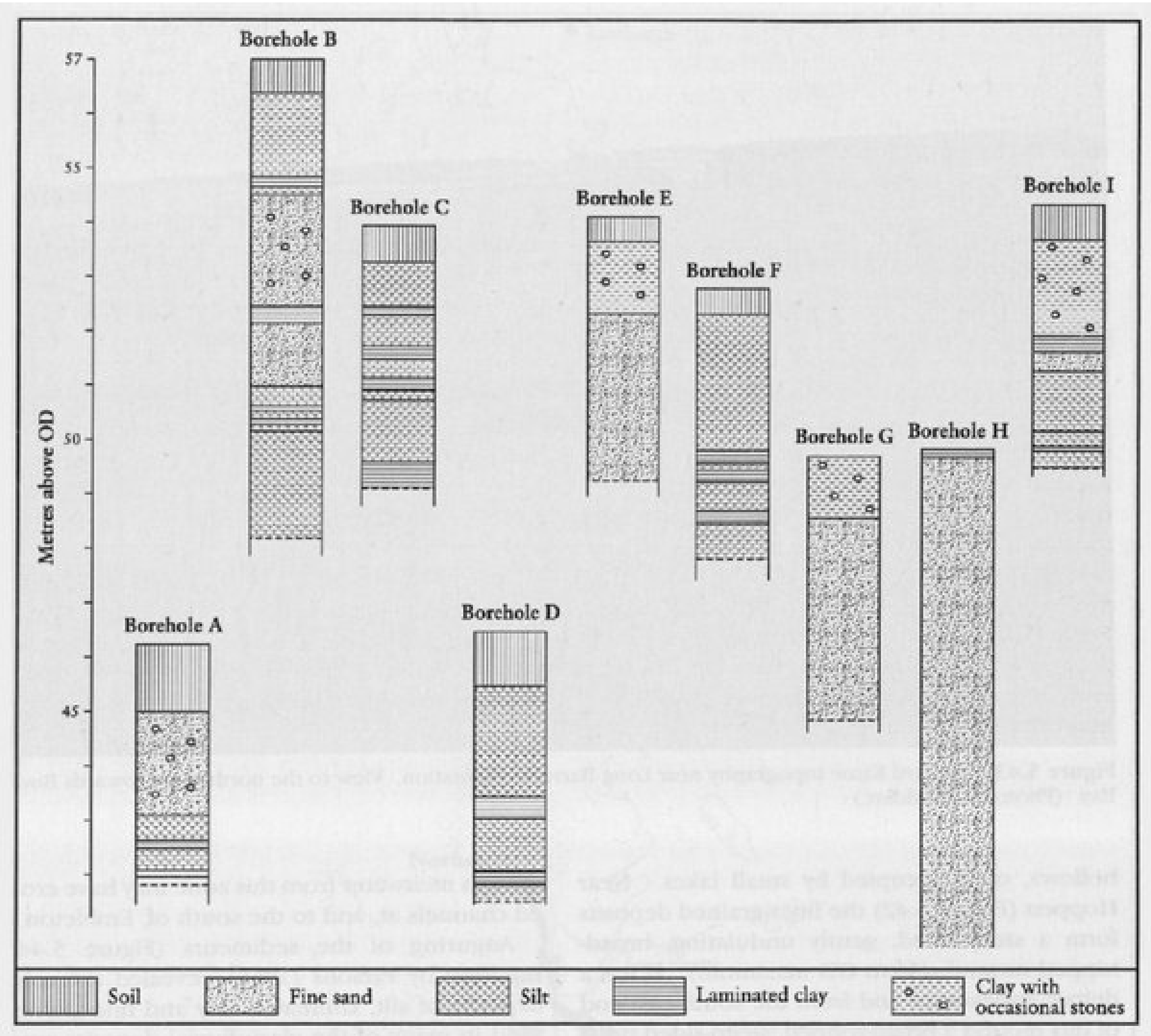
In the account given here, a description of the Bradford Kame Complex is presented and the various hypotheses for its formation discussed. As there are virtually no sediments exposed at the time of writing, the precise depositional environments are difficult to unravel. However, active ice retreat from south to north led to the deposition of proglacial deltas fed from sub-glacial eskers at three stages in the Preston area, at Ell Hill and at Cockle Ridge–Pigdon Hill–Hoppen. To the north of the latter ridges the ice probably became stagnant behind the Whin Sill ridge and a series of supraglacial environments developed. Without detailed sedimentological evidence these suggested stages remain hypothetical.

[References](#)



(Figure 5.42) The Bradford Kames and associated deposits (from Parsons, 1966). Sections corresponding to boreholes A–I are described in (Figure 5.44).

(Figure 5.43) Bradford Kame topography near Long Barracks Plantation. View to the north-west, towards Budle Bay. (Photo: D. Huddart.)



(Figure 5.44) Sediments from auger holes and boreholes (locations are shown in (Figure 5.42)) in the Bradford Kames (adapted from Carruthers et al., 1927; Parsons, 1966).