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Evidence for a stillstand or minor glacial readvance at Powfoot, near Annan

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Charlesworth (1926a,b) cited evidence for five stages of ice sheet recession in southern Scotland based mainly on recognition of arcuate moraine complexes. He concluded that his Corrie and Kirkcowan stages were both associated with relatively major readvances. The former equates with the generally accepted Loch Lomond Readvance (Sissons, 1974), which is confined to the Moffat and Galloway hills. The latter stage, the second oldest of the five, was associated with readvances of the 'Nith Glacier' as far as Dumfries and the 'Annandale Glacier' to near Lockerbie (Merritt and Phillips, this volume fig.1). The supposed moraines at these localities were thought to form part of a discontinuous belt of predominantly gravelly kamiform deposits, the 'Lammermuir - Stranraer Moraine', that stretched westwards to the Rhins of Galloway (Charlesworth, 1926b). Sissons (1967) initially linked the Kirkcowan Stage with his Perth Readvance limits in south-west Scotland, but he later dismissed all but the last stage (Sissons, 1974). In a study of part of Nithsdale, Stone (1959) favoured a model of deglaciation uninterrupted by readvances, whereas Bishop (1963) interpreted small scale, soft-sediment deformation structures that he observed in gravel pit sections in Annandale to be evidence of a local glacial readvance. Huddart (1999) identified deformation structures within the Dumfries Moraine, but considered them to be of syn-sedimentary, non-glacitectonic origin. However he concluded that the Nithsdale kames were in general the product of actively retreating ice, which may have experienced local stillstands and readvances. The features considered here in the vicinity of Powfoot concern events that preceded the Kirkcowan Stage of Charlesworth (1926a), but followed the creation of his 'North-east Ireland-Isle of Man-Cumberland Moraine' (including the 'Scottish Readvance' of Trotter, 1922, 1923) when ice was retreating into the Dumfries Basin.

Charlesworth (1926a) identifies two belts of 'moraine' that extend south-eastwards towards the coast at Powfoot, from Dalton [NY 116 740] and Torthorwald [NY 033 784] respectively. The easternmost belt comprises a prominent chain of ridges that extends 10 km in an arc from Edge Hill [NY 116 699], terminating at Barnkirk Point [NY 192 643], at the mouth of the River Annan. Gregory (1926) named these features as the 'Cummertrees Kame', concluding that they had formed at the eastern margin of a glacier that had flowed down the valley of the Lochar Water carrying erratics of wacke sandstone, red sandstone and breccia from the north. He describes several sections in which beds of sand and gravel dip eastwards away from ridges with the inclusion of boulders up to a metre or more in diameter. This evidence is certainly not at variance with an ice-marginal, morainic origin, especially as the most prominent ridges have steeper, south-westwards facing slopes that were probably in contact with the ice. At Newfield [NY 115 688], a low, 25m long ridge lies 20m to the west and parallel to a steep slope that is capped by reddish brown stony diamicton. M. Brookfield (Personal Communication, 2010) interprets the ridge as a push moraine lying adjacent to an ice-contact slope that is capped by flow till.

Both belts, however, have been mapped subsequently as either moundy or terraced deposits of glaciofluvial sand and gravel with the most prominent ridges identified as eskers (Figure 1) (BGS, 2005, 2006). One such ridge is well developed on the

northern edge of the eastern arc where it is visible from the B724 road between Cummertrees [NY 143 665] and Newfield [NY 112 688]. The railway line from Annan to Dumfries exploits another prominent ridge, the 'Hurkledale Esker' (McMillan et al., 2010b), which provides a natural embankment across boggy ground. These authors describe upward coarsening gravel deposits in a small pit at [NY 1304 6697] and in several others around Powfoot [NY 150 658] and Edge Hill.

East of Powfoot, a discontinuous esker-like ridge backs both the modern beach and fragmentary Holocene raised marine deposits (Figure 1) (BGS, 2006). A section in the ridge 200 m east of Powfoot revealed interbedded reddish brown to orange brown, fine to medium-grained sand with variably sorted, subrounded to well-rounded gravel. An apparently south-eastward palaeocurrent is indicated locally by both cross bedding and imbrication (M. Brookfield, personal communication, 2010). An 8 m section of very poorly sorted cobble-boulder gravel with no discernable bedding occurs at [NY 1693 6485]. Convolute bedding and collapse structures are common towards the top of these coastal sections.

More informative exposures have been examined in a gravel pit immediately inland of the coastal ridge, within the former M.O.D. grounds at Broom [NY 1570 6565]. Some very complicated relationships between units occur hereabout, including sag basins, horizontal folds, vertical to overturned bedding, shearing and extensional microfaulting. The sag basin illustrated in Figure 2 includes frost-shattered gravel; the feature is interpreted as an ice-wedge cast by M. Brookfield (Personal Communication, 2010). Beneath flatter ground (glaciofluvial terrace) to the north-east [NY 1583 6575], about 1 m of well sorted, frost-shattered gravel has been observed resting on over 2 m of poorly sorted cobble gravel (Figure 3).

The origin of the coastal ridge to the east of Powfoot is not absolutely clear on present evidence, but on balance, it is likely to have formed at the margin of an active glacier lobe that splayed out into the Solway Firth. It is possible that the ice lobe pushed past less active, decaying ice to the east along a zone that is analogous to a 'lateral shear margin' (cf. Kleman and Glasser, 2007). This zone was exploited by meltwater to form the ridge. The presence of frost-shattered gravel within sag basins or ice wedge casts adjacent to the ridge, and in terraced glaciofluvial deposits beyond, suggests that the active ice lobe remained for many years whilst stagnant, debris covered ice inland decayed, recording a significant stillstand, if not a minor glacial readvance (Brookfield et al., this volume, fig.2). The event is named here as the 'Powfoot Oscillation'; it probably shortly followed the deposition of the Holme St Cuthbert delta described by Huddart (1991) and Livingston et al. (2010b) on the opposite shore of the Solway Firth (Merritt and Phillips, this volume fig.1.

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Figures

1. The superficial geology of the area around Powfoot at 1:50 000 scale taken from BGS (2005, 2006). Copyright NERC. Glaciofluvial deposits are shown in shades of pink with dark pink representing esker-like ridges. OS topography Crown Copyright. All rights reserved 100017897/2009.

2. Exposures [NY 1570 6565] adjacent to an ESE-orientated ridge of glaciofluvial sand and gravel, 1 km east of Powfoot.

A) Sag basin infill and localised disturbance of otherwise mainly horizontally-bedded, relatively well sorted and rounded sand and gravel, looking east. Poorly sorted, frost-shattered, angular gravel has been deposited at the margins of the basin and has been dragged down into a monoclinal structure to the south, which is formed of sheared silty pebbly sand cut by an extensional system of conjugate microfaults that formed prior to the folding.

B) Sheared, overturned, silty fine-grained sand and well sorted granule gravel, looking NW. Beds of well sorted gravel and laminated silty sand lie to the right, dipping steeply towards the NE.

3. Section in terraced glaciofluvial deposits [NY 1583 6575], 1 km east of Powfoot, adjacent to the ESE-orientated ridge exposed in the sections shown in the previous figure. Close-ups are to the left and right above the spade respectively. The section reveals gravel including many angular, frost-shattered clasts resting on another unit that is more poorly sorted, but containing fewer angular clasts.

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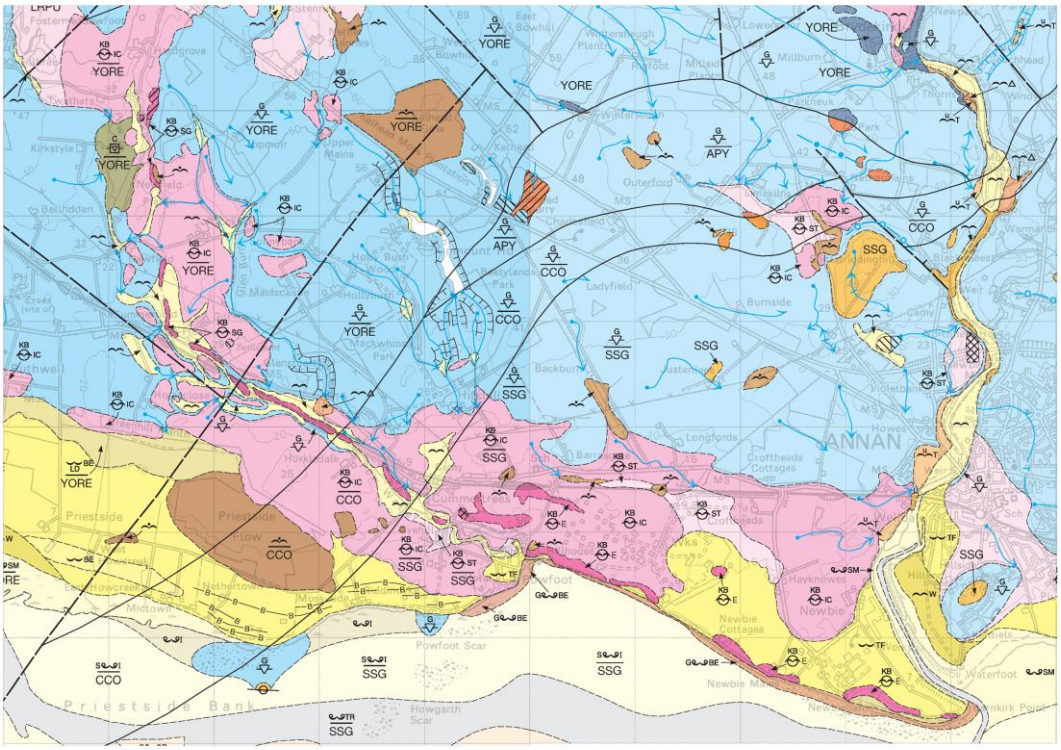

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