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THE STRATIGRAPHY OF THE INTERTIDAL ZONE, TAY ESTUARY, EAST COAST, SCOTLAND

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ABSTRACT

The evidence gathered in this study deals with the surface and sub-surface deposits of the intertidal zone of the upper Tay estuary, Scotland. The intertidal zone deposits of salt marshes, upper mud flats and lower sand flats were excavated and vertical sections upto 50 cm deep examined. The data collected in the field were interpreted by plotting on sediment section logs. A model cross section constructed along the survey line in conjunction with characteristic features of each sub-zone deposit indicates that the salt marsh deposits overlie the upper mud flat deposits and the mud flats themselves overlie the lower sand flat deposits. This may be of use in the recognition of fossil estuarine intertidal deposits.

INTRODUCTION

The intertidal zone of the Tay extends from + 2.5 meters above Ordinance Datum (O.D.) to approximately –3 meters below O.D. (Fig. 1). The width of intertidal zone increases from 200 meters near the Railway Bridge at Dundee to 4 km opposite Birkhill House before reducing to 2–5 km at Powgavie and 1 km at Port Allen. The surface of the intertidal zone is characteristically planar or very gently sloping. The highest part of the intertidal zone is formed by reed marshes and is followed at progressively lower levels by upper mud flats and lower sand flats (Fig. 2). The intertidal zone has been subdivided into three subenvironments (i.e. from high water mark to low water mark these are (i) salt marshes, (ii) upper mud flats, and (iii) lower sand flats).

Technique used

A vertical section upto 50 cm deep and 90 cm wide was excavated with a spade and smoothed with a trovel. The sediment of the principal sub-zones was characterised according to Shepards (1954) classification, i.e.

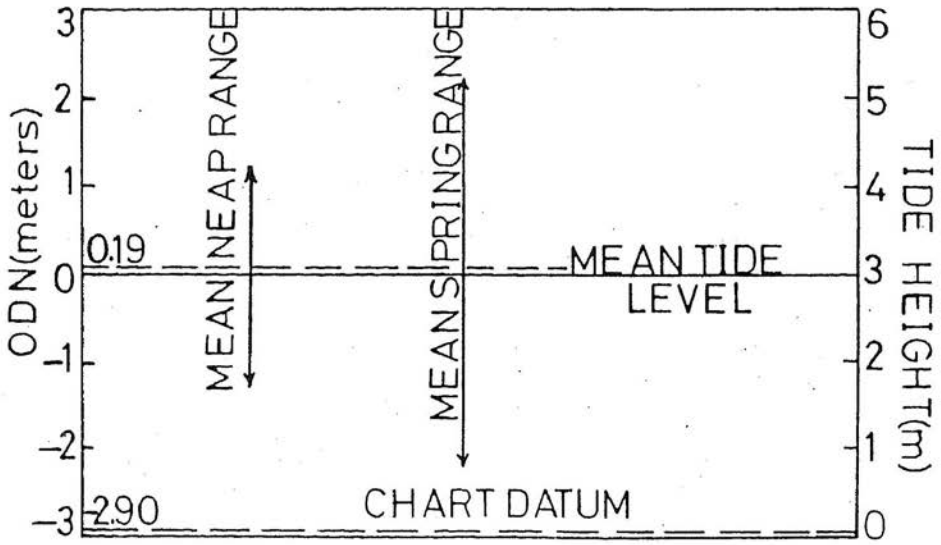

Figure 1. The relationships of tide heights to Ordnance Datum in the upper Tay estuary.

a) Grain size (sand; muddy sand; sandy mud; and mud)

b) The percentage of shell and shell fragments

c) The sorting (poorly sorted — mixture of shells, sand, and mud; moderately sorted — 50% of the sample consists of one material; well sorted — 75% of the sample consists of one material)

d) The occurrence and type of bedding, lamination, cross-lamination, rippling — small and large and the density and type of bioturbation.

THE RESULTS OF EXCAVATION

The sediment logs given in Fig. 3–7 were obtained from sites indicated along a cross section of the intertidal zone in Fig. 8.

The Salt Marsh Deposits

The salt marsh deposits are densely bioturbated by the abundant root systems and consist principally of plant debris. Some 5 per cent of the total bioturbation is caused by *Nereis,* where the sediment has significant very fine sand and silt, the salt marsh deposits show no specific sedimentary features and at most sites finely laminated sediment are bioturbated by root systems (Alizai and McManus, 1980).

The salt marsh deposits which occupy the area between Kingoodie and Cairnie and at Invergowrie, overlie the upper mud flat deposits at or above

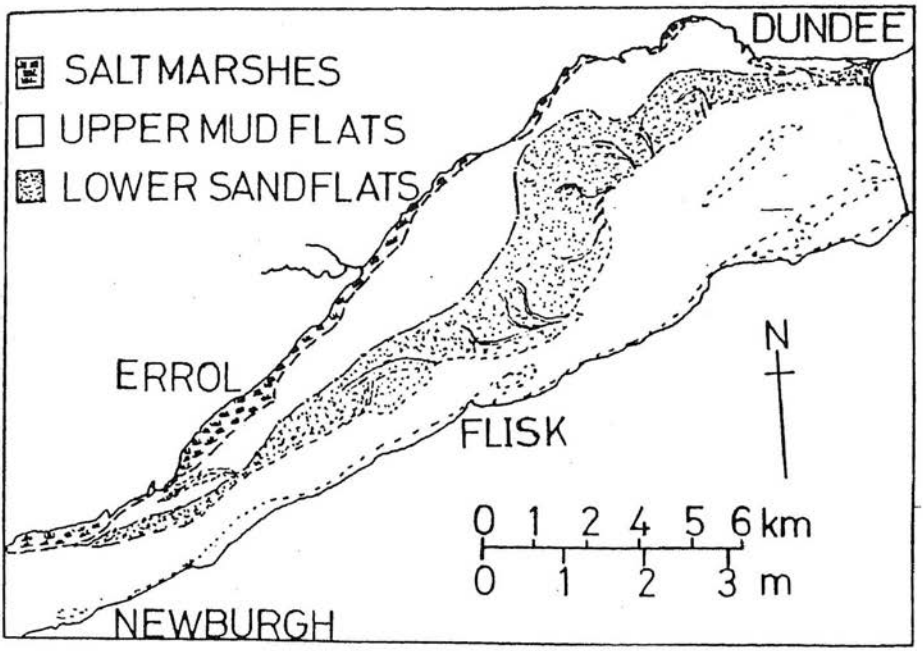

Figure 2. The intertidal zone of upper Tay estuary.

+ 1.5 to 2.0 m O.D. Excavations at Kingoodie (Fig. 5) revealed that at a depth of 20–30 cm, the deposit of salt marsh grades into underlying mud flat deposits. As the marshes are the sites of present day siltation and occur only above a fixed level (Buller and McManus, 1975), it is to be expected that their deposits would thicken landwards. This did not occur in the sections and beyond a rapid thickening in the marsh margin area the thickness of plant rich material remained virtually constant across the marsh. The constancy of thickness (20–35 cm) probably results from the rapid decrease of accretion rates away from the marsh margin (Alizai, 1980) and from slow compression with drying further landwards.

Below the marsh unit, the sediments pass into muddy sand which revealed a layer of plant debris or peat 5–10 cm thick composed of leaves and reeds possibly formed in front of the former marsh margin (McManus and Alizai, 1983).

The Upper Mud Flat Deposits

The deposits of the upper mud flat consist of 30–40 cm of muddy sand or sandy muds which are well stratified and characterised by the abundance of bioturbation, shell concentrations, and muddy lamination. In the outer part they consist of alternate muddy and sandy laminations and sandy lenses, which increase towards the base of the unit. Landwards the muddy laminations are abundant and sandy laminations less common so that the deposits consist largely of thick frequent muddy laminae interspersed with a few thin sandy laminations. The common surface erosional features of the muddy deposits have not been recognised preserved in the deposits.

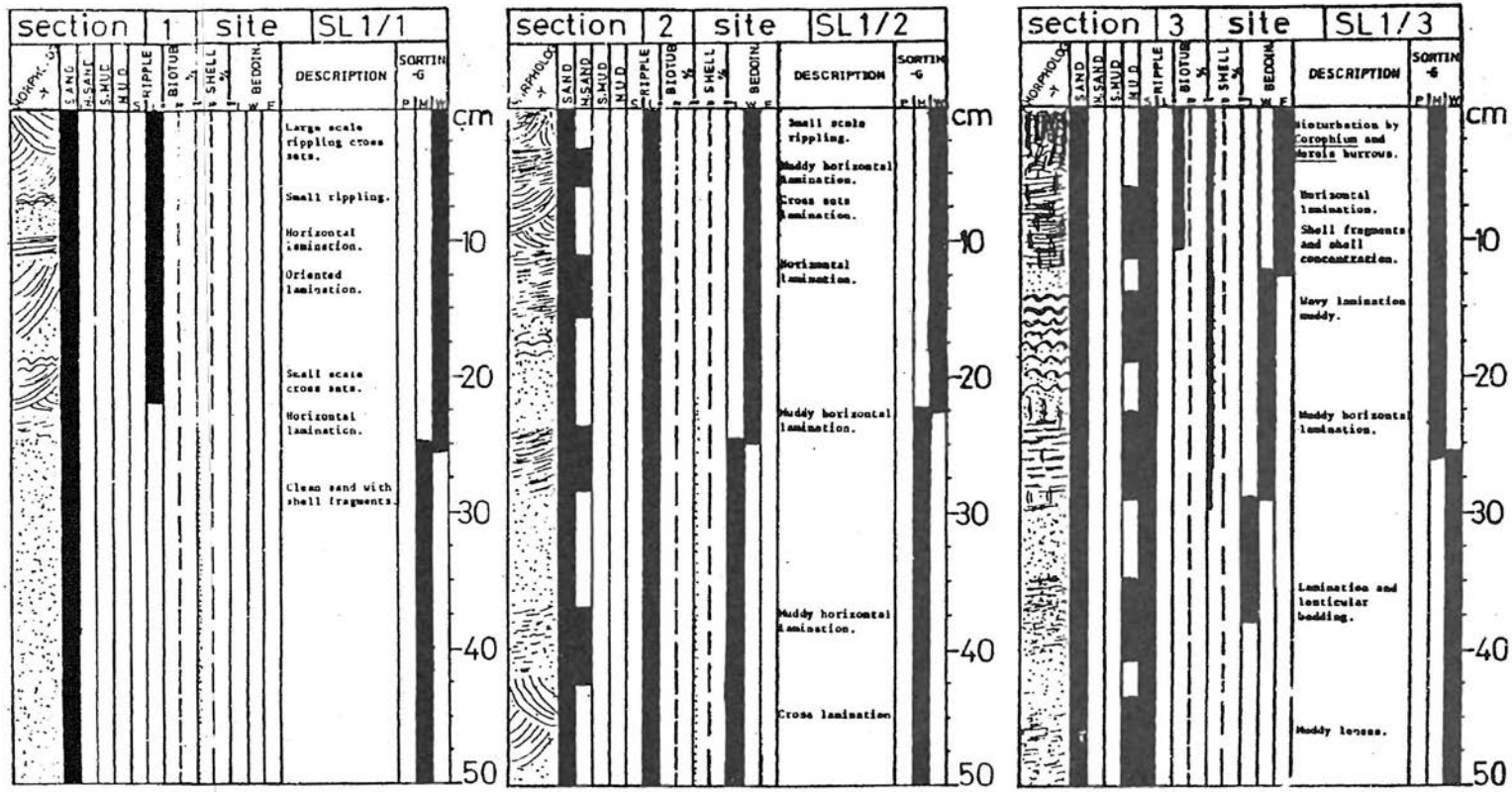

Figure 3. Section logs of sediment sections (50 cm thick) excavated along survey line 1.

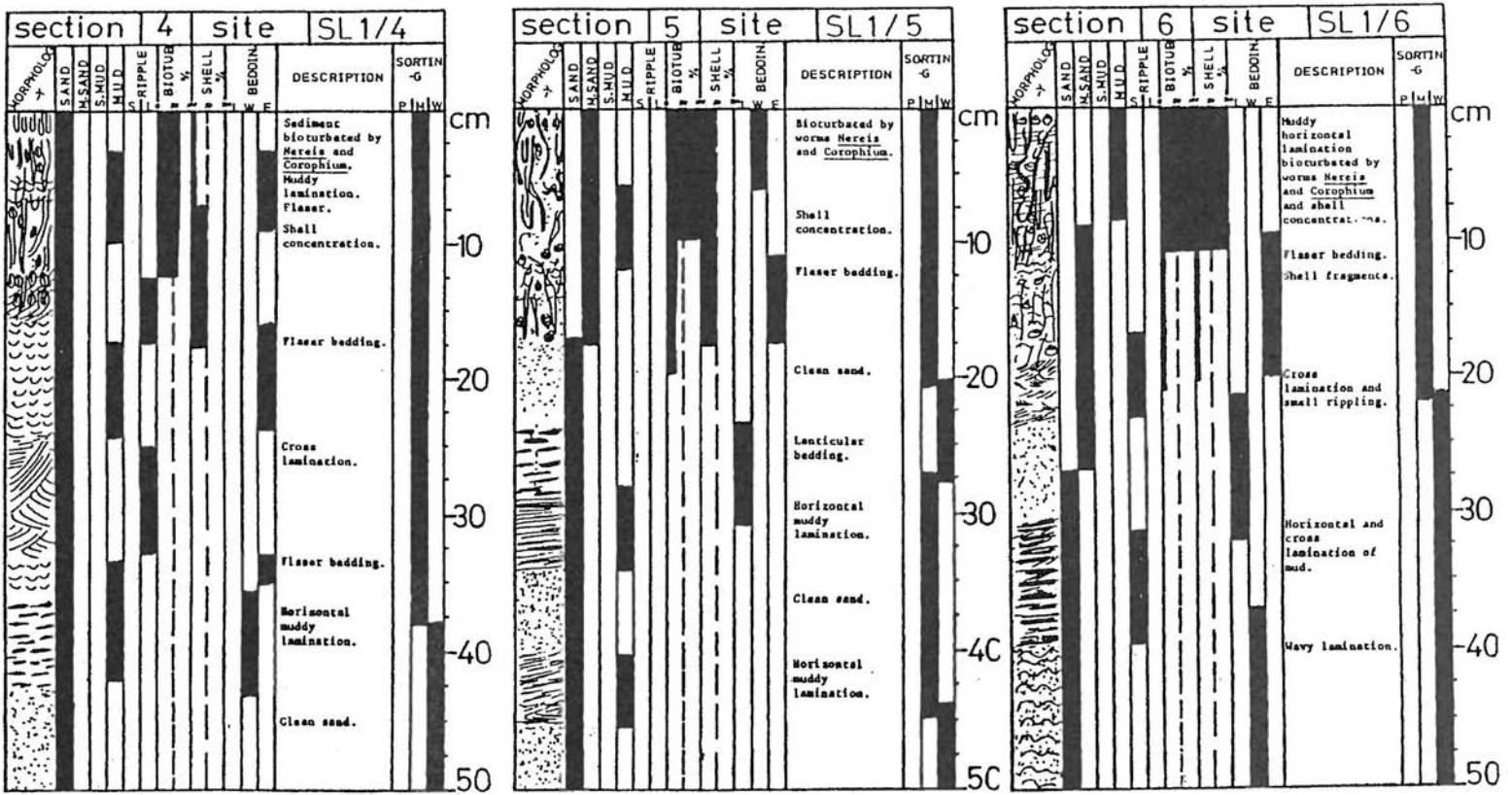

Figure 4. Section logs of sediment sections (50 cm thick) excavated along survey line 1.

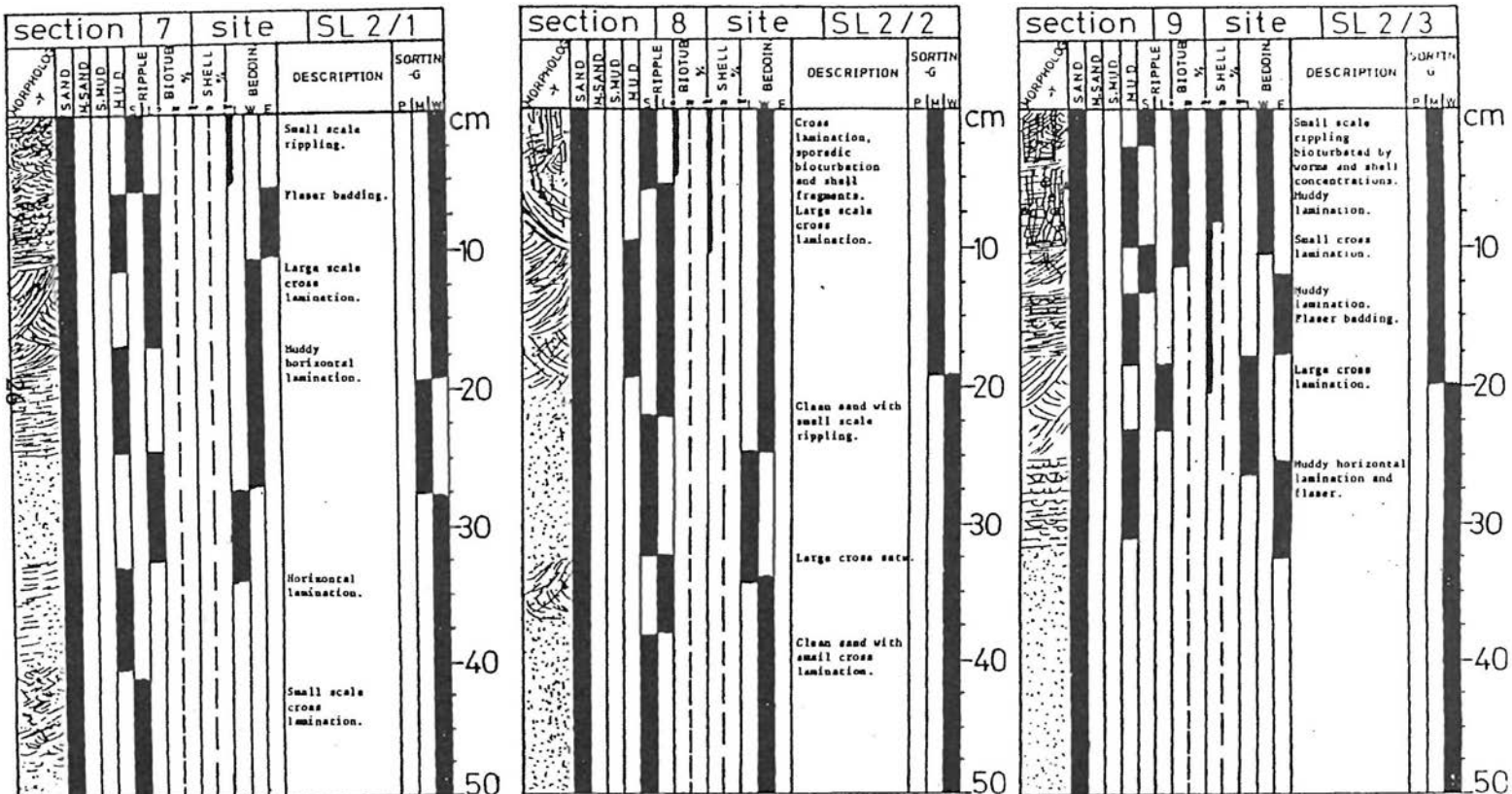

Figure 5. Section logs of sediment sections (50 cm thick) excavated along survey line 2.

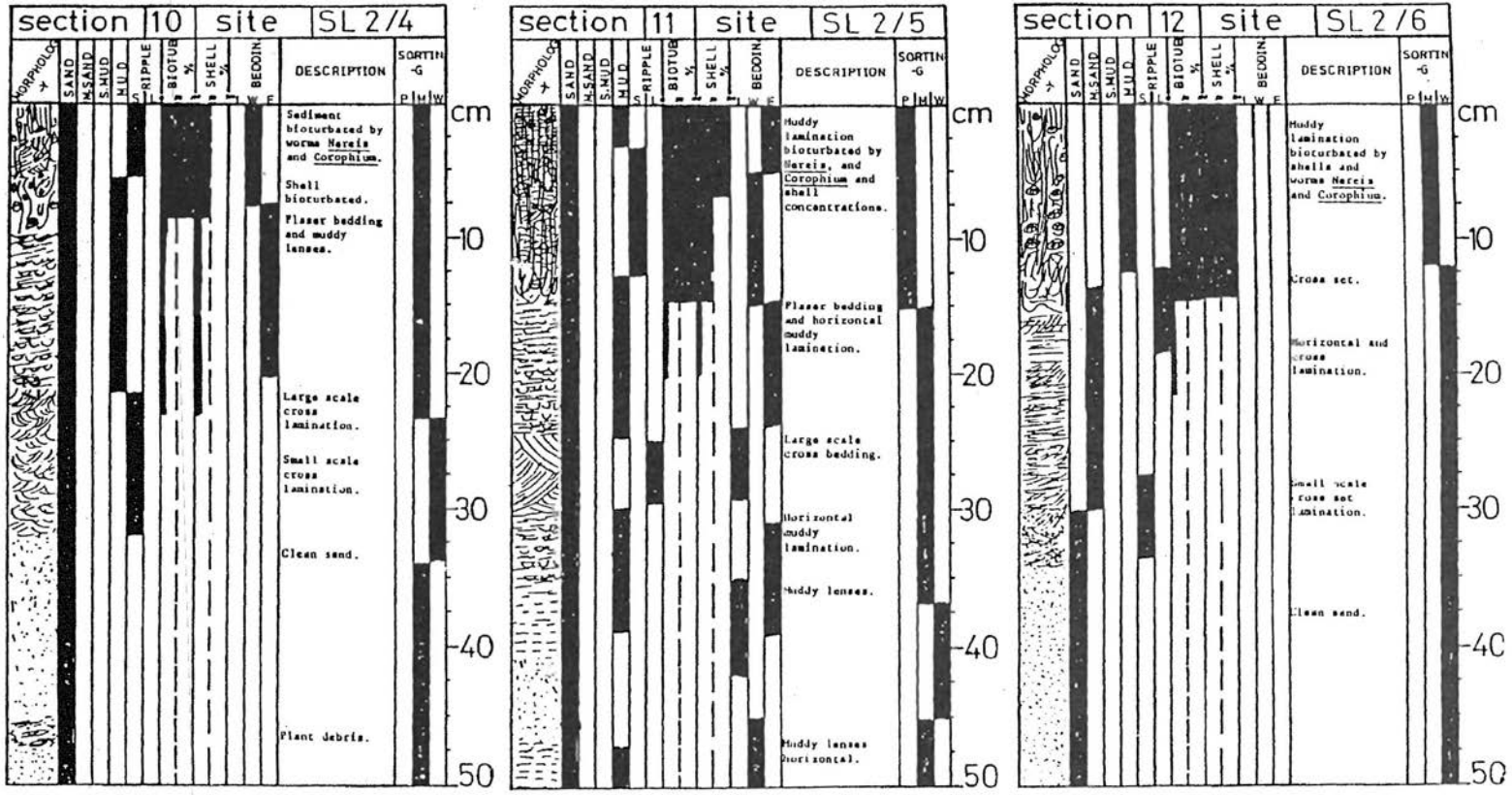

Figure 6. Section logs of sediment sections (50 cm thick) excavated along survey line 2.

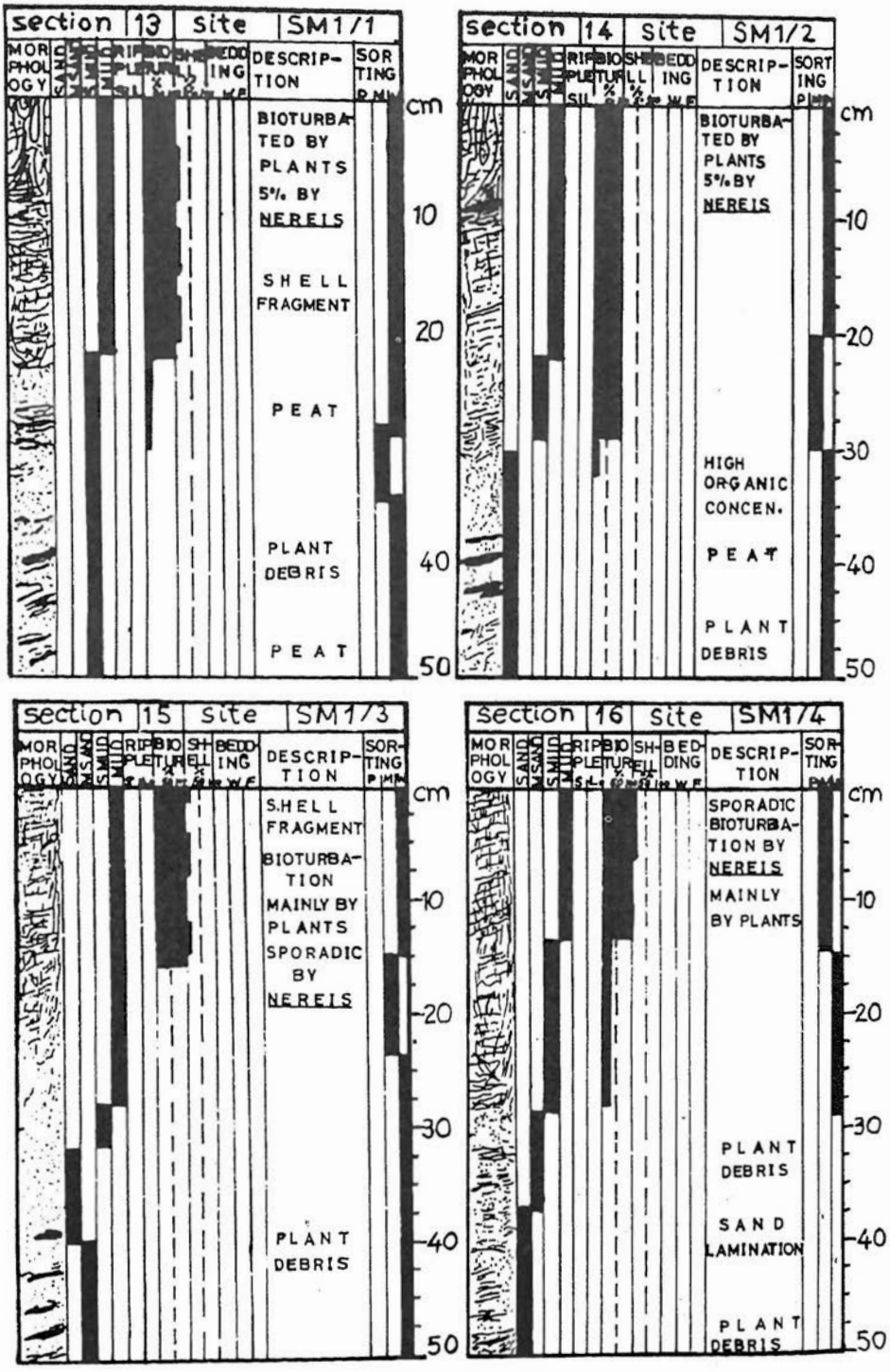

Figure 7. Section logs of sediment sections (50 cm thick) excavated along the salt marsh survey line.

Extension of the upper mud flat deposits seawards has been observed as washout mud structures on the lower sand flats (Alizai, 1980). The layers of upper mud flat deposits grade downwards into the underlying sand deposits. The greatest thickness of these deposits penetrated was 40 cm but the thickness decreases channelwards.

The Lower Sand Flat Deposits

The deposit is recognised by well stratified sandy or muddy sand sediments. The sediment is bioturbated by Arencola in the lower zone and in the upper zone by *Nereis* and *Corophium*. The deposits have abundant large scale rippling in the outer zone while the inner zone consists of small scale rippling, cross sets and shell fragments. They usually contain fewer muddy laminae but sometimes show quite large amounts of muddy lamination and flaser bedding. The characteristic feature of these deposits is the abundant burrowing activity particularly by *Corophium* in the upper part where densities of up to 6000 m^2 were observed (Alizai, 1980). Beds of molluscs shells in the growth positions are found in this deposit.

Although nowhere was the complete succession from the lower sand flat deposits to salt marsh deposits seen in the field, sufficient parts of this record are present to permit a reconstruction to be made (Fig. 8).

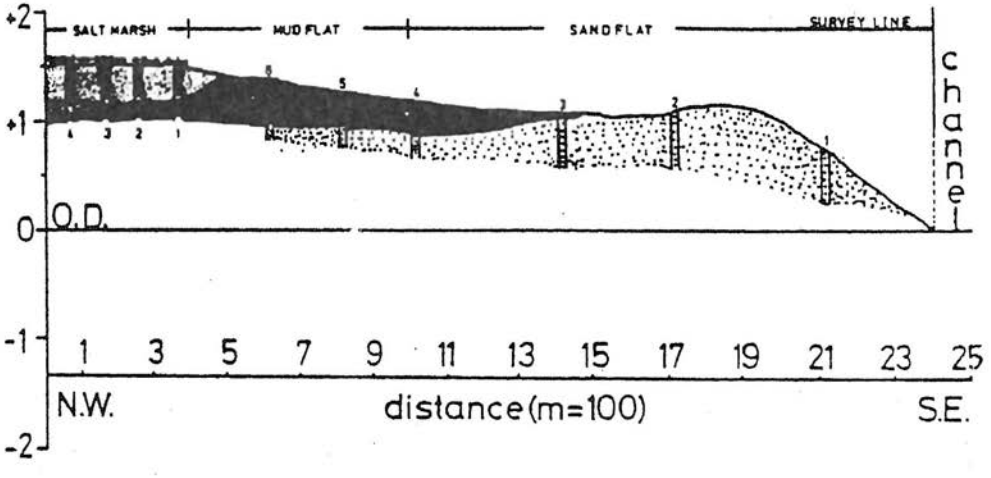

Figure 8. The cross-section of survey line showing the stratigraphy of the three sub zones and location of the excavated sections.

Historical evidence given by McManus (1970) suggested that the intertidal zone has advanced seaward in most places. The comparison of the 1833 charts of the area with modern charts shows that although the submerged sections may have deepened since 1833, there has been general build-up above low

water mark. The actual area above low water mark has increased only slightly on some places and the effect has been of a building up rather than building out (Fig. 9 modified after McManus, 1978).

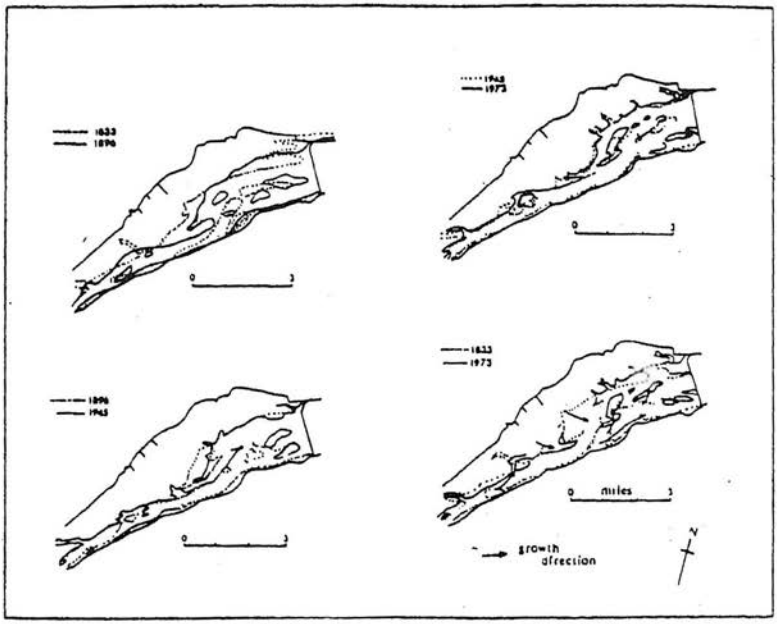

Figure 9. Progressive growth of the intertidal zone between 1833 and 1973. Three comparator charts of low water mark enable progressive change to be identified and the synoptic growth pattern is indicated (after McManus, 1978).

CONCLUSION

Nowhere was a complete sequence from lower intertidal deposits to the saltmarsh deposits seen in a single 50 cm deep section in the field. Excavation of these deposits showed that salt marsh deposits formed only a thin 20–25 cm layer which overlay the deposits of the upper mud flat zone (30–40 cm thick). This indicated that salt marshes have grown rapidly seawards over the deposits of the adjacent mud flats. At their base these later deposits grade into the underlying sand flat deposits. The upper mudflat and lower sand flat deposits appear to have a regular landward dip. The phase of growth of the upper flat deposits depends on the supply of material height of the zone above O.D., and rate of salt marsh siltation.

The study has been limited essentially to the surface sediment and near surface sediments but by synthesizing the evidence gathered by this study, an attempt has been made to discuss the aspects of the intertidal deposits. The evidence is conjectural and much more evidence is needed before a complete sequence of deposits can be established. A more extensive boring program

would be needed before valid comparison could be made between the intertidal sequence found in the Tay estuary and sequences preserved geologically.

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