Keith Water

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Highlights

Stream sections along the Keith Water reveal sequences of tills and glaciofluvial sediments. These deposits are important both for interpreting the sequence and patterns of movement of the Late Devensian ice-sheet, and for demonstrating the complex sedimentary environments associated with the melting of the ice which included flow components from separate sources in the Highlands and Southern Uplands.

Introduction

The site comprises a series of stream and gravel pit exposures along the valley of the Keith Water ([NT 440 621] to [NT 452 639]), a tributary of the River Tyne, located about 20 km south-east of the centre of Edinburgh. On the north side of the Keith Water and in the area between the Keith Water and the Humbie Water, the landscape is underlain by thick drift deposits heavily dissected by former meltwater streams and the present rivers. The deposits comprise thick sequences of till and glaciofluvial materials which appear at the surface as flat-topped areas or mounds. The hummocky glaciofluvial deposits form part of an extensive suite extending along the northern flanks of the Lammermuir and Moorfoot Hills (Young, in Howell *et* al., 1866; J. Geikie, 1877; Kendall and Bailey, 1908; Charlesworth, 1926b; Sisson, 1958a; McAdam, 1978; McAdam and Tulloch, 1985).

A number of the sections along the Keith Water are of longstanding interest and have sometimes been taken to represent a regional glacial stratigraphic standard for the Edinburgh–Lothians area, for which up to three separate glacial episodes have been recognized (see above). An alternative view, however, holds that the considerable lateral and vertical variability in the stratigraphy is a function of purely local ice-margin conditions associated with a single ice-sheet (Young, 1966, 1969; Martin, 1981). The deposits at Keith Water have been described by Kendall and Bailey (1908), Kirby (1966, 1968, 1969b), Young (1966, 1969), Ragg and Futty (1967) and Martin (1981).

Description

Six main sections and a number of smaller exposures have been described from the valley of the Keith Water. These show multiple, interbedded sequences of till and glaciofluvial deposits. Section 1, at [NT 440 621], was described by Young (1966) as showing the following beds:

3. Reddish-brown till containing Carboniferous sandstone and greywacke erratics	1.2–1.4 m
2. Current-bedded sands with inclusions of reddish-brown till at the top	at least 4.6 m
1. Dark-grey till containing coal fragments and Carboniferous sandstone, greywacke and limestone erratics	at least 3.1 m

In 1980 only beds 1 and 2 were exposed.

Section 2, at [NT 438 623], has been the most intensively studied exposure, particularly through the work of Young (1966, 1969) who examined the stratigraphy, till clast-fabrics, particle-size distributions, heavy mineral assemblages, pH and soluble carbonates. The sequence comprises:

6. Dark brown sands	0.9–1.1 m
5. Dark reddish-brown till containing coal fragments, Carboniferous sandstone and greywacke erratics	1.2–1.5 m

4. Pebbly sand	0.6 m
3. Dark-brown till containing coal fragments, Carboniferous sandstone, greywacke and tuff erratics	at least 3.7 m
2. Current-bedded sands with bands of coal fragments	0.9 m
1. Dark-grey till containing coal, Carboniferous sandstone, greywacke and limestone erratics	at least 3.0 m

Young found that variations in clast fabrics were often greater within the same till units than between different ones, and that the dip analyses were inconclusive in demonstrating the ice-movement direction. Particle size, mineralogy and stone-count studies showed no significant differences between the till units. Greywacke and Carboniferous sandstone clasts were the dominant constituents of the deposit; limestone clasts occurred only in the bottom part of the middle till and in the lowest till. No identifiable Highland rocks were found.

Section 3, at [NT 438 631], is the notable Red Scar exposure first described by Kendall and Bailey (1908). They described the following sequence:

4. Sand	16.1 m
3. Boulder clay	4.0 m
2. Sand	4.6 m
1. Boulder clay	up to 11.3 m

Gravel layers interbedded with the sands contained a noticeable proportion of greywacke pebbles, whereas the larger blocks in the tills comprised sandstone.

The succession of deposits was confirmed by Kirby (1966, 1968) and Young (1966). Young described the lower till as very dark grey and containing Carboniferous sandstone, greywacke and limestone erratics and coal fragments; the upper till as reddish brown and containing coal fragments and Carboniferous sandstone and grey-wacke erratics. Kirby noted that the lower till merged, and was interbedded with, the sand above; inorganic laminated clays occurred near the top of the lower sand layer; a sharp junction existed between the lower and upper till; and there was a transitional change from the upper till to the upper sands.

Section 4, at [NT 449 637], was first described by Kendall and Bailey (1908) who recorded:

3.Boulder clay	1.8 m
2.Sand	19.8 m
1.Boulder clay	10.1 m

In more detail, Kirby (1966, 1968) described:

6.Red till	2.1 m
5.Fine- and medium-grained bedded sands	c. 20 m
4. Red till	0.9 m
3. Sand with red till inclusions	1.8 m
2. Silty till	0.9 m
1. Dark till grading up into bed 2	5.2 m

In 1980 the section was completely vegetated over. In the same area, in sections also no longer exposed, Young (1966) had recorded sands and gravels variously overlying dark grey till containing coal fragments and Carboniferous sandstone and greywacke erratics, and reddish-brown till containing similar erratics overlying current-bedded sands.

Between sections 3 and 4 both Kirby (1966) and Young (1966) recorded several small exposures showing either sands and gravels overlying dark grey till or reddish brown-till overlying sands.

Section 5 is at Keith Marischal sandpit [NT 450 640] (Kirby, 1966; Young, 1966; Ragg and Futty, 1967). As described by Young in greatest detail it shows:

4.Dark, reddish-brown till containing Carboniferous sandstone, Old Red Sandstone, coal and greywacke erratics	1.2 m
3.Current-bedded, dark reddish-brown sands	0.08–0.13 m
2.Dark, reddish-brown till containing coal fragments, greywackes, Old Red Sandstone and Carboniferous sandstone erratics	0.05–0.10 m
1.Current-bedded sands at	least 10.7 m

Section 6 is a sandpit, at [NT 453 637]. Here Kirby (1966) described thick, horizontally bedded sands overlain by beds of till of variable thickness interlayered with sands and clays, capped by a horizon of red till.

Interpretation

The first significant synthesis of the glacial stratigraphy of East Lothian was that of Young (in Howell *et al.,* 1866) who established a basic succession of till overlain by sands and gravels. He noted variations in the colour of the till according to the local bedrock and also referred to a sandier till near the coast which merged with the main till of the area.

Following J. Geikie (1877), Kendall and Bailey (1908) confirmed the presence of Highland erratics in East Lothian and distinguished on lithological grounds the till containing Midland Valley material and the overlying sands and gravels dominated by Silurian greywackes. They explained the sequence of deposits in the Keith Water area in terms of an oscillating ice margin. Following deposition of the lower till the ice retreated northwards, and great accumulations of sand and gravel were laid down either in temporary ice-dammed lakes or as gravel spreads extending between the ice and the Lammermuir Hills. Debris washed in from the hills to the south explained the high content of local lithologies. The upper till was subsequently deposited during a forward oscillation of the ice margin. Kendall and Bailey's observations were substantially incorporated into the second edition of the Geological Survey Memoir for East Lothian (Clough *et al.,* 1910). Sissons (1958a), however, disputed Kendall and Bailey's interpretation of oscillatory retreat, and suggested instead that the balance of evidence favoured widespread thinning and stagnation of the ice.

Kirby (1966, 1968) correlated the beds in the different sections along the Keith Water. Using clast fabrics and stone counts as evidence, he inferred that the stratigraphy in the Keith Water area was similar to that in the Esk basin (see Hewan Bank). The two tills in sections such as that at Red Scar corresponded to the Basal and Intermediate tills of his regional stratigraphic scheme. The Intermediate Till was distinguished by a higher percentage of greywackes of southern origin and clast fabrics indicating ice moving to the north, whereas the Basal Till consisted largely of material of western derivation and had clast fabrics orientated to the east. Although the topmost till at sections 5 and 6 corresponded in its stratigraphic position with the Roslin Till (see Hewan Bank), it could be distinguished from the latter on the basis of its fabric and lithology (Kirby, 1968, 1969b). Its characteristics suggested that it was an ablation till associated with the decay of the Southern Uplands ice that produced the Intermediate Till.

Young (1966) studied the stratigraphy of a large number of individual sites in the Upper Tyne area. He stressed the appearance of 'rapid and radical changes' in the succession over very short distances and concluded that 'it would be impossible to construct an isopachyte map of any clarity for any one strata from the results obtained' (p. 15). However, a broad pattern emerged of a dark grey till underlying much of the area, with an overlying reddish-brown till restricted largely to the Keith Water area. From his detailed studies of section 2, Young concluded that all the deposits were laid down by the same ice flowing northwards into the Midlothian basin from the Southern Uplands, subsequently being directed south-eastwards into the Upper Tyne area. In contrast to Kirby, Young found no significant differences in lithology or clast fabric among the tills, including those of section 2 which he studied in great detail.

More recently, Martin (1981) has supported Young's interpretation. From detailed sedimentological studies and comparisons with contemporary glacial environments he concluded that the Keith Valley deposits are best interpreted in terms of a basal lodgement till succeeded by an interbedded sequence of flow tills and delta-fan deposits formed at the receding or thinning ice margin of the Late Devensian ice-sheet.

The Keith Water deposits are of considerable interest from a historical viewpoint because of their role in the development of a regional stratigraphy (see also Hewan Bank). However, more recent studies have emphasized the local variability of the deposits and their spatially restricted distribution. Taken together, therefore, the various sections provide a valuable record of the complex depositional environments associated with Pleistocene ice-sheets. They provide significant evidence for interpreting the patterns and processes of sedimentation beneath and at the margins of former ice-sheets, and thus may allow analogies with modern glacier sedimentary systems (for example see Boulton, 1972b; Lawson, 1979).

Conclusion

The sequences of deposits at Keith Water are important for studying the glacial history of the Lothians area and processes of glacial sedimentation. They were formed by ice from sources both to the west and south during the Late Devensian glaciation (around 18,000 years ago) and are particularly significant in illustrating the complex depositional patterns arising from the interactions of these sediment-carrying ice masses and their subsequent melting. The site is therefore valuable both as a reference locality for the Lothians area and for studies of glacial sedimentary environments.

References