Carey

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Highlights

The deposits exposed in the river-bank section at Carey include a sequence of estuarine sediments and buried peat. They provide important evidence for changes in sea level and coastal environmental conditions in eastern Scotland during the Holocene. In particular, they allow a rare opportunity to study and date the Main Buried Shoreline.

Introduction

The site at Carey [NO 173 171] is an exposure on the south bank of the River Earn, 8 km south-east of Perth. It is important for the study of early and middle Holocene relative sea-level changes and associated environmental changes in an area affected by glacio-isostatic recovery. The stratigraphy of the estuarine sediments revealed in this and similar exposures nearby excited early scientific interest, the first clear descriptions being those of Taylor (1792) and Duncan (1794). The nature and scientific significance of the evidence revealed at Carey were discussed in a wider context by Buist (1841), Jamieson (1865) and Geikie (1881, 1894). The Carey site has figured prominently in morphological, stratigraphic and palaeobotanical studies by Cullingford (1972) and Cullingford *et al.* (1980), and is one of the few locations where the age of the Main Buried Shoreline has been determined by radiocarbon dating.

Description

Although in its broader Scots usage the term 'carse' denotes an alluvial flat or river floodplain, it has also long been applied more specifically to clay flat-lands composed of estuarine deposits. These carselands extend with impressive flatness over an area of about 18 km^2 in Lower Strathearn. They are backed by the Main Postglacial Shoreline, the local altitude of which is 9.8–10.2 m OD, and which has a radiocarbon age (determined elsewhere in eastern Scotland) in the range 6800–5700 BP (Cullingford *et al.,* 1991). The sinuous tidal portion of the River Earn crosses the carselands in a 6 m deep trench, in the cuffed walls of which are exposed the three main elements of the carseland stratigraphy (Cullingford *et al.,* 1980*,* 1989a):

4. Estuarine silty clay and clayey silt(carse)	>6.0 m
3. Terrestrial peat	0.59 m
2. Micaceous fine to medium sand (estuarine buried beach deposits)	0.9 m
1. Coarse sand with fine gravel	?

At the base of the succession is an unknown thickness of coarse sand with fine gravel (bed 1), of presumed fluvial origin, which can only be inspected at low tide. The sandy estuarine deposits (bed 2) consist of bedded, micaceous, fine to medium sand, coarser than the silty fine sand that typifies the buried estuarine materials in the area. The surface of these deposits has been shown to occur as a series of terraces, separated by bluffs, forming a series of buried beaches or estuarine flats. The base of each bluff represents a buried raised shoreline. The surface of the sands at Carey lies at an altitude of 3.2 m OD and the site is located close to a buried shoreline at that altitude. No faunal remains have been found in these deposits at Carey or elsewhere in Lower Strathearn.

The sub-carse peat (bed 3) consists of sedges and grasses, with occasional mosses and abundant woody remains. Macroscopic remains of non-arboreal plants include stems, leaves, roots, and seeds of various marsh and heath plants, including *Carex, Sarothamnus* and *Equisetum.* Macroscopic remains of arboreal plants include bark, leaves, fruit, roots, branches, and trunks of *Alnus, Corylus, Betula, Pinus, Salix* and *Quercus,* the first three being of most common occurrence, and the last rarest. The peat is highly compressed, as shown by its toughness and by the oval cross-sections of flat-lying branches and twigs, and it 'readily splits into laminae, on the surface of which many small seeds ... appear, together with occasional wing cases of beetles' (Geikie, 1894, p. 292). The transition with the overlying carse deposits is gradual, the top few centimetres of peat being silty, and the basal 0.3–0.5 m of silts and clays being heavily charged with both horizontal black streaks of vegetal material and plant stems passing vertically upwards from the peat. The base of the peat is more sharply defined, but roots penetrate from it into the sands below. The thin (0.005–0.05 m) iron pan between the peat and underlying sands is a highly localized consequence of concentrated groundwater flow in the immediate vicinity of the river cliff, for more than 250 boreholes sunk throughout the Lower Strathearn carselands show it to be generally absent. Cullingford *et al.* (1980) obtained radiocarbon dates from the top and bottom of the peat bed (Table 15.1).

(Table 15.1) Radiocarbon dates on the buried peat layer at Carey

Sample	Altitude OD (m)	Date (^{14}C years BP)	Laboratory number
Bottom 0.01 m of peat	3.19	9640 ± 140	I–2796
Bottom 0.04 m of peat	3.19	9524 ± 67	SRR–72
Top 0.01 m of peat	3.78	7605 ± 180	NPL–127
Top 0.04 m of peat	3.78	7778 ± 55	SRR–71

The estuarine clays (bed 4) are bluish-grey when freshly dug, but quickly turn brown on exposure to the air. There is, in general, no distinct stratification, and stones are absent except occasionally near the rising ground at the edge of the carselands. There are occasional thin layers and lenses of sand. Plant remains, chiefly of reeds, are common throughout the deposit and are often fetid. No shells of estuarine molluscs have been recorded in the carse deposits of Lower Strathearn, though they occur in the Carse of Gowrie, where a sparse estuarine microfauna has also been identified (Paterson *et al.,* 1981).

Detailed pollen and diatom analyses have been carried out at Carey by P. Gotts (unpublished data). The pollen record established by analysis of samples at 0.01–0.02 m intervals throughout the peat and the upper 0.07 m and lower 0.06 m of underlying and overlying estuarine sediments predominantly reflects local vegetation changes, but does also have regional indicators. High values for Gramineae occur in the lower peat coincident with the macroscopic remains of *Phragmites,* accompanied by even higher values for Cyperaceae, thus representing a typical reed-swamp environment. Grass pollen is dominant throughout most of the peat, with very few other herb taxa represented. At the lower transition there are continuous curves for Cruciferae and *Filipendula* and occasional grains of aquatics, such as *Alisma, Lemna* and *Equisetum,* but very little unequivocal evidence of vegetation succession from saltwater to freshwater environments. At the upper transition to the carse silts and clays there is more evidence for the rising water table with a peak for *Typha latifolia,* but overall there is the same lack of variety in taxa indicative of changing hydroseral communities. At the peatl sand transition, dated to 9640 ± 140 BP (1–2796), there is a peak in *Betula,* with continuous curves for *Juniperus* and *Salix.* This slightly late date for the presence of juniper suggests that in the birch woodland which characterized eastern Scotland in the early Holocene, juniper was able to survive in marginal environments, as at Carey. With the immigration of hazel, demonstrated in almost all pollen diagrams in Scotland as a significant rise in *Corylus/Myrica* pollen, juniper disappears. This is dated to 8740 ± 55 BP (SRR–1392), which agrees well with other dates for this event (Huntley and Birks, 1983). Locally, close to the peat, hazel would have taken advantage of the marginal drier environment, with the occasional presence of birch and *Salix* on the slightly wetter margins. Elements of mixed oak forest are only represented to any extent in the peat/silt-clay transition and in the carse clay itself. It seems likely that oak woodland would have been present in Strathearn before 7600 BP, and the pollen record probably represents the local exclusion of pollen of mixed oak forest provenance by the surrounding hazel. With the change in sedimentary environment this pollen was then brought to Carey in the estuarine clays.

The diatom assemblage of the basal 0.12 m of carse clays and silts is dominated by several species of *Fragilaria,* averaging over 70% of the total count (1000 valves). Diatoms are abundant only within and above the peat/silt-clay transition, and the micaceous sand deposits contain only small numbers, which include both marine and brackish-water taxa.

Interpretation

It may be inferred from the sedimentary and palaeobotanical information above that the abandonment of the buried beach deposits by the sea was followed without a significant break by the colonization of their surface by terrestrial vegetation, which eventually took the form of a peat bog. The top of the peat in turn represents a former land surface that was gradually inundated by rising estuarine waters in which the silt and clay deposits accumulated.

The base of the peat (altitude 3.2 m OD) at two locations along the Carey exposure has been radiocarbon dated at 9640 ± 140 BP (I–2796) and 9524 ± 67 BP (SRR–72) (Cullingford *et al.,* 1980), giving the approximate date of initiation of peat growth following the withdrawal of the sea. As the Carey exposure is located close to the buried shoreline (altitude 3.2 m OD), the radiocarbon dates must relate closely to the abandonment of the latter. The buried shoreline is believed to correlate with the Main Buried Shoreline of the Forth Valley, which has been similarly dated at about 9600 BP (Sissons, 1983a). The top of the peat at Carey (present altitude 3.8 m OD) gave radiocarbon ages of 7605 ± 180 BP (NPL–127) and 7778 ± 55 BP (SRR–71), dating the onset of peat burial beneath the silt and clay. Use of peat-top dates in constructing a relative sea-level curve requires account to be taken of the peat compaction that accompanied and followed burial by the carse deposits, and a method for estimating compaction was employed at Carey and other sites in Lower Strathearn (Cullingford *et al.,* 1980).

A recently published account of a site nearby at Wester Rhynd (Cullingford *et al.,* 1989a) has further enhanced the importance of Lower Strathearn for sea-level studies in eastern Scotland. The results have suggested 8765 ± 75 BP (GU–1250) as an approximate date for the abandonment of the local equivalent of the Low Buried Beach of the Forth Valley, and have also demonstrated the presence of two brief marine incursions shortly after 8565 + 85 BP (GU–1518) and between 8485 ± 80 BP (GU–1517) and 8510 ± 85 BP (GU–1516), which are consistent with storm surge or tsunami events (Cullingford *et al.,* 1989a). The latter are earlier than the widely recognized event at about 7000 BP in eastern Scotland (Smith *et al.,* 1985a; Dawson *et al.,* 1988; Haggart, 1988b; Long *et al.,* 1989a) and raise the possibility that the record of high-magnitude events is more detailed than previously recognized. Dawson *et al.* (1989) suggested that the 7000 BP event might be represented by a layer of fine silty sand at the base of the carse deposits at Wester Rhynd, but Cullingford *et al.* (1989b) argued that this layer was of very limited extent and that the 7000 BP event might be represented by a sand layer higher in the carse deposits in the Carse of Gowrie on the north side of the Tay Estuary. Further work in Lower Strathearn and the Carse of Gowrie should help to clarify the sequence and depositional environments of these high-magnitude events.

Lower Strathearn is important for studies of relative sea-level change in eastern Scotland, and evidence from the area, including Carey, has allowed the construction of relative sea-level and uplift curves for the Lateglacial and early Holocene (Cullingford *et al.,* 1980; Paterson *et al.,* 1981).

A Lateglacial and early Holocene phase of generally falling relative sea level was punctuated by stillstands and/or transgressive episodes resulting in the formation of now buried estuarine flats (buried beaches) in descending order of age and altitude, the abandonment of the flats being followed by the growth of vegetation, including peat. Later, relative sea level rose again, causing the progressive burial of successive peat-covered flats by the carse deposits, and culminating in the formation of the extensive carseland surface visible today (see also Western Forth Valley). The Carey exposure has afforded vital evidence in dating and elucidating the nature of the environmental changes that accompanied these relative sea-level changes, and is still the only known site in eastern Scotland where exposure of the peat-covered Main Buried Beach deposits occurs close to the former shoreline, allowing accurate dating of the latter. With its thick sub-carse peat and clearly displayed sequence, the Carey site is of great value for demonstration purposes, and it is likely that, with improved analytical techniques in the future, it will have an important research role to play in the further study of Holocene relative sea-level changes.

Conclusion

The sediments at Carey provide important evidence for interpreting the sequence of sea-level changes that occurred during Holocene times (the last 10,000 years) in eastern Scotland. In particular, it allows a rare opportunity for dating the early Holocene Main Buried Shoreline (about 9600 years ago). In addition, subsequent changes in the coastal environment during the middle Holocene have been revealed by detailed pollen, diatom and sediment analyses. Carey is therefore an integral component of the network of reference sites for sea-level history.

References

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