Trent Valley Geoarchaeology 2002

ADVANCING THE AGENDA IN ARCHAEOLOGY AND ALLUVIUM

Component 11c: EXTENDING AND PROTECTING PALAEOENVIRONMENTAL DATA: THE SOURCING OF ALLUVIAL SEDIMENT WITHIN THE TRENT VALLEY

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1. INTRODUCTION

This document provides a final DRAFT report on Component 11c of Trent Valley Geoarchaeology 2002. It principally describes the results of sediment geochemical analyses and should be read in conjunction with the interim report provided immediately following geomorphological survey and geochemical sampling across five river reaches (Havelock and Howard, 2003; Appendix 1).

River valley floors act as large sediment traps capable of providing multiple high-resolution records of environmental change. Over the past decade, establishing the provenance of fine-grained alluvial materials (silts and clays) using sediment mineralogy and geochemistry has been used successfully applied in a number of UK river basins including the Yorkshire Ouse to identify catchment–scale records of agricultural and industrial land-use change over the past 5000 years (Howard *et al*., 1999, Hudson Edwards *et al*., 1999a; Macklin *et al*., 2000). Significantly, in the case of metal mining activities in the Yorkshire Ouse, geochemical and mineralogical information has extended the record of known activity beyond the preserved cultural and documentary evidence (Hudson-Edwards *et al*., 1999b).

The catchment of the River Trent drains a similar suite of lithologies to the Yorkshire Ouse basin comprising Carboniferous sandstones and limestones in the uplands and Permo-Triassic mudstones and sandstones in the lowlands. From the south, it is joined by the River Soar, which drains the igneous and metamorphic complex of Charnwood Forest as well as the Jurassic limestones of the Leicestershire Wolds. In addition, in common with the Yorkshire Ouse, the Trent has also been affected by mining activities for lead and to a lesser extent copper, probably since the later prehistoric-early historic period. Therefore, contrasts in regional geology and distinctive human activities should allow the identification of key erosion and sedimentation episodes, which, when linked to terrace units set within a chronostratigraphic framework, will provide a detailed sequence of natural and human-induced landscape development.

Component 11c had three main aims and objectives:
(i) To use sediment geochemistry and mineralogy to provenance key sedimentary units within the landscape.
(ii) To reconstruct catchment-scale land-use history on the basis of geochemical and mineralogical data.

(iii) To assess the impact of human activities, particularly industrial-scale mining activities, on the natural and human environment.

The most important factors determining the distribution of elements in sediments are: (i) the chemical and mineralogical compositions of the source materials; and (ii) the partitioning of the elements between sediment and surface or ground-water during deposition or diagenesis. Geochemistry thus represents both provenance and conditions of deposition or diagenesis. Within the Holocene of the UK, the bulk of the sediments are of clastic origin, and their chemistry is controlled largely by both source and depositional processes (Ridgway *et al*., 2000). In this project, the mineralogical and multi-element geochemical characteristics of the Holocene sediments in the Trent Valley are used to develop a geochemical stratigraphy and to determine provenance.

2. METHODS and MATERIALS

In order to elucidate the geochemical and mineralogical characteristics of the fine-grained alluvial sediments deposited along the Trent, five key reaches were chosen along the river and its major tributaries (the Dove, Derwent and Soar). For Phase 1 of this Project Component, geomorphological maps were produced for each reach, and sediment samples were taken from key stratigraphic units within the terrace sequences (Havelock and Howard, 2003; Appendix 1). The study reaches are:

- Reach 1: Upper Trent Valley near Great Haywood
- Reach 2: Tributary valley floor of the River Dove near Tutbury
- Reach 3: Tributary valley floor of the River Derwent near Ambaston
- Reach 4: Tributary valley floor of the River Soar near Normanton on Soar
- Reach 5: Middle Trent Valley near Hoveringham, downstream of Nottingham

Up to eleven bulk samples (200-400 g each) were taken from each of the terrace sequences. Terrace units were sampled from natural river bank exposures where possible, but also from small excavations, drainage ditch exposures and sand and gravel quarry faces. Where sections revealed a heterolithic terrace deposit (i.e. comprising several sub-units), sub-samples were taken from each major stratigraphic unit. Source materials from Triassic mudstone, Carboniferous limestone and sandstone, and Precambrian sandstone were also collected. The source material data was augmented by data collected for other alluvial provenancing studies in north-east England (e.g., Macklin *et al*., 2000; Ridgway *et al*., 2000).

In the laboratory, the sediment samples collected from the five study reaches and the source materials were homogenised, and a portion was air-dried, disaggregated and sieved to pass through a 2 mm aperture. Total silica (SiO_2) was determined by $LiBO_2$ fusion followed by analysis using a photometric method. Other major and trace element concentrations (Al_2O_3, Fe_2O_3, MnO, CaO, MgO, Na_2O, K_2O, TiO_2, P_2O_5, Ba, Co, Cu, Ni, Sc, Sr, V, Y, Zn, Cr, Pb) were determined using an $HClO_4$/HF dissolution, followed by analysis by ICP-AES (Phillips instrument, NERC Facility at Royal Holloway College, Egham, UK). All geochemical results are reported in Table 1.

Analytical precision was determined by inserting blind duplicates to approximately 10 percent of the total number of samples analysed. The precisions (for 6 duplicates) are reported in Table 2. The high level of precision is demonstrated by the correlation between data from the 6 replicate pairs (Table 2). Analytical accuracy was determined using the reference sediment standards GBW07309 (Office of Reference materials, Laboratory of the Government Chemist, UK). The accuracies are also shown in Table 2, and are generally within acceptable limits (i.e., within 20% of the published values). Where accuracy values fell outside this limit, the analyses for that particular element or oxide were not used in the interpretation, or were used with caution.

Interpretation of the data relied heavily on the use of normalised multi-element diagrams (spidergrams) to compare the geochemical signatures of the samples to possible source materials. To derive the spidergrams, elements concentrations were normalised to the upper crustal average values of Wedepohl (1995), and plotted on a logarithmic (Y-axis) scale against elements position on the X-axis (e.g., Figure. 1). This allows elements with widely different concentrations in sediments to be plotted easily on the same diagram. Spidergrams have been used to great effect in many river sediment provenance studies (e.g., Howard *et al*., 1999; Macklin *et al*., 2000; Rees *et al*., 2000; Ridgway *et al*., 2000, 2003).

The samples collected for geochemical analysis for this study exhibit a wide range of grain sizes. To compensate for this, elements that are known to have strong associations with the fine (clay mineral) fraction in sediments (Ti, Fe, Mn, V, Cr, Ni, Cu, Ba, Zn, As, Rb, Pb) have been normalised to Al as a grain-size proxy. Aluminium is the most commonly used grain-size proxy in sediment geochemical studies (cf., Loring and Rantala, 1992), and in the Trent dataset, it exhibits the strongest correlations of all other possible proxies that were analysed (SiO_2, K_2O, TiO_2, Sc).

Mineralogical analysis was attempted by XRD, but the results were inconclusive, and do not add to the discussion below.

In order to place the variations observed within the geochemical data within a chronological framework, a high resolution radiometric dating framework is required, which is dependant upon suitable (dating) material being present at the sampling sites. At present, samples suitable for radiocarbon dating were only recovered from a single study reach (Tutbury), and the results are awaited. The results of these analyses will be incorporated within publication associated with this work.

3. RESULTS AND DISCUSSION

3.1. Contamination of Trent alluvium with chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn), and relative dating of stratigraphic units using metal concentrations

Metal concentrations in overbank sediments have been used as stratigraphic markers for provenancing (Passmore and Macklin, 1994), dating (Davies and Lewin, 1974; Lewin *et al*., 1977; Macklin, 1985; Macklin and Lewin, 1989) and examining the contaminant sedimentation histories of vertically accreted fine-grained overbank deposits (Lewin and Macklin, 1987; Macklin *et al*., 1992, 1994; Swennen *et al*., 1994; Hudson-Edwards *et al*., 1999a). This is possible because metal concentrations vary systematically with respect to the contaminant inputs from mining or industrial areas (e.g., Swennen *et al*., 1994).

Concentrations of the metals chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn) for all of the Trent samples were compared to concentrations of these metals in 'background' materials, that is, source materials and pre-1750 A.D. alluvium in the neighbouring Yorkshire Ouse basin (a large part of which is underlain by similar geological units to the Trent) (Table 3, Figure 2). Many of the Trent samples are contaminated (with respect to background) with one or more of these metals. The comparisons in Table 3 have been done without normalisation to Al, but in Figure 2, the plots illustrate that, even with normalisation to account for grain-size differences, many of the samples are still elevated above background levels.

The samples from portions of terraces 2 to 5 in the Derwent reach exhibit the highest, and all of the Middle Trent (Hoveringham) samples the second highest, average Pb and Zn concentrations of all of the reaches. This can probably be attributed to extensive Pb and Zn mining and smelting that took place in the upper parts of the Derwent catchment (Hopkinson, 1958; Bradley and Cox, 1990;

Willies, 1990). Although mining probably began in Roman times or earlier, large-scale exploitation of these deposits took place between the early 17th and early 20th centuries, peaking in the early 19th century following the introduction of mechanised ore dressing (Ford and Rieuwerts, 2000). Two of the Carboniferous limestone samples, used to calculate background levels, exhibit high Pb and Zn concentrations; this may be either a natural enrichment related to enrichment above a mineralised zone, or due to contamination during metal mining. Due to the large-scale nature of metal mining that took place from Carboniferous limestone lithologies in the Trent catchment, and indeed through north-east England, it is difficult to find truly background samples. The high Derwent Pb and Zn concentrations probably resulted from ejection of mine waste into the river. The Middle Trent samples are probably contaminated because the Middle Trent reach lies downstream of the Derwent reach, receiving, through transport and subsequent deposition Pb- and Zn-contaminated sediment from the Derwent (and, to a lesser extent, the other tributaries of the Trent catchment, see below). Concentrations of Pb (338-1423, mean 1023) and Zn (461-854, mean 650) are comparable to those found by Bradley and Cox (1990) for floodplain sediments at Darley Dale, upstream of our reach 3 at Ambaston (Pb 131-1179, Zn 9.3-1696).

Samples from the three other reaches also exhibit elevated Pb concentrations, declining (on average) in the order Upper Trent, Dove and Soar. These reaches, however, exhibit near-background concentrations of Zn. The lack of enrichment in Zn in the Dove catchment is surprising, considering that Zn was extracted from mines such as Ecton (Bradley and Cox, 1986). The lack of Zn enrichment in the Dove, Upper Trent and Soar catchments may, therefore, be due to the small-scale nature, or lack, of Zn mining, or post-depositional remobilisation of Zn from the alluvium (cf., Hudson-Edwards *et al*., 1998). The Pb enrichment in these catchments may be due to inputs of this metal from urban or industrial activity from Stoke-on-Trent or Leicester (Table 3), or from Pb mining (especially in the Dove catchment). Likewise, some of the Pb (and Zn) in the Derwent and Middle Trent catchments may have been derived from Derby or Nottingham (Table 3). In addition, some of the Pb in all the reach samples may be attributed to some degree of twentieth century atmospheric contamination, as it has been for the neighbouring Yorkshire Ouse catchment (Barreiro and Grant 1996).

Samples from terraces three, four and five in the Hoveringham reach of the Middle Trent reach exhibit Cr values that exceed background concentrations. The exact source of this Cr contamination is unknown, but is assumed to be industrial activity in Nottingham. This is analogous to the neighbouring Yorkshire Ouse basin, where since *c.* 1750, disposal of Cr-, Cu-, Pb- and Zn-bearing effluents from urban areas, chemical, coal and metal mining, textile and other industries in the

Leeds and Bradford area has affected sediment quality in the River Aire (Macklin *et al*., 1997; Hudson-Edwards *et al*., 1999). Although samples from the other reaches do exhibit high Cr values relative to Carboniferous lithologies, their Cr values are similar to those of the Triassic mudstone (Table 3). This probably reflects the fact that this mudstone underlies these reaches and acts as source materials for the alluvium (see below). The alluvium from the Upper Trent, Dove, Derwent and Soar is, therefore, not considered to be contaminated with Cr.

All of the Trent reaches have at least some samples that show enrichment in Cu relative to background concentrations. On average, Cu concentrations decline in the order Dove > Middle Trent > Upper Trent > Derwent > Soar. The high Dove Cu concentrations may be due to mining of the Ecton Cu deposits. From 1760 to 1817, this mine produced 66000 tons of concentrates with more than 15% Cu, as well as some Pb and Zn (Bradley and Cox, 1986; Ford and Rieuwerts, 2000). High Cu concentrations in the Middle Trent samples may be attributed to direct input of Cu-contaminated sediment from mining operations such as that at Ecton, or other Cu-enriched mines from within the Trent catchment, or to remobilisation of Cu-contaminated alluvium from the Dove catchment, in particular. Enrichments in alluvial Cu in the other three reaches may be due to mining (especially in the case of the Derwent catchment) or inputs from urban or industrial activity.

As stated above, all of the samples listed in Table 3, and the portions of the terrace units that they represent, are considered to be contaminated with one or more of Cr, Cu, Pb or Zn. Based on this contamination, we assign a young proxy age for the basal parts of these terrace units. The value of this proxy age is unknown, as we do not have independent dating information, but we assume that it is at least as young as less than *c*. 300 years. We make this assumption because, within the last 300 years, floodplain storage of these metals was probably most significant during the peak of mining (that contributed mainly Pb and Zn) and industrial activity (that contributed Cr, Cu, Pb and Zn) from the early 17^{th} to the early 20^{th} century. This is the case with other river systems in north-east England (e.g., Yorkshire Ouse, Tees, Tyne) that have been contaminated with metals from mining of similar Pb-Zn deposits (cf., Macklin and Lewin, 1989; Hudson-Edwards *et al*., 1996, 1997; 1999a, b; Macklin *et al*., 2000). Mining, however, began in the Trent catchment well before the early 17^{th} century, and therefore the metal enrichments seen in the alluvium may be due to contamination from earlier mining. Analogous increases in heavy metal concentrations have been used as age proxies for overbank sedimentary sequences in other river basins affected by metal mining (e.g., Macklin, 1985; Graf *et al.*, 1991; Macklin *et al.*, 1994; Swennen *et al.*, 1994; Ridgway *et al.*, 1995). In addition, the metal-contaminated terraces in the Trent reaches contain anthropogenic materials, including cinder, coal, brick, pottery, leather, burnt shale, slag, and clay pipe fragments that attest to their young age and recent origin (see Appendix 1). We speculate that those portions of the terrace units that lie stratigraphically above the sampled metal-contaminated portions may also be contaminated, given that industrial contamination of the Trent tributaries and physical remobilisation of metal mining-contaminated alluvium will have occurred in the last 300 years. It is possible, however, that these upper, unsampled portions of the terraces may exhibit lower metal concentrations than lower units, given that industrial and mining activity have declined in the last 100 years.

The metal-contaminated units in the Trent reaches exhibit two types of morphology. In the Upper Trent reach, metal contamination is spread across the whole sampled floodplain, and likely occurred by overbank deposition as a thin veneer over the whole floodplain surface (cf., Bradley and Cox, 1990). By contrast, only the youngest inset terraces of the Dove, Soar, Derwent and Middle Trent reaches are contaminated. Deposition of metal-contaminated overbank sediment in these reaches was probably restricted by higher elevation, older terraces.

3.2. Source of sediment

Sediment provenancing was carried out using 'spidergram' signatures and lithological characteristics of the sediment samples. Figure 1 shows a compilation of all the spidergram plots, as well as representative source lithologies, and Table 4 compiles the possible and identified geological source materials, of the alluvial samples. The possible geological sources were deduced from British Geological Survey maps.

Perhaps unsurprisingly, the major geological sources identified for the alluvial samples reflect the underlying geology of the sub-catchment. For example, the Soar catchment is largely underlain by rocks of the Mercia Mudstone Group, and the alluvial samples collected from the Normanton on Soar reach have signatures that are nearly identical to the representative Mercia Mudstone source samples (Figure 1). Samples from the Upper Trent, Dove, Derwent and Middle Trent reaches have mixed signatures that reflect mixing of Carboniferous and Triassic sources.

The Upper Trent samples from Great Haywood (reach 1) have signatures that lie between Carboniferous limestone, Triassic Sherwood Sandstone and Triassic Mudstone. The alluvial samples exhibit similar signatures (Figure 1), except for two samples that have elevated P, Ba, Co and Cu. These are samples GH2a/T1 and TH2a/T1 that were taken from the upper part of Terrace 1 (T1). The elevated concentrations of these elements in these samples may reflect contamination: Co and Cu are used in industrial processes and P in agricultural applications. The source of Ba is presently unknown, but may be geological; all of the samples in the area exhibit relatively high concentrations of Ba (Table 1).

Samples from the Tutbury reach in the Dove catchment are derived from Carboniferous limestone, Millstone Grit and Triassic mudstone sources (Table 4), and exhibit variable multi-element signatures due to the mixing of these sources (Figure 1). In general, however, samples from the older terraces (T1 and T2, Figure 7, Havelock and Howard 2003) have a greater input of Triassic mudstone material than the younger terraces (T3 and T4), which match more closely Carboniferous sources, particularly limestones. This agrees with the metal (Cu, Zn, Pb) contamination of samples within these terraces; this contamination is probably due to metal mining that occurred within Carboniferous lithologies in the upper part of the catchment.

The reach at Ambaston on the River Derwent is underlain by Triassic Mercia Mudstone (Figure 10, Havelock and Howard, 2003, Appendix 1). Despite this, none of the samples exhibits the characteristically flat multi-element signature of this lithology (Figure 1). Most of the samples, especially those from terraces 2 to 5 (Figure 10), exhibit signatures that lie between Carboniferous limestone and sandstone. Like the Dove, samples from these younger terraces are contaminated with Cu, Pb and Zn from mining of ore deposits hosted by Carboniferous lithologies (Table 3).

As previously stated, samples from the Normanton on Soar reach exhibit multi-element signatures typical of the Triassic Mercia Mudstone. Deviations of Ca, Mg, Na and K from the Mudstone signature towards the Precambrian Charwood volcanics suggest that there is some input of the latter to the Soar sediments, but this is considered to be minor due to the lack of similarity in the trace element (which are more resistant to chemical weathering) signatures.

Samples from the reach at Hoveringham in the Middle Trent catchment, like those of the Upper Trent, Dove and Derwent, exhibit a range of source inputs (Table 4, Figure 1). More particular source ascription can be made with the samples that are contaminated with Cu, Cr, Pb and Zn, as in the case of the Dove and Derwent catchments. In the Middle Trent, samples from T2 through to T5 (Figure 16, Havelock and Howard, 2003) are contaminated with metals, have been given a proxy date of < 300 years, and are probably derived mainly from the Carboniferous lithology-underlain areas in the northern part of the Trent catchment that were extensively mined. These samples, however, also exhibit elevated concentrations of Ba, Co, Ni and in some cases, P. The precise sources of these elements are unknown, but similar enrichments for these elements were noted in samples from the Upper Trent reach at Great Haywood. Figure 3 shows the multi-element signatures for the average compositions of all metal-contaminated units within each of the catchments given proxy ages of < 300 years. The < 300 year Middle Trent spidergram closely matches that of the average Upper Trent, with the exception of Pb and Zn (which are close to the average Derwent signature) and some of the major elements (Si, Ca and to some extent, Mg). There are limitations to this averaging method, including the lack of geochemical information for all possible source catchments (e.g., the Tame) and source materials (e.g., alluvium older than 300 year may have been physically remobilised upstream and re-deposited in the Hoveringham reach).

4. CONCLUSIONS

Field survey and analysis of geochemical data obtained for this study has led to a better understanding of the relative ages of terrace units and provenance of alluvial materials within the five study reaches on the Upper Trent, Dove, Derwent, Soar and Middle Trent. Whilst there are clear contrasts between the geochemical signatures of the various terrace units in the five reaches, these datasets highlight a number of interesting questions and issues.

- The older terraces on the Dove (Tutbury), and Soar (Normanton) comprise essentially sediments derived from local lithologies with little input of exotic (i.e. non-local) lithologies. This raises an interesting question concerning the impact of earlier human (i.e. probably mid to late prehistoric) farming activities on the surrounding landscape and the supply of sediment to the valley floors, particularly in the Peak District.
- The terraces of the Derwent comprise essentially post-medieval metal contaminated sediments with no local lithological signature. This suggests that either: humans have had little impact on the supply of local sediment to the valley floor prior to the post-medieval; or that the local sediments are deeply buried; or that earlier terrace sediments have been reworked and flushed from the valley. The first hypothesis seems unlikely given our knowledge of human activity within the Trent Valley (Knight and Howard, 1995) and the latter two hypotheses are more attractive, especially since Brown (1998) has demonstrated the high mobility of the Trent in this part of the valley floor, recently confirmed by the palaeochannel mapping of Baker (2003). The impact of high channel mobility and associated floodplain reworking may be a key issue affecting the geochemical signatures observed within the Trent Valley and certainly needs further investigation; for example, the geochemical signatures of the Trent are not has well defined as those in the Yorkshire Ouse basin (Hudson Edwards *et al*., 1999a, 1999b), despite a number of key similarities between the catchments.

- The geochemical signature recorded in the Derwent raises interesting questions regarding the antiquity of terrace surfaces, which may be applicable valley wide and has clear implications for archaeological preservation. Further, metal contaminated sediments are demonstrated to be spread widely across the valley floors of all the reaches. Given that the majority of this alluvium is relatively young, this veneer (of alluvium) may bury archaeology and present issues for standard techniques of archaeological prospection.

5. RECOMMENDATIONS for FURTHER WORK

This survey has provided a comprehensive first approximation of the geochemistry of the Trent Valley and its major tributaries. However, this work should be as a baseline survey for the building of interesting research questions. Whilst limited radiocarbon dating has been undertaken as part of this survey (results awaited), the construction of a high resolution chronological framework through radiometric dating for further studies is essential. This should be augmented by the collection and dating of artefacts (clay pipes, slag, etc.) within the alluvium.

A number of other initiatives are recommended:

- Further sampling and analysis of possible source materials, including Jurassic limestones in the south-eastern portion of the Trent catchment;
- Further sampling and analysis of metal concentrations within contaminated terraces, to define the magnitude and distribution of contamination from mining and other activities;
- Isotopic analysis (e.g., of Pb) to determine point sources of contamination.

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Table 1. Geochemical data for Trent sediment samples

Catchment	Sample	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	Ba
		Wt. %	Wt.%	Wt.%	Wt. %	Wt.%	Wt.%	Wt. %	Wt.%	Wt.%	Wt.%	ppm
Upper Trent	GH1/T1	70.50	7.77	4.74	0.17	0.50	1.06	0.23	2.48	0.36	0.30	672
Upper Trent	GH2a/T1	79.86	5.07	3.18	0.15	0.54	0.54	0.19	1.92	0.25	0.42	1149
Upper Trent	GH2b/T1	88.21	3.53	2.42	0.06	0.20	0.32	0.14	1.65	0.14	0.18	1074
Upper Trent	GH3a/T2	75.59	6.61	3.75	0.16	0.27	0.76	0.19	2.21	0.31	0.33	650
Upper Trent	GH3b/T2	63.18	14.01	6.91	0.35	0.27	1.55	0.38	3.48	0.77	0.17	905
Upper Trent	GH4a/T2	83.41	4.82	3.78	0.09	0.22	0.54	0.18	1.69	0.20	0.26	536
Upper Trent	GH4b/T2	64.88	15.03	7.66	0.10	0.46	1.93	0.35	4.42	0.72	0.29	1173
Dove	Do1a/T1	71.06	11.07	7.50	0.25	0.37	0.81	0.23	2.28	0.53	0.18	1092
Dove	Do1b/T1	51.91	11.75	4.71	0.01	0.51	0.61	0.17	2.35	0.61	0.15	991
Dove	Do1c/T1	77.42	8.29	3.54	0.01	0.30	0.75	0.17	2.20	0.39	0.12	605
Dove	Do1d/T1	50.69	17.82	10.18	0.03	0.70	1.36	0.21	3.28	0.76	0.09	1214
Dove	Do3/T2	80.29	6.49	3.70	0.10	0.19	1.06	0.15	2.16	0.34	0.10	805
Dove	Do4/T2	78.74	7.03	4.13	0.24	0.07	0.52	0.17	2.13	0.37	0.13	806
Dove	Do5/T3	68.04	9.86	5.50	0.19	0.51	0.90	0.22	2.56	0.48	0.22	1413
Dove	Do6/T3	74.78	8.05	4.79	0.15	0.55	0.85	0.21	2.30	0.45	0.17	1367
Dove	Do7/T4	73.69	8.34	4.97	0.19	0.80	0.83	0.21	2.31	0.45	0.22	1125
Dove	Do8/T4	64.63	8.38	4.78	0.11	1.00	1.47	0.17	2.34	0.41	0.30	1071
Derwent	De1a/T1	76.04	9.49	10.90	0.10	0.19	0.44	0.17	1.68	0.26	0.21	627
Derwent	De1b/T1	74.91	6.90	7.98	0.08	0.31	3.59	0.36	6.93	0.71	0.20	1021
Derwent	De1c/T1	57.24	15.97	7.46	0.24	0.82	1.04	0.39	2.51	0.65	0.38	3209
Derwent	De2/T2	56.79	15.04	7.46	0.24	0.82	1.04	0.39	2.51	0.65	0.38	3209
Derwent	De3/T2	61.42	15.62	7.68	0.40	0.44	0.95	0.34	2.29	0.66	0.26	1513
Derwent	De4/T4	57.96	16.02	7.33	0.16	0.88	1.46	0.36	3.08	0.68	0.26	4092
Derwent	De5/T4	58.43	9.33	6.37	0.25	2.31	0.92	0.36	2.05	0.49	0.57	2546
Derwent	De6/T3	66.29	11.75	5.77	0.16	0.74	0.87	0.46	2.36	0.59	0.18	3856
Derwent	De7/T3	56.83	14.77	7.08	0.20	1.27	1.15	0.43	2.75	0.72	0.27	4541
Derwent	De8/T5	76.45	8.20	4.75	0.04	0.72	0.67	0.32	1.76	0.37	0.22	2311
Derwent	De9/T5	60.97	10.62	5.33	0.16	2.30	0.98	0.42	2.17	0.44	0.51	2470
Soar	So1/T1	67.10	6.33	9.53	0.08	0.32	1.37	0.17	2.52	0.32	0.33	530
Soar	So2/T2	77.70	6.89	5.30	0.08	0.16	0.66	0.18	1.98	0.36	0.24	455
Soar	So3/T3	63.19	12.47	7.23	0.11	0.61	1.50	0.19	3.01	0.64	0.16	626
Soar	So4a/T4	68.31	8.26	5.05	0.11	1.66	1.53	0.19	2.84	0.37	0.35	666
Soar	So4b/T4	74.17	8.37	4.48	0.11	1.27	1.25	0.16	2.85	0.33	0.13	575
Soar	So5/T3	49.62	14.07	7.45	0.16	1.42	1.75	0.16	2.79	0.61	0.42	674
Soar	So6a/T4	53.94	13.37	8.97	0.20	0.77	2.14	0.20	3.61	0.76	0.29	740
Soar	So6b/T4	53.89	17.04	8.72	0.13	0.75	2.34	0.20	3.85	0.71	0.23	675
Middle Trent	Ho1/T3	64.53	9.61	5.78	0.26	1.88	1.34	0.30	2.45	0.43	0.43	2133
Middle Trent	Ho2/T2	74.91	8.54	4.68	0.13	0.33	1.13	0.24	2.60	0.41	0.13	751
Middle Trent	Ho3/T4	68.49	8.32	5.36	0.15	1.53	1.38	0.27	2.60	0.38	0.75	2171
Middle Trent	Ho4/T4	68.53	6.39	4.79	0.16	1.46	1.47	0.27	2.85	0.45	0.28	2484
Middle Trent	Ho5/T5	63.07	9.10	5.59	0.24	1.72	1.56	0.25	2.66	0.46	1.04	1735
Middle Trent	Ho6/T2	81.00	6.30	3.79	0.10	0.27	0.61	0.26	2.21	0.33	0.12	671
Middle Trent	Ho7/T3	67.50	9.15	5.18	0.14	1.69	1.57	0.29	2.87	0.43	0.46	2118
Middle Trent	Ho8/T5	68.80	8.03	4.98	0.18	1.58	1.35	0.26	2.56	0.43	0.81	1698
Middle Trent	Ho9/T1	84.65	5.41	3.32	0.02	0.22	0.37	0.18	2.14	0.29	0.12	422
Carboniferous s'stone source	SOR1	86.77	3.55	5.53	0.41	1.29	0.78	0.36	2.38	0.66	0.19	736
Carboniferous limestone source	SOR2	67.09	10.15	6.34	0.36	1.03	0.98	0.74	2.24	0.69	0.30	533
Precambrian volcanic source	SOR3	62.08	12.89	6.95	0.01	0.26	0.88	0.20	2.58	0.63	0.15	1401

Mercia mudstone from Soar	SOR4	63.67	13.99	4.83	0.04	5.50	7.12	0.22	5.31	0.73	0.23	2826
Mercia Mudstone from Middle Trent	SOR5	51.06	12.55	7.98	0.08	0.31	3.59	0.36	6.93	0.71	0.20	1021

Catchment	Sample	Co	Cu	Liu	Ni	Sc	Sr	V	Y	Zn	Cr	Pb
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Upper Trent	GH1/T1	14	31	5	70	7	52	45	16	158	82	260
Upper Trent	GH2a/T1	27	70	3	64	4	48	29	12	271	72	265
Upper Trent	GH2b/T1	18	70	2	57	2	40	18	8	176	30	107
Upper Trent	GH3a/T2	15	21	4	56	5	43	36	14	206	68	188
Upper Trent	GH3b/T2	17	18	8	87	13	65	78	26	122	134	53
Upper Trent	GH4a/T2	13	18	3	50	4	40	28	12	231	49	197
Upper Trent	GH4b/T2	14	27	10	93	13	80	85	26	246	118	101
Dove	Do1a/T1	19	24	7	120	10	54	77	29	177	121	90
Dove	Do1b/T1	2	36	6	43	12	68	87	18	47	181	90
Dove	Do1c/T1	4	20	5	55	9	50	61	14	72	121	50
Dove	Do1d/T1	23	37	11	135	17	87	107	50	123	167	51
Dove	Do3/T2	8	17	4	62	5	38	40	16	88	83	47
Dove	Do4/T2	12	14	4	70	6	43	45	19	103	64	61
Dove	Do5/T3	16	156	5	113	8	62	65	25	288	109	147
Dove	Do6/T3	13	115	5	90	7	57	51	22	212	89	119
Dove	Do7/T4	14	150	5	97	7	57	57	22	235	92	144
Dove	Do8/T4	13	58	5	93	7	63	62	22	194	92	88
Derwent	De1a/T1	19	14	4	51	6	55	41	17	86	82	42
Derwent	De1b/T1	12	21	3	115	8	43	47	23	159	77	56
Derwent	De1c/T1	18	15	11	128	15	54	76	26	93	118	34
Derwent	De2/T2	21	49	7	150	12	115	82	31	693	156	1423
Derwent	De3/T2	22	27	7	179	15	75	83	37	656	144	338
Derwent	De4/T4	17	33	9	131	13	115	85	29	512	140	1320
Derwent	De5/T4	20	46	5	131	8	97	57	24	854	175	834
Derwent	De6/T3	17	25	5	111	9	103	61	23	479	120	1319
Derwent	De7/T3	20	47	7	140	13	125	81	31	781	99	1399
Derwent	De8/T5	14	26	4	100	6	75	42	18	461	74	803
Derwent	De9/T5	16	36	5	114	8	112	53	24	760	100	746
Soar	So1/T1	9	18	4	74	6	44	67	19	119	89	159
Soar	So2/T2	8	13	5	58	6	40	50	16	55	98	37
Soar	So3/T3	11	19	10	83	11	65	98	25	89	168	50
Soar	So4a/T4	9	23	5	63	7	75	59	19	98	114	66
Soar	So4b/T4	7	12	5	56	7	71	52	17	53	64	33
Soar	So5/T3	11	28	12	99	14	132	103	29	166	161	78
Soar	So6a/T4	18	39	12	124	12	70	125	21	144	260	75
Soar	So6b/T4	14	20	12	106	16	85	115	30	102	152	49
Middle Trent	Ho1/T3	19	166	5	119	8	97	57	24	929	172	603
Middle Trent	Ho2/T2	10	15	5	75	7	49	48	19	138	73	94
Middle Trent	Ho3/T4	18	229	5	278	7	90	52	20	836	403	503
Middle Trent	Ho4/T4	14	71	5	99	6	71	51	18	465	151	430
Middle Trent	Ho5/T5	19	106	6	212	8	102	60	24	643	238	341
Middle Trent	Ho6/T2	7	14	3	51	5	46	35	15	126	57	117
Middle Trent	Ho7/T3	16	205	5	196	7	89	54	21	781	297	494
Middle Trent	Ho8/T5	16	144	5	208	6	91	53	20	665	234	415
Middle Trent	Ho9/T1	4	9	3	34	3	41	28	11	37	37	133
Carboniferous sandstone source	SOR1	<1	7	1	17	1	69	9	5	31	20	39
Carboniferous limestone source	SOR2	13	23	4	119	9	55	71	52	418	160	576
Precambrian volcanic source	SOR3	12	17	3	22	15	100	86	18	56	69	38
Mercia	SOR4	4	24	8	59	13	73	100	22	82	142	62

mudstone from Soar												
Mercia Mudstone from Middle Trent	SOR5	10	12	12	82	11	124	68	27	56	126	25

Table 2. Precision and accuracy of geochemical analysis

Element	Average Precision (%, 6 replicate pairs)	Correlation coefficient (6 replicate pairs)	Accuracy (expressed as % recovered)	Element	Precision (%)	Correlation coefficient (6 replicate pairs)	Accuracy (expressed as % recovered)
SiO_2	1.0	0.992	96	Co	9.3	0.950	118
Al_2O_3	5.1	0.993	105	Cu	10.4	0.899	83
Fe_2O_3	11.3	0.976	109	Ni	5.0	0.991	113
MnO	18.6	0.853	100	Sc	7.6	0.970	92
CaO	6.4	0.999	116	Sr	5.4	0.989	91
MgO	6.0	0.998	92	V	8.0	0.993	85
Na_2O	6.7	0.998	67	Y	3.8	0.982	98
K_2O	4.2	0.959	125	Zn	7.6	0.995	95
TiO_2	7.7	0.997	135	Cr	15.2	0.847	81
P_2O_5	7.1	0.987	89	Pb	13.1	0.958	108
Ba	2.2	0.937	129				

Table 3. Characteristics of metal-contaminated alluvial Trent valley units, and comparison with background and guideline concentrations.

River / Reach	Major urban Conurbation	Terrace Units	Morphology	No. of spls	Cr (ppm) range (mean)	Cu (ppm) range (mean)	Pb (ppm) range (mean)	Zn (ppm) range (mean)
Upper Trent / Great Haywood	Stoke	1, 2	Spread across floodplain	5	30-82 (60)	18-70 (42)	107-265 (203)	158-271 (208)
Dove / Tutbury	None	3, 4	Two youngest inset terraces	4	89-109 (96)	58-156 (120)	88-147 (125)	194-288 (232)
Derwent / Ambaston	Derby	2, 3, 4, 5	All inset terraces	8	74-175 (126)	25-49 (36)	338-1423 (1023)	461-854 (650)
Soar / Normanton on Soar	Leicester	1, 4	Spread across highest terrace & youngest inset terrace	2	89-260	18-39	75-159	119-144
Middle Trent / Hoveringham	Nottingham	2, 3, 4, 5	Youngest inset terraces	7	57-403 (222)	14-229 (134)	117-603 (415)	126-929 (635)
Triassic mudstone		average		3	118-142 (129)	12-24 (17)	25-62 (40)	56-93 (77)
Precambrian lithology		average		1	69	17	38	56
Carboniferous sandstone soil		average		2	20-26	3-7	33-39	6-31
Carboniferous limestone soil		average		3	63-160 (113)	12-23 (18)	46-576 (265)	72-418 (255)
Pre-*c*. 2000 a Yorkshire Ouse basin alluvial sediment[1]		average		120	5-124 (54)	2-40 (15)	4-101 (24)	16-450 (87)
Pleistocene till[1]		average		10	37-124 (77)	12-32 (21)	18-33 (27)	37-97 (68)
ICRCl (1987)		Threshold trigger concentrations			-	250	300	300
MAFF (1993)		Guideline Values			400	80	300	200

[1] calculated from sample data for Yorkshire Ouse basin (Hudson-Edwards *et al*., 1999).

Table 4. Possible and identified sources of alluvium in five study reaches

Reach	Name	Catchment	Possible Major Geological Sources	Sources Identified in Alluvial Samples
1	Great Haywood	Upper Trent	Carboniferous limestone Carboniferous coal measures Triassic Sherwood Sandstone Triassic Mercia Mudstone	Carboniferous limestone Triassic Sherwood Sandstone Triassic Mercia Mudstone
2	Tutbury	Dove	Carboniferous limestone Carboniferous Millstone Grit Triassic Sherwood Sandstone Triassic Mercia Mudstone	Carboniferous limestone Carboniferous Millstone Grit Triassic Mercia Mudstone
3	Ambaston	Derwent	Carboniferous limestone Carboniferous Millstone Grit Triassic Sherwood Sandstone Triassic Mercia Mudstone	Carboniferous limestone Carboniferous Millstone Grit Triassic Mercia Mudstone
4	Normanton on Soar	Soar	Precambrian Charwood Volcanics Triassic Mercia Mudstone	Triassic Mercia Mudstone Precambrian Charwood Volcanics (minor)
5	Hoveringham	Middle Trent	Precambrian Charwood Volcanics Carboniferous limestone Carboniferous Millstone Grit Carboniferous coal measures Triassic Sherwood Sandstone Triassic Mercia Mudstone	Carboniferous limestone Carboniferous Millstone Grit Triassic Mercia Mudstone

Figure 1. ‘Spidergram’ multi-element geochemical plots for samples from five study reaches, and possible source materials.

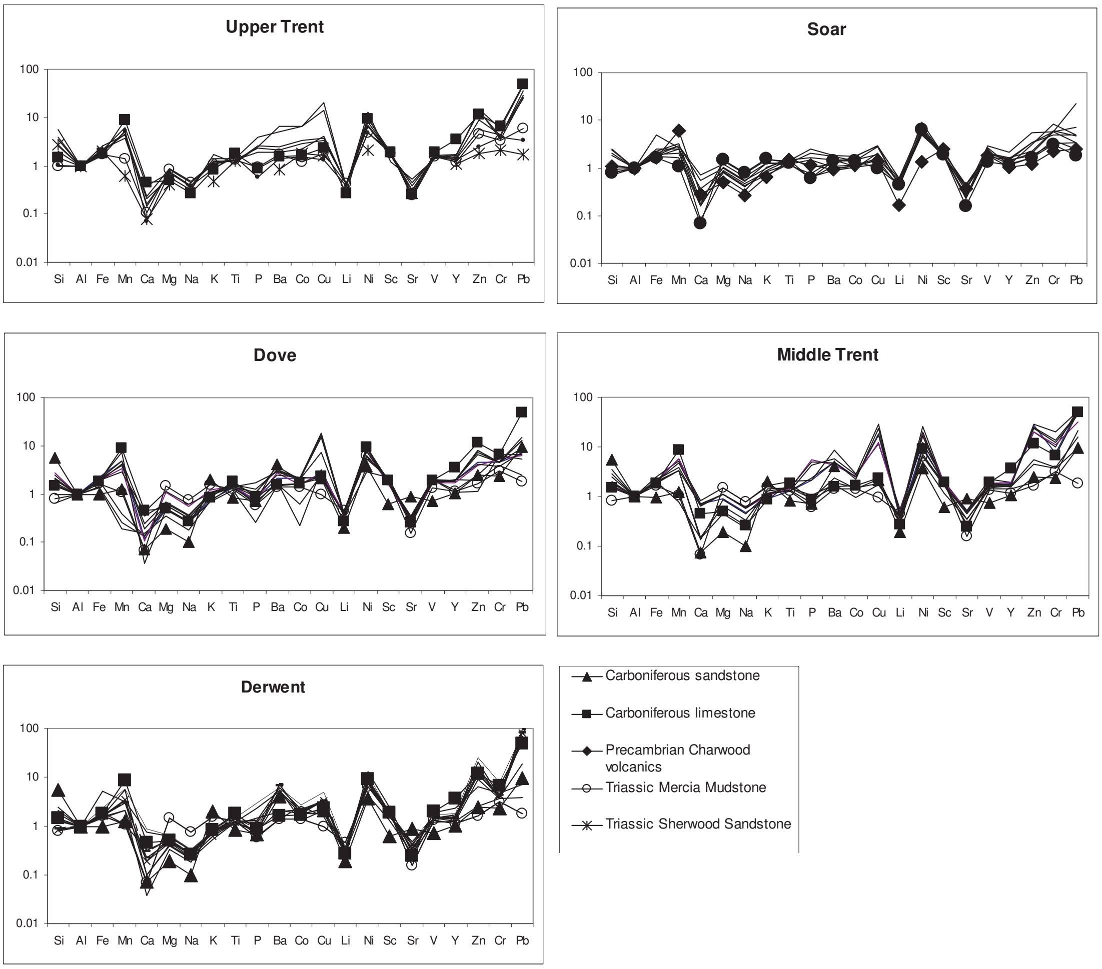


Figure 2. X-Y plots of Cr, Cu, Pb and Zn for metal-contaminated alluvial samples from five study reaches. Plots have been constructed with normalization to Al (to account for grain-size differences) and without normalization (to observe actual concentrations of metals).

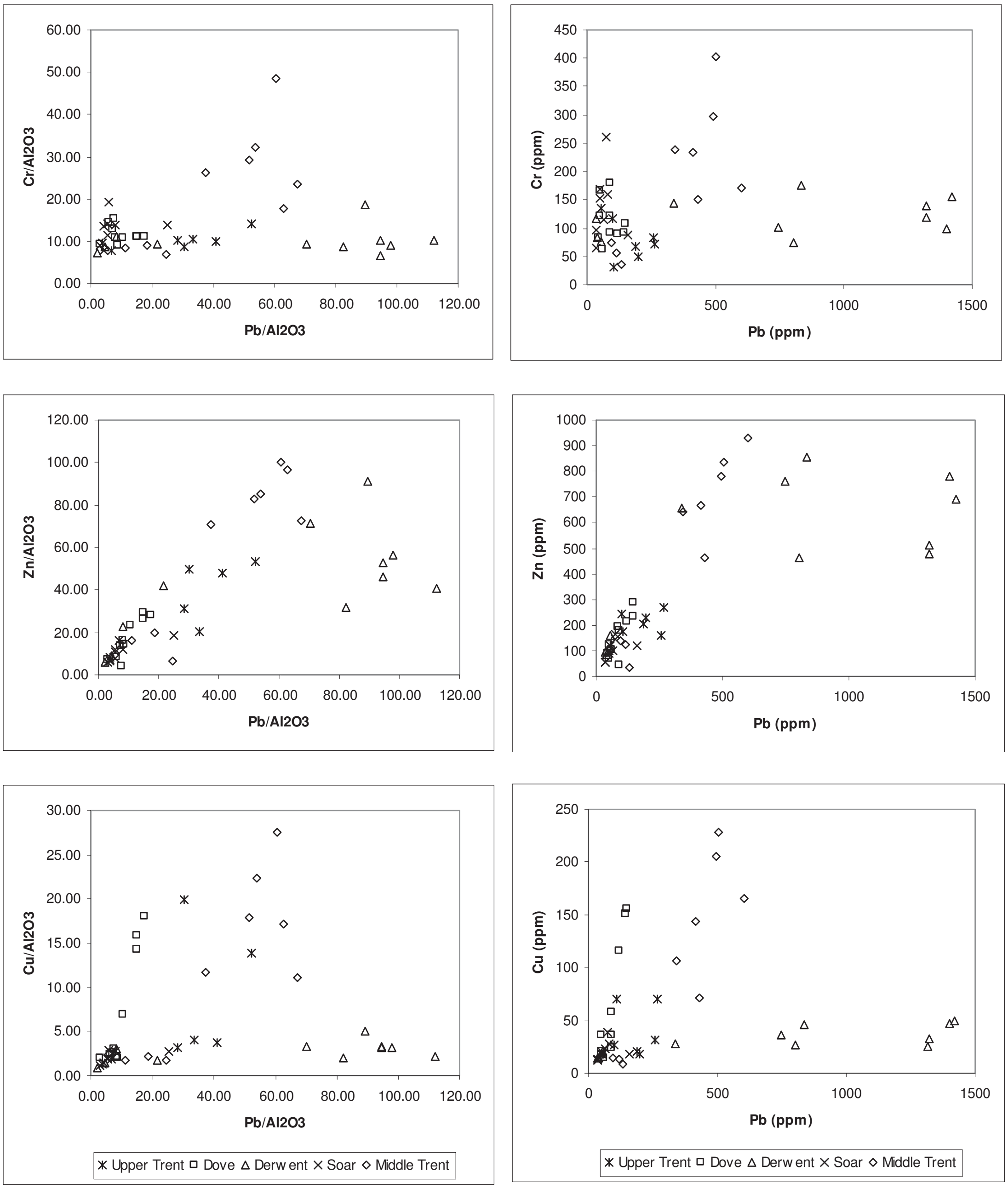
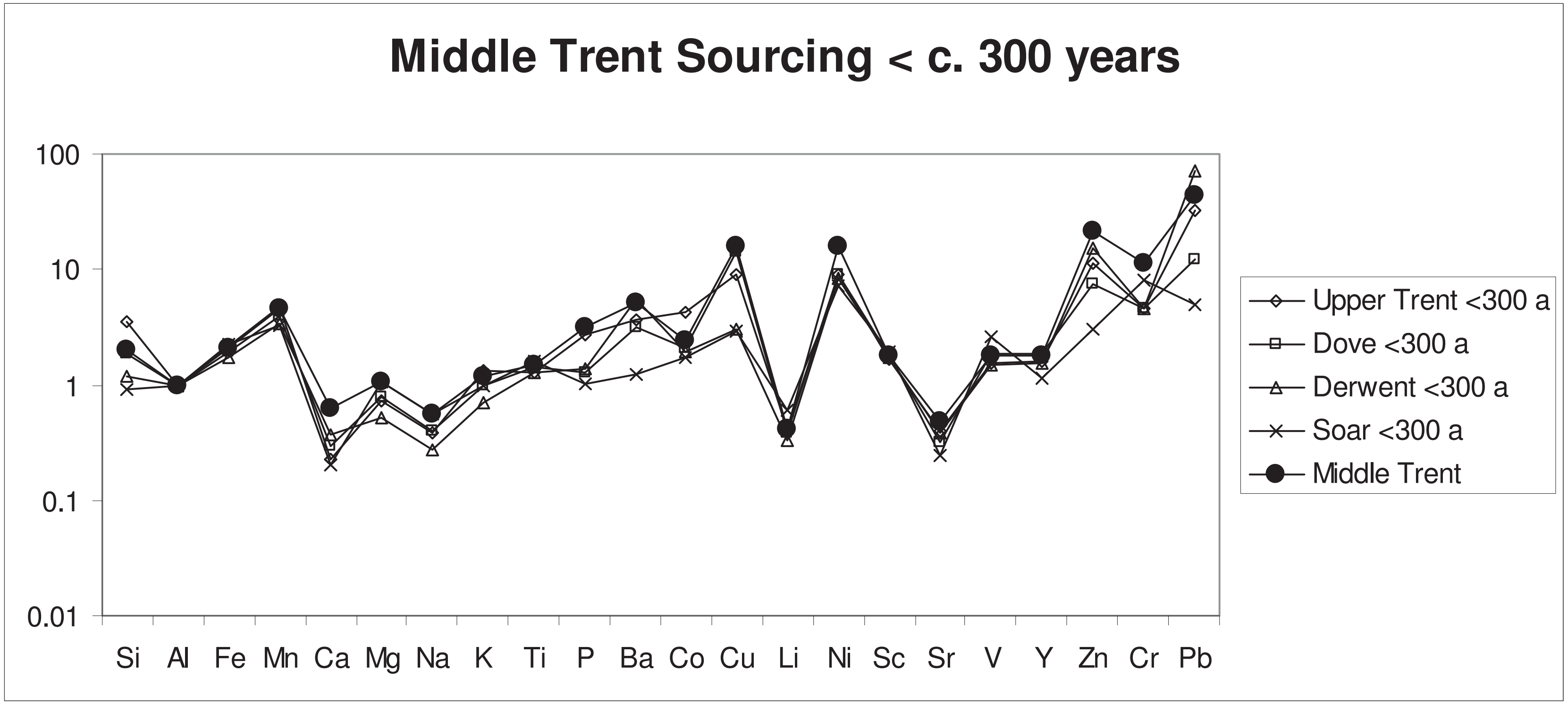


Figure 3. Spidergrams of average compositions of c. < 300 year old alluvial samples from the five study reaches.



APPENDIX 1: Interim Report

COMPONENT 11c.

EXTENDING AND PROTECTING PALAEOENVIRONMENTAL DATA: THE SOURCING OF ALLUVIAL SEDIMENT WITHIN THE TRENT VALLEY

Stage 1: Fieldwork and sediment collection

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TRENT VALLEY GEOARCHAEOLOGY

CONTENTS

1. INTRODUCTION

This component is part of the larger Trent Valley Project being delivered by members of the Trent Valley Geoarchaeology group. It is administered by English Heritage and funded from the Aggregates Levy Sustainability Fund (ALSF).

River valley floors act as large sediment traps capable of providing multiple high-resolution proxy records of environmental change. Over the past decade, establishing the provenance of fine-grained alluvial silts and clays by mineralogy and geochemistry has been successfully used in a number of UK river basins, including the Yorkshire Ouse, to identify catchment-scale records of agricultural and industrial land-use change (Howard *et al*., 1999; Hudson-Edwards *et al*., 1999a; Macklin *et al*., 2000). Significantly, in the case of metal mining activities in the Yorkshire Ouse, geochemical and mineralogical information has extended the record of known activity beyond the preserved archaeological and documentary evidence (Hudson-Edwards *et al*., 1999b).

The catchment of the River Trent drains a similar suite of lithologies to the Yorkshire Ouse basin comprising Carboniferous sandstones and limestones in the uplands and Permo-Triassic mudstones and sandstones in the lowlands. From the south, the Trent is joined by the River Soar, which drains the igneous and metamorphic complex of Charnwood Forest and the Jurassic limestones of the Leicestershire Wolds. In common with the Yorkshire Ouse, the catchment of the Trent has also been affected by mining activities for lead and to a lesser extent copper, probably since the later prehistoric-early historic period. These contrasts in regional geology and distinctive human activities should allow the identification of key erosion and sedimentation episodes, which when linked to terrace units set within a chronostratigraphic framework, will provide a detailed sequence of natural and human-induced landscape development.

This Component has three main aims and objectives:

(i) To use sediment geochemistry and mineralogy to provenance key sedimentary units within the landscape.
(ii) To reconstruct catchment-scale land-use history on the basis of geochemical and mineralogical data.
(iii) To assess the impact of human activities, particularly industrial-scale mining activities on the natural and human environment.

The project involves a two-stage approach with this report presenting the results of Stage 1. This comprises fieldwork and sediment collection. Stage 2 involves the laboratory analysis of sediment samples.

In order to elucidate the geochemical and mineralogical characteristics of the fine-grained alluvial sediments deposited along the Trent, five key reaches were chosen along the course of the river and its major tributaries (the Dove, Derwent and Soar). Geomorphological maps were produced for each reach, and sediment samples were taken from key stratigraphic units within the terrace sequences.

The report includes for each reach: a brief description of the geomorphology and distribution of terraces, a geomorphological map, detailed sample descriptions and a detailed description of the terrace stratigraphy.

2. METHODOLOGY

2.1. REACH SELECTION

Five key reaches were chosen from within the Trent catchment. They were selected so that deposits provenanced from each of the main sediment source regions of the Trent could be analysed. Reaches are located in the Upper and Middle Trent Valley (upstream of the Dove confluence and downstream of Nottingham and the Soar confluence), and each of the major sub-catchments (Dove, Derwent and Soar). The study reaches are:

- Reach 1: Situated in the Upper Trent Valley near Great Haywood.
- Reach 2: Situated on the tributary valley floor of the River Dove near Tutbury.
- Reach 3: Situated on the tributary valley floor of the River Derwent near Ambaston.
- Reach 4: Situated on the tributary valley floor of the River Soar near Normanton on Soar.
- Reach 5: Situated in the Middle Trent Valley near Hoveringham, downstream of Nottingham.

Many of the reaches have some radiometric dating control, derived from Component 11a fieldwork.

2.2. TERRACE MAPPING

Geomorphological maps were produced for each reach, showing the river terrace sequence and other floodplain landforms (*e.g.* palaeochannels). LiDAR digital terrain models of the valley floor were used to aid this process, where available.

2.3. DEPOSIT SAMPLING

Up to eleven bulk samples (200-400g each) were taken from each of the terrace sequences (see appendix). Terrace units are sampled from natural river exposures where possible, but are also derived from small excavations, from drainage ditch exposures, and from sand and gravel quarry faces. Where sections reveal a heterolithic terrace deposit, several sub-samples were taken from the major stratigraphic units. A hand held Garmin GPS was used to record the location of each sampling site.

The geochemical and heavy mineral analysis of samples, to be done in Stage 2 of the project, will enable both a geochemical stratigraphy to be developed for each study site, and will be used to provenance the main alluvial deposits.

3. REACH 1 - UPPER TRENT VALLEY

3.1. SITE LOCATION

This reach of the River Trent is located in the Upper Trent Valley near the village of Great Haywood in Staffordshire (see fig. 1). The study area extends from near Farley Farm in the north, to Shugborough Hall in the south, and contains the confluence of the rivers Sow and Trent.

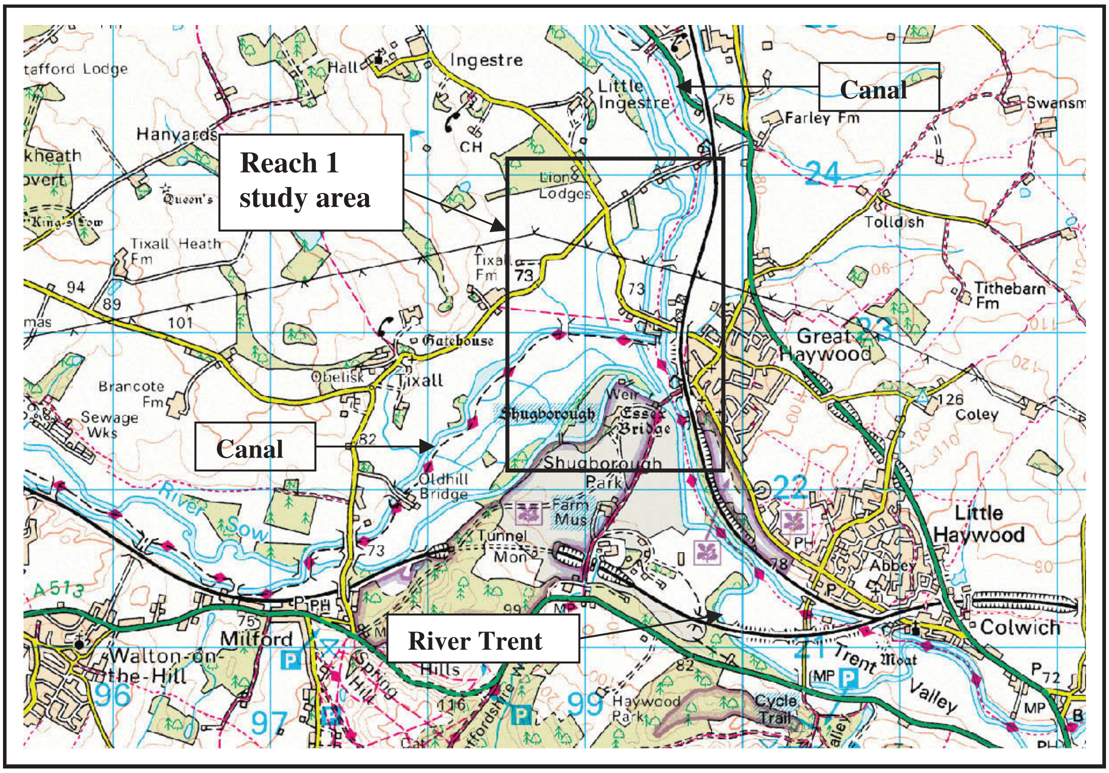

Fig. 1. Location of Reach 1 study area, Upper Trent Valley, Staffordshire, showing rivers Trent and Sow, and several canals.

3.2. GEOMORPHOLOGY

This part of the Upper Trent Valley, and the lower part of the Sow Valley (a tributary of the Trent) contain two river terraces. Fig. 2 shows a geomorphological map of the study area, and indicates the location of the sampling sites. The Terrace 2 surface has several sinuous palaeochannels, of varying sizes, crossing it. Their sinuosity suggests that the modern river has been channelised into a straighter planform at some time in the past. One of these palaeochannnels was cored for use in Component 11a of the Trent Valley Project. Terrace 1 contains two slightly sinuous palaeochannel fragments at the entrance to the Sow valley.

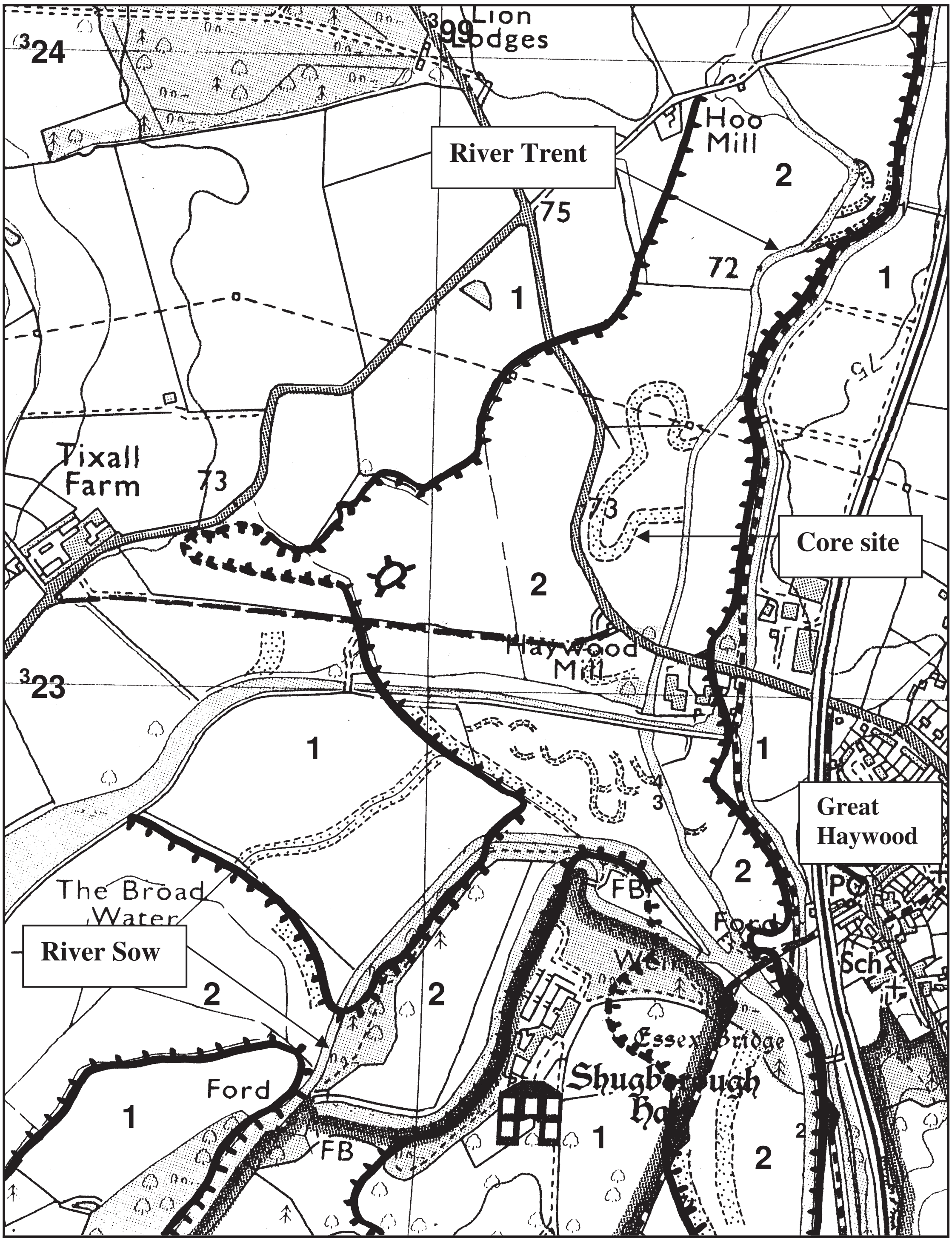

Fig. 2. Geomorphological map of the Upper Trent study reach at Great Haywood, Staffordshire, showing location of two River Terraces. (Small numbers relate to sampling sites.) Terrace 1 is the oldest. Site of Component 11a core is also indicated.

3.3. SAMPLE DESCRIPTIONS

Note: "GH" in sample code refers to Great Haywood and "T1", "T2" etc refer to Terrace 1, Terrace 2 etc.

3.3.1 Sample GH1/T1 GPS ref.: SJ 99716 23833

This sample is taken from the steep front of Terrace 1, on the eastern side of the River Trent valley. A partially vegetated 1.7m slope below the Trent and Mersey Canal, which runs along the edge of Terrace 1, is being eroded at its base by a channelised stream. The sample is taken 90cm below the terrace top, from a 15cm excavation into the bank.

The sample is from a massive grey-brown clayey silty gravely fine-medium SAND. Pebbles are 3-60mm, angular to rounded of sandstone, quartzite, vein quartz, limestone, coal, cinder and occasional brick. The coal/cinder and brick may have been introduced to the bank sediment post-depositionally from the adjacent canal.

3.3.2.1. Sample GH2a/T1 GPS ref.: SJ 99638 22351

An exposure on the east bank of the River Trent reveals a 58cm heterolithic section in Terrace 1. This sub-sample is taken 5-15cm below the terrace top from an upper 18cm unit.

The sub-sample is from a massive grey clayey silty gravely fine-course SAND. Pebbles are 3-40mm, angular to rounded of sandstone, quartzite, vein quartz, limestone, coal and cinder.

3.3.2.2. Sample GH2b/T1 GPS ref.: SJ 99638 22351

This sample is taken from the same section as GH2a, from 25-40cm below the terrace top, in the lower unit.

The sub-sample is from a grey-brown matrix-supported slightly silty sandy (fine-course) GRAVEL. Pebbles and small cobbles are 3-80mm, angular to rounded of sandstone, quartzite, vein quartz and limestone with occasional coal and occasional mudballs (c.3cm). Occasional laminated mud drapes.

3.3.3.1. Sample GH3a/T2 GPS ref.: SJ 99355 22873

A cutbank exposure on the west bank of the River Trent reveals a 1.6m heterolithic section in Terrace 2. This sub-sample is taken 5-15cm below the terrace top from an upper 20cm unit.

The sub-sample is from a massive grey silty fine-medium SAND with occasional gravel. Pebbles are 3-30mm, angular to rounded of sandstone, quartzite, vein quartz and limestone.

3.3.3.2. Sample GH3b/T2 GPS ref.: SJ 99355 22873

This sample is taken from the same section as GH3a, from 50-90cm below the terrace top, in the lower unit.

The sub-sample is from a massive red-brown silty CLAY.

3.3.4.1. Sample GH4a/T2   GPS ref.: SJ 99352 22883

A cutbank exposure on the west bank of the River Trent reveals, in cross-section, a small 7m wide palaeochannel incising through Terrace 2. The channel infill (and surrounding terrace) is draped in a 20cm thick layer of grey silty sand identical to GH3a. This sub-sample is taken 40-45cm below the terrace top within the palaeochannel infill.

The infill is a brown gravely very fine-very course SAND with lenses (up to 5cm thick) of clay. Pebbles and small cobbles are 3-80mm, angular to rounded of sandstone, vein quartz, limestone, mudstone and siltstone.

3.3.4.2. Sample GH4b/T2   GPS ref.: SJ 99352 22883

This sub-sample is a red-brown CLAY and is taken from a clay lense in the same palaeochannel infill as GH4a, at 45cm depth.

3.4. TERRACE STRATIGRAPHY

Note: only brief sediment descriptions are given for stratigraphic units that have been sampled, as these deposits have full descriptions above.

3.4.1. Terrace 1

The terrace consists of sand overlying gravel. The contact is sharp, and locally planar. However, the sand varies in thickness throughout the valley.

0-18(>50)cm	*Description*: clayey silty gravely fine-course **SAND** (see 3.3.2.1) *Lower contact*: sharp, planar *Samples*: GH1 and GH2a *Artefacts*: coal, cinder, brick
18->110cm	*Description*: silty sandy **GRAVEL** with occ. mudballs(see 3.3.2.2) *Lower contact*: not seen *Samples*: GH2b *Artefacts*: none

3.4.2. Terrace 2

The terrace consists of sand overlying clay. The terrace surface is dissected by palaeochannels, the small ones (5m wide) infilled with gravely sand, and the large ones (10m wide) infilled with silt and organic clay. The small palaeochannels are draped in the same 20cm sand bed as the surrounding terrace surface.

0-20cm	*Description*: silty fine-medium **SAND** (see 3.3.3.1) *Lower contact*: sharp, planar *Samples*: GH3a *Artefacts*: none
20->160cm	*Description*: silty **CLAY** (see 3.3.3.2) *Lower contact*: not seen *Samples*: GH3b

Artefacts: none

Small **Palaeochannel** infill:

20->80cm *Description*: gravely very fine-very course SAND with lenses of CLAY (see 3.3.4.1 and 3.3.4.2)
Lower contact: not seen
Samples: GH4a and GH4b
Artefacts: none

Large **Palaeochannel** infill (see Component 11a report, section 3.1.2):
0-70cm *Description*: clayey SILT
Lower contact: gradational
Samples: core 1
Artefacts: none
70-110cm *Description*: organic silty sandy CLAY
Lower contact: sharp
Samples: core 1
Artefacts: none
110-120cm *Description*: well sorted medium-course SAND
Lower contact: sharp
Samples: core 1
Artefacts: none

3.4.3. Summary

The terrace sequence in the Upper Trent Valley is summarised in fig. 3.

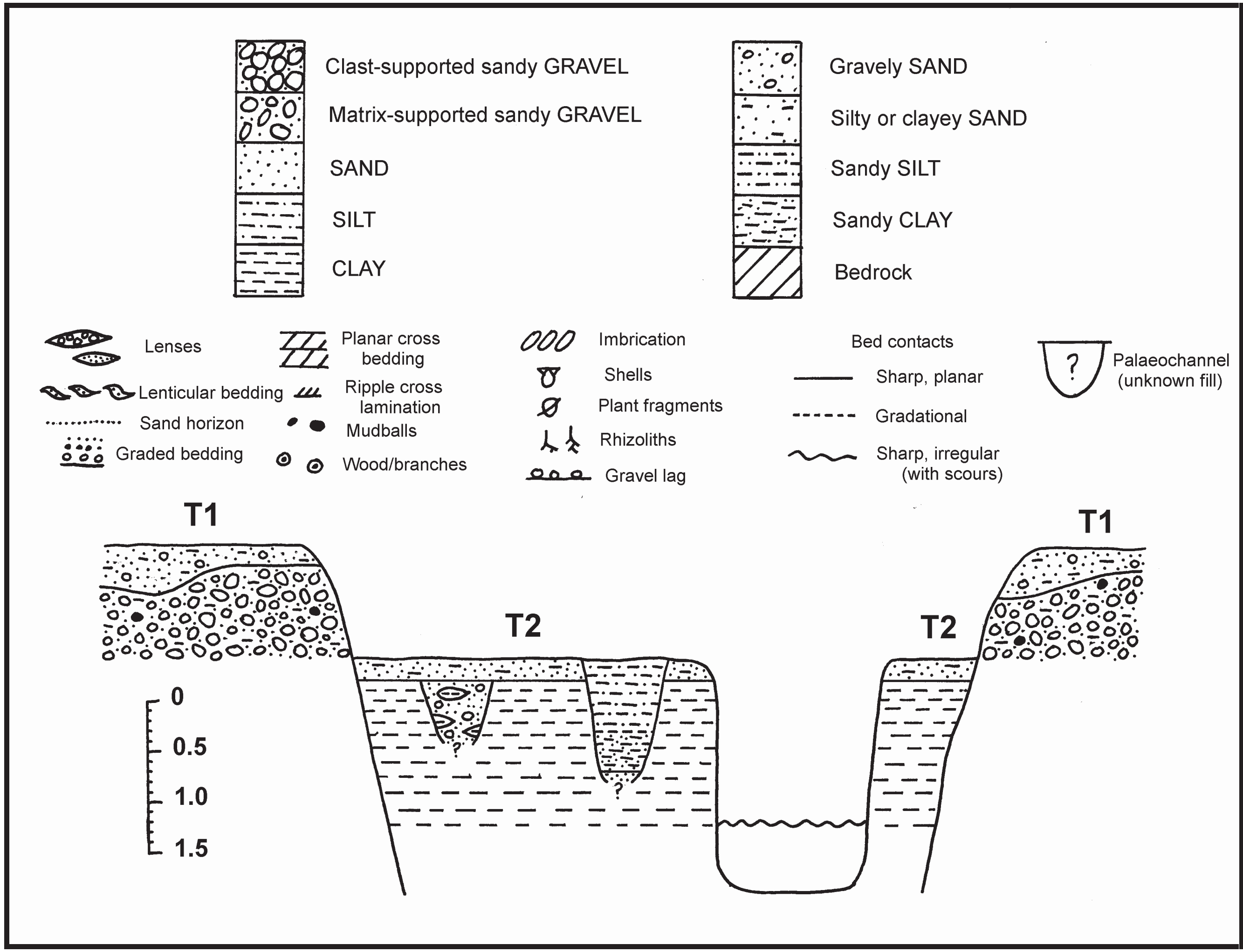

Fig. 3. Schematic transect across the Upper Trent Valley at Reach 1. Vertical (and lateral) distribution of deposits based on stratigraphic logs and other field measurements/observations. Vertical scale in metres.

4. REACH 2 - DOVE VALLEY

4.1. SITE LOCATION

This reach of the River Dove is located beneath Tutbury Castle in the Lower Dove Valley, 8km upstream of the confluence with the River Trent (see fig. 4).

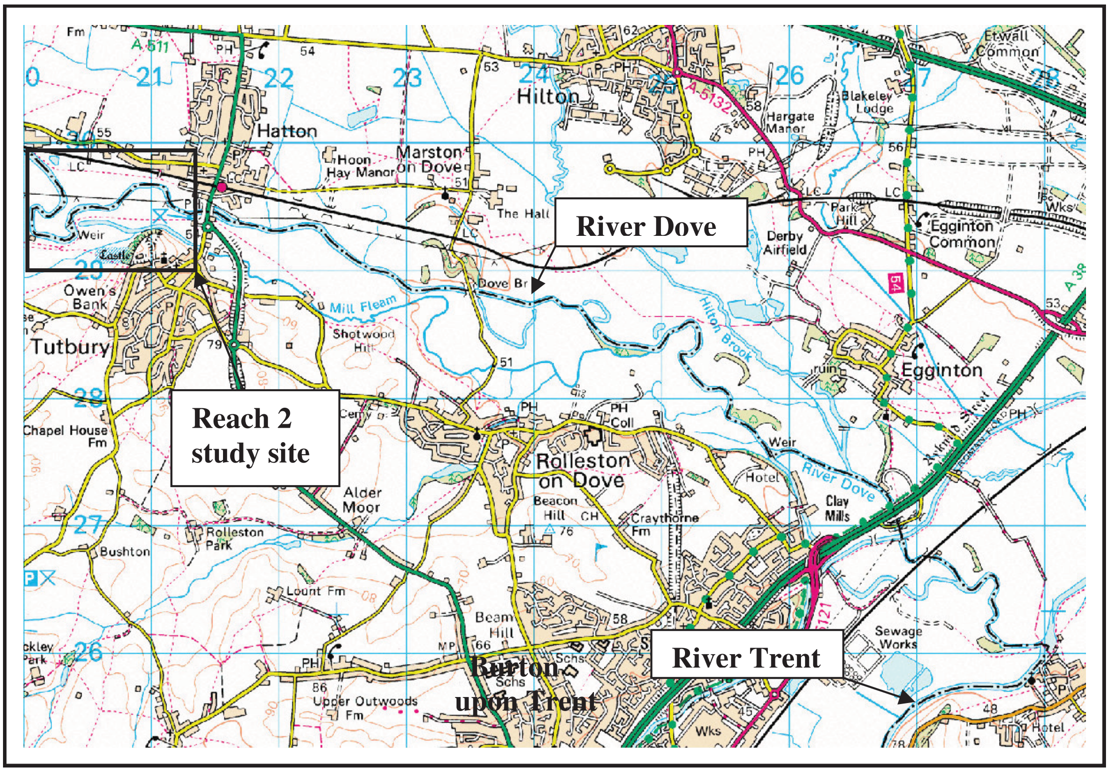

Fig. 4. Location of Reach 2 study area, Lower Dove Valley, Derbyshire.

4.2. GEOMORPHOLOGY

The Lower Dove valley in this area contains four river terraces. Fig. 5 shows a geomorphological map of the study area. Terrace 4 is the contemporary floodplain and is deposited on the inside of meander bends.

Terrace 3 forms an almost continuous ribbon, rarely being deposited further than 50m from the modern river. The exception is a large meander loop of Terrace 3 age, abandoned by neck cutoff, which dissects Terrace 2 on the south side of the river below the castle. Terrace 3 also shows evidence of some braiding, with relict mid-channel bars present.

Terrace 2 is the most arealy extensive terrace on the valley floor, especially south of the river. The terrace top contains occasional narrow slightly sinuous or straight palaeochannels that are probably flood channels or yazoo’s in origin.

The highest and oldest terrace, Terrace 1, is preserved on the north side of the valley and is exposed in high cutbanks where it is being eroded by the modern river. A

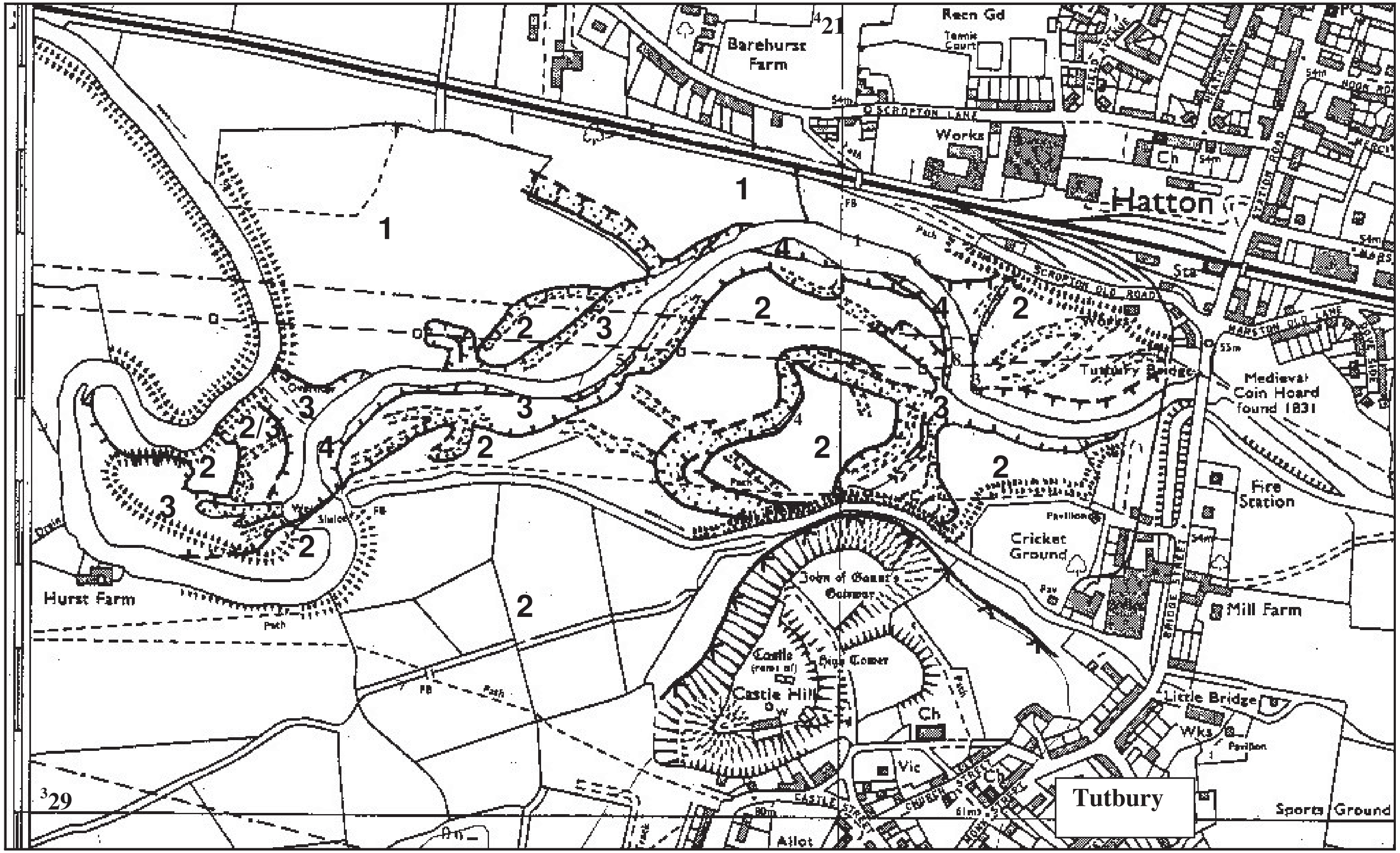

Fig. 5. Geomorphological map of the River Dove study reach at Tutbury, Derbyshire, showing location of 4 River Terraces. (Small numbers relate to sampling sites.) Scale on left is in 100m divisions.

single palaeochannel dissects its top in this reach. Medieval ridge and furrow is present on the terrace surface.

4.3. SAMPLE DESCRIPTIONS

Note: "Do" in sample code refers to Dove valley and "T1", "T2" etc refer to Terrace 1, Terrace 2 etc.

4.3.1.1. Sample Do1a/T1 GPS ref.: SK 21046 29717

On the north bank of the River Dove, a 150m long exposure reveals a 3.5m cutbank section of Terrace 1. A large 17m wide palaeochannel is revealed in cross-section (see fig. 6). This sub-sample is taken from 50-110cm below the terrace top, within an upper alluvium layer that was deposited both on top of the palaeochannel and surrounding gravel, and also forms the upper, final part of the channel infill.

The deposit is an orange-brown massive clayey sandy (fine-medium) SILT. The upper 25cm contains occasional gravel. Pebbles are 2-20mm, sub-angular to well rounded of sandstone, vein quartz, limestone, gritstone and basalt. The lower infill section of the deposit shows orange mottling from root bioturbation.

4.3.1.2. Sample Do1b/T1 GPS ref.: SK 21046 29717

This sub-sample is taken from the same section as Do1a, from a sedimentary unit that forms the basal part of the palaeochannel infill (see fig. 6). The unit is c.15cm thick, with the sub-sample taken from its base at 175cm below the terrace top.

The deposit is a grey fissile thinly laminated peaty silty CLAY with numerous plant macrofossils.

4.3.1.3. Sample Do1c/T1 GPS ref.: SK 21046 29717

This sub-sample is also taken from the Terrace 1 palaeochannel infill, from a sandy unit which represents a relict point-bar deposit (see fig. 6) and was taken 140cm below the terrace top.

The deposit is a mix of: (i) planar cross-bedded (15cm sets; trough cross-bedded in shallowest part of palaeochannel) and ripple cross laminated well sorted course SAND and (ii) massive silty gravely medium-course SAND. Pebbles are 3-60mm, sub-angular to rounded of sandstone, gritstone, limestone and vein quartz. Numerous sub-vertical rhizoliths.

4.3.1.4. Sample Do1d/T1 GPS ref.: SK 21046 29717

This sub-sample is taken at 1.90cm, from a mudball in the gravel below the Terrace 1 paleochannel (see fig. 6).

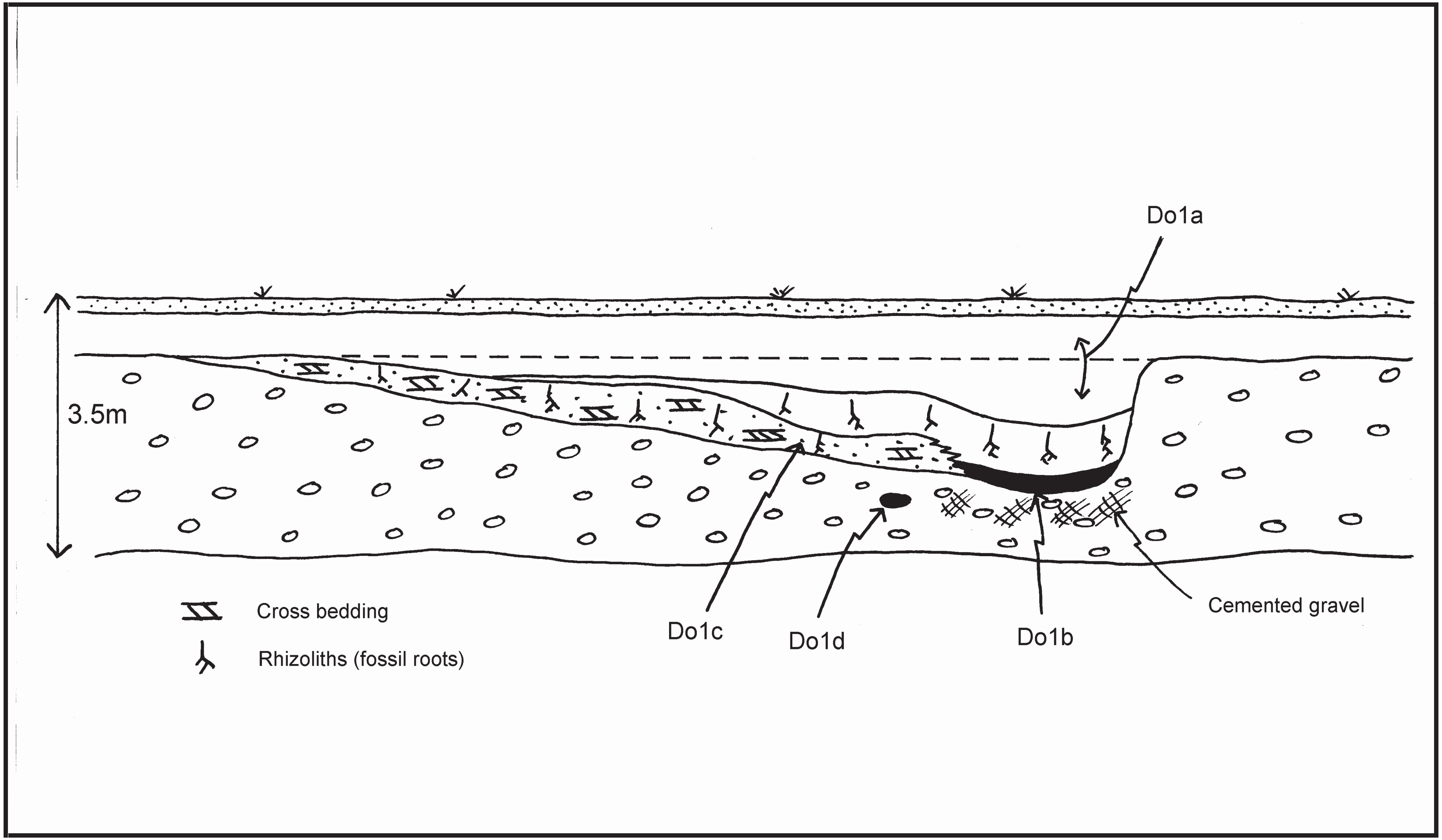

Fig. 6. Cross-section of large palaeochannel (c.17m wide) exposed in Terrace 1 cutbank.

The mudball intraclast has a 35cm a-axis, and is a dark grey-black organic CLAY with orange root traces. The surrounding clast-supported sandy GRAVEL has many imbrication clusters, indicating a palaeocurrent to the south-west (230°). Pebbles and small cobbles are 3-100mm, sub-rounded to well rounded of sandstone, quartzite, vein quartz, limestone, porphyritic basalt and volcanic agglomerate. The matrix is a granular medium-very course sand. The gravel is cemented by $CaCO_3$ below the palaeochannel.

4.3.2. Sample Do3/T2 GPS ref.: SK 21192 29532

A cutbank exposure on the north bank of the River Dove reveals a 2.35m heterolithic section in Terrace 2. This sample is taken 40-80cm below the terrace top, within the sandy infill of a wide palaeochannel that cuts through the surrounding Terrace 2 gravel.

The deposit is a red-brown silty medium-course SAND with isolated occasional small pebbles of Triassic claystone and coal. The red hue is caused by comminuted Triassic claystone within the sand's matrix, often concentrated into red sandy lenses (4-12mm thick). Towards the base of the unit are horizons and lenses (typically c.4cm thick) of clast and matrix-supported Gravel. Pebbles are 4-60mm, sub-rounded to rounded of sandstone, quartzite, vein quartz, limestone, siltstone, basalt and occasional Triassic claystone.

4.3.3. Sample Do4/T2 GPS ref.: SK 20948 29544

This sample is taken from a 1.3m high relic cutbank on the edge of a large palaeochannel that meanders across Terrace 2, north of Tutbury Castle. The sample is taken from an excavation 90cm below the terrace top.

The terrace sediment is an orange-brown silty slightly gravely medium-course SAND. Pebbles are 8-20mm, angular to well rounded of sandstone, quartzite, vein quartz, limestone, mudstone and occasional granules (2-3mm) of coal.

4.3.4. Sample Do5/T3 GPS ref.: SK 20754 29564

A cutbank exposure on the south bank of the River Dove reveals a 1.5m heterolithic section in Terrace 3. This sample is taken from within the upper unit, 40-100cm below the terrace top.

The sample is from a silty fine-medium SAND with occasional gravel. Pebbles are 3-30mm, sub-rounded to rounded of sandstone, siltstone, vein quartz. Occasional horizons with flakes (2-20mm) of charcoal and coal. Brick roof(?) tile fragment found within a stringer of gravel, near base of unit.

4.3.5 Sample Do6/T3. GPS ref.: SK 21107 29671

A cutbank exposure on the north bank of the River Dove reveals a deposit of Terrace 3 infilling two palaeo-gullies (c.5-6m wide each) that steeply incise into Terrace 1 (sloping out of section). One gully infill forms a spur protruding into the river channel, caused by its greater competence than the surrounding Terrace 1 gravel. The sample is taken from 30-80cm below the terrace top, within this spur.

The sample is from a grey silty fine-medium SAND with occasional gravely horizons. Pebbles are 4-20mm, angular to rounded of sandstone, quartzite, limestone and slag, with many cinder and coal fragments, and some pottery fragments and clay pipes.

4.3.6. Sample Do7/T4 GPS ref.: SK 20720 29538

This sample is taken from the cutbank of a narrow (3m wide) vegetated Terrace 4 deposit on the south bank of the River Dove, and is taken from 15-35cm below the terrace top.

The sample is from a massive grey-brown sandy (fine-medium) CLAY.

4.3.7. Sample Do8/T4 GPS ref.: SK 21153 29575

This sample is taken from within a narrow vegetated Terrace 4 deposit on the south bank of the River Dove. The sample is taken from an excavation 40cm below the terrace top.

The sample is from a grey organic sandy (fine-medium) CLAY with many rootlets. Although heavily root bioturbated, there are traces of occasional medium sand layers(c.1cm).

4.4. TERRACE STRATIGRAPHY

Note: only brief sediment descriptions are given for stratigraphic units that have been sampled, as these deposits have full descriptions above.

4.4.1. Terrace 1 (Holme Pierrepont Terrace)

This is the oldest and highest terrace in the reach. The terrace consists of a thin winter flood deposit (100yr flood?) of T3 age sand overlying T1 silt, which overlies gravel. A large infilled paleochannel is preserved at the top of the gravel deposit.

0-25cm	*Description*: grey silty fine-course **SAND** with occasional gravel. Pebbles are 2-20mm, sub-angular to rounded of sandstone, quartzite, vein quartz, basalt, coal and brick . *Lower contact*: sharp, planar, with some gravel lag *Samples*: none *Artefacts*: coal and brick *Comments*: **Terrace 3 age** sediment, deposited on this terrace during a winter flood
25-80cm	*Description*: clayey sandy **SILT** (see 4.3.1.1) *Lower contact*: sharp, planar *Samples*: Do1a *Artefacts*: none

80->350cm *Description*: sandy **GRAVEL** with occ. mudballs. Cemented by CaCo$_3$ below the palaeochannel (see 4.3.1.4).
Lower contact: not seen
Samples: Do1d
Artefacts: none

Palaeochannel infill (see fig. 6):

80-110cm *Description*: clayey sandy SILT (see 4.3.1.1)
Lower contact: gradational, curved
Samples: Do1a
Artefacts: none
Comments: continuation of upper silt unit (see above)

90-160cm *Description*: light grey gleyed silty CLAY with numerous sub-vertical rhizoliths
Lower contact: sharp, non-erosive, irregular
Samples: none
Artefacts: none

80-160cm *Description*: the deposit is a mix of: (i) planar cross-bedded and ripple cross laminated course SAND and (ii) massive silty gravely medium-course SAND. Numerous sub-vertical rhizoliths (see 4.3.1.3)
Lower contact: sharp, inclined
Samples: Do1c
Artefacts: none
Comments: represents a relict point-bar deposit

160-175cm *Description*: fissile thinly laminated peaty silty CLAY with numerous plant macro fossils (see 4.3.1.2)
Lower contact: sharp, erosive
Samples: Do1b
Artefacts: none

4.4.2. Terrace 2 (Hemington Terrace)

The terrace consists of a sand deposit overlying a gravel. The contact is irregular, caused by a depositional topography of gravel bars. The sand infills wide shallow (*c*.80cm) palaeochannels that cut through the gravel surface. The sequence described below was logged through one such channel. A thin winter flood deposit (100yr flood?) of T3 age sand overlies Terrace 2.

0-20cm *Description*: grey silty fine-medium **SAND** with occasional gravel. Pebbles are 5-15mm, angular to rounded of sandstone, quartzite, coal and pottery fragments
Lower contact: sharp (diffused due to root bioturbation), planar
Samples: none
Artefacts: coal, pottery, clay pipe
Comments: **Terrace 3 age** sediment, deposited on this terrace during a winter flood

20-110cm *Description*: silty medium-course **SAND** with horizons/lenses of gravel near the base (see 4.3.2 and 4.3.3)
Lower contact: sharp, irregular, with gravel lag

Samples: Do3 and Do4
Artefacts: coal

110->235cm *Description*: clast-supported sandy **GRAVEL**. Pebbles and small cobbles are 4-90mm, sub-angular to rounded of sandstone, quartzite, vein quartz, limestone, basalt, gritstone, flint and black shale. Matrix is medium-very course granular sand. Occasional imbrication clusters.
Lower contact: not seen
Samples: none
Artefacts: none

4.4.3. Terrace 3

The terrace consists of sand overlying gravel. An irregular erosion surface, with many small channels and scours, separates the two deposits.

Terrace 3 sediment also infills gullies that are steeply incised into the edge of Terrace 1. It is present as a thin layer on the tops of Terrace's 1 and 2, where it was probably deposited during severe winter floods (100yr flood?).

0-100(150)cm *Description*: silty fine-medium **SAND** (see 4.3.4 and 4.3.5). At 25-40cm is an horizon of lenticular lamination, with small lenses (up to 10mm thick) of well sorted medium sand.
Lower contact: sharp, irregular, erosive
Samples: Do5 and Do6
Artefacts: coal, charcoal, brick (roof?) tile, pottery, slag, clay pipe

100(150) >210cm *Description*: clast-supported sandy **GRAVEL**. Pebbles and cobbles are 5-150mm, sub-rounded to well rounded of mainly sandstone, but also quartzite, vein quartz, limestone and occasional flint. Matrix is a grey course-very course sand.
Lower contact: not seen
Samples: none
Artefacts: none

4.4.4. Terrace 4

Terrace 4 is the contemporary floodplain and is a sandy clay with occasional sand layers.

0->75cm *Description*: sandy **CLAY** with occasional very thin beds of medium sand (see 4.3.6 and 4.3.7)
Lower contact: not seen
Samples:Do7 and Do8
Artefacts: none

4.4.5. Summary

The terrace sequence in the Dove Valley is summarised in fig. 7.

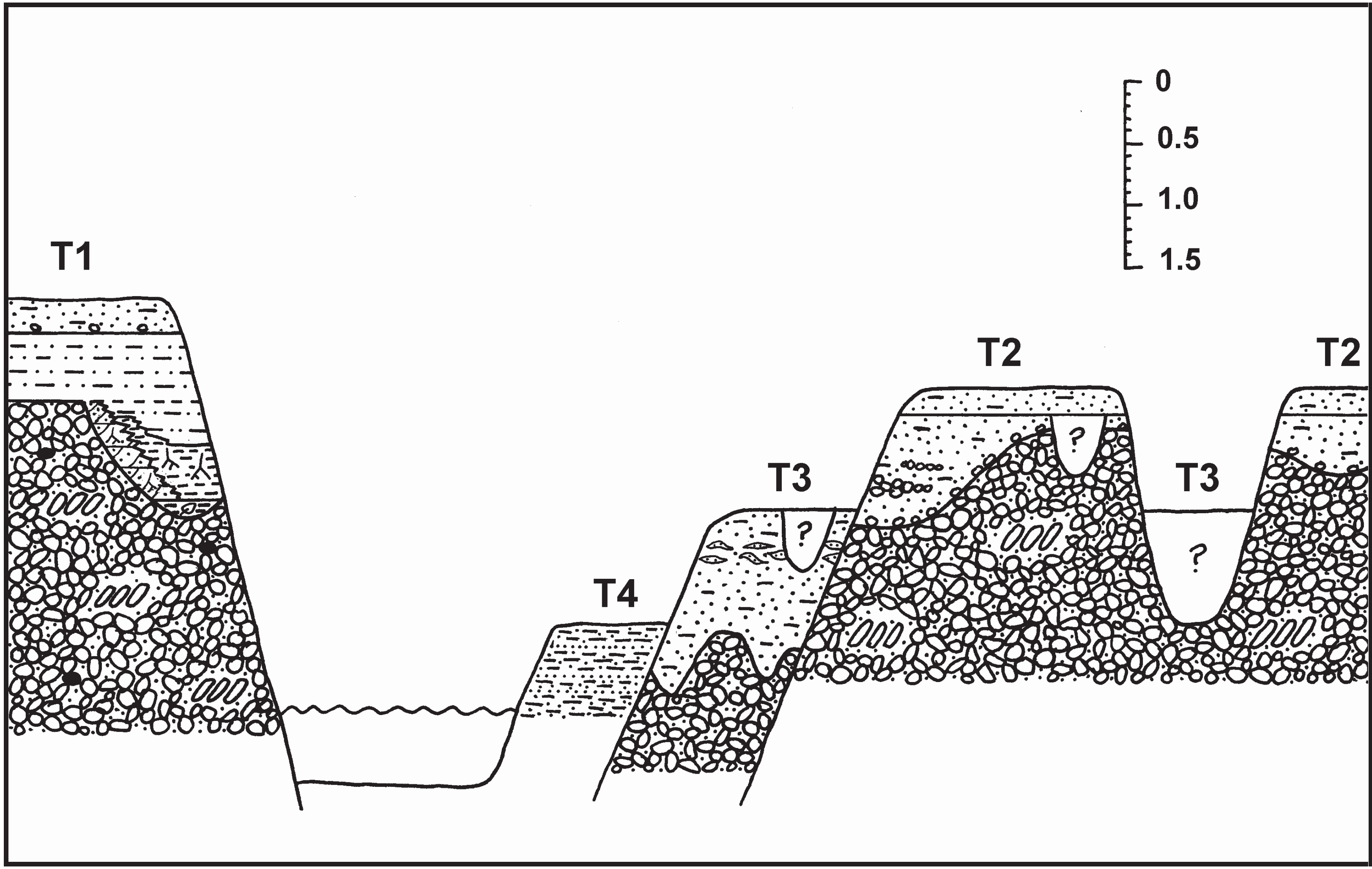

Fig. 7. Schematic transect across the Dove Valley at Reach 2. Vertical (and lateral) distribution of deposits based on stratigraphic logs and other field measurements/observations. See fig. 3 for key. Vertical scale in metres.

5. REACH 3 - DERWENT VALLEY

5.1. SITE LOCATION

This reach of the Lower Derwent Valley is located near the village of Ambaston, 4km upstream of the confluence with the River Trent (see fig. 8).

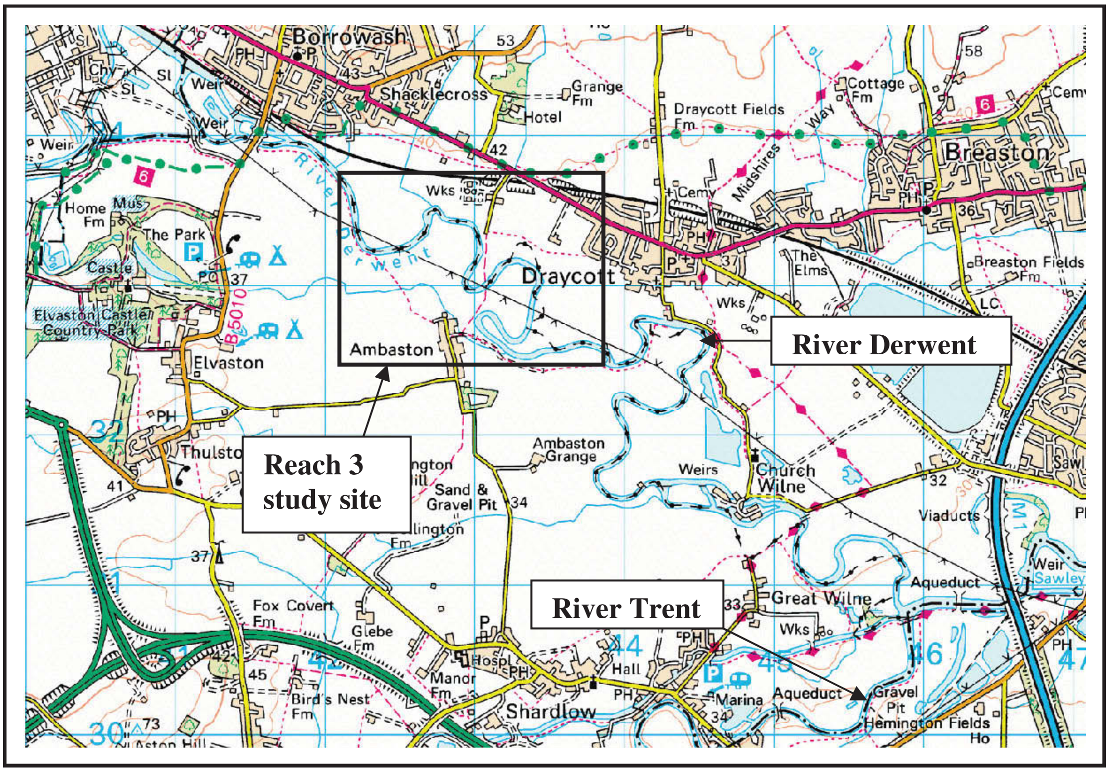

Fig. 8. Location of Reach 3 study area, Lower Derwent Valley, Derbyshire.

5.2. GEOMORPHOLOGY

The Lower Derwent valley in this area contains five river terraces. Fig. 9 shows a geomorphological map of the study area. Terrace 5 is the contemporary floodplain and is deposited as a narrow strip on the margins of the channel, mainly on the inside of meander bends. One terrace fragment on the inside of a meander is backed by a relict chute channel, and another section of terrace 5 contains a palaeochannel.

Terrace 4 is preserved inside one large meander at the upstream end of the reach, and as a small terrace fragment within part of a tight meander core.

Most of the valley beside the modern meander belt is occupied by Terrace 3 sediment. The meander belt is bounded to the north-east by Terrace 1, and to the south-west by Terrace 2. The inside of one meander shows several scroll bars and curved sloughs. Several palaeochannels are also present on the terrace surface, the smaller ones probably being yazoo's in origin.

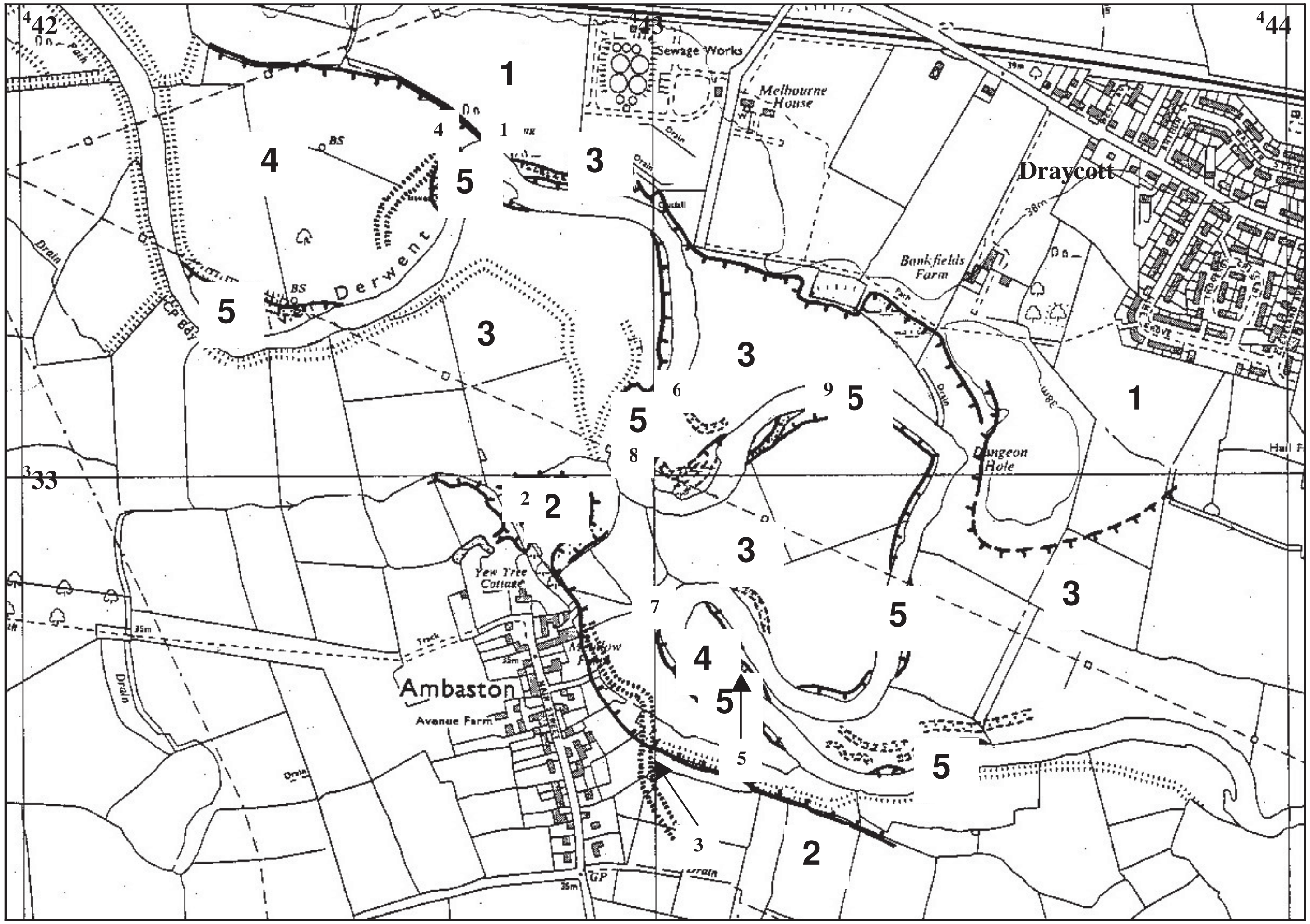

Fig. 9. Geomorphological map of the River Derwent study reach at Ambaston, Derbyshire, showing location of 5 River Terraces. (Small numbers relate to sampling sites.)

Although terrace 2 is extensively preserved to the south-west of the River Derwent, the modern river does not at any point erode into this terrace. The village of Ambaston is built on the edge of this terrace.

Terrace 1 is the highest and oldest terrace, and is preserved to the north-east of the river. It is being actively eroded by the Derwent at only one location. No palaeochannels are present on its surface in this reach.

5.3. SAMPLE DESCRIPTIONS

Note: "De" in sample code refers to Derwent valley and "T1", "T2" etc refer to Terrace 1, Terrace 2 etc.

5.3.1.1. Sample De1a/T1 GPS ref.: SK 42788 33486

A cutbank exposure on the north bank of the River Derwent reveals a 3.75m heterolithic section, with 190cm of Terrace 1 overlying 185cm of Triassic Mudstone. This sub-sample is taken from 30-80cm below the terrace top, within the uppermost Terrace 1 unit.

The sub-sample is from a yellow-brown sandy SILT with occasional gravel. Pebbles are 4-50mm, well rounded of limestone and quartzite.

5.3.1.2. Sample De1b/T1 GPS ref.: SK 42788 33486

This sub-sample is taken from the same section as De1a, but from the lower Terrace 1 unit at 140-180cm.

The sample is from the matrix of a yellow-grey clast-supported sandy GRAVEL. The pebbles and cobbles are 6-200mm (mean size is 40-60mm), well rounded of sandstone, quartzite, vein quartz, limestone and gritstone. The matrix is a silty granular course-very course quartz sand. Granules are of basalt, quartzite and limestone. Angular quartz sand is derived from weathered and eroded gritstone (Millstone Grit).

5.3.1.3. Sample De1c/T1 GPS ref.: SK 42788 33486

This sub-sample is taken from the same section as De1a, but from 2.0-2.5m below the terrace top in the lower bedrock unit.

The sample is from a purple thinly laminated (2-3mm) silty CLAYSTONE with many mudflake intraclasts (Cropwell Bishop Formation, Upper Triassic).

5.3.2. Sample De2/T2 GPS ref.: SK 42762 32969

A small stream dissects Terrace 2 on the south side of the River Derwent. This sample is taken from an excavation on its north-east bank, 65cm below the terrace top.

The sample is from a grey clayey SILT with occasional matrix-supported gravel horizons (2-3cm thick). Pebbles are 10-30mm, sub-angular to rounded of quartzite, limestone and basalt. The gravel matrix is a clayey sandy silt.

5.3.3. Sample De3/T2 GPS ref.: SK 43016 32576

The front of Terrace 2 (vegetated slope), on the south side of the River Derwent, is located c.5m behind a flood embankment. This sample is taken from an excavation 30cm below the terrace top.

The sample is from a grey-brown silty CLAY.

5.3.4. Sample De4/T4 GPS ref.: SK 42721 33537

A drainage ditch to the north of the River Derwent reveals a 1.65m section of Terrace 4. The sample is taken from 40-150cm below the terrace top.

The sample is from a massive grey clayey micaceous SILT.

5.3.5. Sample De5/T4 GPS ref.: SK 43141 32662

Within a tight meander core of the River Derwent, an area of Terrace 4 is preserved. The sample is taken from an excavation in the vegetated terrace front, 7-15cm below the terrace top.

The sample is from a massive grey clayey sandy (very fine-fine) SILT.

5.3.6. Sample De6/T3 GPS ref.: SK 43037 33114

A cutbank exposure reveals a 1.8m section of Terrace 3. The sample is taken from 70-100cm below the terrace top.

The sample is from a light grey silty fine SAND.

5.3.7. Sample De7/T3 GPS ref.: SK42991 32773

A stream channel, east of Ambaston village, exposes a 2.1m section of Terrace 3 near its confluence with the Derwent. This sample is taken from 90-130cm below the terrace top.

The sample is from a massive light grey sandy (very fine-fine) SILT.

5.3.8. Sample De8/T5 GPS ref.: SK 43004 33058

A cutbank exposure on the north bank of the River Derwent reveals a 1.3m heterolithic section of Terrace 5.

Beneath an upper 17cm light grey silty fine-course sand layer, the sediment is a grey clast-supported sandy GRAVEL interbedded with many flasers (occupying scour troughs) and trough cross-bedded beds of SAND and silty CLAY. Pebbles and small cobbles in the gravel are 3-90mm, sub-rounded to well rounded, usually tabular and prolate, of sandstone, quartzite, limestone, gritstone, basalt, coal, and occasional brick and pottery fragments. A piece of leather was also found.

This sample is taken from 80-100cm below the terrace top, from a lense of thickly interlaminated silty slightly gravely medium-course SAND and silty CLAY with many granules and small pebbles of coal. Other pebbles are 2-30mm, sub-rounded to well rounded of sandstone, quartzite, limestone, gritstone and basalt. The clay is contaminated with a noxious industrial chemical.

Other lenses within the gravel are composed of sandy CLAY and clayey gravely fine SAND. Most of the sand and clay beds and flasers contain pieces of timber (planks and posts) and natural wood debris, with a large animal bone found in one lense.

5.3.9. Sample De9/T5 GPS ref.: SK 43245 33125

This sample is taken from an excavation, 80cm below the top of Terrace 5 (contemporary floodplain), located on the inside of a wide meander of the River Derwent.

The sample is from a soft grey silty CLAY with occasional thin (2cm) horizons of fine sand (typically 8-10cm of clay, 2cm of sand).

5.4. TERRACE STRATIGRAPHY

Note: only brief sediment descriptions are given for stratigraphic units that have been sampled, as these deposits have full descriptions above.

5.4.1. Terrace 1 (Allenton Terrace)

This is the oldest and highest terrace in the reach. The terrace consists of a silt overlying a gravel, and is deposited on top of the Triassic Mercia Mudstone.

0-100cm	*Description*: sandy **SILT** (see 5.3.1.1) *Lower contact*: gradational, planar *Samples*: De1a *Artefacts*: none
100-190cm	*Description*: sandy **GRAVEL** (see 5.3.1.2) *Lower contact*: sharp, irregular, erosive *Samples*: De1b *Artefacts*: none
190->375cm	*Description*: 10-60cm bedsets of purple thinly laminated (2-3mm) silty **CLAYSTONE** with many mudflake intraclasts, interbedded with 10-15cm bedsets of very thinly bedded blue-grey micaceous **SILTSTONES** and very fine **SANDSTONES**, with ripple cross lamination (Cropwell Bishop Formation, **Upper Triassic**). (see 5.3.1.3) *Lower contact*: not seen *Samples*: De1c *Artefacts*: none

5.4.2. Terrace 2 (Hemington Terrace)

This terrace consists of clayey silts and silty clays.

0->70cm	*Description*: clayey **SILT** and silty **CLAY** (see 5.3.2 and 5.3.3) *Lower contact*: not seen *Samples*: De2 and De3 *Artefacts*: none

5.4.3. Terrace 3

This terrace consists of silty sands and sandy silts.

0->210cm	*Description*: silty fine SAND and sandy SILT (see 5.3.6 and 5.3.7). Several thin (5-10mm) medium sand horizons are found between 35 and 60cm below the terrace top. They are laterally continuous, throughout the valley. *Lower contact*: not seen *Samples*: De6 and De7 *Artefacts*: none

5.4.4. Terrace 4

This terrace consists of a clayey SILT, sometimes overlying a sandy gravel.

0->165cm (or 0-20cm)	*Description*: clayey **SILT** and clayey sandy **SILT** (see 5.3.4 and 5.3.5) *Lower contact*: either not seen **or** sharp, irregular when underlain by gravel *Samples*: De4 and De5 *Artefacts*: none *Comments*: 20cm thick when overlying gravel
20->50cm	*Description*: clast-supported silty sandy **GRAVEL**. Pebbles are 4-60mm, sub-angular to well rounded of sandstone, quartzite, limestone and basalt *Lower contact*: not seen *Samples*: none *Artefacts*: none *Comments*: not always present

5.4.5. Terrace 5

This terrace, the modern floodplain, has much variation in its lithology. It can either consist of: **(i)** silty clay (see5.3.9), or **(ii)** silty sand overlying a gravel with many flasers and interbeds of sand and silty/sandy clay. The terrace is sometimes contaminated by a noxious industrial chemical (see 5.3.8).

(i)

0->110cm	*Description*: silty **CLAY** with occasional thin horizons of fine sand (see 5.3.9) *Lower contact*: not seen

Samples: De9
Artefacts: none

(ii)

0-17cm	*Description*: light grey silty fine-course **SAND** *Lower contact*: sharp, planar *Samples*: none *Artefacts*: none
17->130cm	*Description*: clast-supported sandy **GRAVEL** with many erosion surfaces and many flasers, lenses and interbeds of SAND and silty and sandy CLAY. Most sand and clay beds/flasers contain both timber fragments (planks and posts) and natural wood debris (see 5.3.8). *Lower contact*: not seen *Samples*: De8 *Artefacts*: coal, timber (planks and posts), brick, pottery, animal bone, leather

5.4.6. Summary

The terrace sequence in the Derwent Valley is summarised in fig. 10.

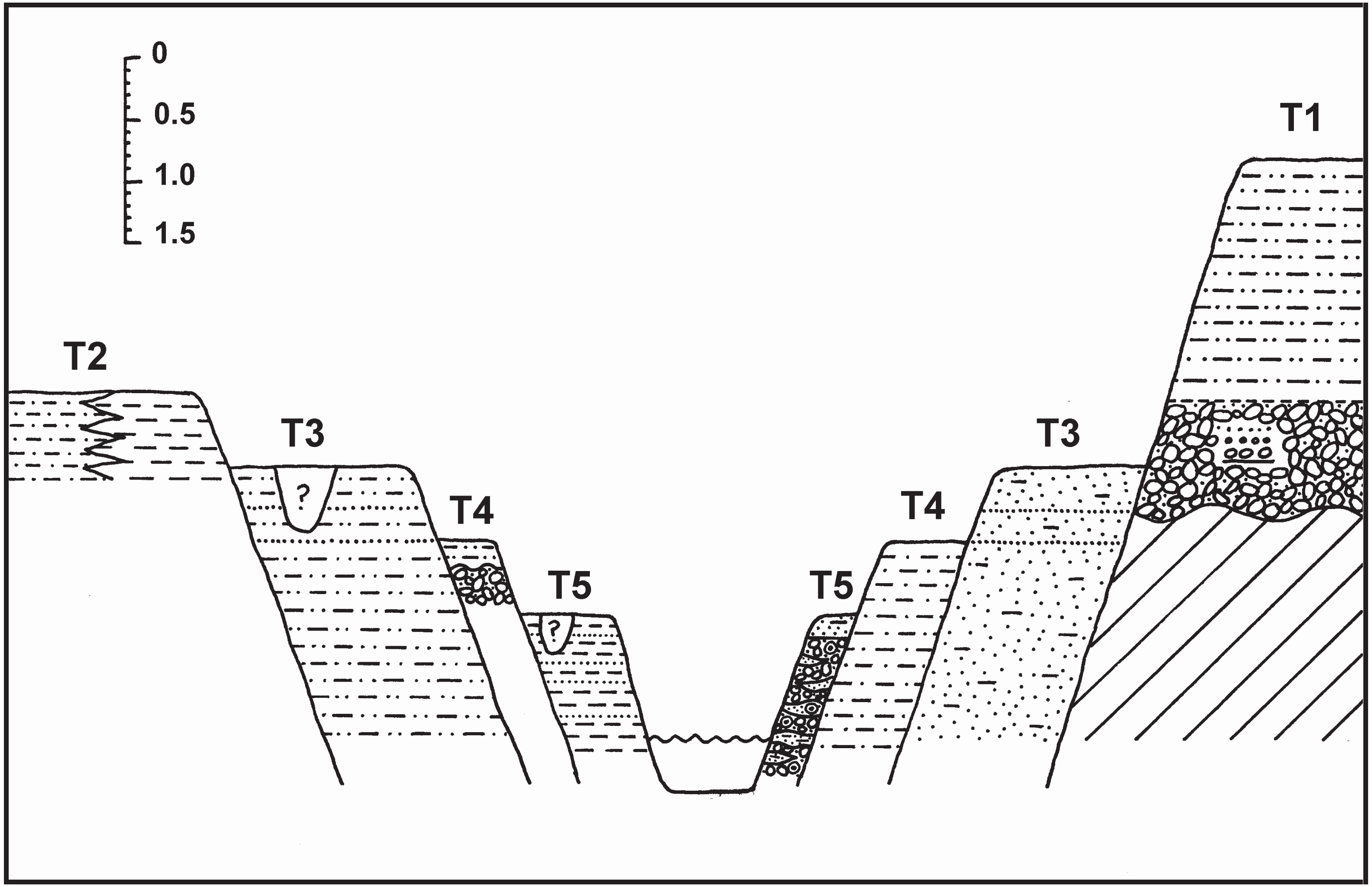

Fig. 10. Schematic transect across the Derwent Valley at Reach 3. Vertical (and lateral) distribution of deposits based on stratigraphic logs and other field measurements/observations. See fig. 3 for key. Vertical scale in metres.

6. REACH 4 - SOAR VALLEY

6.1. SITE LOCATION

This reach of the Lower Soar Valley is located beside the village of Normanton on Soar, approximately 8km upstream of the confluence with the River Trent (see fig. 11). The study area extends from the village of Zouch in the north, to near the outskirts of Loughborough in the south.

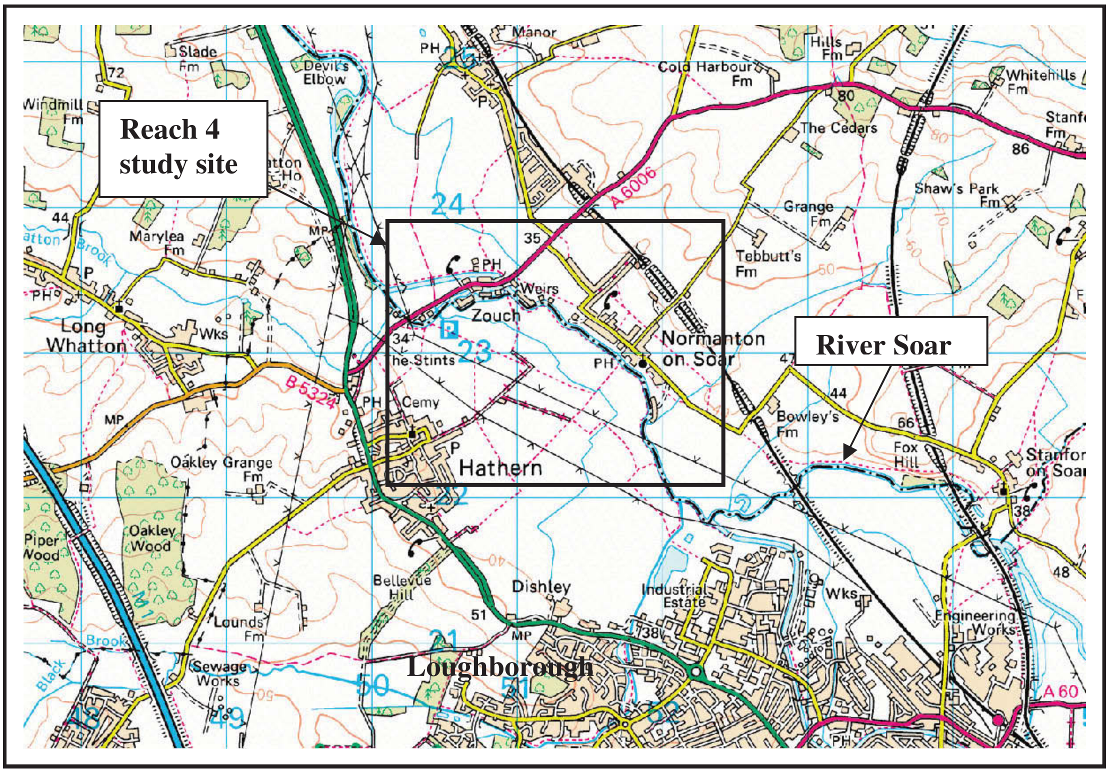

Fig. 11. Location of Reach 4 study area, Lower Soar Valley, Leicestershire/ Nottinghamshire.

6.2. GEOMORPHOLOGY

This reach of the Soar Valley contains four river terraces. Fig. 12 shows a geomorphological map of the study area. The lowest terrace, Terrace 4, is deposited as a continuous belt (100-300m wide) beside the modern River Soar. A single slightly sinuous paleochannel is present on the terrace 4 surface. Because of its narrow width, it is probably a relict yazoo.

Terrace 3 is preserved on both sides of the valley, and is being eroded by the Soar in several locations. A single wide palaeochannel fragment is found south-west of Zouch.

Terrace 2 is also preserved on both sides of the Soar Valley. South-west of the river it outcrops as two large isolated terrace fragments, dissected by younger Terrace 3

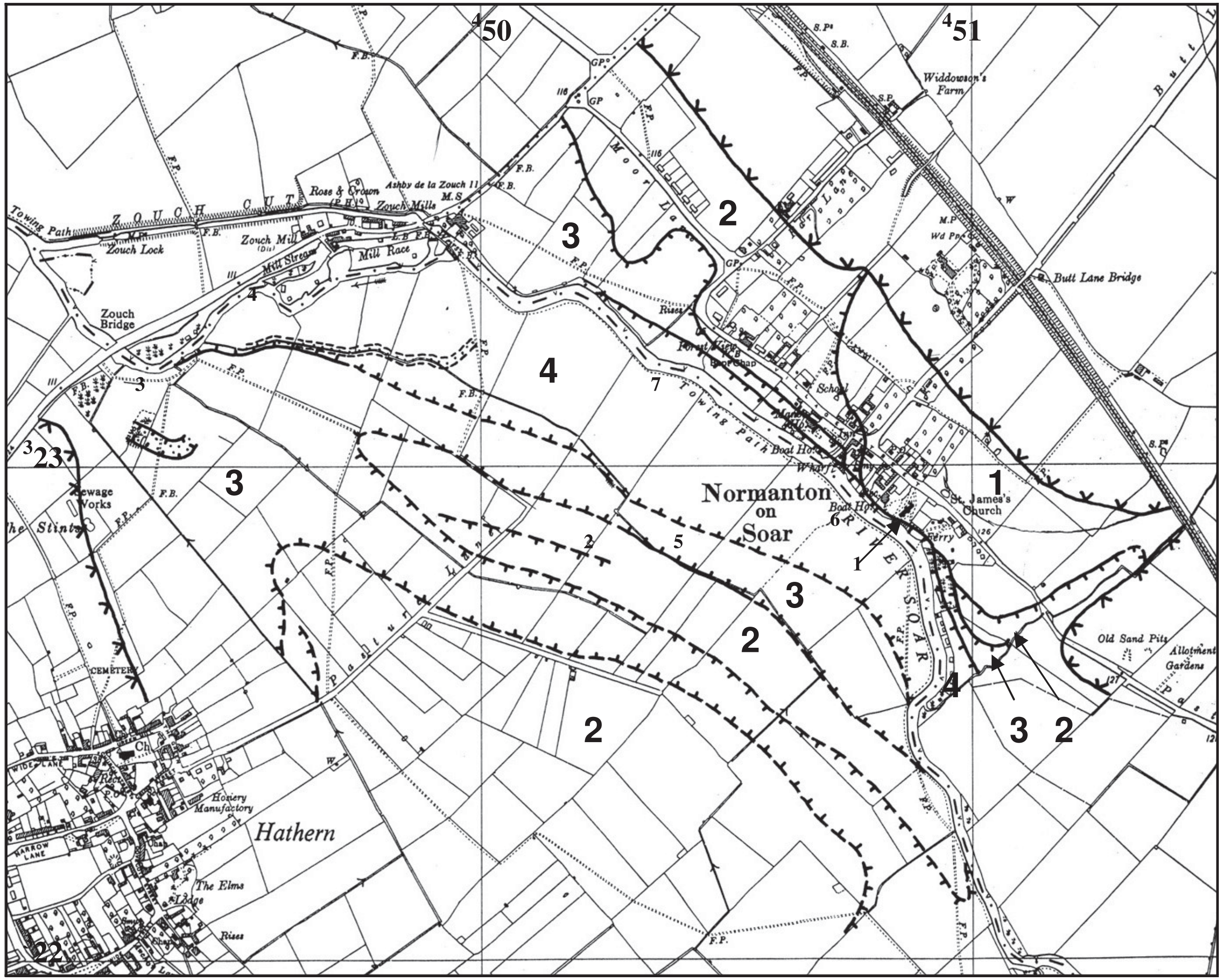

Fig. 12. Geomorphological map of the River Soar study reach at Normanton on Soar, showing location of 4 River Terraces. (Small numbers relate to sampling sites.)

deposits. This was caused by the incision of a palaeochannel through Terrace 2, followed by abandonment (due to avulsion) and infilling with Terrace 3 alluvium.

The oldest terrace, Terrace 1, is preserved as a high bench to the north-east of the River Soar.

6.3. SAMPLE DESCRIPTIONS

Note: "So" in sample code refers to Soar valley and "T1", "T2" etc refer to Terrace 1, Terrace 2 etc.

6.3.1. Sample So1/T1 GPS ref.: SK 51879 22925

Within the churchyard at Normanton on Soar, a 3.55m steep grass slope on the north bank of the River Soar marks the front of Terrace 1. This sample was taken from an excavation 155cm below the terrace top.

The sample is from a massive grey-brown silty gravely fine-course SAND. Pebbles are 3-50mm, angular to sub-rounded of sandstone, quartzite, vein quartz, limestone, flint, gabbro and coal.

6.3.2. Sample So2/T2 GPS ref.: SK 51215 22836

A drainage ditch exposure at a field boundary reveals an 80cm section of Terrace 2. The sample is taken from 30-60cm below the terrace top.

The sample is from a massive orange-brown (grey-brown in top 35cm) silty gravely medium-course SAND. Pebbles are 3-65mm (majority are 15-30mm), sub-angular to rounded of sandstone, quartzite, vein quartz, gritstone and angular flint.

6.3.3. Sample So3/T3 GPS ref.: SK 50321 23194

A cutbank exposure on the south bank of the River Soar reveals a 1.9m heterolithic section of Terrace 3. The sample is taken from 65-100cm below the terrace top.

The sample is from a lower unit of massive orange-grey-brown silty slightly sandy (fine-medium) CLAY with occasional flecks (1-2mm) of coal and occasional 3-70mm, angular pebbles and small cobbles of flint.

6.3.4. Sample So4a/T4 GPS ref.: SK 50533 23355

A cutbank exposure above a gravel point bar, on the south bank of the River Soar, reveals a 1.6m heterolithic section of Terrace 4. This sub-sample is taken from 20-30cm below the terrace top, below two sand beds (see 7.4 for stratigraphy).The sample bed.

The sample is from a 10-15cm bed that varies laterally in thickness and composition from a: (i) clast-supported sandy GRAVEL. Pebbles are 3-55mm, sub-rounded to well rounded of limestone, sandstone and angular flint, coal, cinder and orange burnt shale. The matrix is a granular medium-very course sand. (ii) Grey silty gravely fine-course SAND with many bivalve shell fragments. Pebbles are 3-55mm, sub-rounded to well rounded of limestone, sandstone and angular flint.

6.3.5. Sample So4b/T4 GPS ref.: SK 50533 23355

This sub-sample is taken from 60-80cm below the top of Terrace 4 on the same section as So4a.

The sample is from a massive orange-brown silty fine-medium shelly SAND with many 2-6mm coal fragments. Shells are Gastropods.

6.3.6. Sample So5/T3 GPS ref.: SK 51424 22808

A drainage ditch exposure at a field boundary reveals a 95cm section of Terrace 3. This sample is taken from 45-70cm below the terrace top.

The sample is from a massive grey-brown silty slightly sandy CLAY with some gastropod shell fragments, occasional granules of coal (1-3mm) and occasional 5-12mm angular flint pebbles.

6.3.7. Sample So6a/T4 GPS ref.: SK 51716 22887

A drainage ditch exposure at a field boundary reveals a 1.3m section of Terrace 4. This sub-sample is taken from 20-35cm below the terrace top.

The sample is from an upper unit of massive grey silty slightly sandy (medium-course) CLAY with occasional flecks (1-2mm) of orange burnt shale and occasional 5-7mm rounded pebbles of quartz.

6.3.8. Sample So6b/T4 GPS ref.: SK 51716 22887

This sub-sample is from 50-80cm below the Terrace 4 top in the same drainage ditch section as So6a.

The sample is from the lower unit of massive grey-brown mottled orange-brown silty CLAY.

6.4. TERRACE STRATIGRAPHY

Note: only brief sediment descriptions are given for stratigraphic units that have been sampled, as these deposits have full descriptions above.

6.4.1. Terrace 1 (Wanlip Terrace)

This is the oldest and highest terrace in the reach. The terrace consists of a gravely sand.

0->355cm *Description*: silty gravely fine-course SAND (see 6.3.1)
Lower contact: not seen
Samples: So1

Artefacts: none

6.4.2. Terrace 2 (Syston Terrace)

The terrace consists of a gravely sand.

0->80cm *Description*: silty gravely medium-course SAND (see 6.3.2)
Lower contact: not seen
Samples: So2
Artefacts: none

6.4.3. Terrace 3

The terrace consists of a massive silty sandy clay.

0->190cm *Description*: silty slightly sandy (fine-medium) CLAY with occasional granules of coal and pebbles of flint (see 6.3.3 and 6.3.6)
Lower contact: not seen
Samples: So3 and So5
Artefacts: coal
Comments: contains gastropod shell fragments in some parts of the valley.

6.4.4. Terrace 4

The lowest terrace consists of heterolithic deposits that are quite different in their lithology, depending on whether they are **(i)** in close proximity to the modern river (within *c*.20m), or **(ii)** located away from the river (>20m).

Deposits are: **(i)** Silty sand overlying cross-laminated sand overlying sandy gravel/made ground. This sequence is deposited on top of a shelly sand, separated by an erosion surface. **(ii)** Silty slightly sandy clay overlying a silty clay.

In addition to sampling sites 4 and 6 (see fig. 12), the terrace was investigated in detail, but not sampled, at Site 7 (GPS ref.: SK 51376 23190) where there is a cutbank exposure.

(i)
0-20cm *Description*: grey silty fine-medium **SAND** with occasional gravel in top half of bed. Pebbles are 3-50mm, sub-rounded to well rounded of sandstone, quartzite, limestone and angular flint. In some locations, the top 5cm of the bed contains angular granite cobbles.
Lower contact: gradational, planar
Samples: none
Artefacts: quarried granite
Comments: quarried granite is locally used in construction of flood embankments
20-30cm *Description*: orange-brown well sorted ripple trough cross-laminated medium **SAND** with occasional 1-2mm granules of coal.
Lower contact: gradational, planar

	Samples: none *Artefacts*: coal *Comments*:
30-45cm	*Description*: clast-supported sandy **GRAVEL** and gravely fine-course **SAND**. Pebbles are 3-60mm, sub-angular to well rounded of limestone, sandstone, quartz and angular flint. There are also abundant clasts/fragments of coal, cinder (up to 80mm), brick, oven brick, pottery, slag, orange burnt shale and angular quarried slate gravel. Occasional quarried cobbles and boulders of calcareous sandstone (see 6.3.4). *Lower contact*: sharp, irregular, erosive *Samples*: So4a *Artefacts*: coal, cinder, burnt shale, brick, oven brick, slag, pottery, quarried slate and calcareous sandstone *Comments*: deposit is a mixture of in-situ and reworked **MADE GROUND**. Quarried slate is locally used in construction of flood embankments, and quarried calcareous sandstone cobbles and boulders are locally used to construct retaining walls around sluice gates in embankments.
45->160cm	*Description*: silty fine-medium shelly **SAND** (see 6.3.5) *Lower contact*: not seen *Samples*: So4b *Artefacts*: coal *Comments*: Shells are gastropods

(ii)

0-40cm	*Description*: silty slightly sandy **CLAY** (see 6.3.7) *Lower contact*: gradational, planar *Samples*: So6a *Artefacts*: burnt shale
40->130cm	*Description*: silty **CLAY** (see 6.3.8) *Lower contact*: not seen *Samples*: So6b *Artefacts*: none

6.4.5. Summary

The terrace sequence in the Soar Valley is summarised in fig. 13.

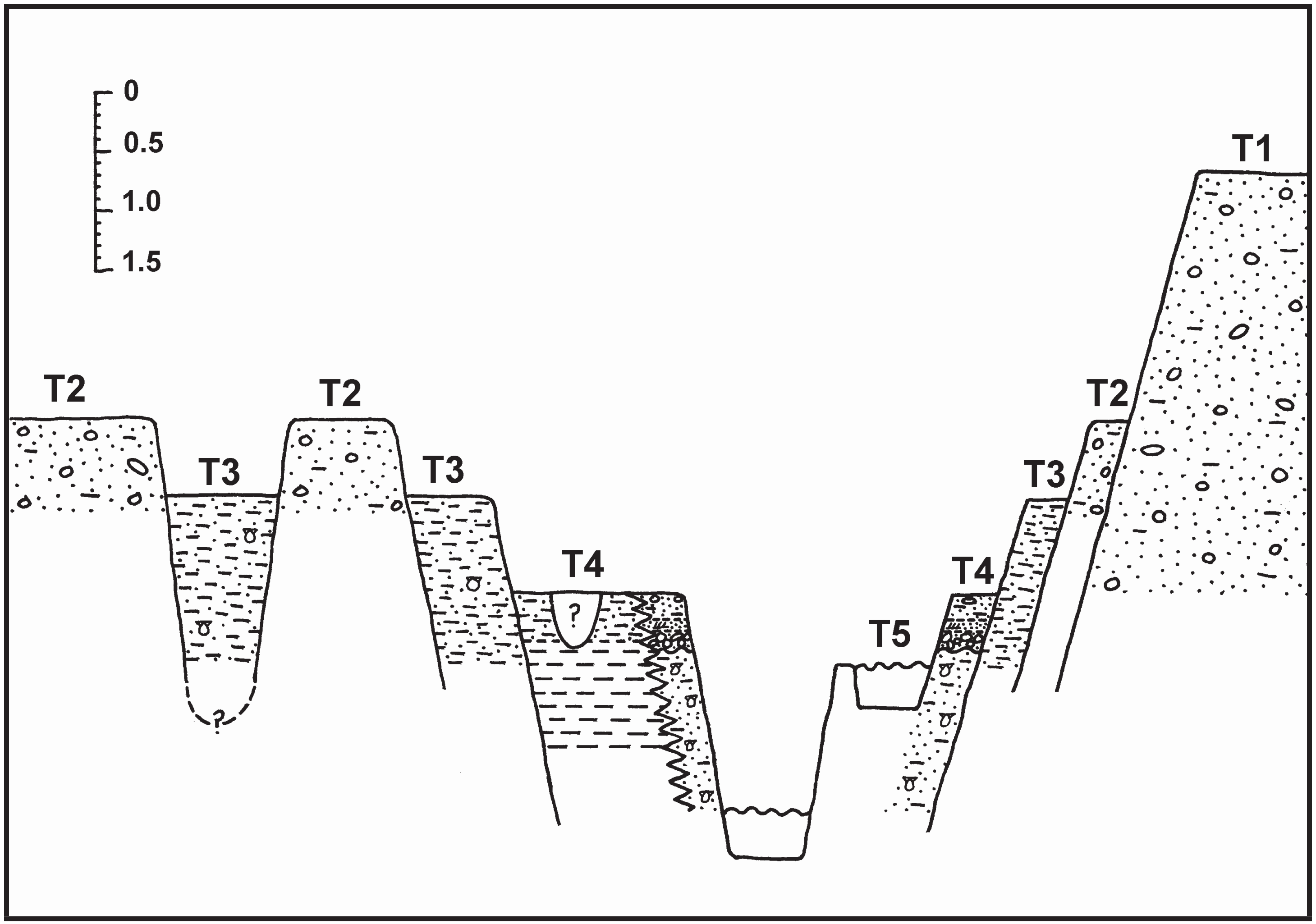

Fig. 13. Schematic transect across the Soar Valley at Reach 4, with River Soar weir illustrated. Vertical (and lateral) distribution of deposits based on stratigraphic logs and other field measurements/observations. See fig. 3 for key. Vertical scale in metres.

7. REACH 5 - MIDDLE TRENT VALLEY

7.1. SITE LOCATION

This reach of the Middle Trent Valley is beside the village of Hoveringham, Nottinghamshire (see fig. 14). The study area extends for 2.5km from Caythorpe and Car Dyke in the south to the edge of flooded gravel pits in the north-east. Sand and gravel extraction is active in the north-west part of the study area.

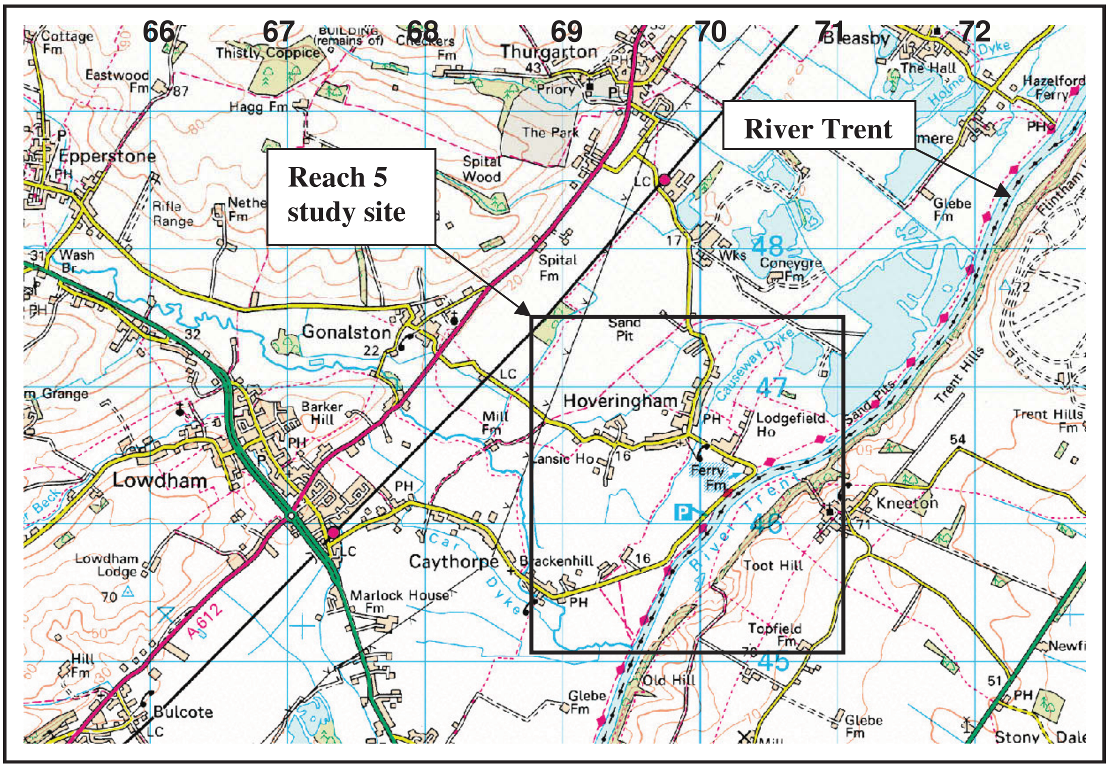

Fig. 14. Location of Reach 5 study area, Middle Trent Valley, Nottinghamshire.

7.2. GEOMORPHOLOGY

This reach of the Middle Trent Valley contains five river terraces. Fig. 15 shows a geomorphological map of the study area. The lowest terrace, Terrace 5, is the new incipient floodplain and forms a narrow bench, 2-5m wide, along some stretches of the river's edge.

Terrace 4 also forms narrow benches on each bank of the Trent. East of the river, the terrace sediment has infilled the bottom of deep flood channels that are incised into Terrace 3 (see below).

On the west side of the Trent, Terrace 3 is preserved as a bench, 5-50m wide, but to the east is deposited more extensively. The terrace surface is incised by several palaeochannels. They are located along the Terrace 3 floodplain margin and as straight diagonal channels incising across the terrace surface. Because of the very deep scour in many of the channels, pools of standing water are often present. They

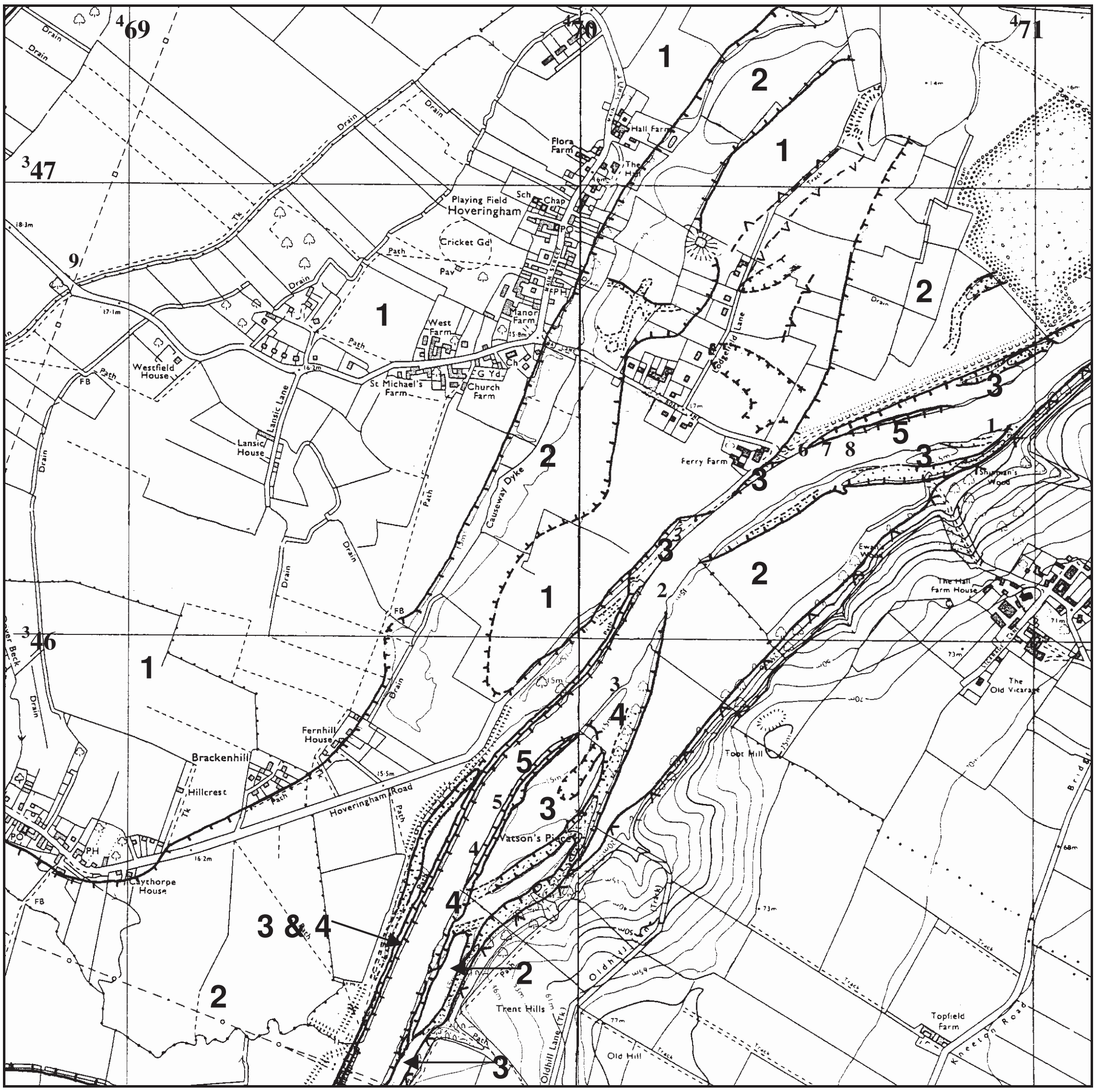

Fig. 15. Geomorphological map of the Middle Trent study reach at Hoveringham, Nottinghamshire, showing location of 5 River Terraces. (Small numbers relate to sampling sites.)

were formed by flood channels, eroded during floods of very high discharge that occurred after Terrace 3 deposition, but before Terrace 4 formation.

Terrace 2 is preserved on both sides of the valley, and is being eroded by the Trent at two locations. Several slightly sinuous palaeochannels are evident on the terrace top. Medieval ridge and furrow is also preserved within some of the pastures.

The oldest terrace, Terrace 1, outcrops on the western side of the river valley. A large terrace fragment is separated from the main outcrop by a 150-200m wide linear band of younger Terrace 2 deposition, presently occupied by the Causeway Dyke. This was caused by the incision of a palaeochannel through Terrace 1, followed by abandonment (due to avulsion) and infilling with Terrace 2 alluvium. The surface of Terrace 1 is very degraded by slope movement.

7.3. SAMPLE DESCRIPTIONS

Note: "Ho" in sample code refers to Hoveringham and "T1", "T2" etc refer to Terrace 1, Terrace 2 etc.

7.3.1. Sample Ho1/T3 GPS ref.: SK 70762 46430

A cutbank exposure on the east bank of the River Trent reveals a 1.5m heterolithic section of Terrace 3. The sample is taken from the lower bedset, from 75-100cm below the terrace top.

This lower bedset (below 75cm) consists of couplets of very thinly/thinly interbedded grey clayey SILTS and red medium-course SANDS (1-4cm planar beds) with many 1-1.5cm gravely shelly (gastropod) medium-course SAND layers. Pebbles/granules are 1-6mm of coal. Occasional lenses (c.10cm thick) of matrix-supported sandy (course) gravel. Pebbles are 4-30mm, angular to rounded of flint, sandstone, quartzite, vein quartz and basalt. Occasional lense of matrix-supported 5-60mm, sub-angular silty sandy (medium) monomictic coal gravel.

7.3.2. Sample Ho2/T2 GPS ref.: SK 70176 46018

A cutbank exposure on the east bank of the River Trent reveals a 2.6m section of Terrace 2. The sample is taken from 45-160cm below the terrace top.

The sample is from a red-brown silty fine-medium/course SAND with occasional isolated 30-40mm, sub-rounded pebbles of quartz. Some horizons are clayey fine-medium sand.

7.3.3. Sample Ho3/T4 GPS ref.: SK 70073 45879

A cutbank exposure on the east bank of the River Trent reveals a 1.5m heterolithic section of Terrace 4. This sample is taken from 35-135cm below the terrace top.

The section is composed of planar, and lenticular, very thinly interbedded red-brown fine-medium SANDS (5-30mm beds) and grey silty sandy (very fine-fine) CLAYS (7-25mm beds).

7.3.4. Sample Ho4/T4 GPS ref.: SK 69810 45566

An exposure on the east bank of the River Trent reveals a 45cm section of Terrace 4. The sample is taken from 15-35cm below the terrace top.

The sample is from a grey silty sandy (fine-course) CLAY with occasional 2-40mm granules and pebbles of coal and occasional shell fragments. Many lenses (3-6mm thick) of red-brown fine SAND. Occasional lenses (3-8cm thick, up to 6m long) of clast-supported GRAVEL. Pebbles are 6-27mm, sub-angular to sub-rounded of quartz, sandstone and flint.

7.3.5. Sample Ho5/T5 GPS ref.: SK 69850 45636

A strip, 2-5m wide, of Terrace 5 is exposed in places on the east bank of the River Trent. This sample is taken from 8-20cm, from the upper layer of a 60cm heterolithic section.

The sample is from a grey silty sandy (fine) CLAY with occasional small lenses of red medium sand.

7.3.6. Sample Ho6/T2 GPS ref.: SK 70534 46449

A cutbank exposure on the west bank of the River Trent reveals a 2.05m section, where Terrace 3 sediment onlaps over the older Terrace 2 deposit. This sample is taken from the southern end of the section, where the upper T3 sediment is only 30cm thick and wedging out (T3 thickens to the north). The sample is taken from the Terrace 2 deposit, 85-110cm below the terrace.

The sample is from a massive red-brown silty fine-medium SAND with occasional gravel. Pebbles are 3-40mm, sub-angular to well rounded of sandstone, quartzite, vein quartz, mudstone and angular flint.

7.3.7. Sample Ho7/T3 GPS ref.: SK 70554 46455

This sample is taken from a 1.1m cutbank section of Terrace 3, located 15m north of the sample Ho6 site.

The sample is taken from 50-70cm below the terrace top. The section consists of planar and lenticular very thinly interbedded red medium SAND (8-23mm beds) and grey SILT (4-25mm beds/ thick laminations).

7.3.8. Sample Ho8/T5 GPS ref.: SK 70555 46454

Immediately below the Ho7 Terrace 3 exposure is a narrow 2m wide strip of Terrace 5. A 30cm heterolithic section is exposed at its front and the sample is taken from the upper bed, 10-17cm below the terrace top.

The sample is from a dark grey mottled brown clayey fine-medium SAND. The lower part of the bed is contaminated with a noxious industrial chemical.

7.3.9. Sample Ho9/T1 GPS ref.: SK 68917 46803

Terrace 1 is presently being quarried to the north-west of Hoveringham by Tarmac. Approximately 6.0m of Terrace 1 is exposed on a quarry face at the western end of the pit. This sample is taken from a mound of recently quarried Terrace 1 sediment.

The sample is from a massive matrix-supported orange-brown sandy (very fine-course) GRAVEL. Pebbles are 3-50mm, sub-angular to rounded of sandstone, quartzite, vein quartz, limestone, flint and basalt.

7.4. TERRACE STRATIGRAPHY

Note: only brief sediment descriptions are given for stratigraphic units that have been sampled, as these deposits have full descriptions above.

7.4.1. Terrace 1 (Holme Pierrepont Terrace)

The terrace consists of a grey gravely sand overlying a thick deposit of orange-brown sandy gravel.

0-60cm	*Description*: grey gravely **SAND** *Lower contact*: sharp, planar *Samples*: none *Artefacts*: none
60->600cm	*Description*: sandy **GRAVEL** (see 7.3.9) *Lower contact*: not seen *Samples*: Ho9 *Artefacts*: none

7.4.2. Terrace 2

The terrace consists of a massive silty sand with occasional gravel.

0->260cm	*Description*: silty fine- medium/course **SAND** with occasional gravel (see 7.3.2 and 7.3.6) *Lower contact*: not seen *Samples*: Ho2 and Ho6

7.4.3. Terrace 3

The terrace consists of planar and lenticular very thinly interbedded sand (with coal lag) and silt. Coal content increases below 75cm. This overlies a thin basal gravel.

0-75cm	*Description*: planar and lenticular very thinly bedded fining up couplets of ripple cross-laminated **SAND** (with granular coal lag) and **SILT** (see 7.3.7). *Lower contact*: sharp, planar *Samples*: Ho7 *Artefacts*: coal
75-170cm	*Description*: planar very thinly interbedded **SAND**, gravely (coal) shelly **SAND** and clayey **SILT**. Occasional lenses (*c*.10cm thick) of sandy gravel and silty sandy coal gravel (see 7.3.1). *Lower contact*: sharp, planar *Samples*: Ho1 *Artefacts*: coal
170-195cm	*Description*: clast-supported **GRAVEL**. Pebbles are sub-angular to well rounded of sandstone, quartzite, vein quartz, limestone, siltstone and angular flint. *Lower contact*: sharp, planar, erosive *Samples*: none

	Artefacts: none *Comments*: gravel is seen to be deposited on the eroded edge of Terrace 2.

7.4.4. Terrace 4

The terrace consists of planar and lenticular very thinly interbedded sand and clay, sometimes overlying a sandy gravel.

0->150(65)cm	*Description*: planar and lenticular very thinly interbedded **SAND** and silty sandy **CLAY** with occasional lenses of gravel. Clay contains occasional coal clasts and shell fragments (see 7.3.3 and 7.3.4). *Lower contact*: sharp, planar *Samples*: Ho3 and Ho4 *Artefacts*: coal
65->130cm	*Description*: clast-supported sandy (course) **GRAVEL**. Pebbles are 5-70mm, sub-rounded to well rounded of sandstone, quartzite, vein quartz, gritstone, basalt and angular flint. *Lower contact*: not seen *Samples*: none *Artefacts*: none *Comments*: not always present in terrace

7.4.5. Terrace 5

The lowest terrace consists of sandy clays and clayey sands overlying a sandy gravel. The terrace is sometimes contaminated by a noxious industrial chemical.

0-20cm	*Description*: silty sandy **CLAY** and clayey **SAND** (see 7.3.5 and 7.3.8) *Lower contact*: gradational, planar *Samples*: Ho5 and Ho8 *Artefacts*: none
20->70cm	*Description*: clast-supported sandy (medium-course) **GRAVEL**. Pebbles are 8-50mm, sub-angular to rounded of sandstone, quartzite and flint. *Lower contact*: not seen *Samples*: none *Artefacts*: none

7.4.6. Summary

The terrace sequence in the Middle Trent Valley at Hoveringham is summarised in fig. 16.

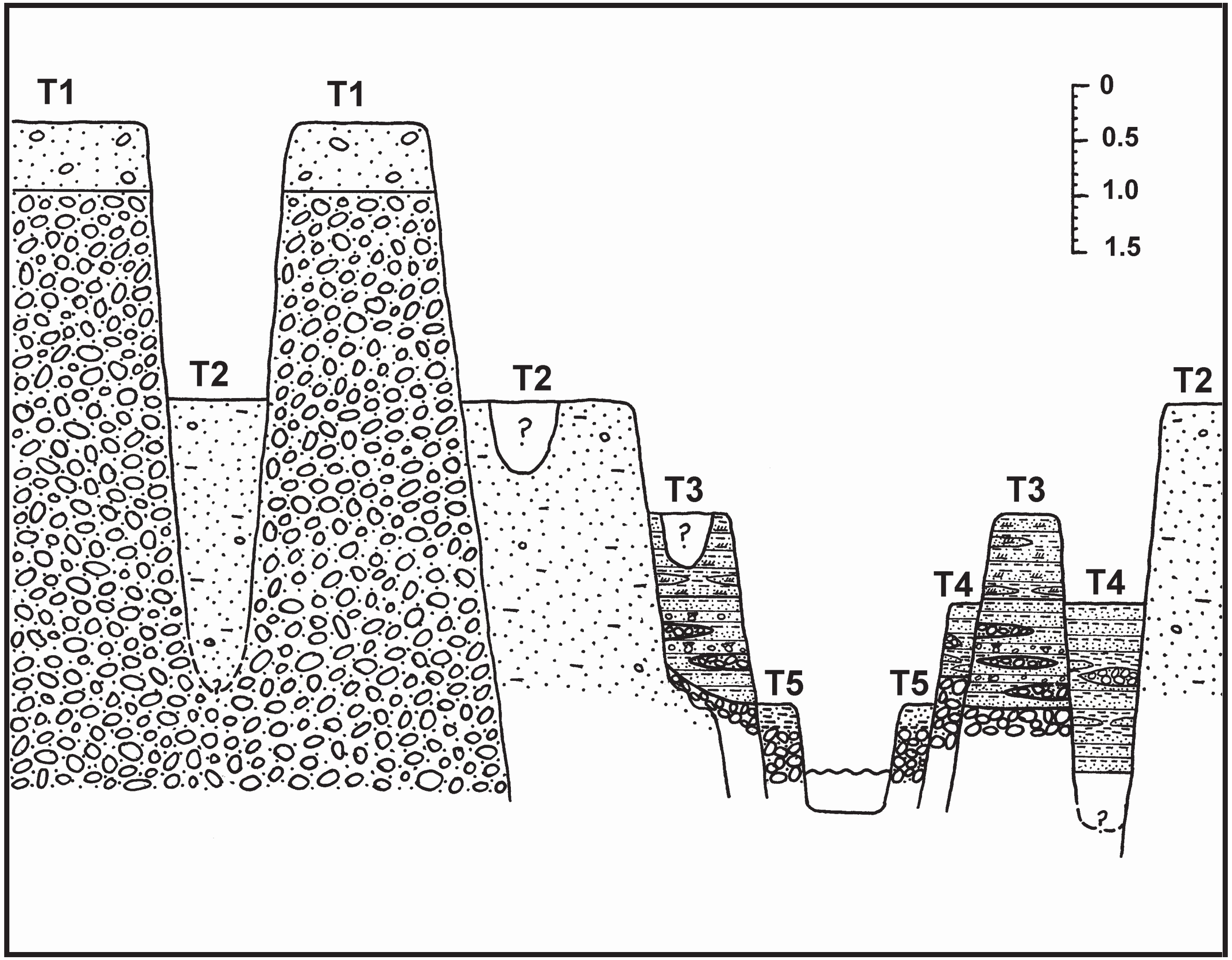

Fig. 16. Schematic transect across the Middle Trent Valley at Reach 5. Vertical (and lateral) distribution of deposits based on stratigraphic logs and other field measurements/observations. See fig. 3 for key. Vertical scale in metres.

APPENDIX

Sample information

Sampling Site No.	**Derwent Valley** (De)	**Dove Valley** (Do)	**Soar Valley** (So)	**Middle Trent Valley** (at Hoveringham) (Ho)	**Upper Trent Valley** (at Great Haywood) (GH)
1	De1a/T1 , De1b/T1 , De1c/T1	Do1a/T1 , Do1b/T1 , Do1c/T1 , Do1d/T1	So1/T1	Ho1/T3	GH1/T1
2	De2/T2		So2/T2	Ho2/T2	GH2a/T1 , GH2b/T1
3	De3/T2	Do3/T2	So3/T3	Ho3/T4	GH3a/T2 , GH3b/T2
4	De4/T4	Do4/T2	So4a/T4 , So4b/T4	Ho4/T4	GH4a/T2 , GH4b/T2
5	De5/T4	Do5/T3	So5/T3	Ho5/T5	
6	De6/T3	Do6/T3	So6a/T4 , So6b/T4	Ho6/T2	
7	De7/T3	Do7/T4	no sample	Ho7/T3	
8	De8/T5	Do8/T4		Ho8/T5	
9	De9/T5			Ho9/T1	
	11 samples	**10 samples**	**8 samples**	**9 samples**	**7 samples**

Note: T1, T2 etc in sample names refer to Terrace 1, Terrace 2 etc.

Derwent Valley (De)

Sampling Site No. (number on map)	**Sample**	**Brief Description**	**Depth** (below Terrace top) (cm)	**Notes**	**Anthropogenic artefacts**
1	De1a/T1	Sandy SILT with occ. gravel	30-80		
1	De1b/T1	Sandy GRAVEL	140-180	Matrix sample	
1	De1c/T1	Laminated Triassic MUDSTONE (Cropwell Bishop Fm)	200-250	Alluvium source material	
2	De2/T2	Clayey SILT	65		
3	De3/T2	Silty CLAY	30		
4	De4/T4	Clayey SILT	40-150		
5	De5/T4	Clayey sandy SILT	7-15		
6	De6/T3	Silty fine SAND	70-100		
7	De7/T3	Sandy SILT	90-130		
8	De8/T5	Interlaminated silty slightly gravelly med-cs SAND and silty CLAY	80-100	From lenticular beds within a sandy GRAVEL Contaminated	Coal, brick, pottery, leather, wood (planks & posts), large animal bone
9	De9/T5	Silty CLAY, with occ. thin horizons of fine sand	80		

11 samples

Dove Valley (Do)

Sampling Site No. (number on map)	**Sample**	**Brief Description**	**Depth** (below Terrace top) (cm)	**Notes**	**Anthropogenic artefacts**
1	Do1a/T1	Clayey sandy SILT	50-110	Below 80cm is within large palaeochannel infill	
1	Do1b/T1	Fissile thinly laminated peaty silty CLAY	175	Numerous plant macrofossils Palaeochannel infill	
1	Do1c/T1	Cross-bedded cs SAND and massive silty gravelly med-cs SAND	140	Numerous rhizoliths Palaeochannel infill	
1	Do1d/T1	Organic CLAY mudball within sandy GRAVEL	190	Mudball sample	
3	Do3/T2	Silty med-cs SAND with occ. horizons of gravel	40-80	Red hue from comminuted Triassic Claystone	Coal
4	Do4/T2	Silty slightly gravelly med-cs SAND	90		Coal
5	Do5/T3	Very silty fine-med SAND with occ. gravel	40-100		Coal, charcoal, brick roof(?) tile
6	Do6/T3	Silty fine-med SAND with occ gravelly horizons	30-80	Deposit infills gully on edge of T1	Coal, pottery, slag, clay pipe
7	Do7/T4	Sandy CLAY	15-35		
8	Do8/T4	Sandy Clay with occ. med sand horizons	40		

10 samples

Soar Valley (So)

Sampling Site No. (number on map)	**Sample**	**Brief Description**	**Depth** (below Terrace top) (cm)	**Notes**	**Anthropogenic artefacts**
1	So1/T1	Silty gravelly fine-cs SAND	155		
2	So2/T2	Silty gravelly med-cs SAND	30-60		
3	So3/T3	Silty slightly sandy CLAY with occ. gravel	65-100		Coal
4	So4a/T4	Sandy GRAVEL and gravelly fine-cs SAND	20-30	Much lateral variation in this horizon. Below med SAND and silty fine-med SAND horizons.	Coal, cinders, burnt shale
4	So4b/T4	Silty shelly fine-med SAND	60-80	Gastropod shells	Coal
5	So5/T3	Silty slightly sandy CLAY with occ. shell fragments and occ. gravel	45-70		Coal
6	So6a/T4	Silty slightly sandy CLAY with occ. gravel	20-35		Burnt shale
6	So6b/T4	Silty CLAY	50-80		
7	No chem' sample (T4)	Sandy GRAVEL (Horizon equivalent to So4a)	30-45	Below med SAND and silty fine-med SAND horizons. Above silty fine-med SAND (contaminated).	Coal, cinders, brick, slag, pottery, oven brick

8 samples

Middle Trent Valley (at Hoveringham) **(Ho)**

Sampling Site No. (number on map)	**Sample**	**Brief Description**	**Depth** (below Terrace top) (cm)	**Notes**	**Anthropogenic artefacts**
1	Ho1/T3	Very thinly interbedded clayey SILT and ripple cross-laminated med-cs SAND with many horizons rich in coal and shell fragments. Occ. lenses of sandy gravel.	75-100	Thin chalky horizon present at 32cm.	Coal
2	Ho2/T2	Silty fine-med/cs SAND with occ. gravel clast	45-160		
3	Ho3/T4	Very thinly interbedded silty sandy CLAY and fine-med SAND	35-135		
4	Ho4/T4	Silty sandy CLAY with occ. coal gravel and shell fragments. Lenses of fine SAND and occ lenses of gravel.	15-35		Coal
5	Ho5/T5	Silty sandy CLAY with occ. lenses of med sand	8-20		
6	Ho6/T2	Silty fine-med SAND with occ. gravel	55-80		
7	Ho7/T3	Very thinly interbedded SILT and med SAND	50-70		
8	Ho8/T5	Clayey fine-med SAND	10-17	Contaminated	
9	Ho9/T1	Sandy GRAVEL	n/a	Sample taken from mound of recently quarried material	

9 samples

Upper Trent Valley (at Great Haywood) **(GH)**

Sampling Site No. (number on map)	**Sample**	**Brief Description**	**Depth** (below Terrace top) (cm)	**Notes**	**Anthropogenic artefacts**
1	GH1/T1	Clayey silty gravelly fine-med SAND	90	Artifacts may have been introduced post-depositionally from the adjacent canal	Coal, cinder, brick
2	GH2a/T1	Clayey silty gravelly fine-cs SAND	5-15		Coal, cinder
2	GH2b/T1	Slightly silty sandy GRAVEL with occ. mudballs	25-40		
3	GH3a/T2	Silty fine-med SAND with occ. gravel	5-15		
3	GH3b/T2	Silty CLAY	50-90		
4	GH4a/T2	v.fine-v.cs gravelly SAND with lenses of clay	40-45		
4	GH4b/T2	CLAY lense	45	Sample from clay lense within GH4a	
	7 samples				

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