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Conceptual cross-sections of superficial deposits in Cardiff

Geology and Regional Geophysics Programme
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Conceptual cross-sections of superficial deposits in Cardiff

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Foreword

This report is the published product of a study by the British Geological Survey (BGS). This report describes a series of conceptual cross-sections of Cardiff, with a brief description of the superficial deposits, constructed to inform a program of borehole coding for the area. The literature which was used to inform them and some of the potential uncertainties associated with them are also presented.

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Summary

A series of three conceptual cross-sections have been constructed to illustrate the superficial deposits of the Cardiff area. Deposits of Devensian-age Till, Hummocky Glacial Deposits and Glaciofluvial Deposits, provide evidence for the limit of the Late Pleistocene glaciation in the area, while Alluvium, Peat and Tidal Flat Deposits record the post-glacial landscape evolution. The conceptual sections have been constructed to inform a program of borehole classification and 3D model construction as part of the BGS Wales Cardiff City Region research program. Conceptual cross-sections, a review of key literature, a summary of the superficial geology of Cardiff are all presented in this report. Some of the challenges presented by reconstructing subsurface spatial relationships from borehole log data are also discussed.

1 Introduction

At the time of writing, BGS Wales is undertaking a research program in the Cardiff City region that has necessitated developing an understanding of the surface and subsurface distribution of superficial deposits of the area. The motivation for this program includes a research task to characterise the potential for ground source heat in the city, where the resource is thought to be, in part, controlled by the distribution and lithology of the superficial deposits as well as one to provide geotechnical data in support of building and infrastructure projects.

A series of three conceptual cross-sections have been constructed and will be used to inform interpretation of borehole data which will be used to construct a 3D model of the superficial deposits of Cardiff using GSI3D software.

2 Key literature

The conceptual cross-sections presented in this report are primarily based on interpretation of the details given in the BGS memoir for the Cardiff district (Waters and Lawrence, 1987) and associated 1:50,000 Superficial Deposits map (BGS, 1989) but are also informed by published papers and observations made in the field and in borehole records.

The first edition of the memoir for Cardiff was published in 1902 (Strahan and Cantrill, 1902) with a second edition (Strahan and Cantrill, 1912) with minor changes in 1912. These memoirs are especially useful for providing details of contemporary excavations which exposed sections in drift.

The third edition was published in 1987 (Waters and Lawrence, 1987) following a program of resurvey and provides a more up to date view on the Superficial Deposits and the landforms of the district. The mapping was contemporaneous with major infrastructure projects such as the new M4 and development of the Culverhouse Cross area of the city which also provided fresh sections in the drift of the district, described in the memoir.

There are a number of other publications which provide background information on the Superficial Deposits of the Cardiff area. Bowen (1970; 1999; 2005) Charlesworth (1929) and David, J.W.E (1883) all provided regional overviews. J.R.L. Allen produced a number of key papers which focus on the Quaternary history of the Severn Estuary. These include discussions on the late Quaternary stratigraphy of the Gwent Levels (Allen, 2001), Holocene palaeochannels in the Gwent Levels (Allen, 2000) and salt-marsh growth (Allen, 1995). Another key paper by Anderson and Blundell (1965) discusses the distribution of buried channels and their fill of the Cardiff District. Booth *et al* (2015) provide a description of the processes responsible for the kinds of landforms found in areas of plateau and valley which is how it classifies the Quaternary landscape of the region.

3 Overview of Superficial Geology

During the Late Devensian age, glaciers are thought to have originated in the Brecon Beacons and Fforest Fawr uplands and flowed south through the South Wales Coalfield to finally emerge onto the Vale of Glamorgan (David, 1883, Lewis, 1970). The glaciers, at their bedrock-ice interface, deposited well consolidated, lodgement Tills. The composition of the Till reflects the bedrock geology over which the glacier has flowed, namely the Old Red Sandstone Supergroup, the Marros Group, and Pennant Sandstone Formation. These rock units lithologies have imparted a sandy and gravelly character to the tills of the Cardiff area.

During its retreat, morainic Hummocky Glacial Deposits were left behind at the ice margins, and are indicative of glacier ice stagnation. Hummocky Glacial Deposits have a distinctive egg box

like topography, with very a chaotic lithology and structure. Fans, terraces and spreads of Glaciofluvial Sand and Gravel were deposited from meltwater streams which reworked and redeposited the Tills during deglaciation. Small lenses of Glaciolacustrine Deposits locally formed in ice dammed lakes and ponds.

Within the Cardiff area, the surface extent of Devensian deposits is limited to the north of a line running from St Nicholas, close to Culverhouse Cross, north of Leckwith extending south-eastwards to the coast (Figure 1). The deposits are part of a larger area of gravelly glacial drift, that skirts the rim of the coalfield from Swansea Bay to west of Newport, defining the southern limit of the Late Devensian Glaciation (Charlesworth, 1929) in the region.

During the Holocene, Alluvium and Tidal Flat Deposits were deposited in the river valleys and Severn Estuary as modern river systems including the Ely, Taff and Rhymney became superimposed upon the pre-existing relief and rapid post-glacial sea-level rise led to the drowning of the lower reaches of river valleys. Peat accumulated in hollows with restricted drainage and head formed in response to downslope movement of eroded material under the influence of periglacial climatic conditions.

The following deposits are also found within the Cardiff district but are not found within the area of interest for the City Region project. These include: deposits of calcareous tufa are locally preserved where limestone of the Porthkerry Formation, has been subject to dissolution. Storm beach gravels and coastal dunes that have accumulated on the coast.

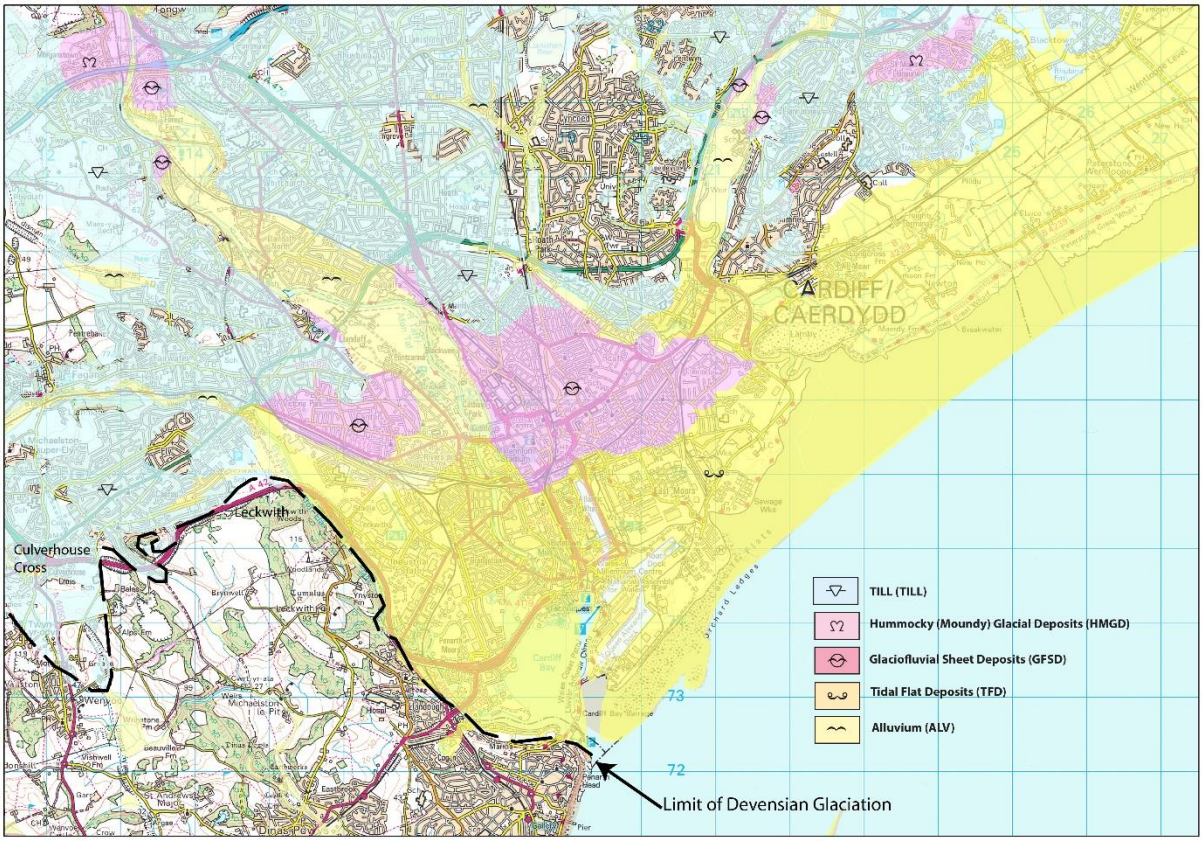


Figure 1 Principal superficial deposits in and around Cardiff

3.1 SUMMARIES OF THE MAIN SUPERFICIAL DEPOSITS.

Till. In the Cardiff district, the dominant type of glacial drift is gravelly till with lenses of sand and gravel. The Till has a variable composition ranging from stiff, stony, silty clay to clayey gravel. Gravel grade material is usually pebble to cobble sized. The matrix consists of variable mixtures of sand silt and clay. Lenses of sand and gravel comprise grey to buff sands and sandy pebble-cobble gravels. The sands are commonly laminated or cross bedded when seen in exposures.

Hummocky (Moundy) Glacial Deposits. Glacial sand and gravel deposits of the Cardiff memoir are here referred to as Hummocky Glacial Deposits. These comprise a heterogeneous, largely unbedded admixture of sandy pebble-cobble gravel with lenses of locally pebbly sand, laminated clay and gravelly till.

Glaciofluvial Sheet Deposits. Clayey sandy pebble-cobble gravels with thin beds of gravel which are matrix free. Glaciofluivial sheet deposits are often overlain by very fine clayey sand/silt and may be cryoturbated in their upper parts. Glaciofluvial deposits can be bedded or cross bedded,

Glaciolacustrine Deposits. Laminated clays occur in lenses throughout the Till and Hummocky Glacial Deposits. Glaciolacustrine deposits also typically contain silts.

Tidal Flat Deposits. In the memoir these deposits are referred to as Estuarine Alluvium. The deposit mainly comprises blue clay with very subordinate silts, sands and gravels. A peat is commonly present at the base and scattered thin peats are found throughout. Interbeds of sand and gravel are noted in borehole logs.

Alluvium. This is a variable deposit, associated with the major streams and rivers. It commonly comprises clay, sand and gravel. Typically, alluvial deposits can be parallel and cross stratified

Peat. A diachronous basal peat is commonly present at the base of the Tidal Flat Deposits as well as occurring as scattered thin layers. The basal peat is well developed beneath the former East Moors Steelworks site but rarely present beneath the estuaries. Two other higher peats are also recorded from boreholes. Peat is also recorded as accumulating in kettle-holes within areas of Till deposits.

4 Cross-sections

A series of three conceptual cross-sections (Figure 2) have been constructed for the Cardiff area. They are intended to communicate how the main superficial lithostratigraphic units might spatially relate to each other within the subsurface.

The first section is envisaged to represent what might be found beneath the centre of the city. In this area, there is a glaciofluvial terrace or fan complex exposed at the southernmost extent of the Till complex. The glaciofluvial deposits are cut into the tills and have been dissected by the modern rivers which have deposited Alluvium. To the south, the glaciofluvial gravels are overlain unconformably by Tidal Flat Deposits formed during post-glacial sea-level rise, drowning the river valleys. The rivers Rhymney and Taff locally both cut through the terrace into the bedrock beneath, creating buried valleys, much deeper than beneath the adjacent areas. The buried valleys are thought to have been incised by glacial meltwater channels with modern drainage superimposed on top. The relationship between Tidal Flat Deposits and Alluvium is poorly constrained and will largely be controlled by post-glacial fluctuation in sea-level, as such it is shown on this section as an interdigitating relationship.

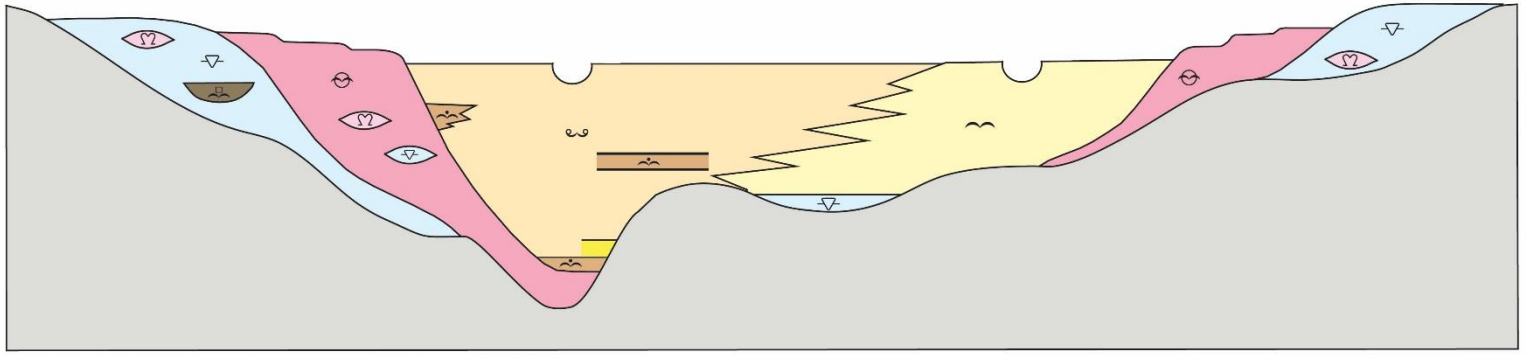
The second section is for the Morganstown/Radyr area, where Hummocky Glacial Deposits were identified during mapping (BGS, 1989). Hummocky Glacial Deposits are ice contact or supraglacial deposits formed during ice marginal retreat and are likely to overlie Till which is

largely deposited during advance phases in a subglacial setting. The Hummocky Glacial Deposits may be coevol or predate deposition of glaciofluvial fans, however, as ice margins fluctuated these are likely to form complex interdigitating relationships in the subsurface.

The third section illustrates the likely relationship that may be encountered in Lower Rhymney, but could equally represent any of the three major rivers in Cardiff. The section shows a channel, cut into bedrock, partially lined with till or glaciofluvial deposits with the modern river locally incising down to bedrock. Modern deposits in rivers can conceal deeply buried valleys, filled with sands and gravels.

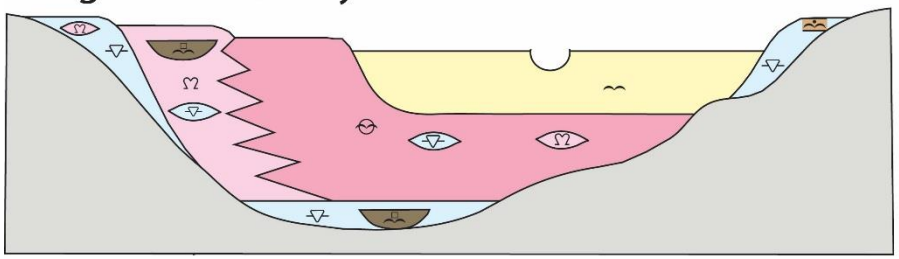
Conceptual cross-sections through superfical deposits in Cardiff

City Centre



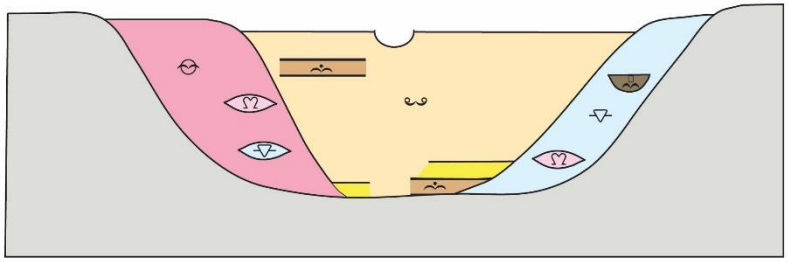
Indicative scale: Width approximately 2km Height approximately <15m

Morganstown/Radyr



Indicative scale: Width approximately 1.5km Height approximately <10m

Lower Rhymney



Indicative scale: Width approximately 1km Height approximately <10m

TILL (TILL). In the Cardiff district, the dominant type of glacial drift is gravelly till with lenses of sand and gravel. The Tills have a variable composition ranging from stiff, stony, silty clay (CSVLB) to clayey gravel (CLGV). Gravel grade material is usually pebble to cobble sized. The matrix consists of variable mixtures of sand silt and clay. Lenses of sand and gravel (SAGR) are sands and sandy pebble-cobble gravels which are commonly cross bedded.

Hummocky (Moundy) Glacial Deposits (HMGD). Glacial sand and gravel deposits of the Cardiff memoir are here referred to as Hummocky Glacial Deposits. These comprise chaotic sandy pebble-cobble gravel (VSL) with lenses of locally pebbly sand (SAGR), laminated clay (GLD-C) and gravelly till (CLGV).

Glaciofluvial Sheet Deposits (GFSD). Clayey sandy pebble-cobble gravels (CSVLB) with thin beds of gravel which are matrix free (SAGR). GFSD is often overlain by very fine clayey sand/silt (CS). May be cryoturbated in upper parts.

Glaciolacustrine (GLD). Laminated clays (C) occur in lenses throughout the TILL and HMGD

Tidal Flat Deposits (TFD). In the Cardiff district, these deposits are referred to as Estuarine Alluvium. The deposit mainly comprises clay with very subordinate silts, sands and gravels (CZSV). A peat is commonly present at the base (PEAT-PEAT) and scattered thin peats (PEAT-CPS). Interbeds of sand and gravel (SAGR) are noted in borehole logs.

Alluvium (ALV). Variable deposits, commonly clay, sand and gravel (CZSV) and sand and gravel which could be the same deposit with the fines washed away.

Peat (PEAT) A diachronous basal peat is commonly present at the base of the Tidal Flat deposits as well as occurring as scattered thin layers. The basal peat is well developed beneath the former East Moors Steelworks site but rarely present beneath the estuaries. Two other higher peats are also recorded from boreholes. Peat is also recorded as accumulating in kettle-holes on the supragacial till complex.

Basal Gravels occur at or near the base if the Tiadal Flat Deposits and are impossible to distinguish from older fluvioglacial gravels unless separated by a basal peat.

Bedrock, undifferentiated.

AFTER: Waters, R.A. and Lawrence, D.J.J. 1987. Geology of the South Wales Coalfield, part III, the Country around Cardiff. Memoir for 1:50,000 geological sheet 263 (England and Wales)

Rhian Kendall - 31st July. CardiffConceptualxsection_v5.ai

Figure 2 Conceptual Cross-sections though superficial deposits in Cardiff

5 Challenges for interpreting borehole logs.

One of the biggest difficulties envisaged with discerning the various superficial deposits beneath Cardiff is that many of them, with the exception of the Tidal Flat Deposits are essentially stony lithologies. The challenge of distinguishing between the various stony deposits is compounded by the fact that fluvioglacial deposits and modern alluvium are essentially reworked tills. Many of the borehole records will not contain enough information to confidently assign the lithologies described to a deposit type.

It may be possible to gain confidence on deciding what the lithologies represent by considering their distribution using the geological map (BGS, 1989). The distribution of the deposits on the map was in part defined by distinctive landforms and larger outcrop sections where features such as bedding may have been available in temporary sections at the time of the mapping. The conceptual cross-sections will also give an indication of the relationship of a deposit to others that could be reasonably expected to occur adjacent to it.

Although the conceptual cross-sections provide an indication of the relationship of one deposit to another, there is considerable uncertainty regarding the amount of down-cutting and erosion which may have occurred before the deposition on the next deposit. The Quaternary history of the area is one dominated by erosion and rapid / localised deposition: ice-sheets cutting into bedrock and depositing tills; outwash rivers eroding away till and bedrock and depositing gravels; rivers cutting into the gravels and tills and depositing their alluvium. From the perspective of predicting the presence or absence of each deposit, the uncertainty lies in how deeply each erosive event cut into the previous – the previous deposit may be partly or completely removed by the subsequent erosional event.

Another area of uncertainty when interpreting borehole logs lies in the variability of the deposits. For example, the till is described as gravelly but also contains lenses of sand and gravel and lenses of clays. There is a challenge to distinguish between a lens of different material and what might be a more laterally-extensive deposit from a point source of information, such as a borehole. Where it is known that this variability exists, lenses of different lithologies are shown on the conceptual cross-sections to help with interpretation.

Buried valleys (Anderson and Blundell, 1965) present another feature which may cause ambiguity in interpreting logs. Buried valleys occur widely in areas of Britain affected by lowland glaciation and are deep scours formed by focussed meltwater erosion beneath a glacier. In other parts of Britain, these valleys can be upto 80 metres deep and contain a chaotic admixture of Till and sand and gravel. If the log does not reach rockhead, identifying the presence or absence of a buried valley can be difficult to determine. Likewise, determining the genetic context of basal sands and gravels can also prove to be challenging.

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