Sandy Bay

[NZ 305 860]

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Introduction

The Devensian glacial landforms along the Northumberland coastal plain are predominantly of subglacial origin (Eyles and Sladen, 1981; Eyles *et al.,* 1982; Douglas, 1991) and there is a low-relief, extensive, drumlinized till plain extending inland from the North Sea coast at heights below 100 m OD. This plain is defined to the west of Morpeth by emerging streamlined rock highs and the rivers Tyne and Aln to the south and north. This drumlinized topography comprises the Acklington Formation (Thomas, 1999). It is composed of glaciotectonic and rafted bedrock overlain by cross-cutting lodgement till units, within and between which occur sub-glacially channelled gravels, sands and silts deposited in a single phase of subglacial deposition. It has been modified extensively by periglacial slope processes (Anson and Sharp, 1960) and overlies a dissected rockhead surface. Carruthers (1947, 1953) considered that the glacial sediments in this area were the result of the undermelt of a single, stratified ice sheet. Later workers recognized a tripartite stratigraphy composed of a lower, blue grey till (the Lower Boulder Clay) and an upper brown till (the Upper Boulder Clay), separated in many areas by a middle unit of gravel, sand and/or laminated clay. The entire sequence was thought to be produced by two separate glacial phases (Raistrick, 1931b; Taylor *et al.,* 1971) but with no clear evidence of either interglacial or interstadial status for the intervening glaciofluvial sediments (Woolacott, 1921).

Sandy Bay [NZ 305 860] is one of the longest and best-exposed till sections on the Northumberland coast and is situated between Spital Burn and the River Wansbeck, south of Newbiggin-by-the-Sea. It comprises a 1.8 km coastal strip of foreshore and cliff section and forms part of the Cresswell and Newbiggin Shores SSSI. The site has been used to suggest that the till originated by the lodgement process, whereby deposition occurred by continued accretionary lodging and local, pressure melt-out of dispersed englacial debris particles, or aggregated debris masses, which were being transported along flow lines at the ice–bed interface (Eyles *et al.,* 1982). The model for deposition also has been simplified to suggest deposition from one glacial phase, with the upper brown or reddened tills a result of post-glacial weathering (Eyles and Sladen, 1981; Douglas, 1991).

Description

The glacial till is best exposed between the middle and southern part of the site and the stratigraphy described by Bullerwell (1910) included a basal, coarse gravel, up to 6 m thick, which thinned to the south ((Figure 5.37) and (Figure 5.38)). The grain size of this deposit varied between pebble and boulder gravel with patches of finer gravel and coarse sand. It contained Cheviot rocks, granite, Carboniferous Limestone, gneissose and schistose rocks and flints, with one shell fragment noted. It was thought to be a fragment of a pre-till beach, eroded away since the original description. It has been suggested as a possible Ipswichian beach (Lunn, 1995). The overlying till is up to 4 m thick and rests in part on rockhead. This rockhead consists of either striated surfaces of Carboniferous sandstone, or of fragmentary and glaciotectonized masses of sandstone, shale, coal or mudstone that have been attenuated by glacial shear as a deformed local facies of the till. Sandstone rafts have been transported to the south over tectonized shale and mudstones that underlie the till. The clay fraction of the till in north-east England is derived almost entirely from such sources (Beaumont, 1972; Tarbet, 1973). Local sandstones predominate in the till units immediately above rockhead, with sheared out stringers and smudges of shale and coal. Farther travelled erratics from the Southern Uplands and Cheviot Hills are found higher up the sections. However, there are no major lithological differences between individual till units at this location, except that the carbonate lithologies are under-represented in the upper part of the sections as a result of post-glacial weathering (Eyles and Sladen, 1981; Eyles *et al.,* 1982). The general characteristics of the till in coastal Northumberland are summarized in (Figure 5.39).

Major sub-horizontal, undulatory bedding planes divide the till stratigraphy into several distinct lensoid till units. These bedding planes are erosional disconformities and affect both the till units and the channelled glaciofluvial sediments. Erosional interfaces define multiple till units over much of the exposed section, but these are not laterally continuous and fade out within a single thick till. The till units show a matrix colour that is uniform grey at depth but which becomes reddish-brown in the upper part of the section. Striated limestone clasts are common in the lower part of this grey till. Part of the exposed section is illustrated in (Figure 5.40), but the section continues to the south for 500 m as a single massive till. Towards the southern end of the section there is sometimes a purple till between the grey and the reddish brown till, with a merging boundary between the units. Glaciofluvial lenses in the till sequences frequently define the base of the reddened upper till from the lower grey till below. There has been much debate as to the glacial, interglacial or interstadial status of the interbeds (Woolacott, 1921; Raistrick, 1931b; Taylor *et al.,* 1971; Land, 1974; Lunn, 1980). These glaciofluvial sediments are in two forms:

1. shoestring channel fills orientated sub-parallel to the regional direction of ice movement, where the channel bases are choked with dirty, matrix-supported gravels, lag boulders and commonly armoured till balls overlain invariably by massive, plane-bedded or ripple cross-laminated sand units or massive, irregularly laminated clays, with frequent clusters or clots of till-like debris embedded throughout;
2. units of variable geometry and restricted size from thin, under 5-cm-thick, sub-horizontal sand partings to contorted, highly deformed and attenuated masses of dirty gravels and sands, which lack any lateral connectivity.

The tills at Sandy Bay show prominent sub-horizontal bedding plane shears and well-developed vertical joint sets. The sandstone and Whin Sill dolerite boulders within the red-brown till show a weathering rind and commonly are completely rotten. Gleyed, prismatic desiccation joints disrupt the surface of the upper red till to a depth of 1.5 m and this typically forms the Prismatic Clay or Prismatic Boulder Clay of north-east England. This upper unit is decalcified, for example the $CaCO_3$ contents for this location are given in (Figure 5.41), where it can be seen that below 2 m the level of $CaCO_3$ is constant. This is thought to be the primary carbonate content of the till. Above 2 m this content decreases to close to zero near ground level and clearly indicates leaching of the primary carbonate.

Interpretation

The basal gravels are likely to be either a last interglacial beach (Bullerwell, 1910; Lunn, 1995) or Devensian, glaciofluvial, probably pro-glacial or conceivably subglacial gravels. The till sequence at Sandy Bay is thought to result from a single complex episode of wet-based, sub-glacial sedimentation (Eyles *et al.,* 1982) as accretionary lodgement of debris took place. The shoestring channels also appear to have also been cut subglacially into the till bed, with irregular debris masses, from the glacier sole, dropping from the roof into the subglacial channel. Variable palaeodischarges are indicated by clays, which indicate ponding episodes, possibly the closure of the channel downstream by ice flow, or by deformation of the till bed (Eyles *et al.,* 1982). Thin, sub-horizontal sand partings are comparable to those reported by Menzies (1979b), which result from the release of water during local melt-out accompanying the lodgement process (Rose, 1974). Subglacial streams of restricted discharge are indicated by the intra-till channel fills, and these, coupled with the dense network of subglacial meltwater channels eroded into the rockhead on the flanks of the Cheviot Massif (e.g. Clapperton, 1971a, b), below the till plain (Anson and Sharp, 1960) and on the floor of the adjacent North Sea (Dingle, 1971) are evidence that these channel fills are part of an integrated and widespread subglacial network draining a wet-based ice sheet.

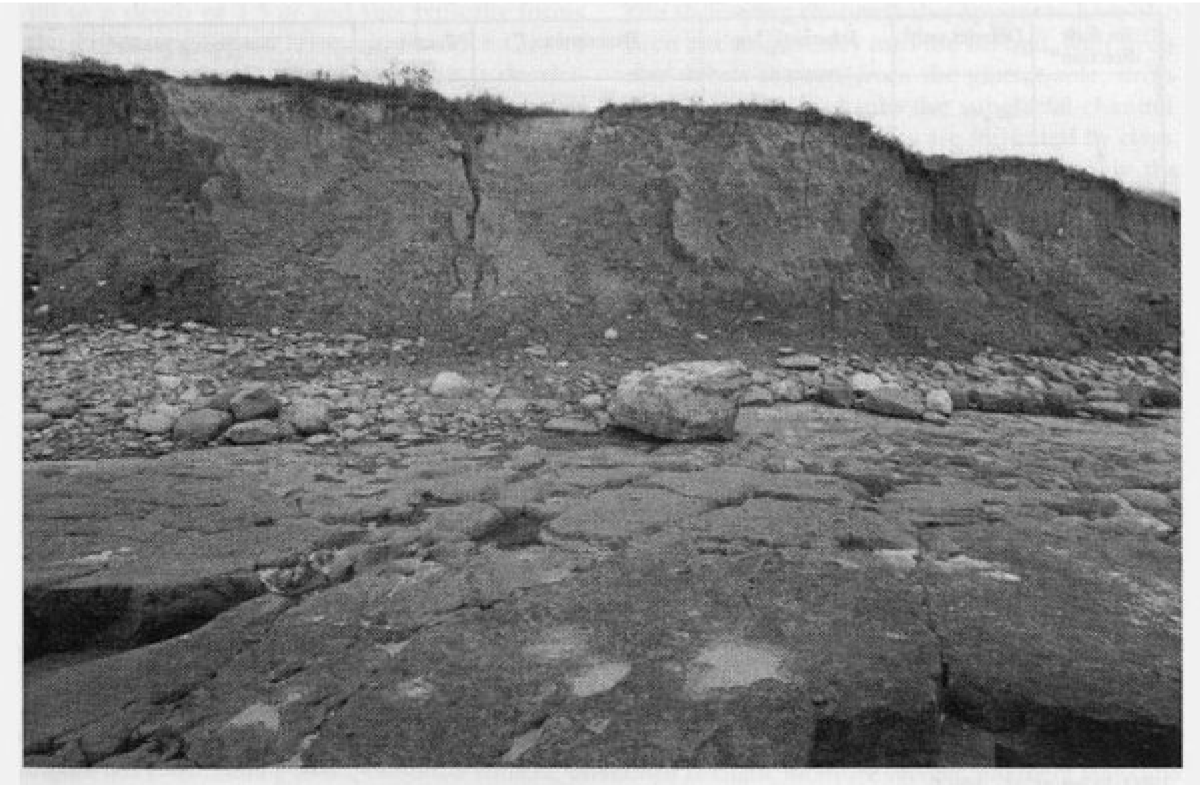
The reddened colour of the uppermost till unit and the presence of glaciofluvial interbeds has prompted the use of a tripartite glacial stratigraphy for Northumberland comprising lower grey tills, middle sands, gravels and clays and upper reddened tills (Mitchell *et al.,* 1973). However, Eyles and Sladen (1981) have demonstrated that along the coast the reddened colour of the uppermost till units is the result of post-glacial weathering, the depth and definition of which is directly related to the presence of glaciofluvial interbeds. The latter act to underdrain the overlying till units, which become fractured by desiccation, and the high bulk permeability thereby generated accelerates weathering processes. This is seen as a reddened, oxidized till, separated from the grey, unoxidized till below by the glaciofluvial interbeds. Along the Northumberland coast at those sites where till depths are under 4 m (e.g. Church Point, Newbiggin, to the north of Sandy Bay) a single reddened and clay-rich 'upper' till has been mapped in the past (e.g. Carruthers *et al.,* 1927). Significantly 'lower' grey tills have never been recorded at the surface. Land (1974) also pointed out that the distinction between the two tills in the field is vague unless separated by glaciofluvial sediments. The origin of the deep weathering that has affected these tills is oxidation of disseminated pyrite, primarily by soil bacteria, with sulphuric acid as a by-product (Madgett and Catt, 1978). This provides the initial acidic conditions for the subsequent solution of soil carbonate and deep weathering of the till sequences, which in Northumberland is the result partly of glacial quarrying of the sulphide-containing, Upper Carboniferous lithologies and partly it is climatically controlled because deep weathering has been reported where the annual precipitation is under 75 cm and where a large summer soil moisture deficit occurs (over 100 mm). As a result, the surface till is subject to seasonal cracking and the prismatic jointing is observed above 1.5 m depth so promoting deep oxidation of finely disseminated sulphides.

Other effects of weathering on the geotechnical properties of the till have been discussed by Eyles and Sladen (1981). They include a weathering scheme or zonation from I, unweathered till, to IV, highly weathered tills. The unweathered tills are separated from those in zone III–IV on particle size distribution, as disintegration of larger particles takes place and there is an increase in the clay and silt content; there is an increase in the natural moisture contents, increased plasticity, increased drained brittleness and a reduction in the undisturbed, undrained shear strength (Figure 5.41), although at a given moisture content the shear strength is higher for weathered till. There are also good examples of weathered Carboniferous Sandstone bedrock occurring in the cliffs to the north of the till section in Sandy Bay. However, doubts remain about this weathering model because of recent work in County Durham at some open cast sites, such as Herrington, where there is brown till, both above and below grey till (Hughes *et al,* 1998; Hughes and Teasdale, 1999; Teasdale and Hughes, 1999).

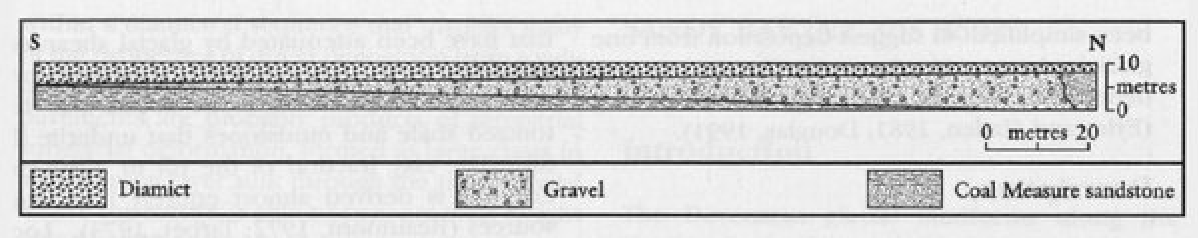
Conclusions

This site at Sandy Bay is an important location where it has been demonstrated that the till sequence is formed in one complex phase of lodgement from a wet-based ice sheet. There seems no need to invoke more than one glacial phase. Weathering of the surface till has been shown to change the characteristics of the till in terms of colour, grain size and geotechnical properties but there still remains doubt about this weathering model in north-east England for all locations.

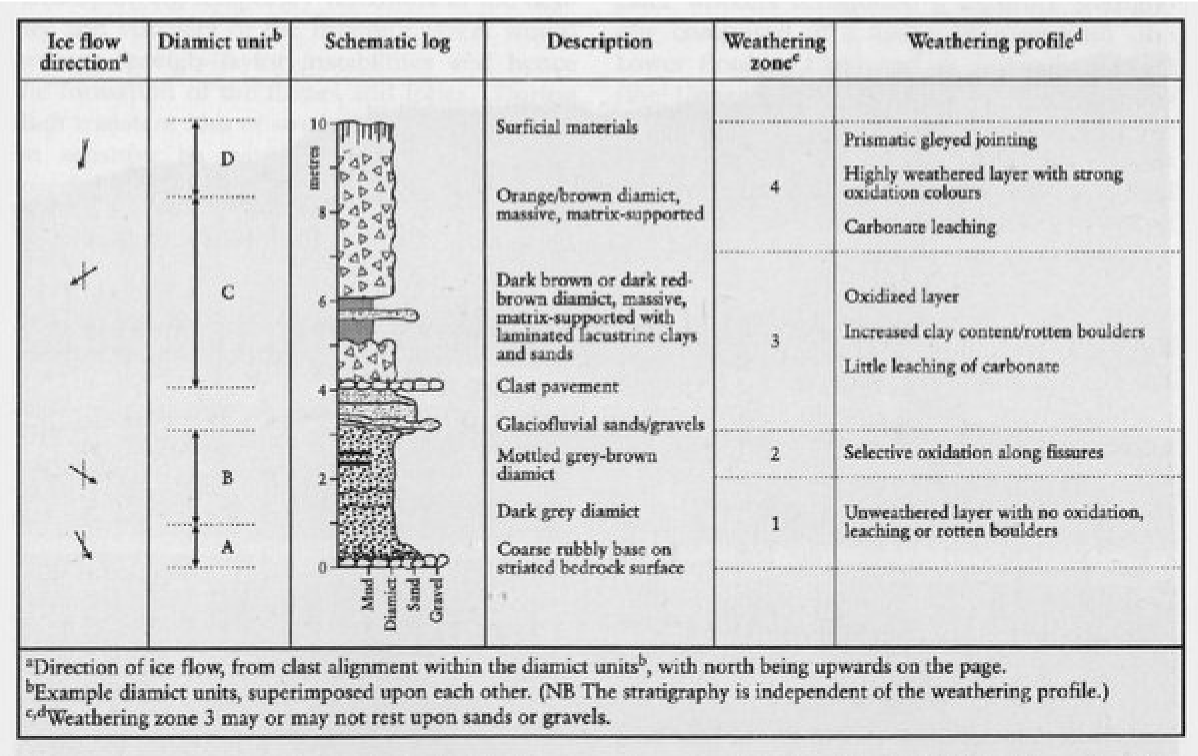
[References]



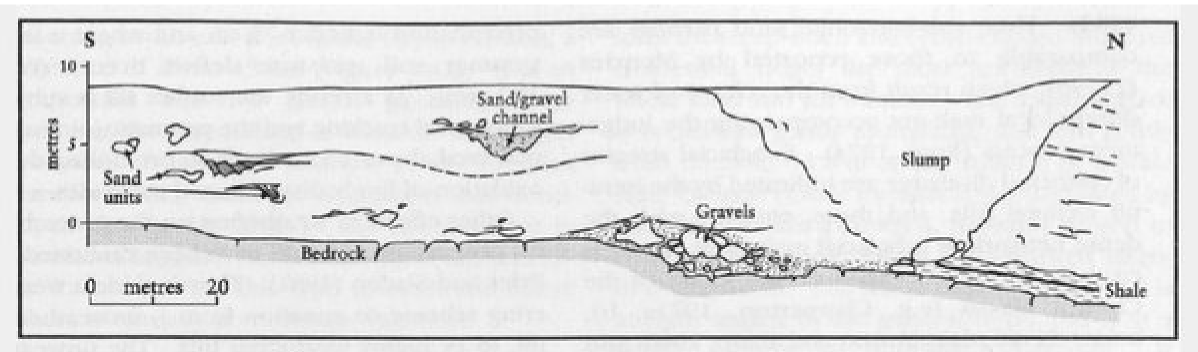
(Figure 5.37) Lodgement till at Sandy Bay, resting on bedrock. (Photo: D. Huddart).



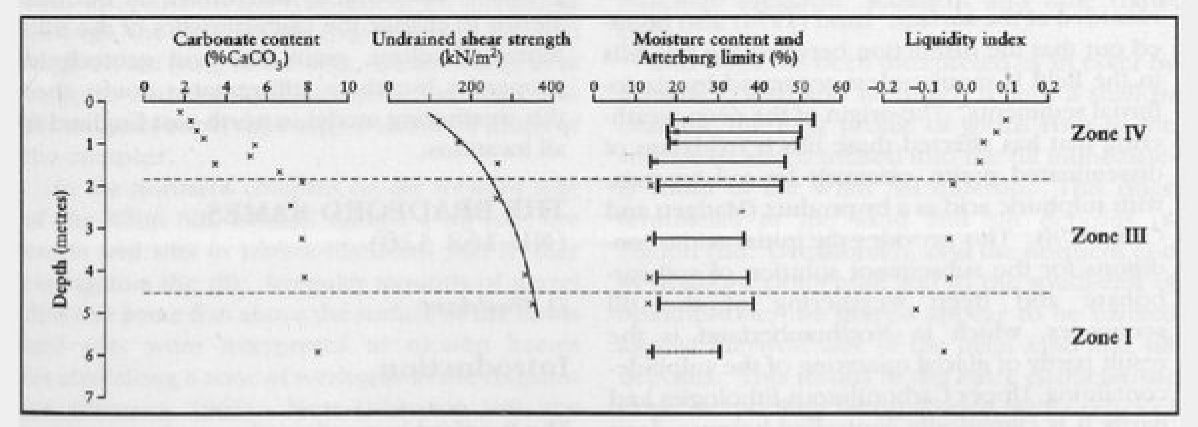
(Figure 5.38) Stratigraphy of the cliff near Newbiggin (north end of Sandy Bay). After Bullerwell (1910).



(Figure 5.39) Generalized characteristics of lodgement till in coastal Northumberland (after Eyles and Sladen, 1981;Eyles et al., 1982)



(Figure 5.40) Lodgement till stratigraphy at Sandy Bay (after Eyles et al., 1982).



(Figure 5.41) Weathering zones, carbonate content, undrained strength, moisture content, Atterberg limits and liquidity index versus depth in the lodgement till at Sandy Bay (after Eyles and Sladen, 1981).