PALAEOLITHIC MATERIAL FROM DUNBRIDGE, HAMPSHIRE

Deposit Modelling Report

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Summary

Deposit modelling has been undertaken for the area of the prolific Palaeolithic site Dunbridge, Hampshire. The results have demonstrated that there are two distinct Pleistocene terrace deposits within the study area. An upper terrace, original called the Dunbridge Unit, can with confidence be related to the Belbin Stage, which is supported by the high number of Palaeolithic finds recovered from it. A lower terrace, original called the Barley Hill Unit, can be related to the Mottisfont Stage. The results of the deposit modelling allow the terrace stratigraphy from Dunbridge to be related to the established schemes within the River Test and Solent Basin.

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This report was prepared by Dr Michael J Grant, who also undertook the deposit modelling contained within. Development of the deposit model was undertaken by Dr Michael J Grant in consultation with Phil Harding regarding the designation of the units to each of the stratigraphic units defined within the report, and also the results and on-going development of the model. Dr David Bridgland and Phil Harding are thanked for their constructive comments and suggestions on an earlier draft of this manuscript. Figures 1, 2 and 15 were drawn by Elizabeth James.

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Deposit Modelling Report

1 INTRODUCTION

1.1 Project background

1.1.1 In 1987 Halls Aggregates (South Coast Limited), now Cemex, applied for planning permission to extract Tertiary sand capped by a layer of Pleistocene fluvial sand and gravel (hoggin) from land adjacent to former pits at Kimbridge Farm, Dunbridge, 5 km north of Romsey, Hants (Fig. 1). The overlying gravel from these pits, now a Site of Special Scientific Interest (SSSI), comprised terrace deposits of the River Test and in the early 20th century produced the largest number of Palaeolithic handaxes, almost 1,000, known from Hampshire (Roe 1968).

1.1.2 The planning application for renewed extraction at the site coincided with a period of increased pressure by central Government on counties to meet demands for aggregates nationally, including gravels, as reserves became exhausted. Concurrently, planning authorities were required to consider the preservation of valuable archaeological remains under PPG16 (Department of the Environment 1990).

1.1.3 Palaeolithic sites are particularly at risk in quarries and the Hampshire County Archaeological Officer recommended, in view of the apparent significance of the site, that the application be refused.

1.1.4 The resultant Dunbridge planning inquiry was lengthy and the application was eventually resolved at Government level after a transect of machined test pits, dug to evaluate the deposits and supplemented by borehole data, had confirmed that the Pleistocene gravels are of fluvial origin (Collcutt *et al*. 1988). A small number of Palaeolithic artefacts was recovered which were all derived from a secondary context.

1.1.5 The Southern and English Rivers Palaeolithic Projects were subsequently commissioned by English Heritage to highlight sensitive deposits and locations to assist decision making for future aggregates extraction and the management of valuable Palaeolithic deposits. The initial report of the Southern Rivers Palaeolithic Survey, which included Dunbridge, reiterated the need to place the deposits "in their correct Quaternary context" (Wessex Archaeology 1993, 92), particularly with relation to the gravels mapped by the BGS at Romsey and to resolve the possibility that some implements were stratified, a question which remained unanswered following the evaluation.

1.1.6 The deposition, movement and distribution of artefacts in gravel is a crucial part of secondary site formation in Palaeolithic archaeology. Artefacts are often concentrated at specific locations, of which Dunbridge is an important example. The results of the Dunbridge watching brief demonstrated that the fluvial gravels incorporated bleached cryoturbated material in the upper parts but failed to confirm the belief that they contained stratified industries. Additional handaxes were recovered, including one of probable later Middle Palaeolithic date, and a Levallois core.

1.1.7 As part of the approach to understanding the area under investigation and placing the Dunbridge Pelistocene gravels in their correct Quaternary context, deposit modelling was proposed (Wessex Archaeology 2010). The key objectives was to model the surface of the underlying Tertiary deposits of the site and demonstrate how this influences the distribution and taphonomy of artefacts relative to the terrace geology. In addition simple modelling of the surface of the Tertiary deposits may help to clarify the question of whether a lower terrace can be identified along the eastern edge of the site.

1.2 Site location and geology

1.2.1 The gravel pit lay on the western slopes of the River Test valley, approximately 900 m from the present river channel and 500 m south of the confluence with the River Dun (**Figure 1**). The site occupied an elongated rectangle of land, 19 ha in extent, centred on NGR 432000 125500. The land surface slopes down from 47 mOD in the north to 36 mOD in the south, but rises more steeply to 60 mOD in the west, beyond the terrace edge.

1.2.2 The former Dunbridge Pits, now heavily wooded, lay to the north with Dunbridge Lane forming the eastern boundary. At the time of the original application, the site and surrounding area comprised arable land. The pit underwent systematic reinstatement as extraction progressed and the land reverted to pasture.

1.2.3 The solid geology is Upper Chalk capped by Palaeogene Reading Beds. The predominant bedrock type is well-bedded (usually cross-bedded) medium-fine sand, with staining and partial cementation by iron and/or manganese. Beds of well-rounded flint pebbles occur sporadically. Large lenses of clay occur less frequently within the bedrock (Wessex Archaeology 1992). These are overlain by a series of Pleistocene gravel terraces, discussed below.

1.3 Stratigraphic Background

1.3.1 Dale (1912) subdivided the gravel based upon colour, which he also recognised in other pits in the area: a lower dark red gravel containing rolled handaxes; a middle yellow-brown gravel; and an upper white gravel which contained implements in mint condition. Dale (1918) claimed that this represented gravels of two periods, with the fresh handaxes in the upper white gravels to be of later character than those in the lower one (Bridgland and Harding (1987, 51) assumed Dale combined the middle and lower gravel units mentioned above into this single basal unit). Dale (1918) also noted that these two deposits were separated by a “ferruginous band” which extended widely around the Dunbridge Pit. Dale (1912) does, however, also note that this stratification could have been the result of post-depositional modification by percolating ground water.

1.3.2 Recent investigations of the Dunbridge site by Bridgland and Harding (1987, 1993; Harding 1998; Wessex Archaeology 1992) determined that the patinated flints processes leading to the appearance of the upper ‘white’ gravel unit was the presence of a pale bleached clayey / loamy matrix resulting from the translocation (leaching) of mineral soils in ground water. They also observed that the uppermost 1-2 m of the gravels were often heavy contorted by the effects of cryoturbation (frost heaving) which has destroyed all traces of former bedding. In some areas a clear distinction between the upper bleached and lower unbleached gravel was not possible, with bleached flints common throughout the sequence in the old Dunbridge Pit at Dunbridge Pines.

1.3.3 The gravels are of fluvial origin, laid down under cold conditions in a fast flowing stream (Harding 1998). The topography of the underlying geology shows the presence of a system of elongated scoured 'deeps' trending north east to south west, two of which had widths of 15-40 m and up to 6.5 m deep dominating the floor of the quarry in the north east corner of the workings with bedded material contained within them (Harding 1998).

1.3.4 Dale (1912) considered the gravels from both the Dunbridge and neighbouring Kimbridge pits to be closely related, even though there was an altitudinal difference. White (1912) suggested that there were two 'groups' or 'stages' of terrace-gravels which yielded palaeoliths shown from these pits, an upper 'Belbin Stage', named after Belbin's Pit, Romsey, and a lower 'Mottisfont Stage'. He ascribed the gravel at the Dunbridge pit to the Belbin Stage, and that at Kimbridge Pit to the Mottisfont Stage, noting further gravel deposits connecting these on the intervening slope. Terraces attributable to the Belbin Stage have been a rich source of palaeoliths wherever they have been uncovered, though those at Dunbridge have remained the most prolific in Hampshire (Harding 1998).

1.3.5 Assessment of the geological sequence across the modern quarry site by Collcutt *et al*. (1988) suggested the presence of two terrace formations - an upper Dunbridge unit on the north west of the site, and a lower Barley Hill Unit to the south east, which lies along the eastern edge of the quarry and extends beneath Dunbridge Lane. The lower terrace was suggested as being the upper edge of the terrace remnant exploited by the Kimbridge Pits (White 1912), which were also a source of palaeoliths, although less prolific than the Dunbridge pits.

1.3.6 However, it has not been possible to resolve whether the lower terrace identified by Collcutt *et al*. (1988) is attributable to the Mottisfont Stage identified at the Kimbridge Pits to the south east of the site, or, indeed, represents a previously unrecognised intermediate formation between the Belbin and Mottisfont Stages (Harding 1998, 73; Wessex Archaeology 1992, 7). The correlation of the two terrace stages with those within the wider area of the River Test and Southampton Water area has been subject to much speculation both stratigraphically and chronologically, including whether these do actually signify two distinct units. For example, Westaway *et al*. (2006) assign the deposits to Terraces 4 and 5, Bates and Briant (2009) to Terrace 5, and Wessex Archaeology (1993) to Terraces 5 or 6.

1.4 Archaeological Background

1.4.1 The quarries at Dunbridge have provided the most prolific Palaeolithic site in Hampshire with over 1000 bifaces and five Levallois artefacts recovered from various pits at Dunbridge since the pits opened in the early twentieth century. Roe (1981) classified the Dunbridge handaxes as predominantly pointed forms with a few ovates, though the watching brief has found roughly equal quantities of ovates, none with twisted profiles, and pointed implements (Harding 1998). Most handaxes from the watching brief are rolled or very rolled and are stained, some heavily, which confirms that they are derived and almost certainly come from the base of the gravels, with isolated pieces showing rolling on one side indicating that they have been exposed to the erosive force of the current and not moved far (Harding 1998, 75). Harding (1998) states that the palaeolith artefacts are of different periods with those fresher in appearance occurring nearer the surface (Harding 1998, 75). However, the implements with the best preservation are situated to the north of the current workings in the old Dunbridge Pits, and clearly represent minimal movement since their abandonment indicating occupation which occurred on the surface of the gravel after its deposition or at least contemporary with it (Harding 1998, 75).

2 METHODOLOGY

2.1 Deposit modelling

Data preparation

2.1.1 Deposit modelling was undertaken in early 2010 to assess the distribution of the gravel terrace deposits within the area of the Dunbridge gravel extraction site and neighbouring areas. Geotechnical data available from Dunbridge Quarry and adjacent area have been derived from a range of different sources collected over the last 23 years. This has resulted in 260 data points derived from the following:

- 68 geotechnical boreholes (CEMEX 2004; Mennie 2000; RMC 1988)
- 33 test pits (Collcott *et al*. 1988; RMC 1988)
- 13 detailed geological section recordings (Bridgland and Hardling 1987; 1993; Wessex Archaeology 1992; 2010)
- 130 points taken from exposed quarry sections, recorded by P. Harding (Harding 1998; Wessex Archaeology 1992; 2010)
- 16 points taken from the top of the geology after stripping (RMC 2004)

2.1.2 The distribution of sample points is shown in **Figure 2**. Information contained within each of these data sets varied from very detailed sedimentary descriptions to datums relating to the key stratigraphic units. Records of the lithology are therefore variable between each data set and absent in over half of the records used. To undertake the deposit modelling it has therefore been necessary to utilise stratigraphic units alone. Assessment of the dataset identified that four basic stratigraphic units could be defined:

- **Topsoil**
- **Upper Clay** (a band of clay dominated sediments was found at the top of some sequences (16 sample points) and may be related to the presence of overburden, colluvium or the result of cryoturbation / solifluction)
- **River Terrace Deposits** (RTD) (Pleistocene deposits of principle interest in this study. These are gravel dominated and often defined as Hoggin within the geotechnical reports)
- **Tertiary Geology** (predominantly Palaeogene Reading Beds, with Pebble Beds and, if present, Eocene London Clay)

2.1.3 The area of the resultant deposit model has been constrained by a polygon around the margin of all the sample points, including the area of most recent workings, to minimise extrapolation of the results beyond the available dataset. The limit of this polygon is shown in **Figure 2**.

2.1.4 All data was processed through Rockworks 2006, with 2D and 3D stratigraphic maps plotted. All position data is presented in 12 unit OSGB format, with the ground surface datum in metres measured against Ordnance Datum Newlyn (OD).

2.2 Gridding methods

2.2.1 Modelling was initially undertaken using two griding methods: Kriging and Inverse Distance Weighting (IDW).

2.2.2 Kriging is based on the assumption that the parameter being interpolated can be treated as a regionalised variable. A regionalised variable is intermediate between a truly random variable and a completely deterministic variable in that it varies in a continuous manner from one location to the next and therefore points that are near each other have a certain degree of spatial correlation, but points that are widely separated are statistically independent. Kriging is a set of linear regression routines which minimise estimation variance from a predefined covariance model, and have an advantage over other gridding methods by bringing out directional influences within a data set.

2.2.3 IDW is one of the most commonly used techniques for interpolation of scatter points. The method is based on the assumption that the interpolating surface should be influenced most by the nearby points and less by the more distant points. The interpolating surface is a weighted average of the scatter points and the weight assigned to each scatter point diminishes as the distance from the interpolation point to the scatter point increases. The method has the advantage that it will not exaggerate its extrapolations beyond the given data set, but can be problematic in some datasets by producing a “bulls-eye” effect.

2.2.4 These two methods were run upon the thickness of the RTD unit to enable a comparison of the resultant models produced by the two methods. These are shown in **Figure 3**.

2.2.5 As expected, there are strong similarities in the models by the two methods used. RTD is shown as two parcels (green, yellow and red), intercepted by a thinner layer of RTD running in a north east – south west direction. This layer of thinning RTD is represented most strongly in the IDW model, extending towards the east of the study area where it joins the area with shallow or absent Pleistocene deposits east of the Burley Hill Cottages along Dunbridge Lane, running in a north west – south east direction.

2.2.6 On balance, the modelling outputs, although very similar, provide the most conservative estimates of RTD thickness and distribution using the IDW method. The IDW method provides the most likely interpolation of the thinning of the RTD in the south of the model related to the rise in the topography with the hill topped by Hyde Farm, whereas the directional influence built into the Kriging method results (in this instance) an extension of deposits in a north - south direction. The insertion of different directional influences within the Kirging method results in a similar linear extensions in a different direction within the model. The apparent conservative estimates within the IDW method means that in this instance it is the most appropriate method for modelling the extent of the RTD deposits within the study area.

3 RESULTS

3.1 Tertiary Geology Topography

3.1.1 The topography of the underlying geology is shown in **Figure 4**. It shows a general decline in the altitude moving from the west to the east of the study area, with a general altitudinal relief of 12m (average reduction across the study area is 44-32 mOD), with the highest elevation associated with the hill beneath Hyde Farm Cottage (reaching 50 mOD) to the south of the study area. The topography can be divided into three main areas: two wide terraces intercepted by an increase in the slope gradient running through the centre (37 – 40 mOD contours) of the study area in a north-south direction. The terrace in the west has a dip of 0.78°, with the terrace in the east having a dip of 0.98°, and the intercepting increase in slope gradient having a dip of 2.87°, measuring approximately 50-150 m in width. The topography reduces across the study area in a general eastern direction.

3.2 River Terrace Deposits

3.2.1 The thickness of the RTD is shown in **Figure 5**, along with the 37 and 40 mOD contours of the underlying Tertiary geology, which appears to demarcate the boundary between the two terraces. These two contours appear to provide a useful boundary between the two thickest RTD and implies the presence of two separate Pleistocene terraces within the study area. Within the centre of the study area there is a distinct thinning of the RTD (shown in dark blue), coinciding with the 40 mOD Tertiary geology contour. This suggests a thinning of the RTD towards the edge of the upper terrace. This thinning of the RTD coincides with the Tertiary ‘ridge’ observed by Collcutt *et al.* (1988), with the upper Dunbridge gravel unit to the north west, and lower Burley Hill gravel unit to its south east. However, the underlying Tertiary geology topography, discussed above, did not identify a notable ridge, so this feature is instead a thinning of the overlying RTD and subsequent presence of the underlying geology nearer to the modern surface. The thickest RTD deposits are present in the centre of the upper terrace and in part coincide with the location of the channel ‘deeps’ identified by Harding (1998), though the distinction of separate deeps is not possible due to the spatial distribution of the sample points. This upper terrace is immediately adjacent to the old Dunbridge Pits which White (1912) attributed to the Belbin Stage.

3.2.2 To the south west of the area of RTD thinning in the centre of the study area there are thicker RTD deposits. In **Figure 5** these appear to be contiguous with the lower terrace deposits. However, these are present above the 40 mOD tertiary geology contour and are probably an extension of the upper terrace, as discussed below. The apparent connection with the lower terrace may be a result of the wider distribution between sample points in this area.

3.2.3 The lower terrace does appear to largely conform to the 37mOD contour of the underlying Tertiary geology based upon the data used within the model. This terrace runs beneath Dunbridge Lane and extends to the south east of the study area. However, the north-west (upper) boundary of this terrace probably lies close to the 40 mOD bedrock-surface contour, coincident with a break in slope as plotted in the watching brief. Recorded sections (14, 15, 16, 28 and 29) confirm that gravel thickens to the south east. Thus the boundary of the lower terrace has been extended in a north-west direction towards the edge of the Belbin Formation (**Figure 13**).

3.2.4 The south eastern corner of this terrace is immediately adjacent to the former Kimbridge Pits, which were recorded by White (1912) as being correlated with the Mottisfont Stage. The apparent continuation of this lower terrace into the Kimbridge Pits would suggest that they are both contemporary. This would therefore imply that within the study area only two Pleistocene terraces are present – the upper Dunbridge Unit in the north west and west belonging to the Belbin Stage, and the Barley Hill Unit in the south east and east belonging to the Mottisfont Stage. The altitudinal differences in the two deposits are most clearly shown in **Figure 6**. This figure shows a three dimensional representation of the Tertiary geology topography (**Figure 4**) with the thickness of the RTD draped over it (see **Figure 5** for key to colours used). It clearly shows that the Dunbridge and Barley Hill Units occupy different altitudinal heights and are separated by the increased slope between the 37 and 40mOD contours of the underlying Tertiary geology.

3.2.5 The local variation in the nature of the RTD is discussed in more detail below through the presentation of a series of stratigraphy transects drawn across the study area. The location of each of the transects is shown in **Figure 7**.

Transect 1 (Figure 8)

3.2.6 The transect runs from the north west of the study area adjacent to the old Dunbridge Pits quarry to the south east where it meets the site of the former Kimbridge Pits quarry. This transect crosses the centre of the thin RTD sector in the middle of the study area (samples TH9/84, SEC1993/1 and TH8/84 at 170-270 m) and shows that a rise in the underlying Tertiary topography is present, associated with an absence of RTD in TH8/84. However, this apparent rise in the underlying Tertiary geology topography may be related to due to the transect passing through the 'deeps' recorded by Harding (1998) which when created would have scoured the underlying Tertiary geology surface.

3.2.7 The transect also shows the two distinct RTD terraces - between 40-47 mOD in the north west, and between 31-40 mOD to the south east. The altitudinal difference between these two RTD pockets does suggests that these are distinct terraces. The lower terrace is shown by contiguous RTD between 300-750 m along the transect and, as discussed above, extends to the meet former Kimbridge Pits at its south eastern end, so both can be regarded as being contemporary.

Transect 2 (Figure 9)

3.2.8 This transect runs across the centre of the study area from the west to the east, following the same line as that investigated by Collcutt *et al.* (1988). The samples prefixed Arch- are those used within that original study. Similar to Transect 1, two separate RTD are shown, with the transect crossing the centre of the thin RTD sector in the centre of the study area (samples ArchS7 and Arch S8 at 180-230 m) and shows that a rise in the underlying Tertiary topography is present, associated with an absence of RTD in Arch S7, though again this transect does pass through the southern edge of the 'deeps' shown in Harding (1988). The upper RTD lies to the west of the ridge between 42-48 mOD, with the lower RTD to the east between 35-41 mOD. The eastern extent of the lower terrace is undefined due to a gap of 150 m in the transect shown. The two outlying boreholes on the east of the transect (FA-BH1704 and FA-BH2204) show an absence of RTD in this area.

Transect 3 (Figure 10)

3.2.9 This transect runs in a north – south direction crossing the south side of the thin RTD deposits in the centre of the study area. The transect originates adjacent to the railway line south of Dunbridge Copse, terminating to the south on the foot of the hill just north of Hyde Farm Cottage. The transect shows a gradual rise in the topography, with RTD represented in all samples. The transect runs along the 40mOD contour of the underlying Tertiary geology between 200-540 m, so in this sector is most likely to be associated with the margin of the upper terrace. However, it is notable that RTD are thin in the centre of the transect. The northern end of the transect most likely relates to the lower terrace, with RTD in BH1-84 present between 33-36 mOD. This is in comparison with the RTD in TH16/84 present between 42-46 mOD which is probably a continuation of the upper terrace from further north.

Transect 4 (Figure 11)

3.2.10 The transect runs in a west – east direction across the upper terrace. The transect shows the thick upper terrace deposits for the first 250 m, at an altitude of 40-48 mOD. The thickest RTD in this upper terrace is from SEC1992/180 which coincides with one of the 'deeps' shown in Harding (1988) Sample FA-BH07/04 has RTD at a lower altitude (39-40 mOD) and is at an intercept with Transect 3 mentioned above. This sample lies between the 37-40 mOD contours of the underlying Tertiary geology. The altitude of this thin deposit is noticeable higher than the small isolated deposit to its east in samples FA-BH0904 and FA-BH2404 which are at an altitude of 29-34 mOD. **Figure 7** would suggest that it is the leading edge of the upper terrace on its eastern margin, lowered by cambering or a similar process. The small patch of RTD on the east of this transect lies between 28-34 mOD and is deeper that the RTD deposits in the lower terrace to the south. It is probable that this deposit is also related to the Mottisfont stage, however its lower altitude might imply it is derived from a later terrace. The limited number of sample points within this area of the study area mean that the spatial extent of this deposits cannot be defined further.

Transect 5 (Figure 12)

3.2.11 This transect runs in a south west – north east direction, from the hill by Hyde Farm Cottage towards the railway line, crossing the southern edge of the quarry site. This transect shows the presence of RTD within the centre of the transect between 350-530 m, at an altitude of 32-36 mOD.

3.3 Altitudinal variations in the River Terrace Deposits

3.3.1 Altitudinal differences in the terrace deposits can be a useful way of distinguishing them from each other and correlating them with those in the wider River Test area, though the nature of the Palaeoliths and dating (e.g. Optically Stimulated Luminescence (OSL)) can provide more reliable correlations. In the River Test, Westaway *et al.* (2006) notes that, in comparison to terrace sequences from other areas, those of the River Test show a greater range of terrace altitudes. Westaway *et al.* (2006) show the longitudinal profile of the terraces along the River Test between Dunbridge and Southampton Water, including those for the Belbin and Mottisfont Stage deposits.

3.3.2 The altitudinal profile of the RTD for the study area is shown in **Figure 14**, with the areas from which the different data sets are derived shown in **Figure 13**. These are shown in both north-south and west-east profiles, with the upper and lower altitudes of each deposit shown and coloured according to which terrace they appear to be derived from based upon the data presented above. In general terms this is a clear reduction in the profile of the terraces in the west–east profile, with the gradient of both the upper and lower terrace similar. The altitudinal difference of the two terraces is clearly shown on the north–south transect. However, in both profiles there are four outliers prevalent, and these have been circled. Originally these were defined as being a part of the upper Belbin Formation. However, in both Transect 3 and 4 they were discussed as being difficult to classify as they are located on the eastern edge of the RTD associated with the upper terrace, but at a notably lower altitude. The longitudinal profile demonstrates how these four samples show a greater similarity to the Mottisfont deposits.

3.3.3 The altitude of the two terraces demonstrates good agreement with the data of Westaway *et al.* (2006). The Belbin Formation (excluding the four outliers) provides an average altitude of 38.2±2.3 mOD for the top and 35.7±2.9 mOD for the base of the RTD. The altitudinal range for the Belbin Stage deposits in the Dunbridge area given by Westaway *et al.* (2006) was *c.*41-48 mOD and therefore encompasses the terrace classified as B Formation at the Dunbridge Site. The Mottisfont Formation provides an average altitude of 38.2±2.3 mOD for the top and 35.7±2.9 mOD for the base of the RTD. The altitudinal range for the Mottisfont Stage deposits in the Dunbridge area given by Westaway *et al.* (2006) was *c.*30-38 mOD and therefore encompasses the terrace classified as Mottisfont Formation at the Dunbridge site.

3.4 Distribution of Palaeoliths in relation to River Terrace Deposits

3.4.1 The distribution of palaeoliths is given in **Figure 15** plotted overlying the terrace boundaries. Palaeoliths from outside this area (notably the old Dunbridge Pits to the north) are therefore not shown.

3.4.2 The distribution of the palaeoliths shows a clear correlation with upper terrace. Of particular note are three single platform 'proto-Levallois' flake cores (513, 588 and 653) and two others (538 and 685) demonstrating fully developed Levallois technology. The presence of the Levallois technology upon this terrace correlates with those that were also found in the old Dunbridge Pits, and in the wider area such as those at Belbin's Pit. This correlation, combined with the altitudinal data for this terrace, strengthens the case that this terrace does correlate with the Belbin Stage.

3.4.3 In comparison, the distribution of palaeoliths upon the lower terrace is reduced to only a few chance finds of Core Tools and a Blade Core. Of particular note in the Belbin Formation was the occurrence of a Levallois core 671 found on a bund in bleached gravel approximately 20 m south of the edge of the Mottisfont Gravel. Its origin is therefore uncertain as it could have originated from either terrace deposit.

3.4.4 The difference in the abundance of palaeoliths between the two terraces strengthens the claim that these are two distinctly separate terraces. However, the Kimbridge Pits are recorded as having yielded 77 handaxes and 4 Levallois flakes (Roe 1968), so this lower terrace should still be regarded as potential to yield some Palaeolithic assemblages.

4 CONCLUSIONS

4.1.1 The deposit modelling has demonstrated that there are two distinct Pleistocene terrace deposits within the study area. The uppermost terrace, original called the Dunbridge Unit, can with some confidence be related to the Belbin Formation, based upon the terrace elevation and palaeolithic finds from the both the area of modern quarrying and the neighbouring old Dunbridge Pits. This terrace can therefore be equated with Terrace T4 of the Westaway *et al*. (2006) and Edwards and Freshney (1987) schemes, and Terrace T5 of the Bates and Briant (2009; Wilkinson 2007) scheme. However, although different terrace numbers, both schemes suggest that the Belbin Stage relates to Marine Oxygen Isotope Stage

(MIS) 10. The presence of Levallois technology from the Belbin stage terrace would potentially indicate that this terrace is slightly later in date, probably attributed to MIS 9-7. White *et al.* (2006) and Ashton and Hosfield (2010) highlight that Levallois in many sites has been associated with MIS 8-7, though an early emergence is found at Purfleet, Kent during MIS 9 (Bridgland *et al.*, submitted). Ashton and Hosfield (2010) have raised doubts over the use of Levallois technology to date the terrace deposits in the Solent basin due to their low abundance of finds, lack of scrutiny of the published identifications or actual contexts (Ashton and Hosfield 2010, 739) and few dating constraints, and suggested that the chronology provided by Westaway *et al.* (2006) using Levallois material from Warsash (to define the Test Valley terrace stratigraphy) is problematic suggesting this material was derived from above the terrace deposits (Ashton and Hosfield 2010, 744). However, the work conducted at the Dunbridge Quarry Site has addressed these concerns (Harding *et al*. submitted) and provided more rigorous evidence in support of the occurrence of 'proto-Levallois' in quantity within this gravel formation, equating it with MIS 9b.

4.1.2 Similarly, the lower lowermost terrace, original called the Barley Hill Unit, can be related to the Mottisfont Formation, based upon the terrace elevation and correlation with the Kimbridge Pits. This terrace can therefore be equated with Terrace T3 of the Westaway *et al*. (2006) and Edwards and Freshney (1987) schemes, and Terrace T4 of the Bates and Briant (2009; Wilkinson 2007) scheme. However, the T4 terrace at Dunbridge was not shown in the study by Bates and Briant (2009, 25)) who had combined it with the T4 terrace in the Dunbridge area. The dating for this lower terrace is again largely in agreement between the two schemes, which were associated with MIS 8. Finds of Levallois flakes from the Kimbridge Pits (Roe 1968) upon this lower terrace are potentially significant, though again their origin and context are unclear and may not be strictly associated with this terrace itself. The application of OSL dating upon sediments from this lower terrace will provide an independent chronology for this lower terrace and remove some of the uncertainties raised above.

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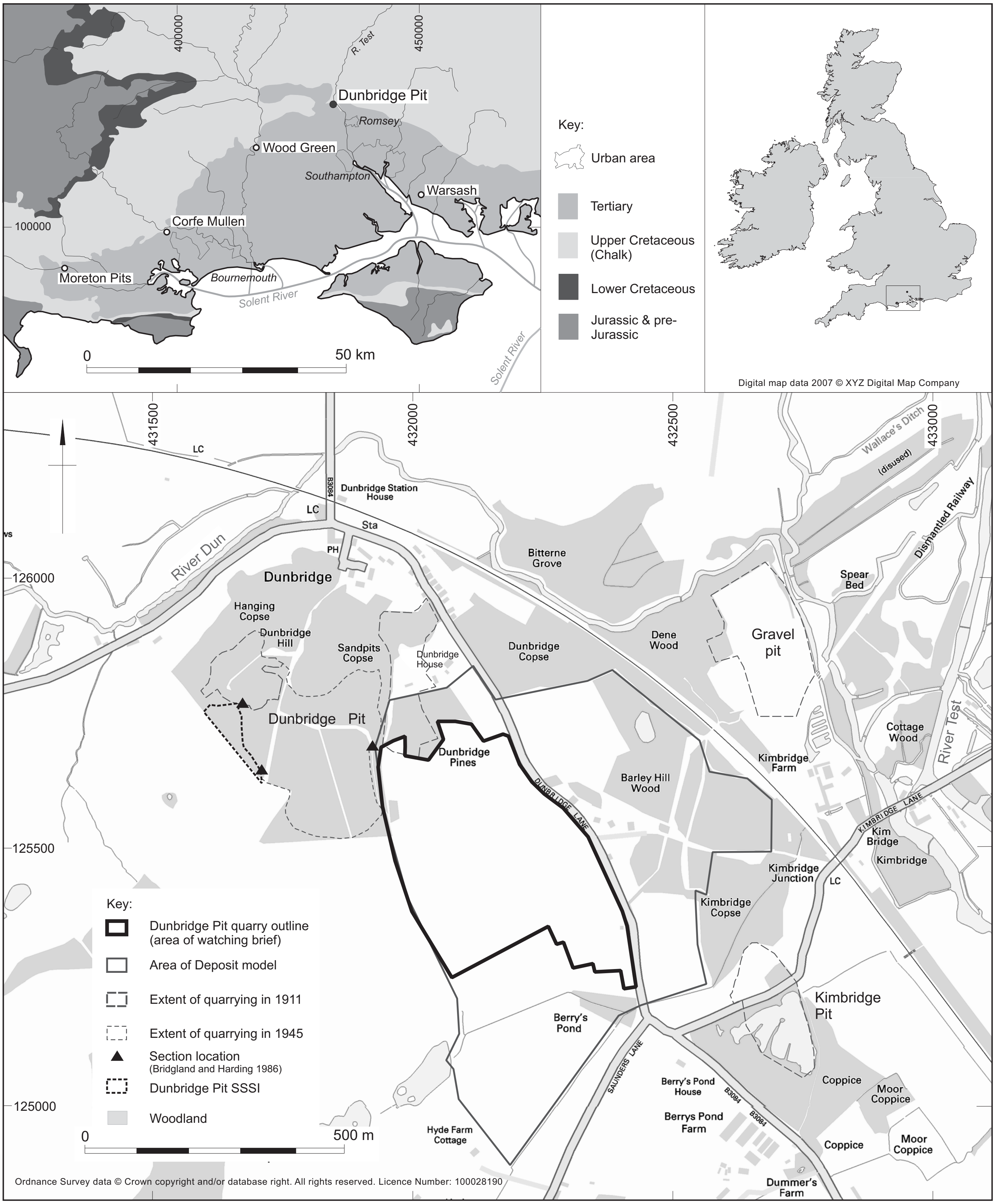


Figure 1: Location of the study area.

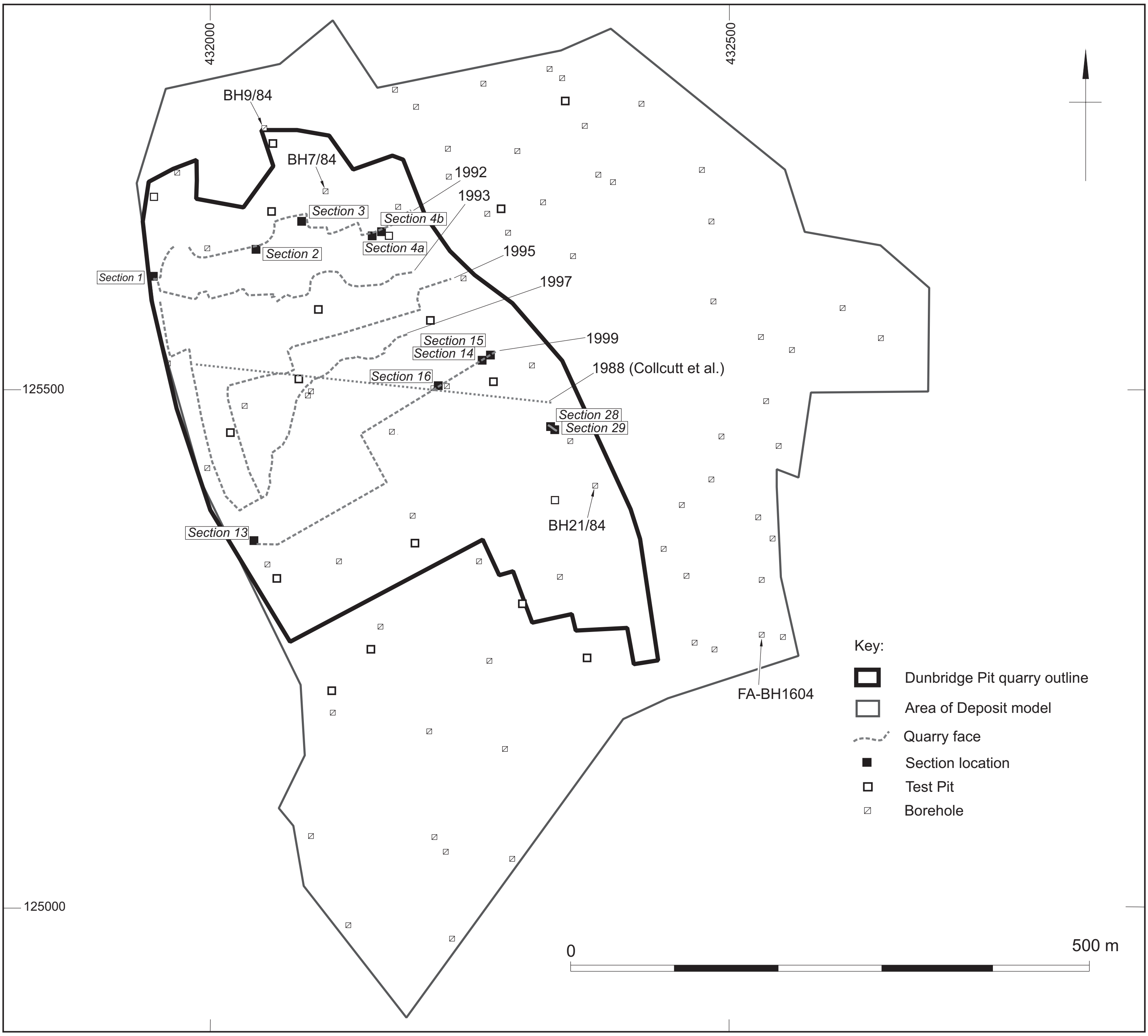
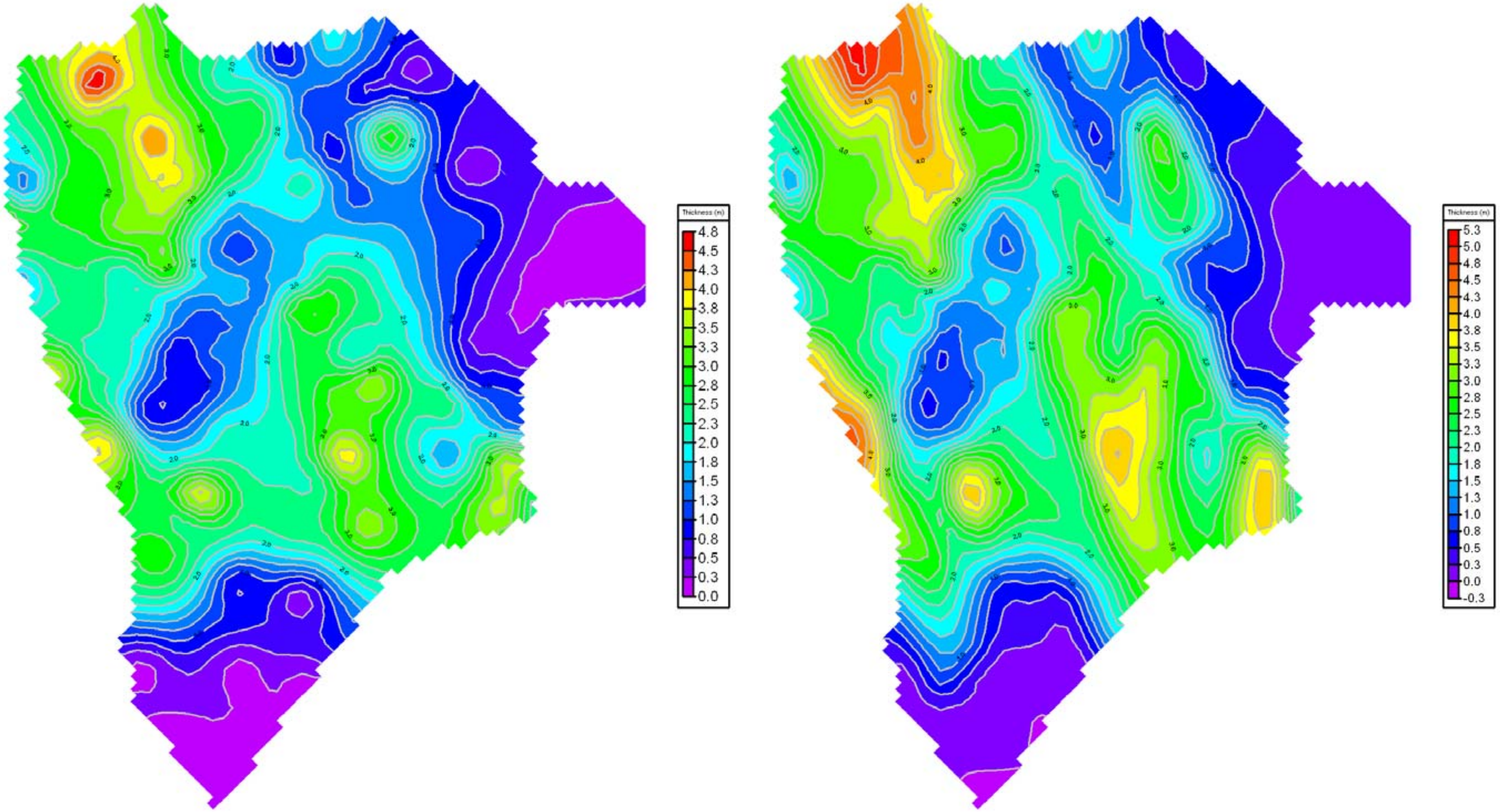


Figure 2: Area of deposit model, showing the distribution and nature of individual sample points (boreholes, test pits and sections).

Figure 3: Comparison of griding methods, showing the thickness of the River Terrace Deposits: a) IDW; b) Kriging



a b

Figure 4: Tertiary geology topography

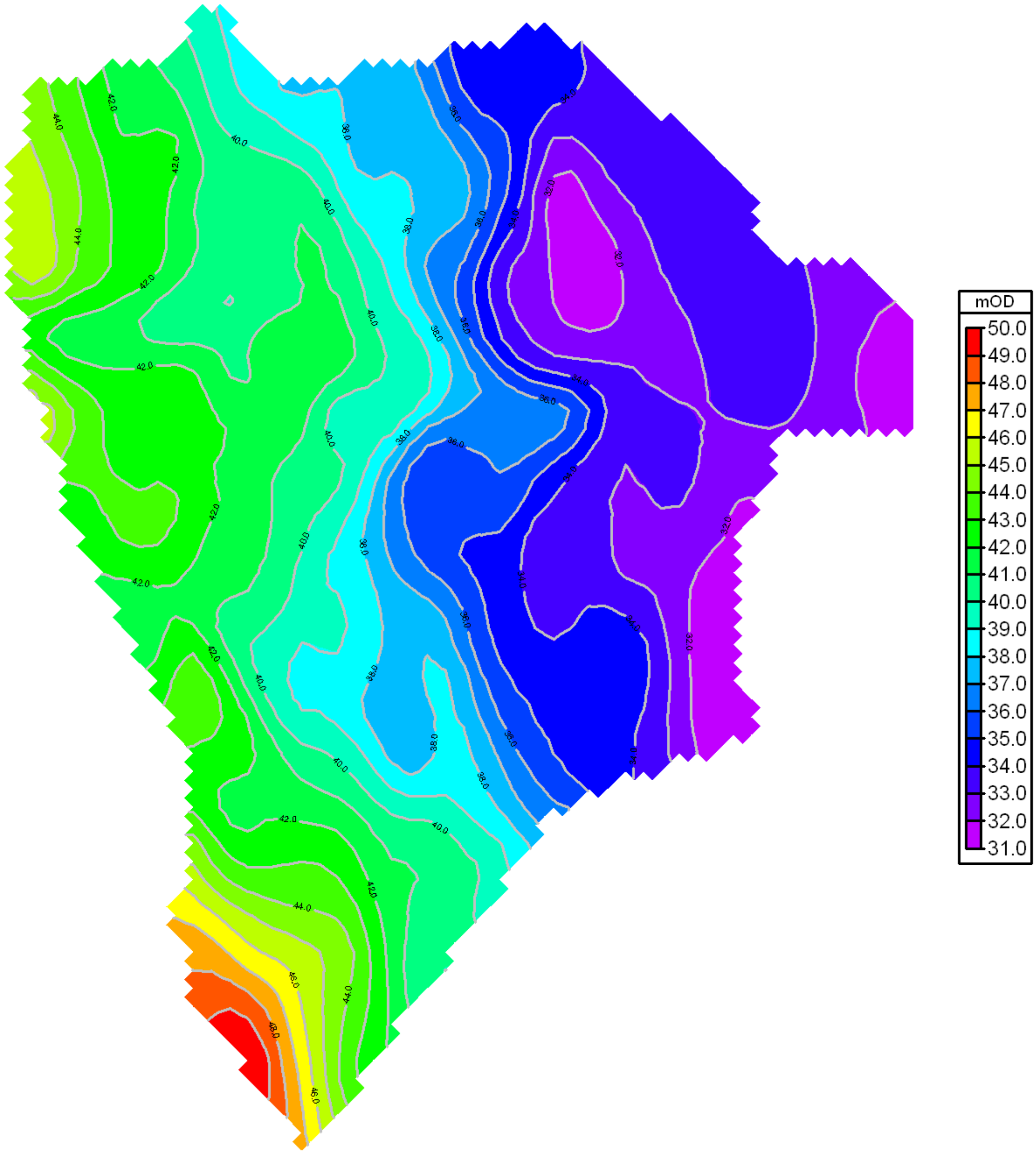


Figure 5: River terrace Deposits thickness with 40 and 37mOD contours from the underlying Tertiary geology topography shown.

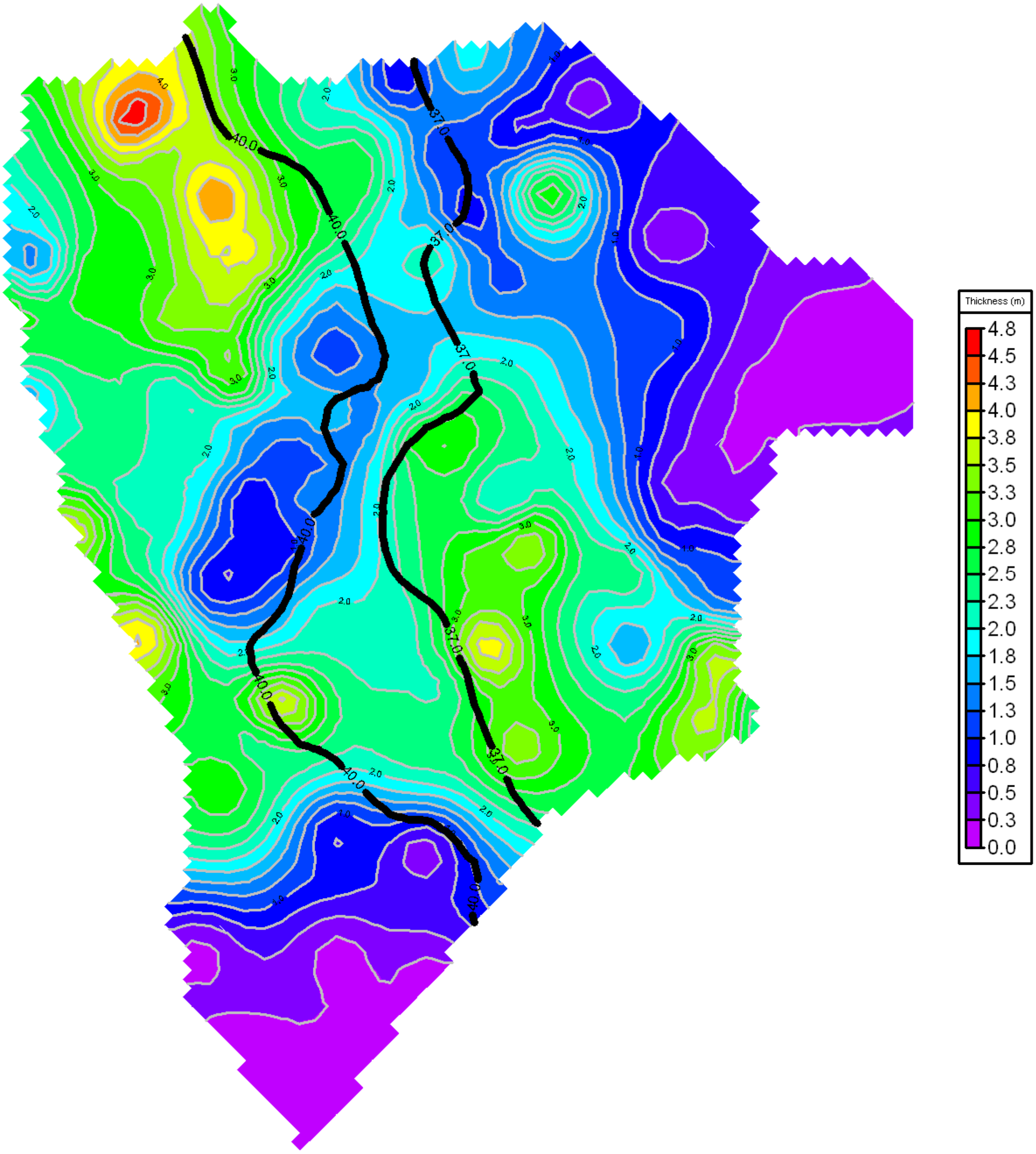


Figure 6: Tertiary geology topography (3D) overlain by map of the River Terrace Deposits thickness to show how they relate to each other

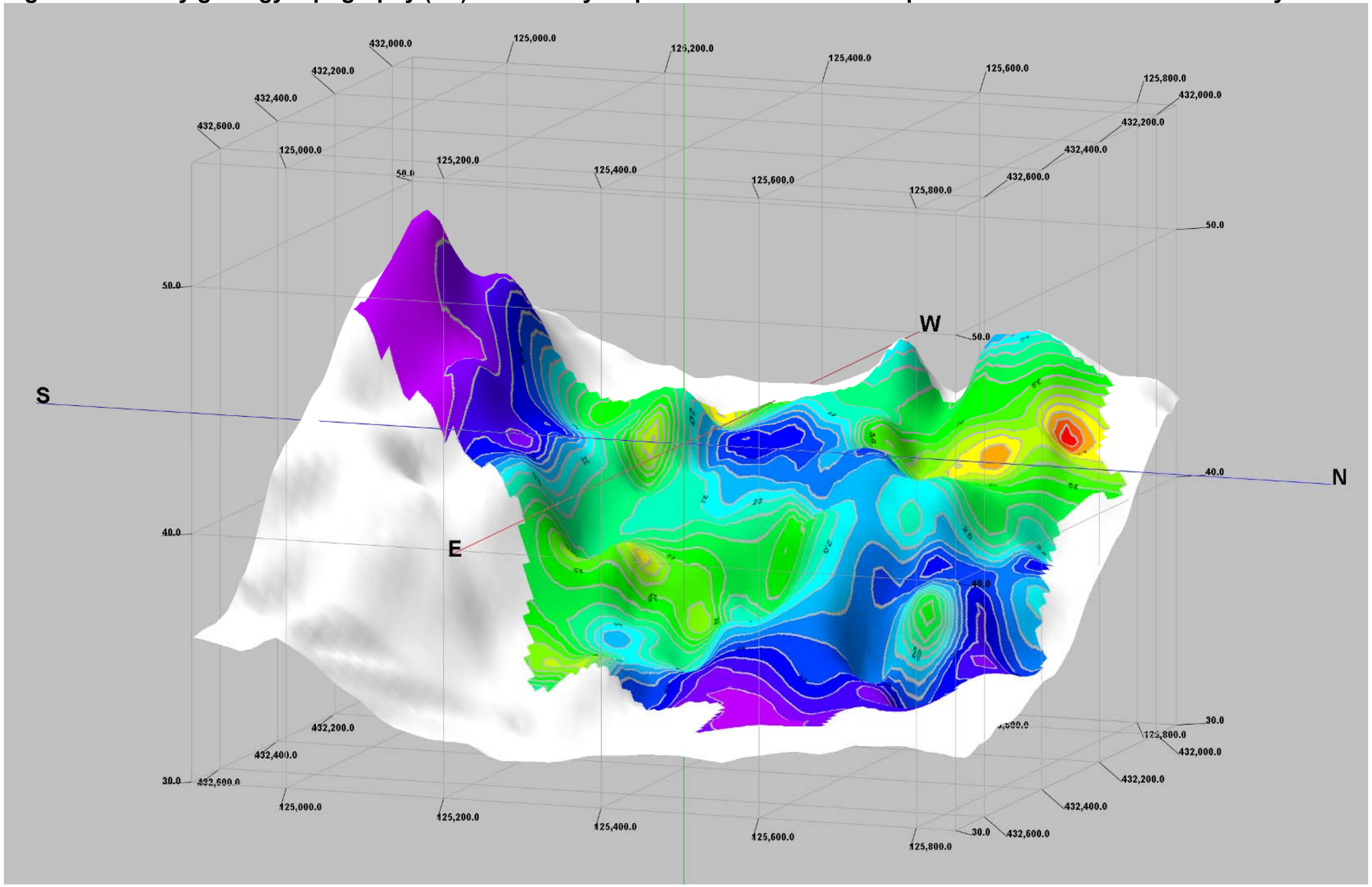


Figure 7: Location of transects, overlying map of the River Terrace Deposits thickness with all sample points shown

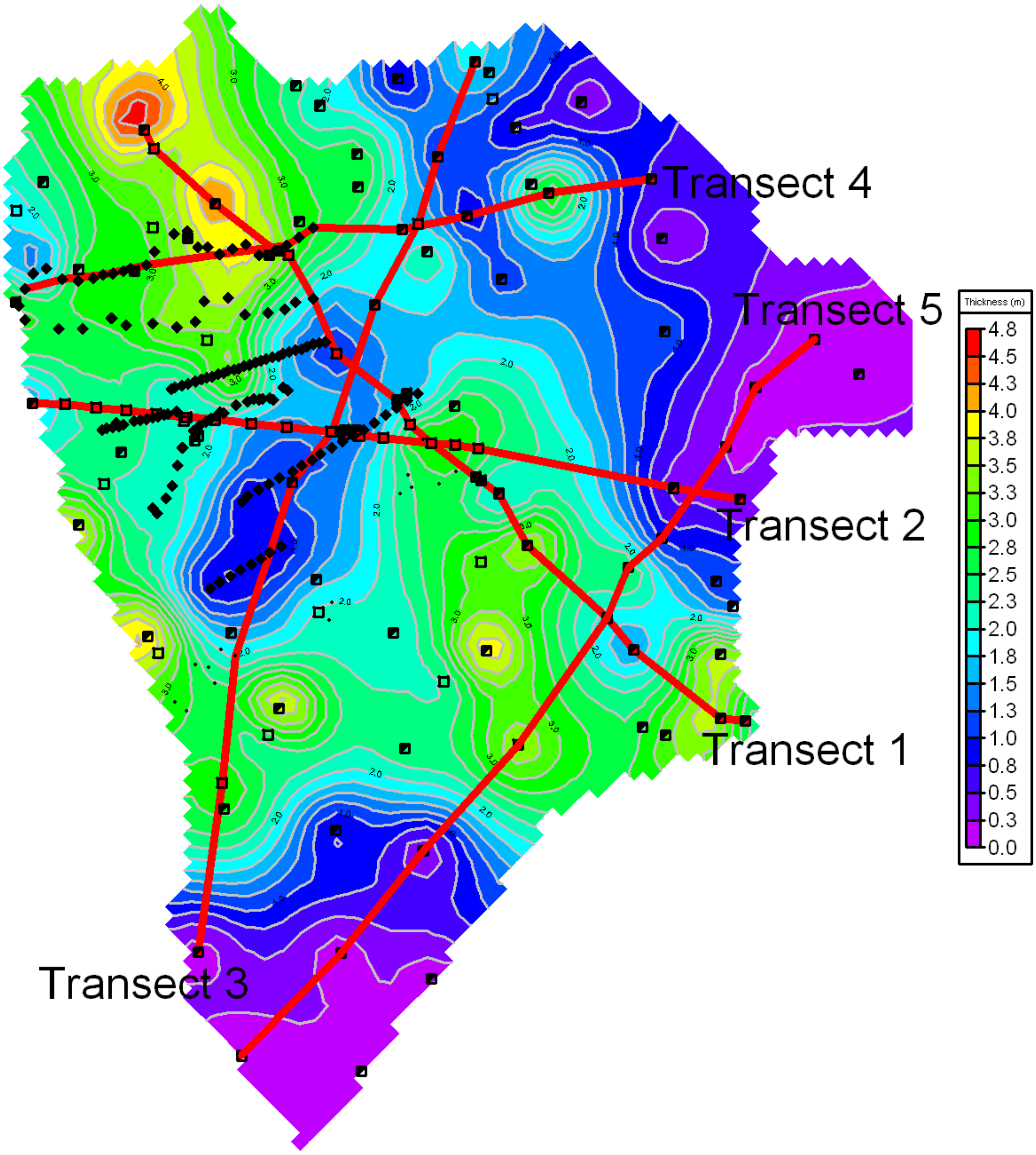


Figure 8: Transect 1 - see Figure 7 for transect location.

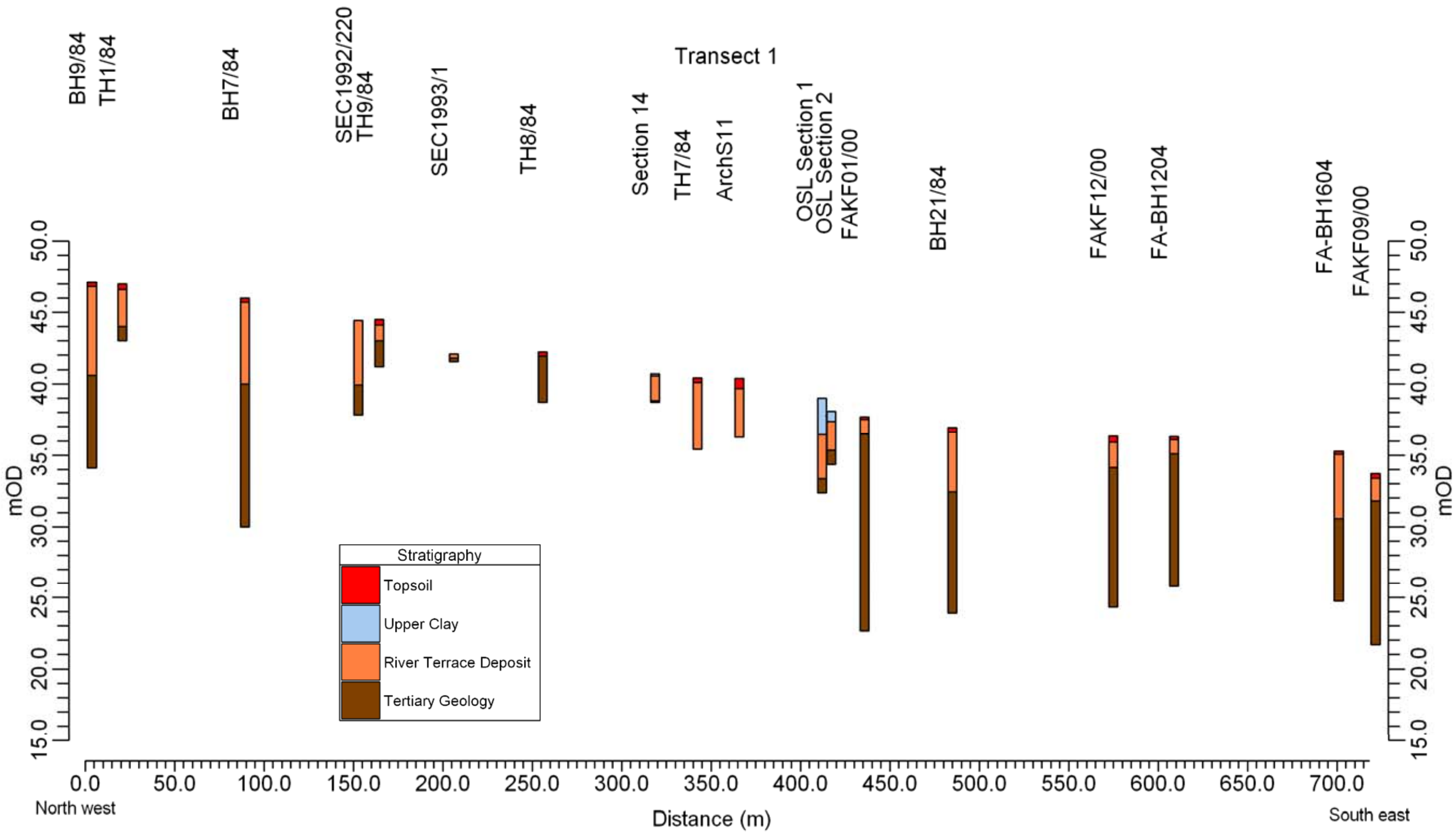


Figure 9: Transect 2 - see Figure 7 for transect location, and Figure 8 for key to stratigraphy.

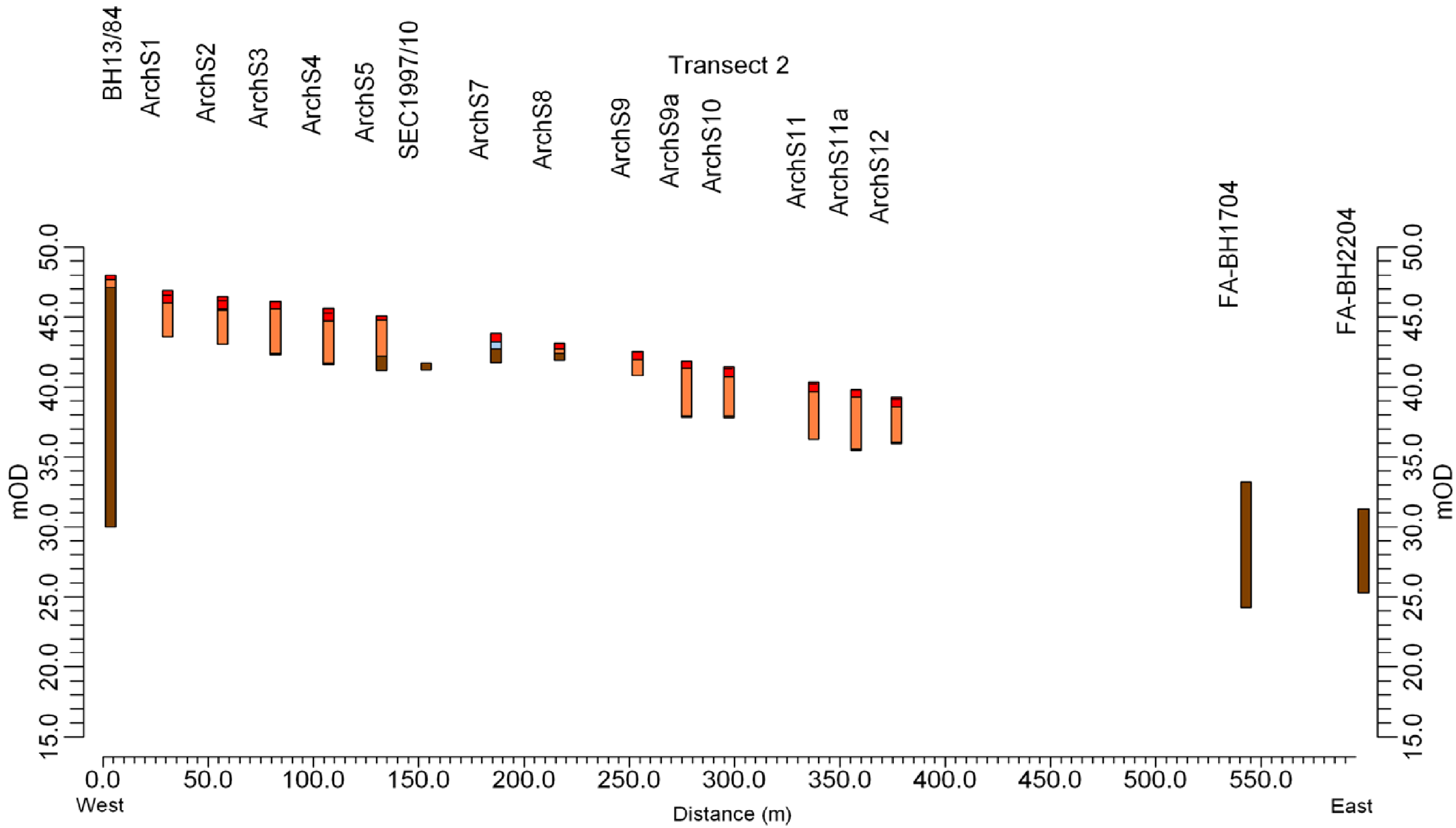


Figure 10: Transect 3 – see Figure 7 for transect location, and Figure 8 for key to stratigraphy.

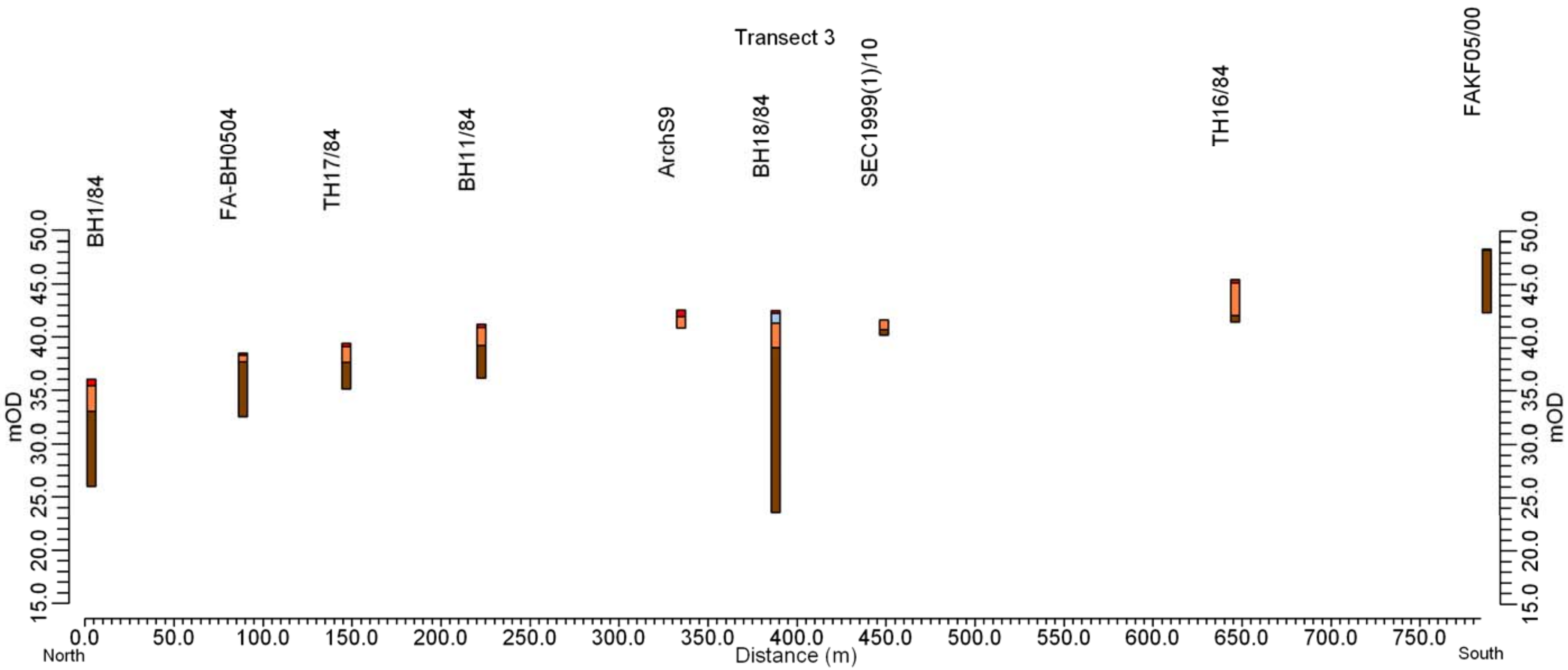


Figure 11: Transect 4 - see Figure 7 for transect location, and Figure 8 for key to stratigraphy.

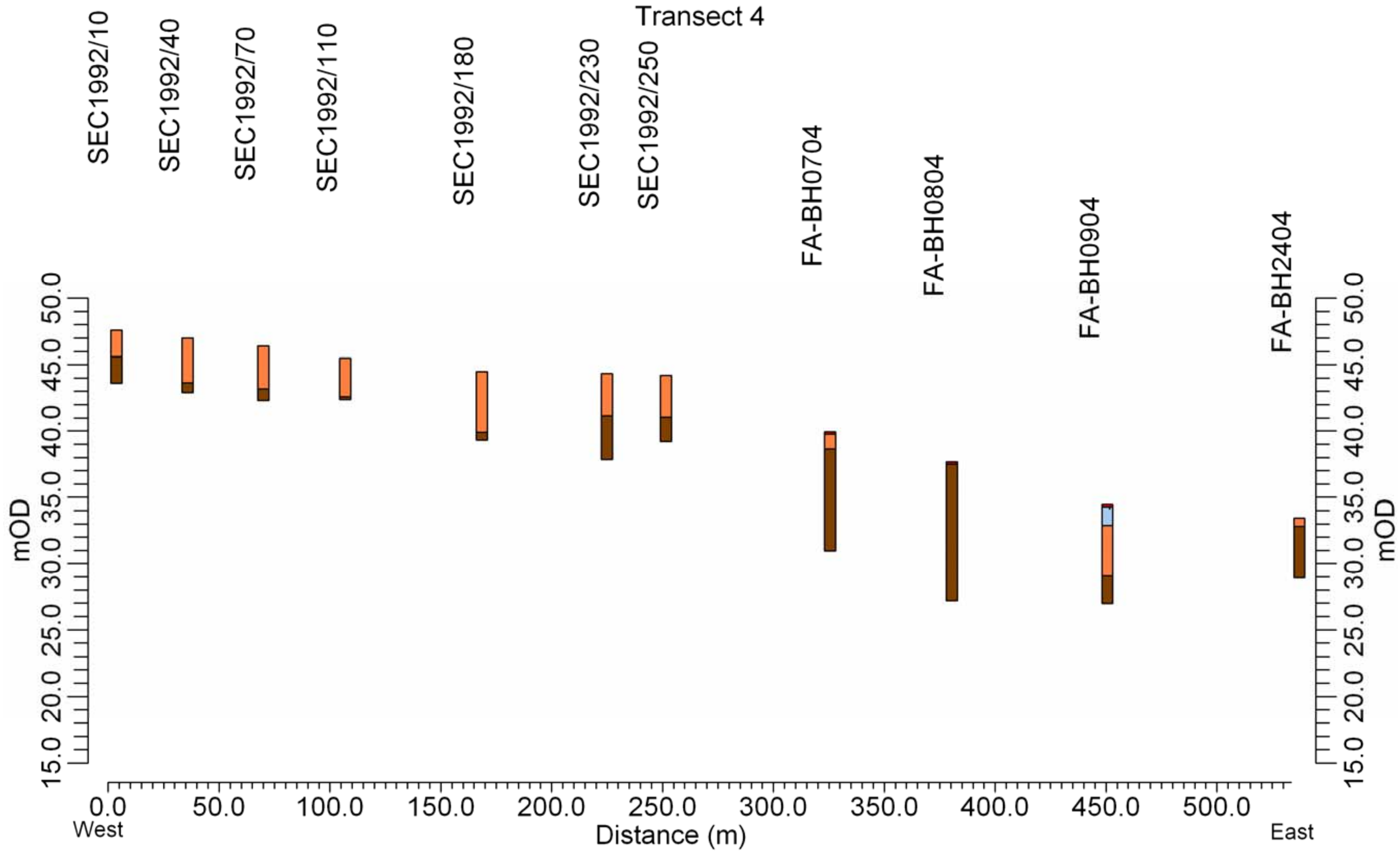


Figure 12: Transect 5 - see Figure 7 for transect location, and Figure 8 for key to stratigraphy.

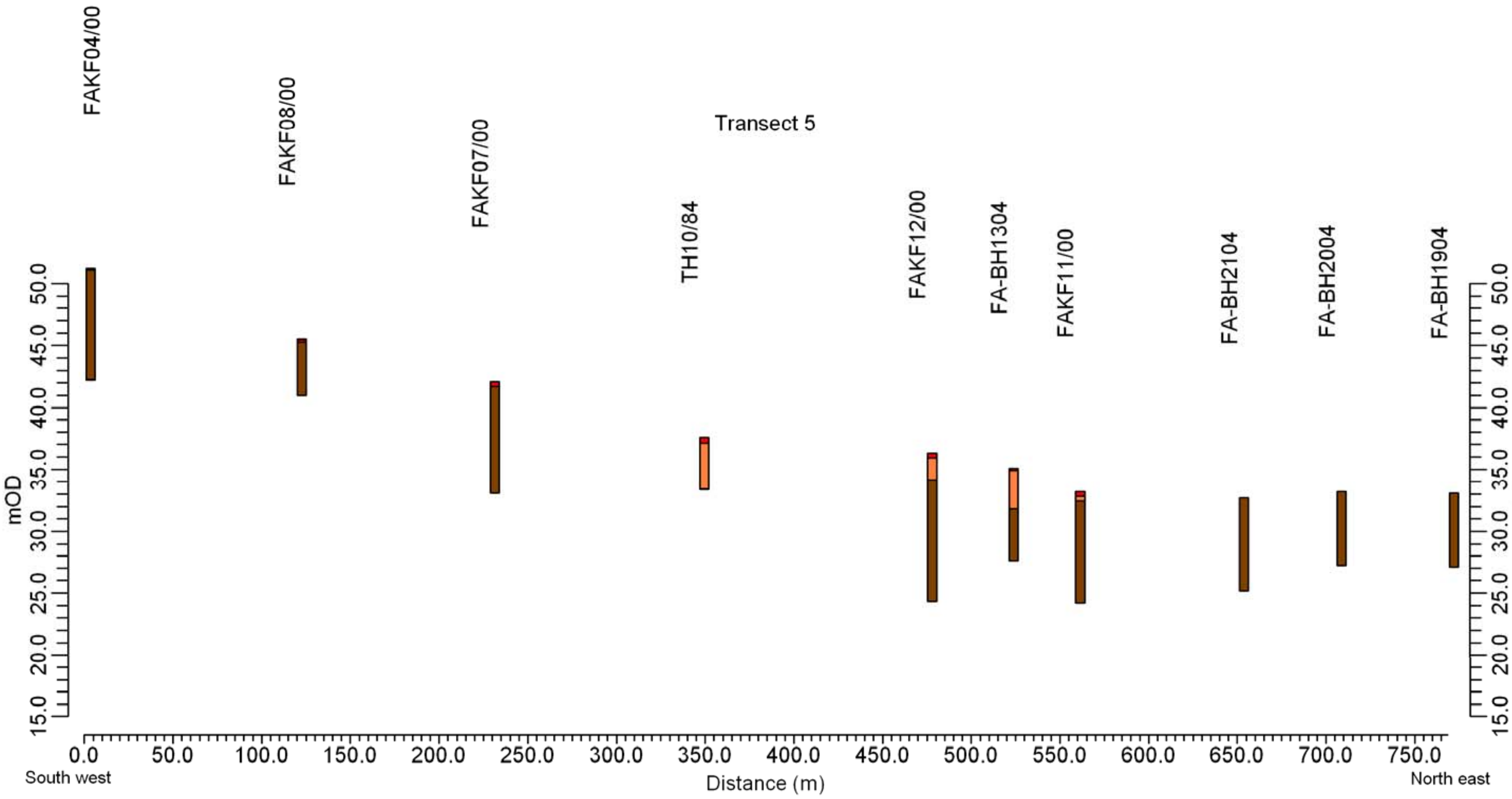


Figure 13: Approximate locations of the Dunbridge and Barley Hill Units, and the areas from which data used to show the different altitudinal profiles in Figure 14 have been taken.

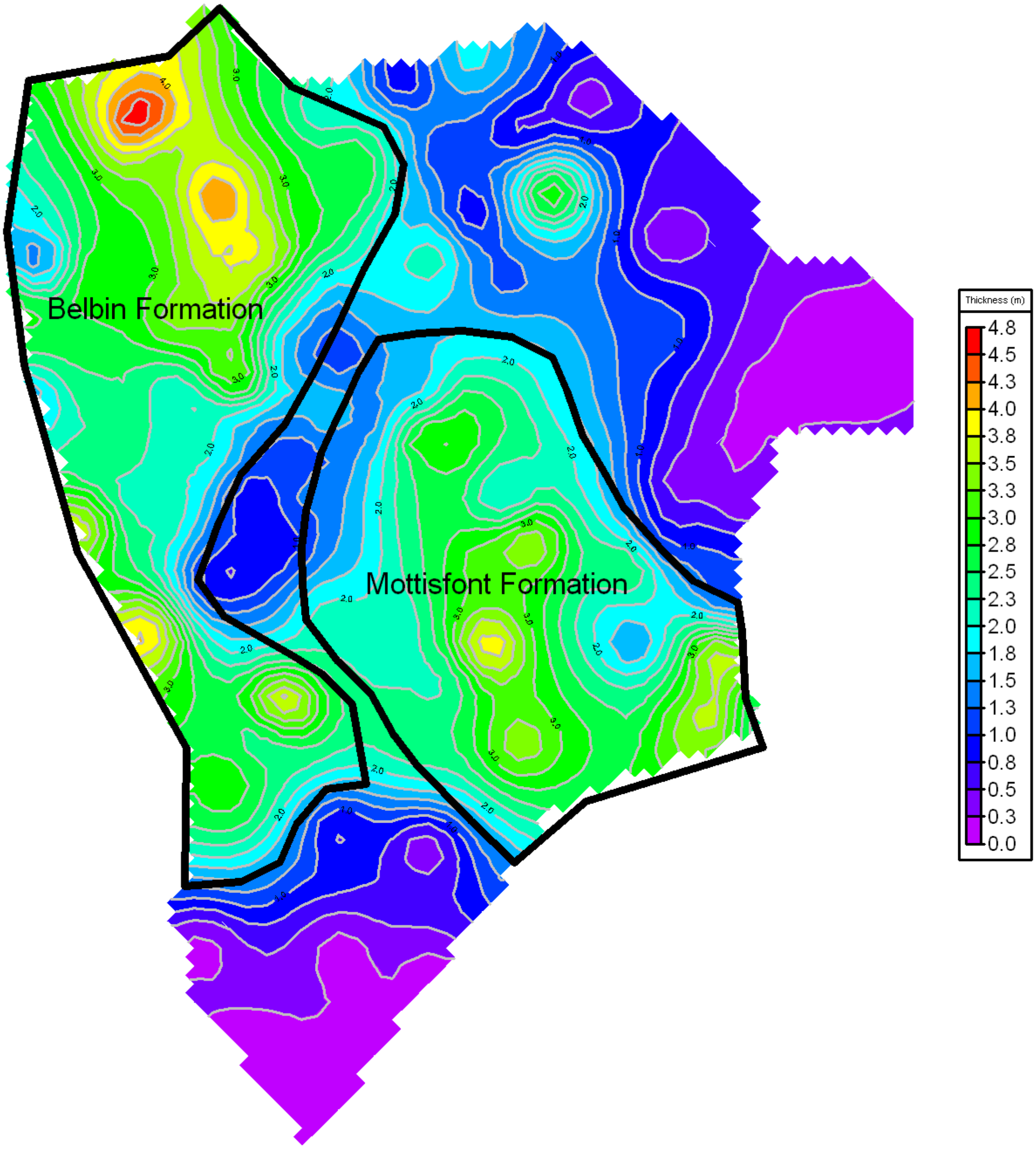
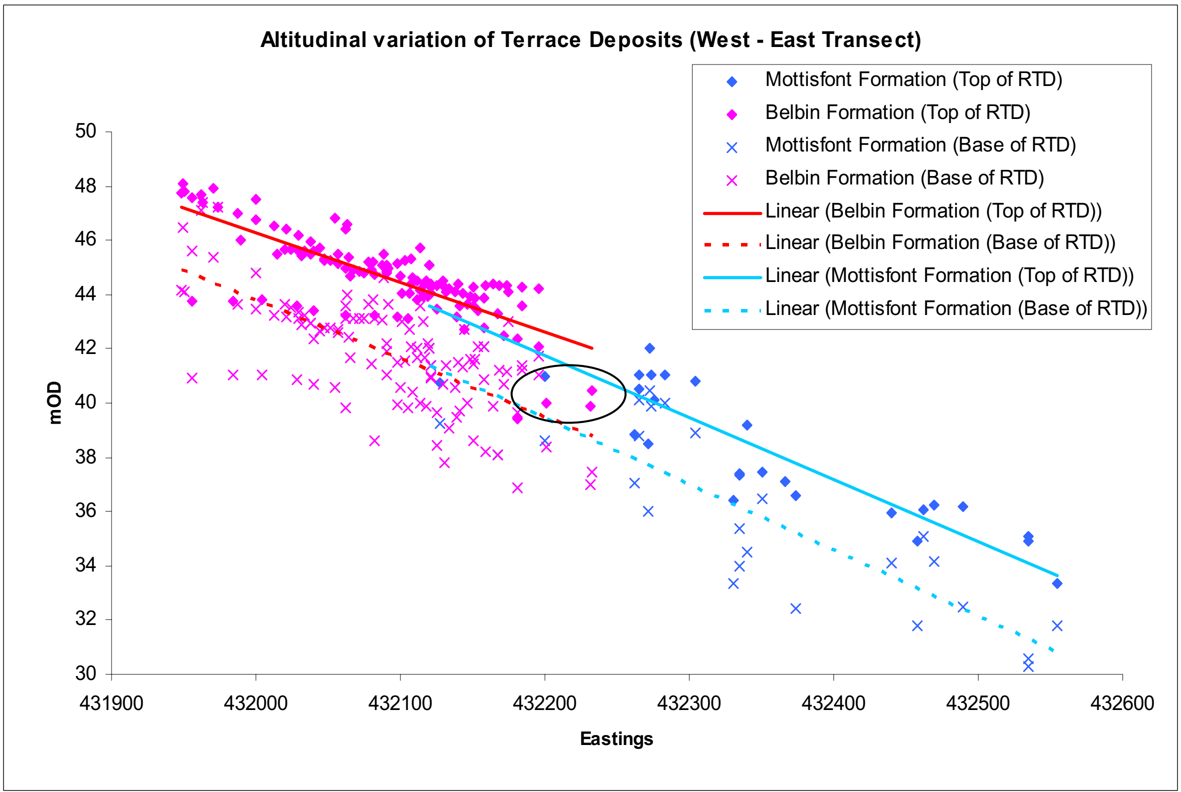
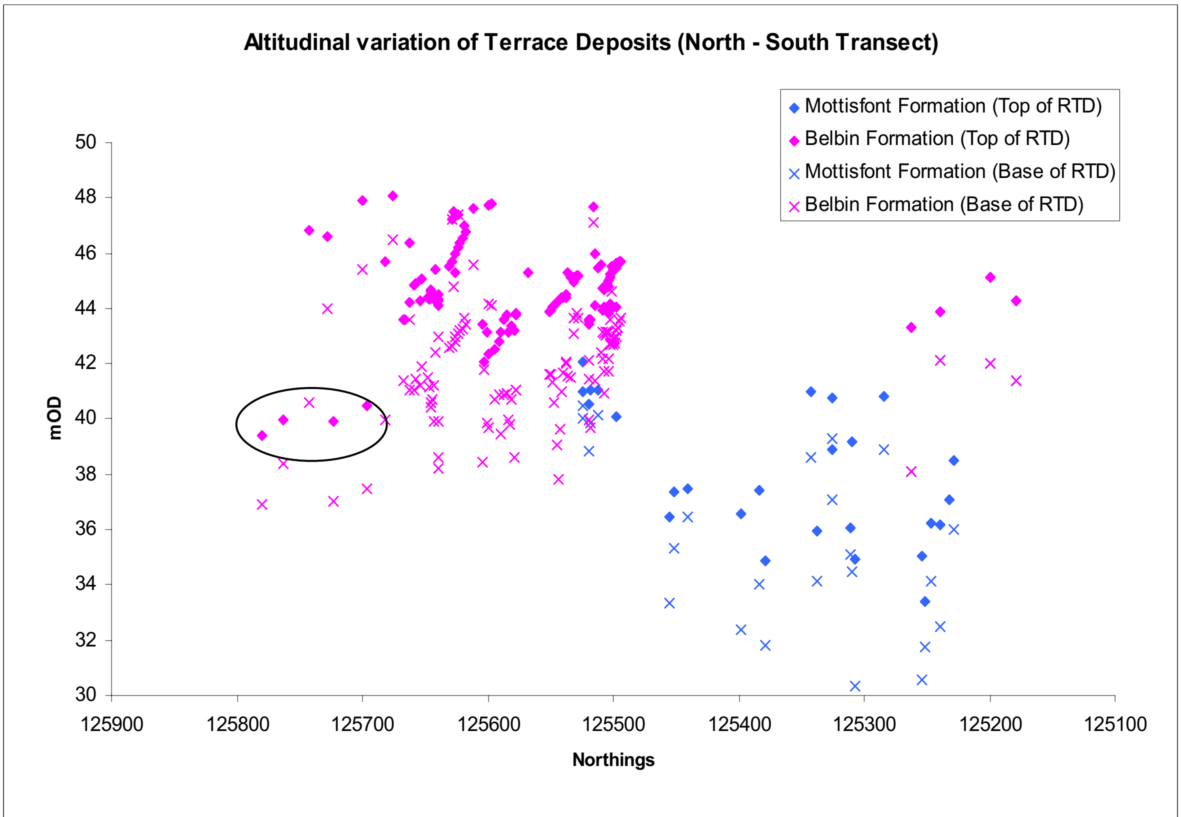


Figure 14: Altitudinal profiles for River Terrace Deposits from the study area. Areas from which data are taken are shown in Figure 13.





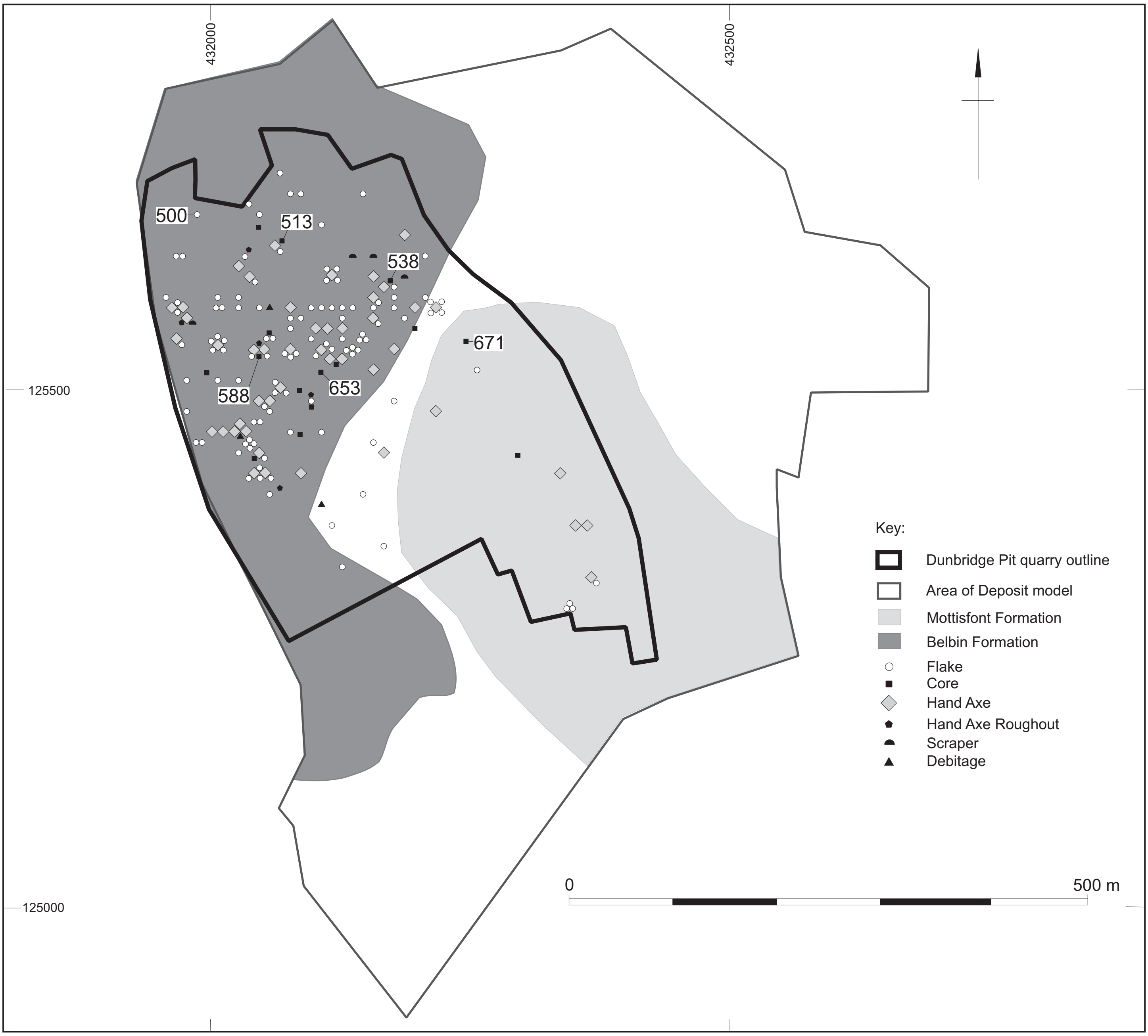


Figure 15: Artefact distribution plotted over the approximate terrace footprints as derived from the deposit modelling (Figure 13).