Burn of Benholm

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Highlights

Stream sections at Burn of Benholm have revealed a sequence of deposits including a pre-Late Devensian shelly clay with marine molluscs and an interstadial peat of Early or Middle Devensian origin. These deposits provide important evidence for interpreting the Quaternary history of eastern Scotland.

Introduction

This site [NO 795 691] comprises a series of stream sections at *c.* 45 m OD along the Burn of Benholm, 14 km north of Montrose. It is notable for a dark shelly deposit interpreted as a till, and for peat lenses incorporated near the base of an overlying red till. These deposits have played an important role in reconstructing the glacial history and environmental changes in the area (Campbell, 1934; Donner, 1960, 1979). More recently, Sutherland (1981a) has proposed an alternative explanation that the shelly sediment is an *in situ* marine deposit. He described its possible wider correlations with other sites in Scotland and how it might relate to a model of glacio-isostatic sea-level changes associated with the inception of the last ice-sheet during the Early Devensian.

Description

The deposits at Burn of Benholm were first described by Campbell (1934). He recorded the following sequence in several sections:

4. Coarse gravel	0.3–0.8 m
3. Red till derived from the Old Red Sandstone rocks of Strathmore and typical of the tills of this part of eastern Scotland	0.3–1.2 m
2. Greyish-black till containing abundant 'arctic' shells, the commonest being *Arctica islandica* (L.), and relatively few clasts, but of lithologies quite distinct from those in the overlying red till (Lower Old Red Sandstone, basalt, gneiss, troctolite, limestone (including chalk), shale, flint and jet)	0.6–1.8 m
1. Andesite bedrock	

In the sections described by Campbell the shelly till (bed 2), which extended almost continuously for a distance of over 550 m, was locally underlain by sands and gravels (0.2–0.3 m thick) and, in places, it was mixed with the red till (bed 3). At one locality, finely laminated silts and a band of peat (total thickness 0.3 m) were incorporated at the base of the red till (bed 3).

The present exposures clearly demonstrate (1) red till overlying grey, shelly clay with a low stone content, as described by Campbell (1934); (2) in some sections a sharp, undulating contact between the grey clay and the red till, varying from subhorizontal to steeply dipping; (3) in other sections, a zone of mixing up to 0.4 m thick of red till and grey clay; (4) deformation of the upper surface of the grey clay and interfingering with the red till; (5) stringers and bands of grey clay incorporated into the red till; (6) a layer of reddish sand (0.01–0.02 m thick) 0.03–0.04 m below the contact of the red till and the grey clay; (7) deformation of the grey clay and underlying bands of sand and gravel against a bedrock knoll. Hall and Connell (1991) have reported that the grey clay contains reworked Upper Cretaceous and Tertiary dinoflagellate cysts which they considered were derived from the North Sea Basin to the south-east.

Bremner (1943a) recorded that analysis of the peat (base of bed 3) by I. M. Robertson had revealed pollen of oak, pine, alder and elm. Donner (1960) noted that the peat, which is no longer exposed, occurred in thin lenses. The pollen content, however, was dominated by non-arboreal types, notably Gramineae and Cyperaceae, representing herb communities (Donner, 1979). Radiocarbon dating of the peat gave an age of >42,000 BP (Hel–1098) (Donner, 1979).

Interpretation

The dark shelly deposit at Burn of Benholm is one of several such occurrences in Kincardineshire described by Campbell (1934), but it is the only one presently exposed. It is also the only locality where peat deposits have been recorded in the sequence. Campbell (1934) concluded that the shelly deposit was a till emplaced by ice moving across the floor of the North Sea when Scottish and Scandinavian ice-sheets coalesced (but see Nigg Bay). The peat represented interglacial conditions, being formed after retreat of the North Sea ice and before the advance of the Strathmore ice-sheet.

Donner (1960) reinterpreted the sequence inferring that the red till was not *in situ,* but had been transported by solifluction or a small landslide during the Loch Lomond Stadial. In support he cited the results of pollen analysis on the peat which showed similarities with Lateglacial Interstadial deposits elsewhere in Scotland, and he concluded that the peat had also been displaced by solifluction during the stadial. Subsequently, however, from the radiocarbon date and a re-evaluation of the pollen data, Donner (1979) revised his conclusions. He considered that the peat represented the remains of an organic deposit formed in a tundra environment of predominantly grassland communities, probably during the Early or Middle Devensian. It was then incorporated into the base of the red till during the Late Devensian glaciation in Strathmore. As noted by Edwards and Connell (1981), the discrepancy between the pollen records of Bremner (1943a) and Donner (1960, 1979) either casts doubts on the earlier identifications or suggests that peat of more than one age or environment was present.

Sutherland (1981a) presented a radically different interpretation of the shelly deposit at Burn of Benholm. He inferred that it was an *in situ* marine bed on the basis that it formed part of a suite of high-level marine shell beds buried by till and that its altitude conformed with a model that involved a marine transgression associated with depression of the Earth's crust as the last ice-sheet began to accumulate. Sutherland argued that this occurred during the Early Devensian rather than during the Late Devensian, as in more conventional interpretations (Sissons, 1976b).

The Burn of Benholm deposits therefore have a significant bearing on the interpretation of the Late Pleistocene history of eastern Scotland. In the conventional view the shelly deposit is a till and provides support for the onshore movement of ice, possibly deflected by the presence of Scandinavian ice in the North Sea during a glacial episode pre-dating the last ice-sheet. Although the presence of Scandinavian ice has also been held responsible for the movement of Strathmore ice north-eastwards along the east coast during the last glaciation (see Nigg Bay), recent evidence from the central North Sea (Sutherland, 1984a; Stoker *et al.,* 1985; Sejrup *et al.,* 1987) suggests this to have been unlikely. Hall and Connell (1991) have maintained the interpretation of the shelly deposit as a till, and proposed deposition by ice flowing from the east or south-east. This, they suggested, may have occurred during the Wolstonian' glaciation.

In the model of Sutherland (1981a), the shelly deposit at Burn of Benholm forms part of a network of *in situ,* high-level shell beds in Scotland (see Afton Lodge, Clava and Tangy Glen). Together these were considered to reflect ice-sheet growth and high relative sea level during the Early Devensian. However, correla tions with other high-level shell beds are, at present, conjectural; before either interpretation can be tested, several key questions remain to be answered. These concern first, the origin of the shelly deposit and whether it is a till, an *in situ* marine deposit, or possibly a glaciomarine deposit or an ice-rafted marine deposit; second, the age of the shelly deposit; and third, whether the shelly deposit and the overlying red till are broadly contemporaneous or separated by a significant time interval, possibly represented by the deposition of the peat. The deposits therefore have significant potential for detailed sedimentary and faunal studies. In addition, amino acid analyses of the shells should help to clarify the age of the shelly deposit and provide a firmer basis for any wider correlations. Reported results indicate isoleucine ratios of 0.36 from *Arctica* shells (Bowen, 1991). Therefore, according to Bowen (1991), if the shelly clay is glaciomarine in origin, then it dates from the time of deglaciation of the Anglian ice-sheet (Oxygen Isotope Stage 12). However, if the deposit is a till, then it is younger than Stage 11.

The peat at Burn of Benholm, although no longer exposed, is also significant in having provided a rare pollen record of interstadial environmental conditions during Early or Middle Devensian times. Middle Devensian pollen profiles are also recorded from Tolsta Head, Crossbrae, St Kilda, and possibly Teindland (see Lowe, 1984), but as yet the record of this time period in Scotland is highly fragmentary. The available radiocarbon dates suggest that the Burn of Benholm peat represents an earlier phase than the organic deposits at the other sites.

Conclusion

Burn of Benholm is notable for a sequence of deposits that provide important evidence for interpreting the glacial history of eastern Scotland. Of particular interest is a clay deposit, the origin and age of which are controversial. It contains shells of marine molluscs and may be an *in situ* marine deposit representing a high sea-level stand pre-dating the Late Devensian, possibly as old as 450,000 years, or it may be a deposit transported by ice from offshore, that is by the last or earlier ice-sheets. In either case it is a deposit of great interest for Quaternary studies. Also of note is an interstadial peat bed formerly exposed at the site. This provided a rare pollen record of environmental conditions during Early or Mid-Devensian times.

References