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Geological notes and local details for Geological Sheet SS 91 SE (Tiverton)

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Summary

This report describes and provides an initial interpretation of the bedrock and superficial geology of 1:10, 000 Geological Sheet SS 91 SE Tiverton (Devon). The geology of the area consists of Carboniferous sandstones and mudstones, which belong to the Bude Formation (Culm), in-turn these are unconformably overlain by Permian sandstone and breccias. The sandstone, typically a fine-grained sandstone or sandy mudstone, is informally called the 'Tidcombe Sands', whilst two breccias can be recognised and distinguished on the basis of clast morphology and lithology – the Chevithorne Breccia and Cadbury Breccia. Previous studies suggest that the 'Tidcombe Sands' and Chevithorne Breccia intercalate to the north of Tiverton, whilst present mapping to the south of the town reveals that the sands are also inter-digitated with the southern Cadbury Breccia, and the latter is derived from the southwest. Resting unconformably upon the Permian strata are thick accumulations of Palaeogene and Quaternary deposits. These include terrace deposits and alluvium associated with the rivers that drain the sheet, and a significant distribution of blanket head, regolith and colluvium.

1 Introduction

This geological report is designed to be used in conjunction with 1:10, 000 Geological Sheet SS 91 SE. The area lies within the area of the 1:50 000 Geological Sheet 310 (Tiverton). This was originally mapped at one-inch to one-mile scale by H. De la Beche and W.A.E. Usher during the mid- and late- nineteenth century and corresponds to Old Series Sheets 21 and 26 (although no accompanying memoir was produced).

The district covered by Sheet SS 91 SE covers the area around the Devon market town of Tiverton, which lies approximately 18 km north of Exeter (Fig.1.). It is crossed from north to south on the western edge by the River Exe, and from east to west by an east-bank tributary of the Exe, the River Lowman. Several minor tributaries of the Lowman drain the steep hills to the north and south of Tiverton, which rise to in excess of 130m OD. The town of Tiverton, is situated between 65-90m OD.

Most of the rural land within the district is given over to agriculture. The steeper terrain, generally underlain by Permian breccias and Upper Carboniferous Culm, and the poorly-drained terrain covered by Cenozoic head and alluvium are predominantly used for grazing cattle. Less steep terrain, including the sandstones, terrace sands and gravels, blanket head on hill tops, and the lower slopes of the breccia, are mainly arable with wheat and barley commonly grown.

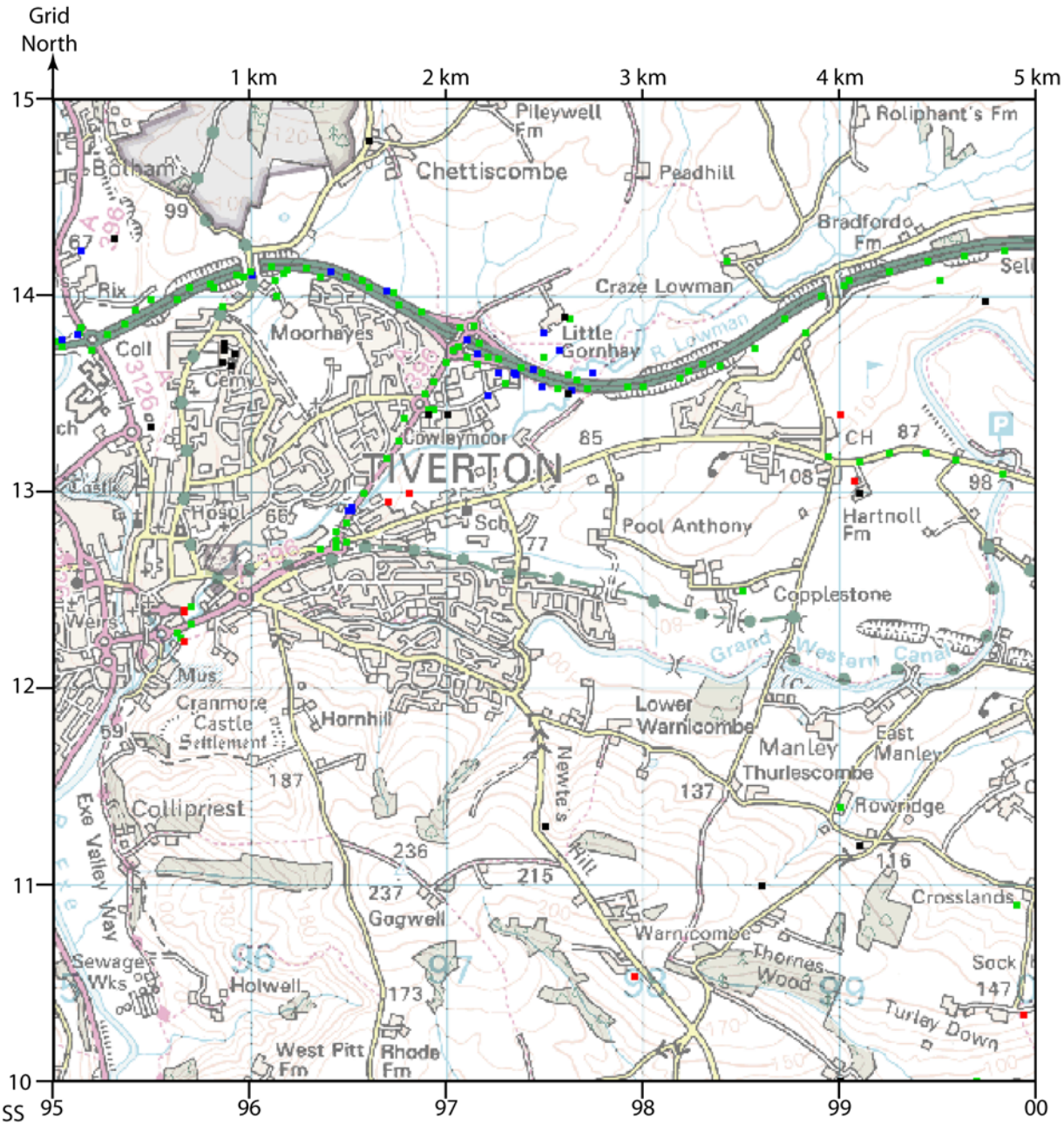

Figure 1. Topographic map of SS 91 SE (Tiverton) including the location of boreholes (coloured dots).

National grid references within this report are given to six figures and all fall within the 100km square SS.

2 Geological notes on SS 91 SE

The geology of SS 91 SE (Tiverton) consists of Palaeozoic bedrock from the Carboniferous and Permian systems, overlain by head and fluvial deposits of Neogene-Quaternary age. The full stratigraphic sequence is shown in Table 1.

System / Subsystem -Series	Group / Formation	Lithofacies	Palaeoenvironment
PALAEOGENE – QUATERNARY	Alluvium	Clast-supported gravels, silty sand	Fluvial floodplain
	River terraces	Clast-supported gravels	Fluvial, braided
	Head, regolith	Muddy gravel	
PERMIAN	Exeter Group		
	Cadbury Breccia	Clast-supported breccia	Alluvial fan
	Tidcombe Sands	Stratified sands and muds	Distal braided channel, playa lakes
	Chevithorne Breccia?	Clast-supported breccia	Alluvial fan
CARBONIFEROUS Upper Carboniferous (Silesian - Westphalian)	Bude Formation	Massive bedded sandstones and mudstones	Fluvial – deltaic?

Table 1. Stratigraphy of the Tiverton district (SS 91 SE).

2.1 CARBONIFEROUS

2.1.1 Upper Culm (Bude Formation)

Culm crops-out throughout the southern portions of SS 91 SE to the south of Tiverton. It is correlated with the Bude Formation of Edmonds et al. (1968) and Edwards & Scrivener (1999) based upon its lithological similarity to deposits in the Okehampton and Exeter districts. Within the SS 91 SE area, the Bude Formation consists of massive thickly-bedded brown and purple sandstones separated and inter-bedded with thin grey limestones and fissile grey mudstones. As with adjacent areas, the Bude Formation has been folded although locally, this appears to be less intensive than in adjoining areas (Edwards, 1990) with beds folded and tilted towards the south and southwest. A distinctive feature of soils developed on top of the Bude Formation, is their reddish colouration, and dominance of large tabular blocks of purple sandstone with rounded edges.

There are numerous exposures of Culm on the eastern side of the Exe Valley. At the confluence of the River Exe and River Lowman [954120], sub-vertically bedded pebbly sandstones and mudstones crop-out within the banks of the channel. Downstream, adjacent to Collipriest Dairy [954119] and Collipriest Farm [954111], there are several outcrops (upto 5 m in height) of purple pebbly sandstones and dark grey fissile mudstones. Sandstones beds are largely massive in structure, typically between 0.4-0.6m thickness, and are sub-vertically aligned dipping at angles of 25-35º towards the south and south-west. To the east of Warnicombe Farm, thick horizontally-bedded purple sandstones crop-out within the bed of a disused farm track [982107]; beds are inclined towards the southwest at angles of 34-40º. Four disused quarries are

present on the western side of the track, however they are all overgrown and no exposures were evident. Stream sections at the western edge of Thornes Wood [989103], approximately 800m east-southeast of the previous site at Warnicombe Farm, reveal thinly-bedded dark grey mudstones, separated by beds (up to 0.3m thick) of purple sandstone inclined towards the southwest at 25º.

2.2 PERMIAN

2.2.1 Exeter Group

Breccias

Breccias crop-out both to the north and south of Tiverton where they form a distinctive steep (>25º), elevated topography compared to the sandstone. Hodgson & Laming (1994) identified two breccias within the Tiverton district, which they differentiated on the basis of clast content and clast morphology, and both of these have been recognised within the present survey.

To the north of Tiverton, breccia was recorded within sunken road cuttings [954148] and adjacent to a disused railway embankment [954143] south of Bolham, and within the steep valley slopes north-east of Chettiscombe Farm [968149]. The lithofacies consist of a clast-supported breccia with a sandy silt matrix texture, that contain sub-angular to angular clasts of Culm-derived sandstone, and more rarely, mudstone, limestone and colourless vein quartz. Structurally, the breccias are massive with a crude imbrication present, or exhibit planar cross-bedding with foresets dipping towards the south-south-east at low angles of between 4-13º. Their sedimentology, geometry and distribution of palaeocurrents are consistent with deposition associated with steep local gradients, high energy chaotic braided channel systems within an alluvial fan. This breccia was named the 'Chevithorne Breccia' by Hodgson & Lambing (1994), who also identified the deposit in deep excavations within the centre of Tiverton [955128].

Within the south of the district, 'breccia' occurs as a west-north-west – east-south-east trending outcrop that forms the steep north-facing slopes on the southern fringes of Tiverton. It is distinct from the 'Chevithorne Breccia' in that clast assemblages typically exhibit a greater degree of edge rounding, and contain trace quantities of quartz porphyry and other possible weathered igneous materials. The contact of the breccia with the sandstone rises from 100m OD on the western side of the district to 115m OD in the east near Thurlescombe Cross [985115]. Exposures of breccia are rare and largely confined to road cuttings that ascend from Tiverton – for example Exeter Hill [962119] and southwest of Dinham Crossroads [989111]. In addition, a temporary section was observed within a new housing development on Canal Hill [965123], where approximately 5m of crudely stratified clast-supported breccia were recorded. Clasts are

subangular to subrounded (i.e. edge-rounded) in morphology, and dominated by local lithologies derived from the underlying Culm – principally purple sandstones, limestone with subordinate proportions of colourless vein quartz, mudstone and rare occurrences of far-travelled quartz porphyry and weathered basalt and / or andesite. Crude imbrication and bedding planes indicate local flow to the north and north-east. An outlier of breccia overlying Culm is present at Gogwell [968110], whilst further south on the southern boundary of SS 91 SE between Rhode Farm [967103] and Remberton [999101], an outcrop of breccia was also noted. Examination of the lithological composition of this breccia at Thornes Cross [983104] revealed the constituents of this breccia identical to those outlined earlier. The sedimentological and geometric characteristics of the breccia, are consistent with an alluvial fan origin.

This breccia has been called the 'Tiverton Breccia' by Hodgson & Lambing (1994), however the trace presence of quartz porphyry and higher degree of edge rounding on the clasts is suggestive of a regional correlation with the 'Cadbury Breccia' found further to the south-west within the Crediton area (Edwards & Scrivener, 1999). The presence of non-local lithologies plus the edge rounded morphology of the clasts indicates a greater distance of transport and / or a longer and more complex (i.e. polyphase) transportation history.

Red sandstones and mudstones

Red sandstones and mudstones are the dominant surface lithofacies throughout the northern and central portions of SS 91 SE, and are commonly overlain by thick accumulations of regolith, valley head and river terrace deposits. They have been called the 'Tidcombe Sands' by Hodgson & Laming (1994) and that informal term has been provisionally applied here, however their sedimentological characteristics are similar to the Clyst St Lawrence Formation (Aylesbeare Mudstone Group) of the Exeter area (Elaine Burt, personnel communication, 2004). Terrain dominated by these lithologies generally forms a gently undulating topography, with brownish red fine sandy to silty soils that frequently contain sub-angular to sub-rounded clasts of sandstone and limestone.

Exposures of sandstone and mudstone are numerous. In the vicinity of a new housing development at Cowley Moor [964136], sandstone was exposed within major excavations for building foundations. Sediments consist of beds of low-angle planar cross-stratified red fine-grained sandstone, separated by thin horizontal beds of pale grey fine-grained sandy mudstone. Palaeocurrent measurements taken on ten foresets reveal a slightly spread bimodal distribution with azimuths dipping between the north-east and east at angles of between 3-7º. These lithofacies record ephemeral episodes of fluvial deposition punctuated by the localised development of playa lakes. Similar lithofacies as described above, underlain by a 1.3m thick

clast-supported massive conglomerate, were observed within a deep excavation for a garden wall to the southeast of Craze Lowman [988137]. Due south, in the vicinity of Shamel's End [988126] and Pool Anthony [978127] several exposures are evident within sunken road cuttings, which exhibit upto 1.2m of brownish red massive and horizontally-bedded sandstone and sandy mudstone. To the south of the Grand Western Canal, sandstones form the base of the north-facing slope that rises from Tiverton. Exposures are rare although a road cutting at Dinhams crossroads [992112] revealed horizontal and low-angle planar cross-bedded fine-grained sandstones (c. 7º towards to the NE). Their general sedimentary properties are typical of deposition within a low-moderate energy fluvial environment, with the development of ephemeral playa lakes.

2.3 PALAEOGENE-QUATERNARY

2.3.1 River terrace deposits

Several river terrace deposits have been recognised within the Exe Valley further south in the Exeter district (Durrance, 1974). Within SS 91 SE, at least one river terrace can be mapped on the eastern side of the Exe Valley, mapped simply on the basis of morphology. This terrace can be traced southwards from Bolham [952149] to Tiverton Football Ground [954133]. No terrace deposits were observed south of Tiverton.

Indirect evidence also exists for additional discrete river terrace deposits further to the east on SS 91 SE since many of the sandstone hills around Chettiscombe and Craze Lowman are capped by a veneer of weathered sand and gravel. These deposits could represent colluvium derived from the elevated Culm topography to the north, however presence of traces of white and brown flint within soil brash is suggestive of an easterly provenance from the Hampshire Basin. The white and brown colouration of the flint is typical of groundwater leaching and surface weathering over considerable periods of time within river terraces (Whiteman & Rose, 1992). It is a strong possibility that these gravels were therefore emplaced by the Lowman (or ancestor of the Lowman) when the catchment dynamics were considerably bigger than those of the present day.

2.3.2 Alluvium

Considerable quantities of alluvium are present on SS 91 SE, and these correspond to the modern floodplains of the River Exe and its tributaries. At its widest the floodplain of the River Exe is approximately 300m wide, and in the vicinity of Bolham, it exhibits several abandoned channels and meander cut-offs. The alluvium itself generally consists of a basal cobble gravel, comprised mainly of edge-rounded sandstone clasts with interstitial dark grey silty sand, overlain by ≤1.5m

of dark brown sandy silt with sporadic gravel clasts and seams. A wide floodplain containing abandoned channels and meander cut-offs, can also be seen associated with the River Lowman in the vicinity of Craze Lowman [9813] and Blundell's School on the eastern outskirts of Tiverton [970132].

2.3.3 Head

Blanket head and regolith

Much of the bedrock in the Tiverton area is covered by a veneer of unconsolidated, poorly sorted diamicton. This is derived from the *in situ* weathering of bedrock material, and its occasional minor reworking by slope processes. Within boreholes, blanket head can often be recognised by the progressive downwards transition from unconsolidated to consolidated materials. These deposits appear to be particularly well-developed on the Bude Formation and tend to be thickest on shallow slopes adjacent to pronounced ridges typically reaching thicknesses of between 1 and 2.5 m.

Valley head

Valley head is common over much of SS 91 SE, and can be subdivided on the basis of geometry and underlying geology. Within the northern part of the district, large accumulations of valley head exist as broad, low relief fans derived from south verging valleys descending from the Culm to the north, into the Lowman valley. A good example of a large valley head fan occurs between Chettiscombe [967147] and Gornhay Cross [972140]. Many of these valley head fans have now been partially dissected and eroded by the Lowman and its smaller northbank tributaries.

Within the southern sector of the Tiverton district, valley head lobes tend to be smaller and related to less prominent gullies and minor valleys. To the south of the Grand Western Canal, the breccia and sandstone are dissected by several small lobes. Along the eastern side of the Exe Valley, several distinctive gullies incised into the Bude Formation are partially in-filled with head.

2.4 STRUCTURAL AND STRATIGRAPHIC ARRANGEMENT OF BEDROCK UNITS

The dip azimuth and angle of beds within the Bude Formation demonstrates that following their deposition, they have been tilted and folded, and this is in accord with previous observations from the district (Edwards, 1990). Permian-age breccias and sandstone units were

then deposited upon this angular unconformity, although the stratigraphic arrangement of these units is still speculative.

Based upon field evidence, Hodgson & Laming (1994) considered the Chevithorne Breccia and Tidcombe Sands to be inter-bedded and therefore broadly contemporaneous. Field data collected from this survey reveals that although the stratigraphic inferences of Hodgson & Laming may be correct (although unproven), the interpretation of the Tidcombe Sands as a distal facies of the Chevithorne Breccia is not supported by palaeocurrent evidence. This evidence indicates deposition within an anastomising braided river channel system (Miall, 1977) with a western, rather than northern, source area. In-turn, this is suggestive of an affinity with the Cadbury Breccia that outcrops to the south of Tiverton, and derivation from a source to the southwest of the survey region - this is supported by field evidence from road cuttings at Little Curharn [992112] reveals that the two deposits are inter-digitated.

The unity of these two deposits does create a significant stratigraphic problem however, especially if the correlation of the 'Tidscome Sands' with the Aylesbeare Mudstone Group is accepted. This is because within the Exeter District, a significant unconformity exists between the Exeter Group (including the Cadbury Breccia) and the Aylesbeare Mudstone Group, and this is characterised in-part, by the aggradation of the Dawlish Sandstone (Edwards & Scrivener, 1999). If this hypothesis were to be correct, then this would challenge previous interpretations of the New Red Sandstone sequence within the Exeter region (Elaine Burt, personal communication, 2004). An alternative hypothesis, is that the 'Tidscome Sands' do not correlate with the Aylesbeare Mudstone Group. Within this model, the apparent similarity between the two deposits simply reflects derivation from a similar Culm-dominated source area, and deposition under a similar sedimentological and climatic regime.

3 Conclusions

The geology of SS 91 SE (Tiverton) contains Culm sandstones and mudstones, unconformably overlain by Permian sandstones and breccias. These Permian deposits represent the progradation of large clastic alluvial fans, from both the north and south, into a topographic low (i.e. a basin), whilst the sandstones and sandy mudstones represent sedimentation during more quiescent phases of braided channel discharge and playa lake deposition. It is a strong possibility that this basin was at least in-part fault controlled, since this would generate the abrupt temporal and spatial variations in gradient which would drive fluvial dynamics. Blanketing the bedrock deposits of the sheet are considerable thicknesses of Palaeogene-Quaternary deposits. These

include a variety of head deposits including regolith, blanket head, and valley head; river terrace deposits and alluvium associated with the local drainage networks.

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