

## **Chapter 5 The aerial extent, surface morphology and geometry of the Gordano Valley Pleistocene sediments**

### **5.1 Introduction**

The structure of the chapter is based on the first objective, outlined in Chapter 1; to determine the aerial extent, surface morphology and geometries of the Pleistocene sediments. Each element of the objective is discussed in turn. The methods used are those outlined in Chapter 4 (sections 4.3, 4.4 and 4.5). First, based on the results from manual coring, a brief overview of the stratigraphy of the overlying biogenic sediments is presented and the various units identified from this are summarised; this provides a context for the Pleistocene minerogenic sediments. Following this maps delineating the aerial extent of the sediments are presented, and the location of morphological features determined from these maps is outlined. The overall surface morphology of the minerogenic sediments is then considered in both two- and three-dimensions. Finally key sections and their geometries are presented and interpreted.

### **5.2 Stratigraphy and aerial extent of overlying biogenic deposits**

This section provides the stratigraphic context for the Pleistocene minerogenic sediments. Manual coring revealed a number of variations in the biogenic sediments and this information was later used to determine placement of percussion cores (Chapter 4, section 4.6.1) as well as placing the minerogenic sediments in stratigraphic context. Units were identified based on field assessment of the lithology from a total of 489 manual cores; 349 from Weston Moor and 140 from Clapton Moor. Stratigraphic descriptions of manual cores, including grid reference and altitude, are provided in Appendix I. Beneath the valley-wide deposits of peat, a sequence of biogenic mud was identified which, with the exception of two outliers on Clapton Moor, is found entirely on Weston Moor. Boundaries between these units are usually sharp, though occasional gradual transitions suggest that the sharp boundaries may be the result of surface erosion. The sequence of units (Table 5.1) is collectively referred to throughout this thesis as “biogenic mud”.

Table 5.1: Stratigraphy of biogenic mud (in descending stratigraphic order)

Approximate depth below surface (m)	Description
2.50 to 2.60	Blue grey (Gley2 5/1 5PB) to Dark bluish grey (Gley1 4/1 5PB) gritty clay, occasionally containing detrital woody organic remains
2.60 to 2.75	Greyish brown (10YR 5/2) silt or very fine sand, sometimes containing rootlets
2.75 to 3.00	Very dark greyish brown (10 YR 3/2) silt, rich in rootlets and detrital organic material
3.00 to 3.30	Yellowish brown (10YR 5/4) to light olive brown (2.5Y 5/4) silt, biogenic, sometimes with leaves and stems apparently <i>in situ</i>

A number of variations to the biogenic mud sequence are found on the study site; these are illustrated in Figure 5.1. Intercalations of biogenic and minerogenic deposits were found within the biogenic mud along the northern and southern edge of the valley floor. The intercalations comprise millimetre thick biogenic deposits and millimetre to centimetre thick minerogenic deposits. The southern edge of the biogenic mud was also marked by the increasingly sandy texture of deposits. Outside both the northern and southern margins of the biogenic mud, where the sequence laps up at the valley sides, was a direct interface between sand and overlying peat. Results from manual coring form the basis for a series of maps, produced from the field data using Digimap Landline Plus (Ordnance Survey/EDINA 2005) and ESRI ArcMap 9.1<sup>®</sup> software, which illustrate the extent of various deposits. The location of the biogenic mud and their associated variations are shown in Figure 5.2.

The biogenic mud on Weston Moor comprises the hydrosere succession identified by Hill *et al.* (2008), who provide dates of 15060-13820 Cal. BP for the onset of biogenic sedimentation and 9580-9520 Cal. BP for the onset of accumulation of the overlying peat. This indicates that minerogenic sediments below the biogenic mud are at least 13820 Cal. BP in age, and therefore Pleistocene, whilst those directly below peat are potentially either Pleistocene or early Holocene (MIS 1).



Figure 5.1: Variations in Weston Moor biogenic mud deposits. A. Sandier deposits from the south of Weston Moor. B. Direct peat/sand interface. C. Intercalated biogenic and minerogenic sediments. Arrows indicate the locations of the biogenic material. D. Weston Moor biogenic mud sequence

Intercalated biogenic and fine-grained marly minerogenic deposits within the biogenic mud are consistent with paludal deposition in a shallow pool of calcium carbonate-saturated water (Pedley *et al.* 2003). They are interpreted as having formed by hydrological oscillations at the fluctuating edge of a low energy water body, possibly associated with the development of temporary ponds following flood events (Collins *et al.* 2006). The sandier nature of biogenic mud towards the southern side of the valley is, according to Gilbertson & Hawkins (1983), due to reworking of periglacial coversands by running water. The combined locations of these variations in the Weston Moor deposits were used primarily to delineate the boundaries of a body of water subsequently infilled by hydroseral succession (Hill *et al.* 2008). This is defined by sedimentary evidence of shores and terrestrial environments which were outside the body of water, as well as the extent of the biogenic mud (Figure 5.2). This indicates that Weston Moor was probably once

occupied by a substantial body of water. The two biogenic mud outliers on Clapton Moor may represent local ponding.

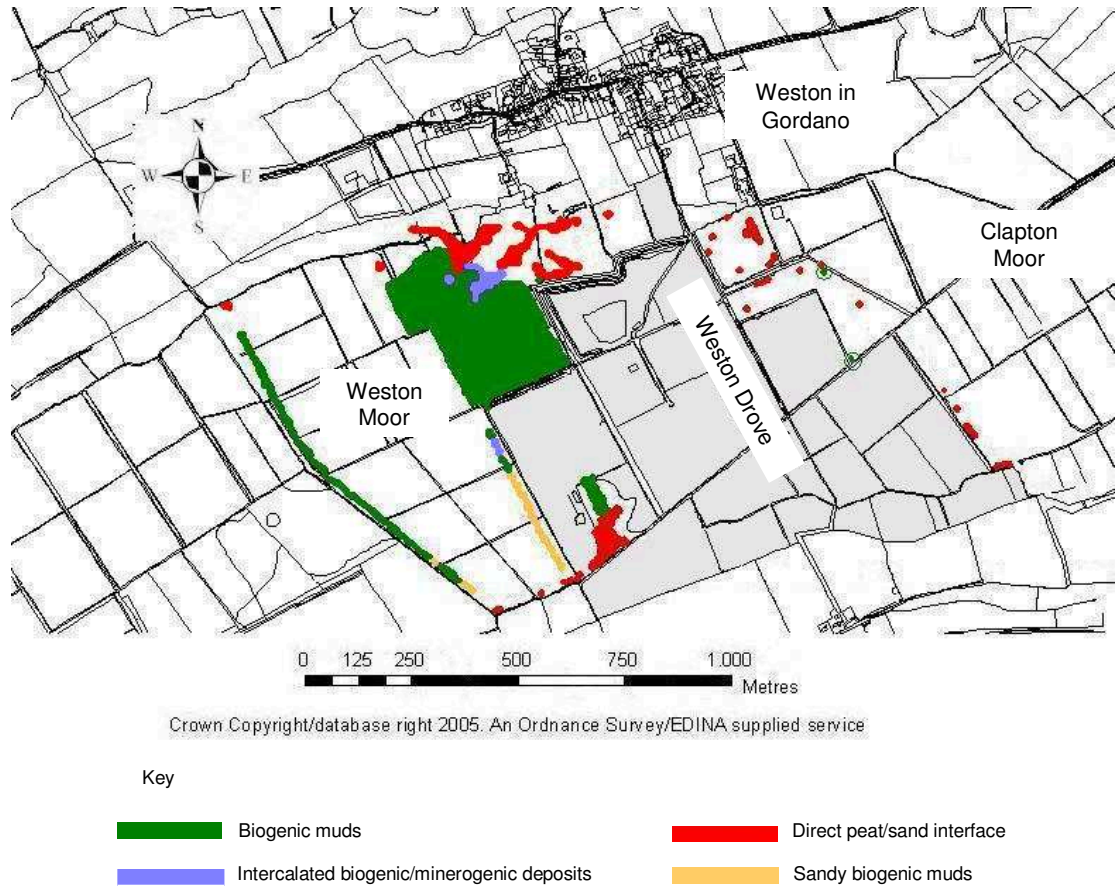


Figure 5.2: Location of biogenic mud, associated variations and boundary deposits. Biogenic mud outlier sites on Clapton Moor are circled

### 5.3 Aerial extent of the Pleistocene minerogenic sediments

The known extent of Pleistocene minerogenic sediments is shown in Figure 5.3. Occasional inability to recover sediment by manual coring has resulted in a rather patchy appearance. The most widely found deposit is fine sand, with occasional pockets of medium sand and coarse sand deposits around the fringes of the valley floor. Pockets of gravel were also found; these occurred more frequently on Clapton Moor than on Weston Moor. However, although Figure 5.3 makes clear that minerogenic sediments exist across the full width of the valley floor and at least for some distance eastwards and westwards of



Weston Drove, it does not reveal a planform which might be diagnostic of any particular morphological feature.

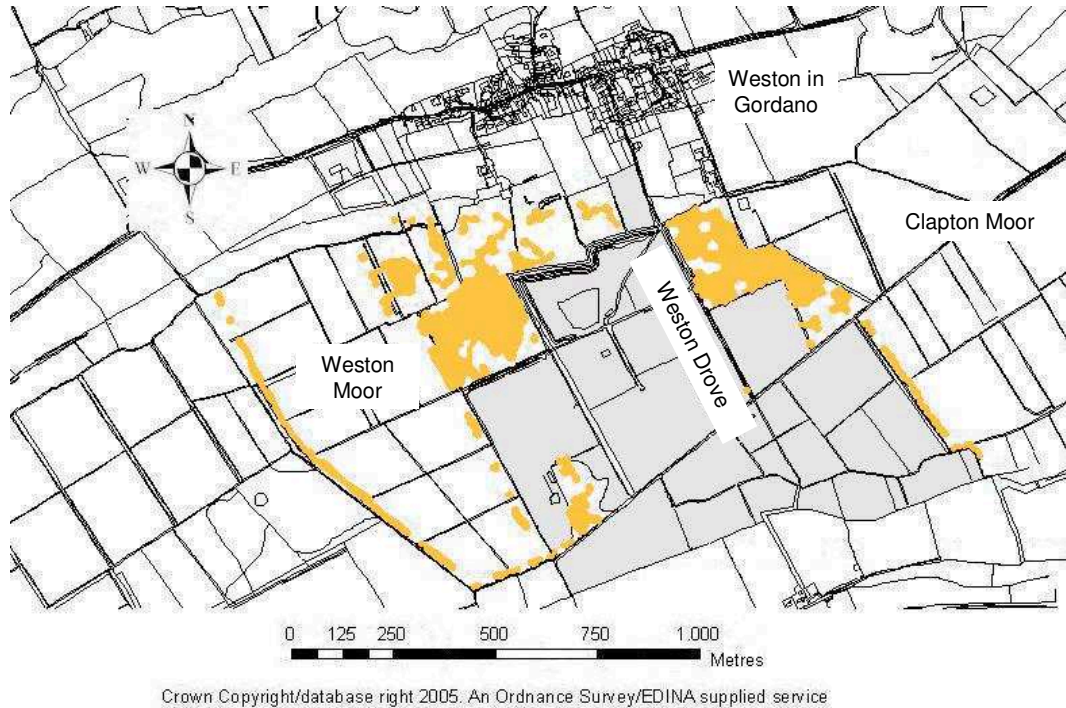


Figure 5.3: Known extent of Pleistocene minerogenic deposits on the Gordano Valley floor (yellow)

Some of these deposits are widespread whilst others are more localised in their distribution. A light blue to white soft, smooth clay with millimetre thick sandy lenses was recorded on Weston Moor (Figure 5.4A). The presence of this soft clay coincides with the thickest minerogenic deposits found during manual coring (section 5.5) and is confined to a small area approximately in the mid-line of the valley. Stiff, dense blue-grey clay (Figure 5.4B) was found mainly on Clapton Moor but also extended onto Weston Moor a short distance west of Weston Drove. This clay was occasionally intercalated with peat, suggesting deposition was in response to periodic hydrological changes. The locations of these two clays are shown in Figure 5.5. Again, the planforms are not diagnostic of any particular morphological feature, although the planform of the soft light blue clay on Weston Moor might represent a channel or a basin.



Figure 5.4: Clay deposits in the Gordano Valley. A. Soft light blue clay found on Weston Moor. B. Stiff blue-grey clay, mainly found on Clapton Moor

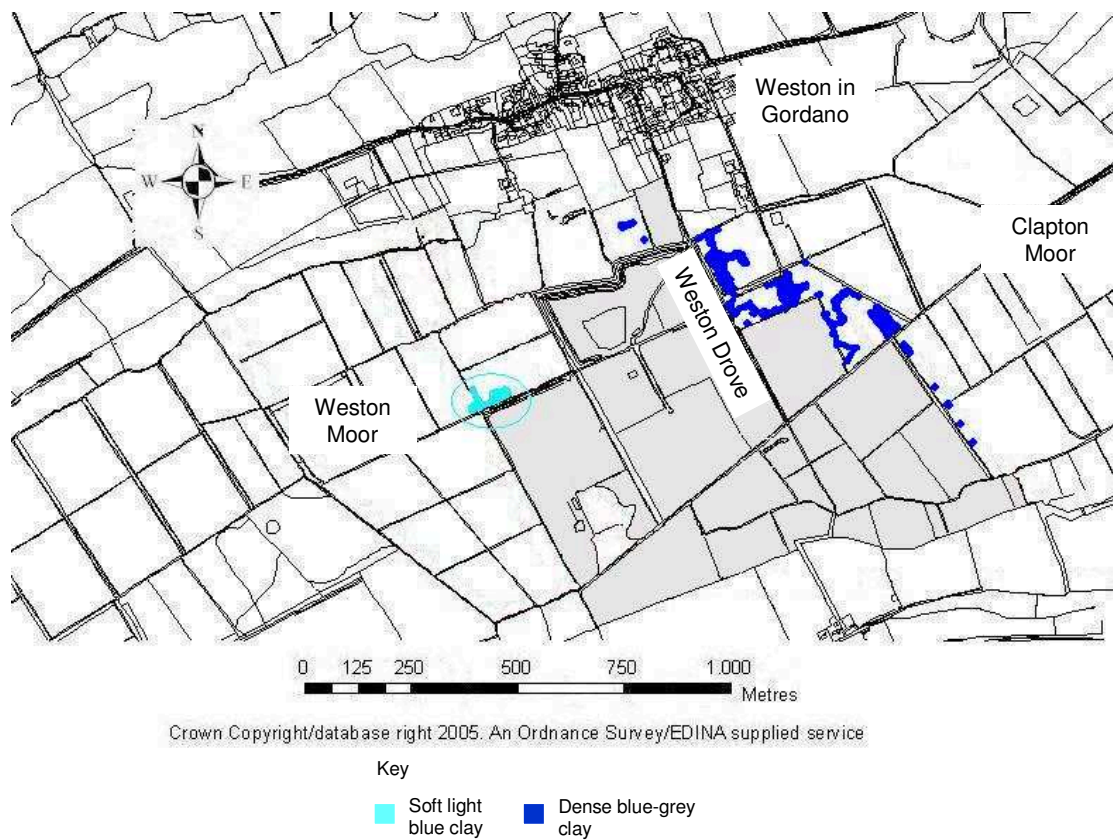


Figure 5.5: Known extent of soft clay deposits on Weston Moor (circled) and stiff, dense clay on Clapton Moor

#### 5.4 Surface morphology of the Pleistocene minerogenic sediments

The computer package Surfer® 7 (Golden Software 1999, version 7.04, 2001) was used to provide a three-dimensional representation of the minerogenic surface morphology, as outlined in Chapter 4 (section 4.4.5). Only levelled data was used to produce the three-dimensional representations, with the exception of Weston Moor (South) where four

LiDAR elevations, which show good agreement with the nearest levelled altitudes, have been used.

### 5.4.1 Morphology of the minerogenic surface

#### Description

Figure 5.6 shows three contour plots of the minerogenic surface for the three main areas of sampling. This shows a shallow central basin on Weston Moor (North) with the minerogenic surface rising towards the north and a number of small areas of topographically higher and lower ground. The minerogenic surface of Weston Moor (South) forms a low amplitude topographic high which shallows eastwards and, more noticeably, northwards. The minerogenic surface of Clapton Moor rises towards the northwest and also demonstrates a number of high and low points, mainly across the middle of the plot.

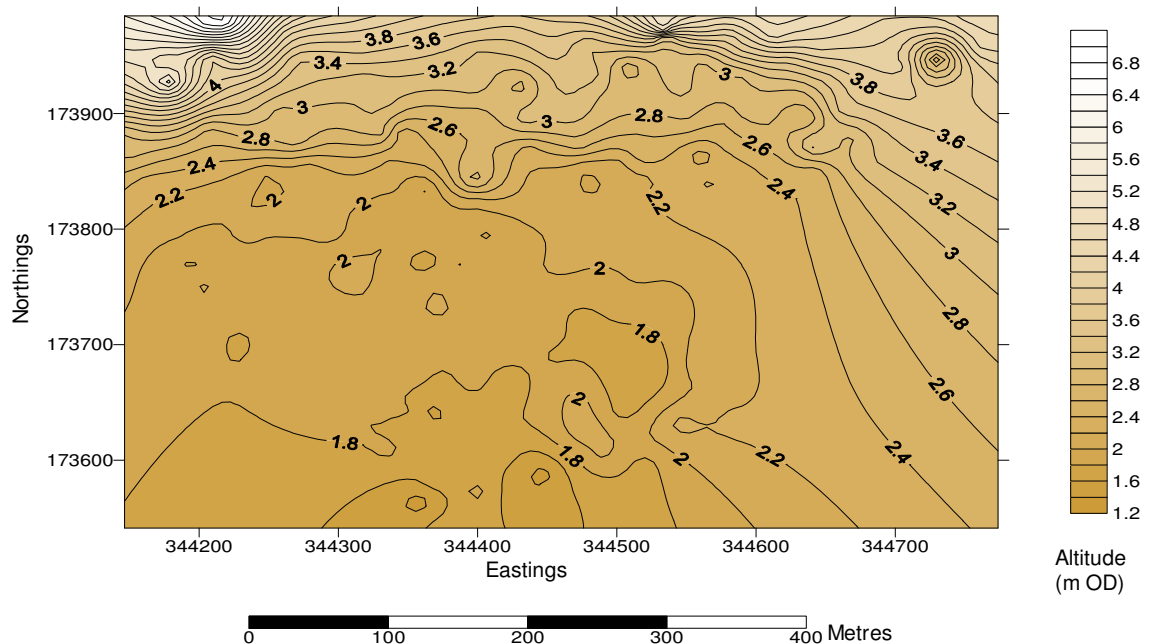


Figure 5.6: Surfer® contour plots of the minerogenic surface. Contours are at 20 cm intervals. Scale bars are in metres. A. Weston Moor (North)

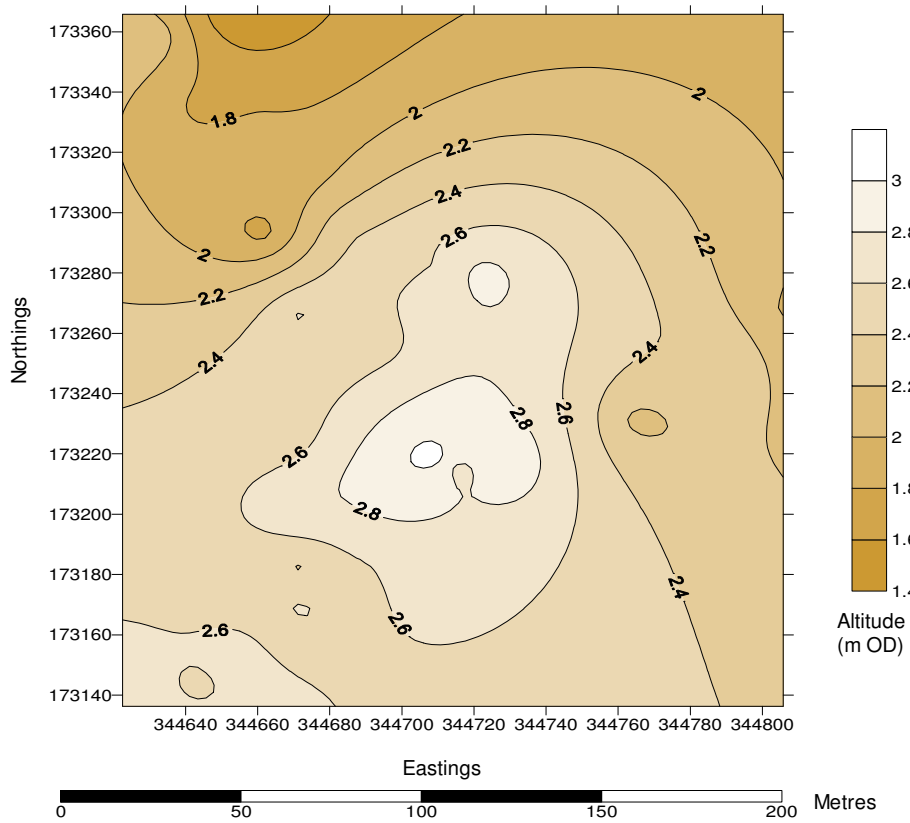


Figure 5.6 (continued): Surfer® contour plots of the minerogenic surface. B. Weston Moor (South)

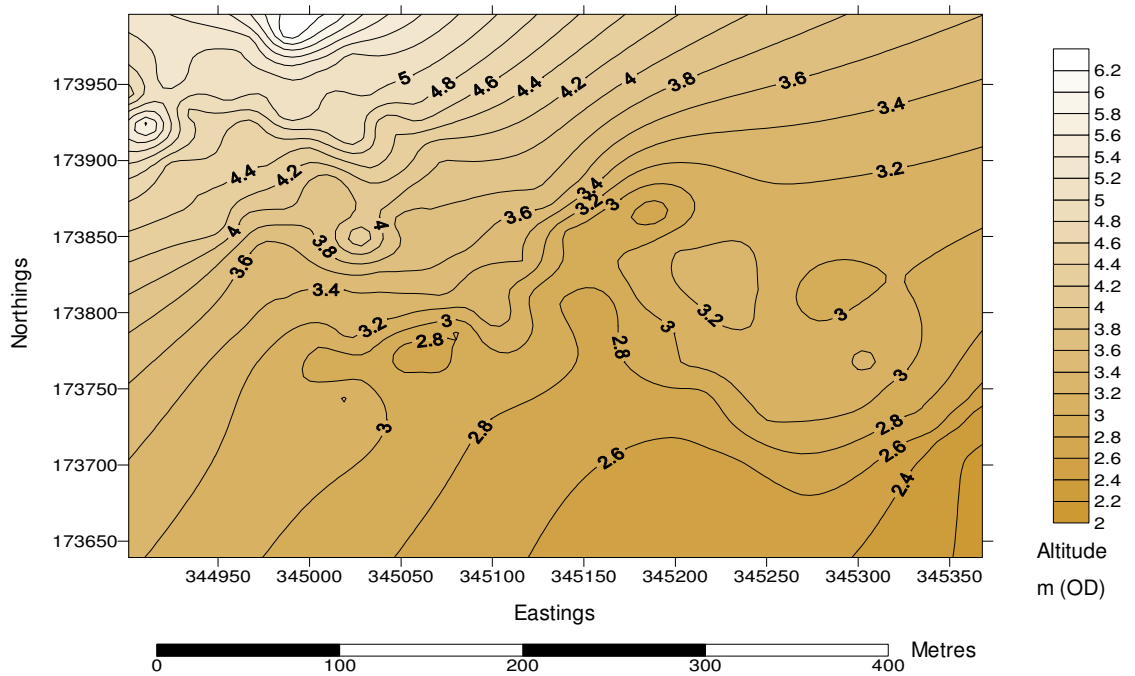


Figure 5.6 (continued): Surfer® contour plots of the minerogenic surface. C. Clapton Moor



Figure 5.7 shows the three-dimensional Surfer® plots of the minerogenic surface. These show a steep-sided valley with an irregular valley floor surface, marked by shallow depressions and hummocks of 30-60 cm amplitude. The surface is more irregular and hummocky at the valley margins, particularly the northern margins of Weston Moor and Clapton Moor, whilst Weston Moor (South) demonstrates a topographic high point. A gap between two high points in the northwest of the study site on Weston Moor (North) is arrowed, as is a possible channel feature on Weston Moor (South).

### **Interpretation**

The contour and three-dimensional plots indicate the existence of a depositional basin on Weston Moor in which biogenic mud later accumulated. The minerogenic sediments display a surface of low amplitude hummocks which on Weston Moor (South) appear to have been superimposed on a slightly higher surface. There is a gap between two high points on the valley side of Weston Moor (North) from which material appears to have slumped onto the valley floor and a possible channel in the northwest quadrant of Weston Moor (South) which appears to drain the higher ground to the south and east. The irregular surface appears to be the result of slope instability at the valley sides resulting in a surface morphology of poorly drained hollows separated by better drained hummocks.

The contour and three-dimensional plots provide information on sediment geometries which were further explored through section diagrams (section 5.5.1).

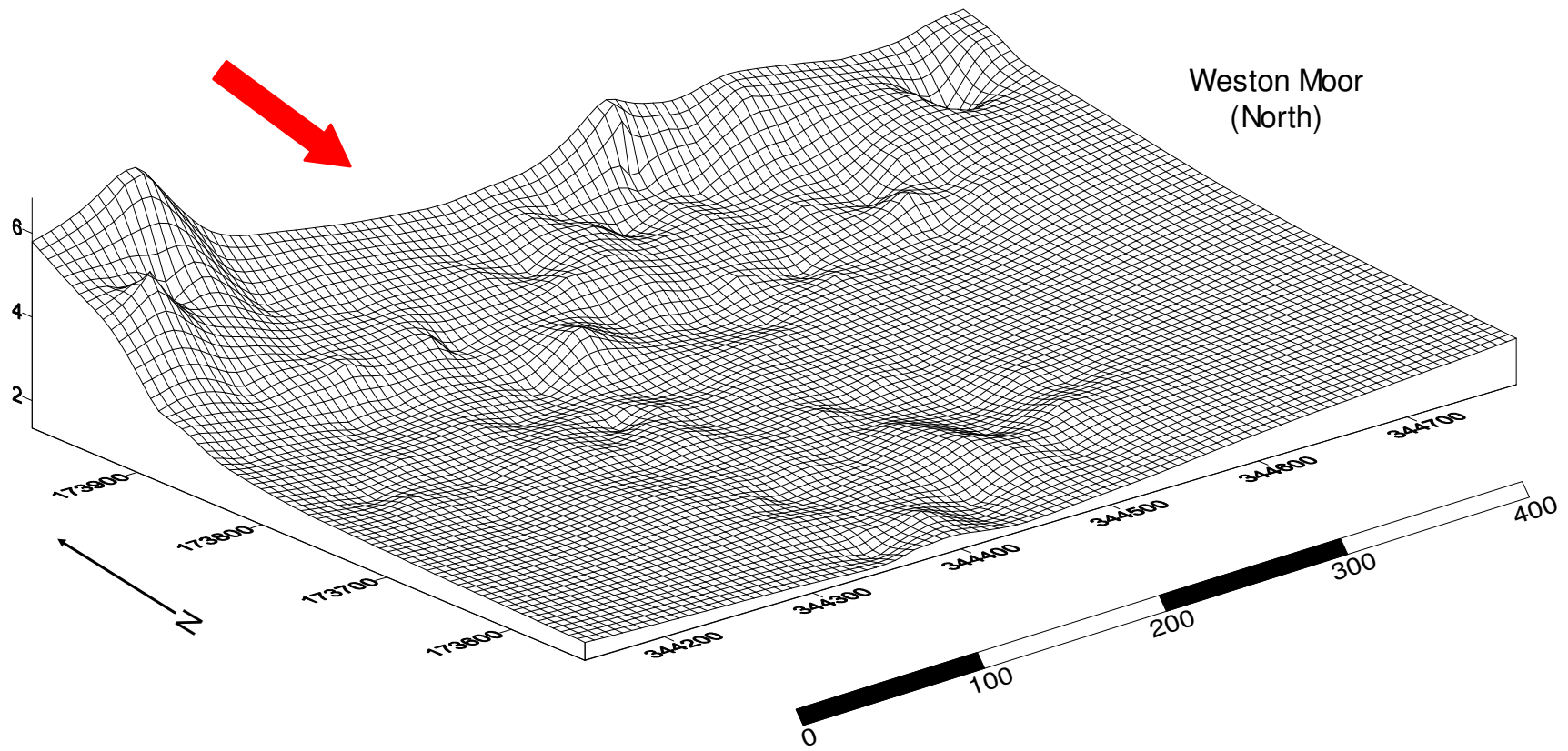


Figure 5.7: Three-dimensional Surfer® plots of the minero-genic surface of the Gordano Valley. Scale bars are in metres; vertical scales are metres OD. A. Weston Moor (North). A gap between two high points on the valley fringe is arrowed

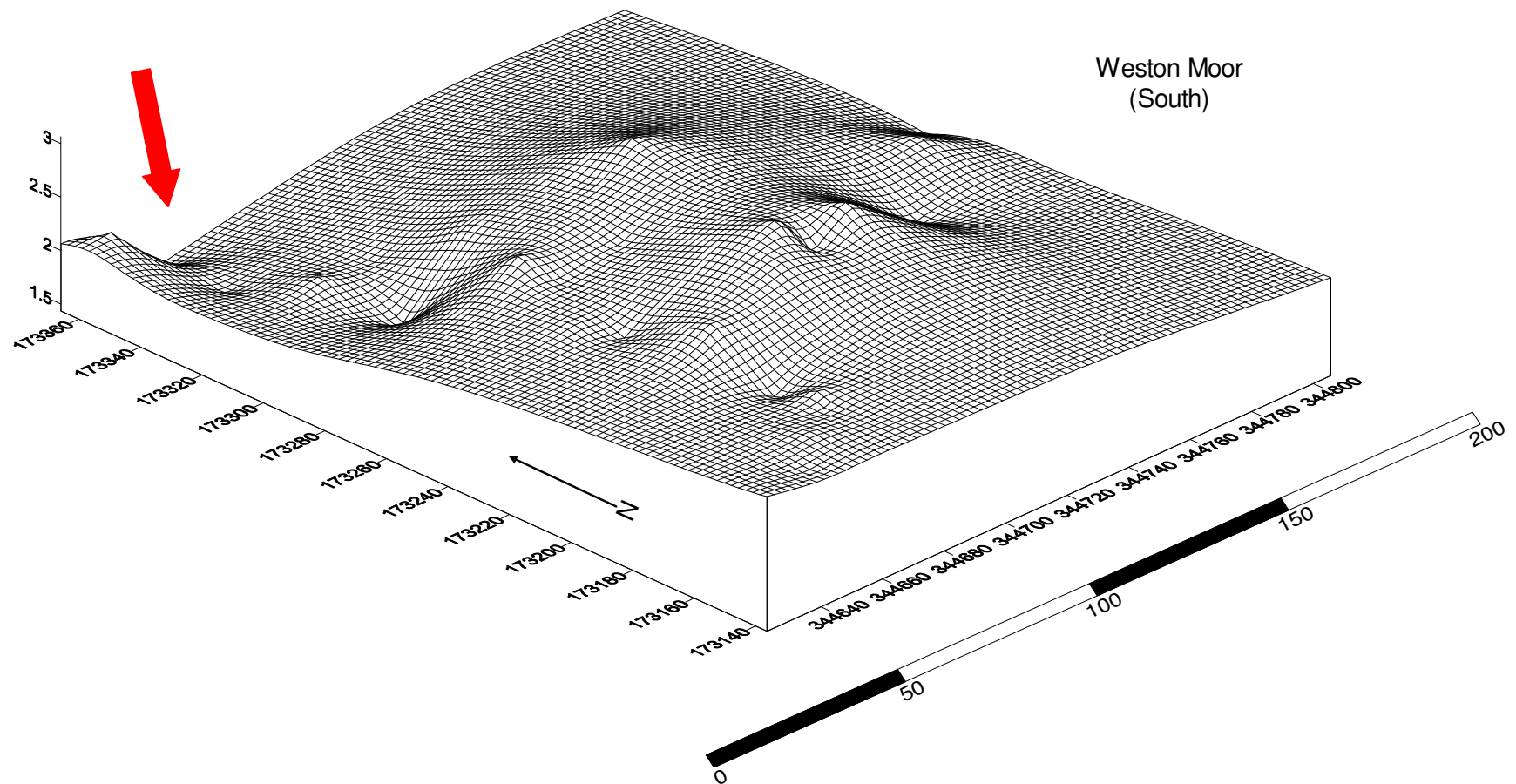


Figure 5.7(continued): Three-dimensional Surfer® plots of the minerogetic surface of the Gordano Valley. B. Weston Moor (South).  
A possible channel at the north of the plot is arrowed.

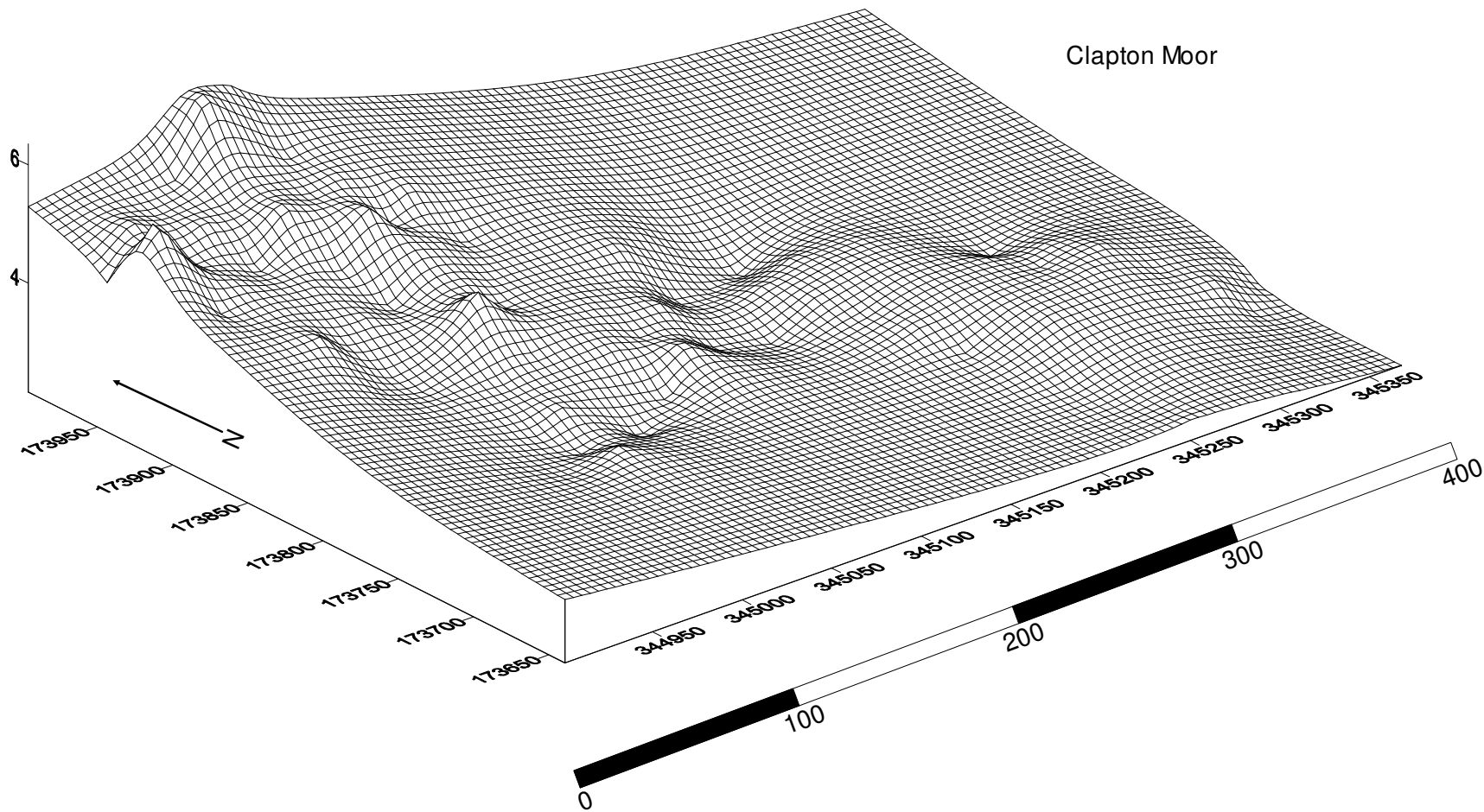


Figure 5.7(continued): Three-dimensional Surfer® plots of the mineralogic surface of the Gordano Valley. C. Clapton Moor



## 5.5 Geometries of the Pleistocene minerogenic sediments

The thicknesses of the minerogenic sediments present a more complex picture than that of the surfaces, although this may be a function of where sediment recovery was most successful. This was dependent mainly on sediment texture, so that clays were more easily recovered than sands or gravels and their thicknesses may be overrepresented as a result.

Average thicknesses and thickness ranges of the minerogenic sediments are summarised in Table 5.2. The biogenic mud on Weston Moor tapers out towards the valley fringes and also eastwards towards Weston Drove. In general, the minerogenic deposits thicken westwards towards the head of the valley and shallow rapidly northwards and eastwards on the fringes of the valley floor, before thickening again on Clapton Moor, where deposits are generally less thick than those on Weston Moor. The thickest deposits (up to 1.69 m) were found along the valley axis on Weston Moor.

Table 5.2: Average thickness and thickness ranges of deposits (in metres)

Facies	Average thickness of deposits	Average thickness of Weston Moor deposits	Average thickness of Clapton Moor deposits	Thickness range of deposits	Thickness range of Weston Moor deposits	Thickness range of Clapton Moor deposits
Biogenic mud	0.62	0.62	-	0.17-1.27	0.17-1.27	0.03-0.12
Minerogenic sediments	0.38	0.37	0.39	0.01-1.69	0.01-1.69	0.01-1.01

Field scale sections linking core stratigraphies were used to provide two-dimensional representations of the sediments as described in Chapter 4 (section 4.5.2). The sections followed the axial trend of the valley from WSW-ENE and across the valley from NW-SE and provided more complete information about the extent of the minerogenic sediments. Field data regarding sediment textures and thickness together with levelled surface altitudes were used to construct a network of two-dimensional representations of the deposits across the study site. Sketches of these sections were produced that allowed the deposits to be traced and correlated across the study site and which provided a visual impression of the geometries of the minerogenic sedimentary units. Most sections demonstrate laterally impersistent deposits. Their broad geometries reveal a pattern of

undulation, with depressions and raised areas that repeated in north-south and east-west directions, suggesting the existence of shallow basins rather than channels. The undulation is most prominent on Weston Moor, although it is repeated to a lesser extent on Clapton Moor.

### **5.5.1 Key sections**

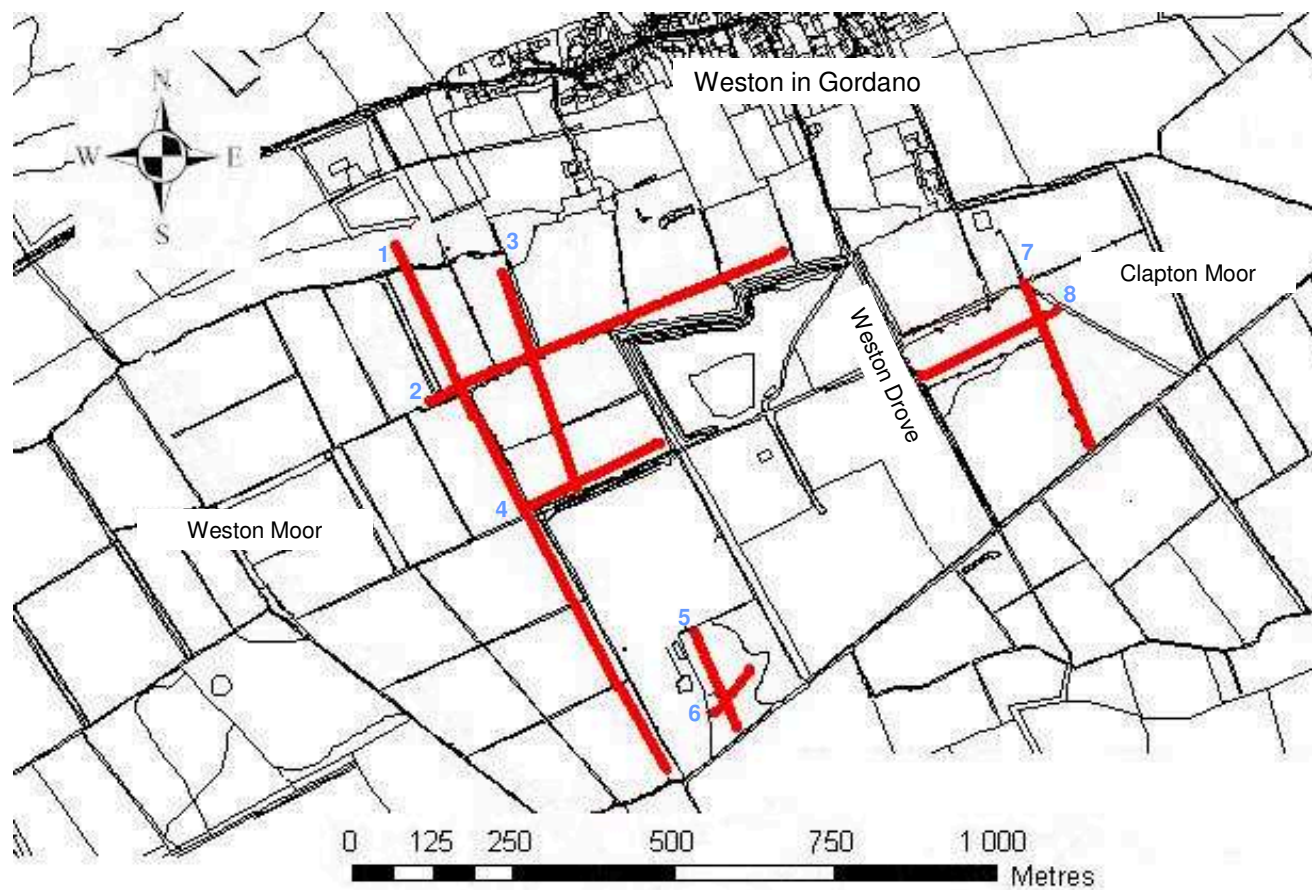
Eight key sections have been identified which best represent the cross-valley and down-valley relationships of the different sedimentary facies. These sections are based on extrapolation of information gained from manual coring using the 25 m grid scheme set out in Chapter 4 (section 4.4.3). The locations of key sections are shown in Figure 5.8.

### **5.5.2 Description of Weston Moor (North) sections**

The descriptions of Sections 1 - 4 which follow provide information about the geometries of the sediments found on Weston Moor (North).

#### **Section 1**

Section 1 (Figure 5.9) is a long cross-valley section along the western edge of the main sampling site and represents the north-to-south changes that occur across Weston Moor. It is crossed by Section 2 and adjoins Section 4. The section displays a shallow depositional basin of minerogenic deposits in which biogenic mud and peat have accumulated. Three possible channels incised into the minerogenic surface are visible in the middle of the section; the most southerly of these is slightly wider. The minerogenic surface exhibits low amplitude undulations of shallow (~ 0.2 m) depressions and hummocks with high width to depth ratios. Superimposed on this is biogenic mud; this also exhibits a surface of low amplitude depressions and hummocks. Two possible channels are visible at the northern edge of the biogenic muds, with a further possible channel in the middle of the section. The northern edge of the section is marked by the presence of



Crown Copyright/database right 2005. An Ordnance Survey/EDINA supplied service

Figure 5.8: Locations of key sections. Section identification is provided by numbers in blue

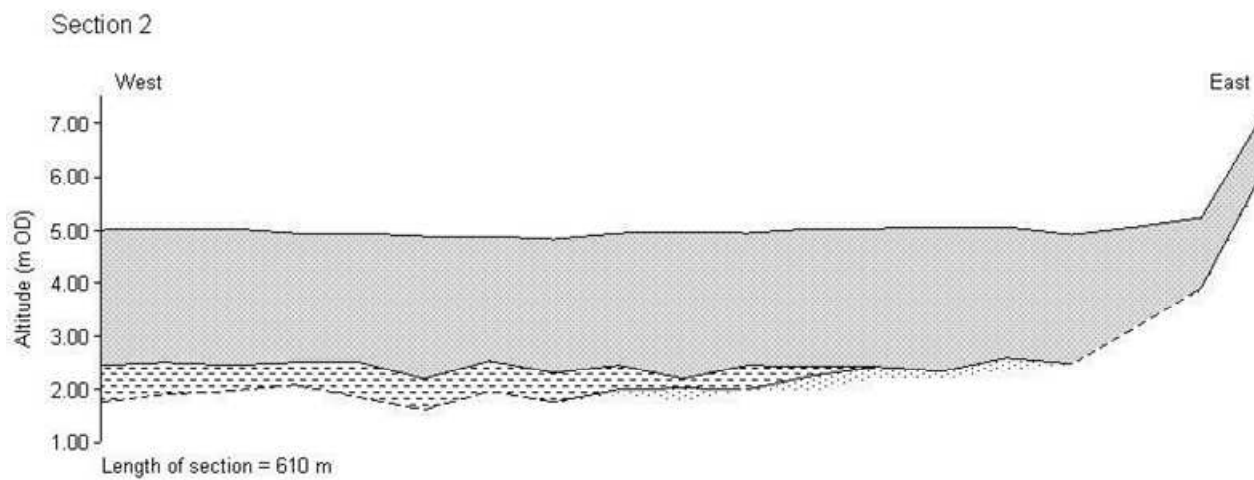
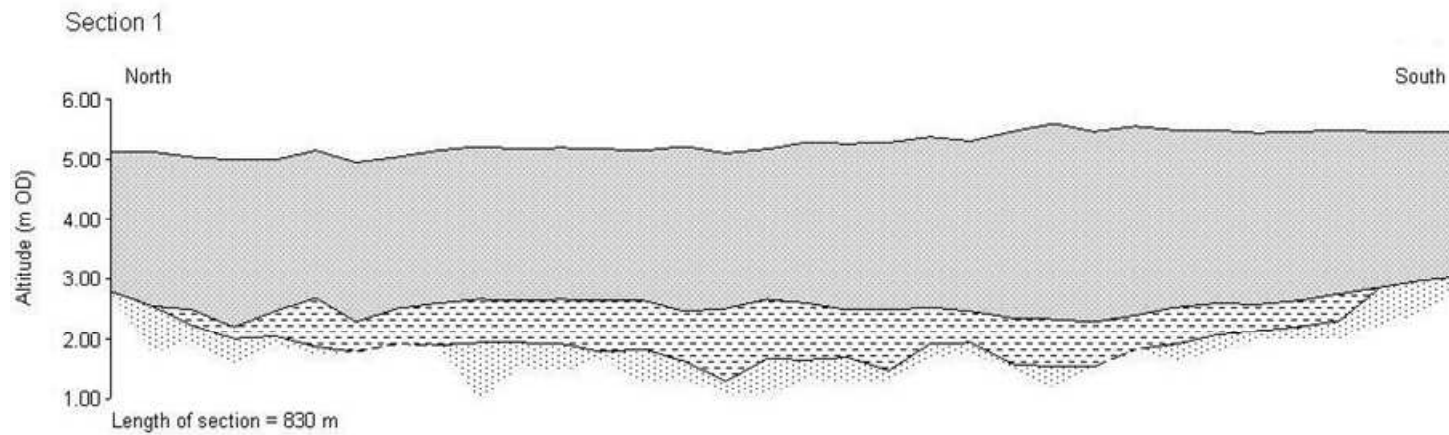


Figure 5.9: Sections 1 and 2



intercalations of biogenic and minerogenic sediments within the biogenic mud, which tapers out on the north slope of the minerogenic basin. At the southern edge of the section the Weston Moor depositional sequence becomes sandier, extending to the southern fringe of the valley where it tapers out against the south slope of the basin.

## **Section 2**

Section 2 (Figure 5.9) crosses both Sections 1 and 3 almost orthogonally. It demonstrates the down-valley changes of the northern edge of Weston Moor and clarifies the relationship between the biogenic mud and minerogenic sediments at the eastern edge of the moor. Probably because of its position towards the northern edge of the valley floor, Section 2 has no biogenic mud deposits with a thickness of more than 0.70 m. As in Section 1, the surfaces of both the minerogenic deposits and the biogenic mud display low amplitude depressions and hummocks, although the amplitude of these ( $< 0.4$  m) is more pronounced than for those of Section 1.

To the east of the section the biogenic muds taper out at the edge of the basin and minerogenic deposits are found directly below peat; their surface rises abruptly to approximately 3.5 m above the surface of the biogenic mud deposits to the west. From the middle part of the section eastwards a thin ( $< 0.05$  m) covering of silt has accumulated on the surface of the biogenic mud and in the same area deposits displaying biogenic and minerogenic laminae occur within biogenic mud.

## **Section 3**

Section 3 (Figure 5.10) crosses Sections 2 and 4, demonstrates cross-valley depositional changes, illustrates the surface on which biogenic mud accumulated and provides evidence of the potential thickness of minerogenic deposits. The surfaces of biogenic mud and minerogenic deposits both demonstrate very low amplitude undulations ( $< 0.2$  m). At the northern edge of the section biogenic mud tapers out against the slope of the valley margin. The southern edge of the section shows a slightly more pronounced depression in the minerogenic sediment surface beneath which are deposits that are over 2 m thick, including a soft clay unit over 0.90 m thick.

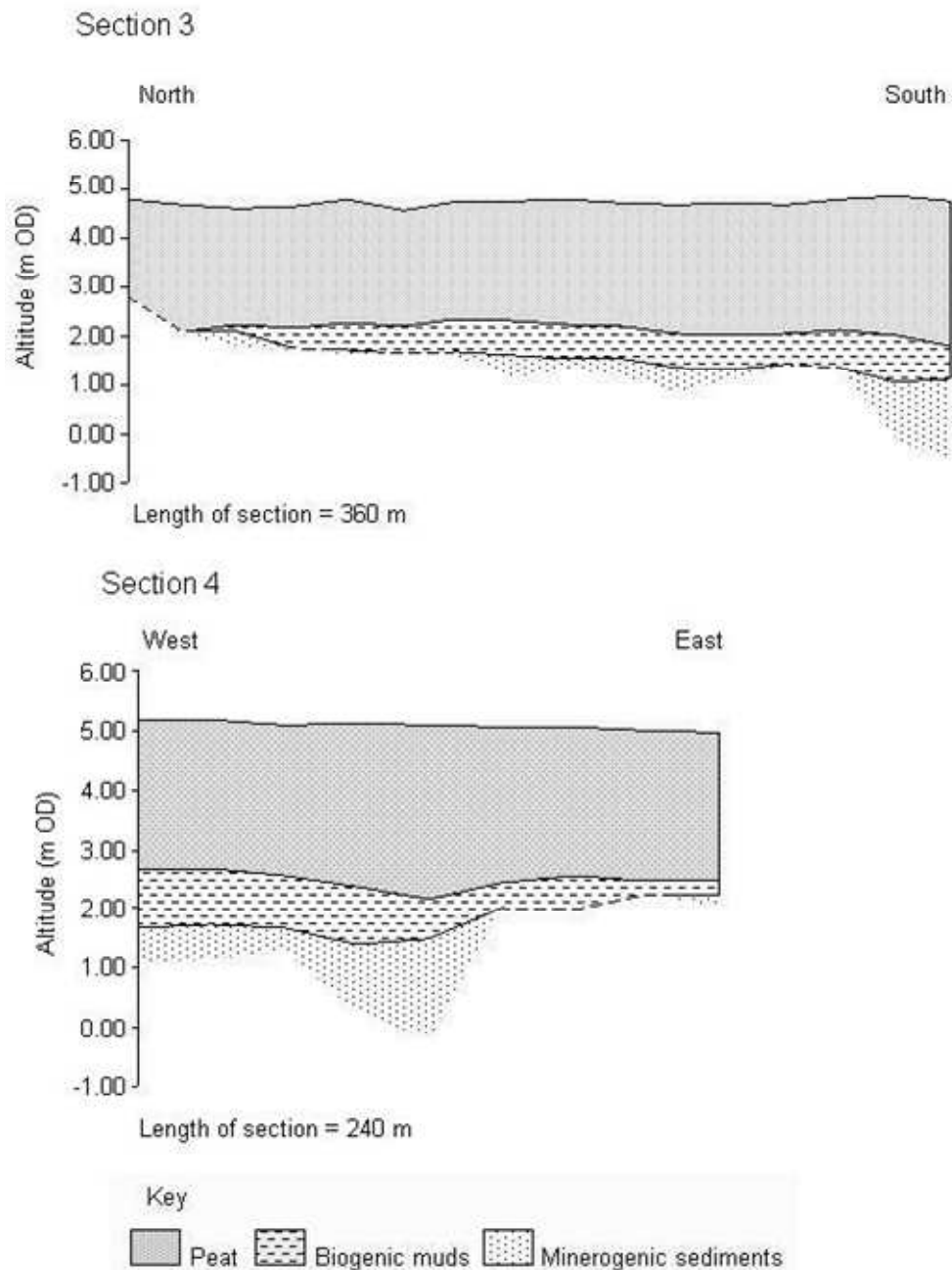


Figure 5.10: Sections 3 and 4

#### Section 4

Section 4 (Figure 5.10) adjoins Sections 1 and 3, providing a further down-valley cross-section. The surfaces of both biogenic mud and minerogenic sediments are gently undulating, with a shallow depression in the mid-part of the section. Two features on this section stand out: firstly, minerogenic deposits in the middle of the section are at least 1.50

m thick, and include a unit of soft clay that thickens to 0.90 m; a shallow depression in the surfaces of both biogenic mud and minerogenic deposits is roughly coincident with this unit. Secondly, the biogenic mud shallows abruptly and starts to taper out from the mid-point eastwards.

### **5.5.3 Interpretation of Weston Moor (North) sections**

Figure 5.11 provides a summary fence diagram of the geometries of the Weston Moor sediments constructed from Sections 2, 3 and 4. The broad geometries of the sections reveal a pattern of undulation, with depressions and raised areas that appear in both north-south and east-west directions, suggesting the presence of shallow basins rather than channels. Depressions in the minerogenic surface are more noticeable in the middle of the sections and appear to be more pronounced in an east-west direction, possibly indicating channelling of surface water. The biogenic mud surface largely mirrors that of the minerogenic sediments, suggesting possible draped beds, although undulations in the surface of the biogenic mud may also be due to differential sediment compaction, mud being more susceptible to this than sand or gravel (Allen 1999, Edwards 2006, Massey *et al.* 2006b).

The biogenic muds have accumulated in a shallow depositional basin less than 1 m deep. The thickness of biogenic mud is apparent, as is a sharp decline in thickness towards the northern end of Section 1. The thickest deposits, those of 0.90 m thick soft clay shown in Sections 3 and 4, appear to form the infill of a small basin within the larger depositional basin or, since they do not appear to be laterally extensive, possibly a channel.

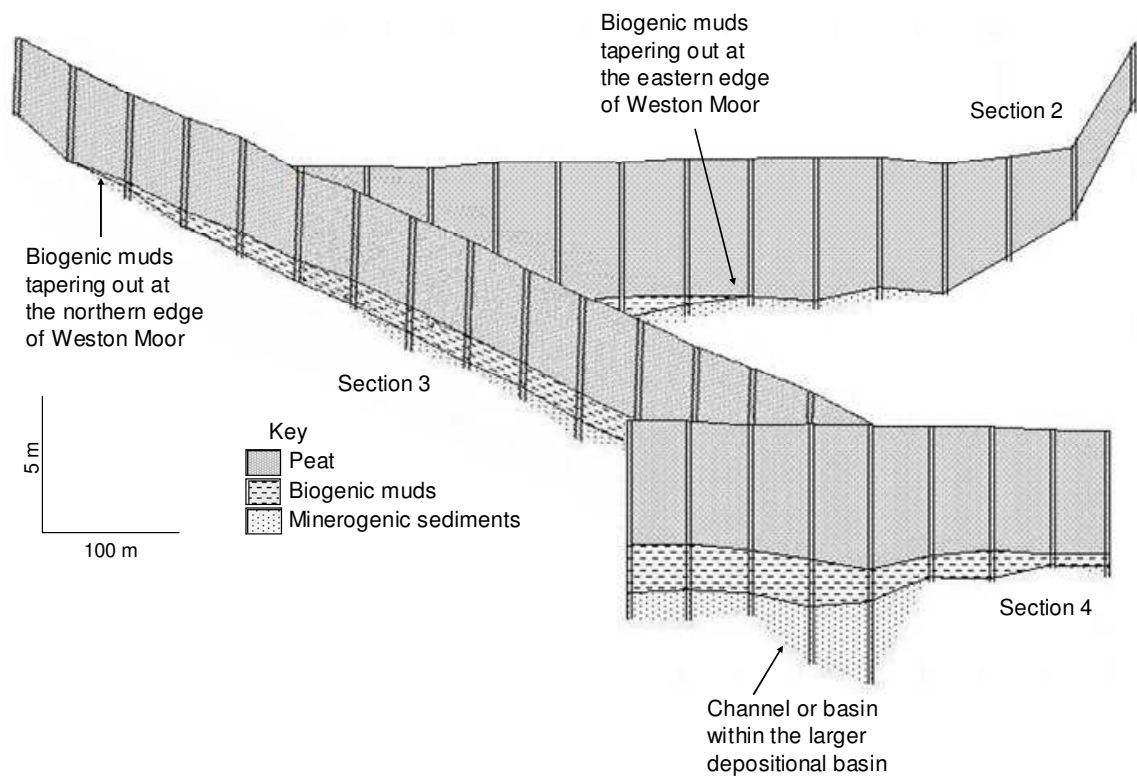


Figure 5.11: Summary fence diagram of Sections 2, 3 and 4 showing main geometries of Weston Moor sediments. Narrow vertical lines represent locations of manual cores

#### 5.5.4 Description of Weston Moor (South) sections

Sections 5 and 6 (Figure 5.12) provide information about the geometries of sediments in the southern part of the valley.

##### Section 5

Section 5 demonstrates cross-valley depositional changes on the southern part of Weston Moor and also illustrates the south eastern extent of biogenic mud accumulation. The minerogenic sediment surface is undulating, with two shallow depressions possibly surface water channels. The minerogenic surface rises rapidly to the south to form a shallow basin in which biogenic mud later accumulated. The surface of the biogenic mud is also undulating, with shallow depressions mirroring the minerogenic surface. Biogenic mud tapers out in two directions; at the northern edge of the section and towards the middle of the section.



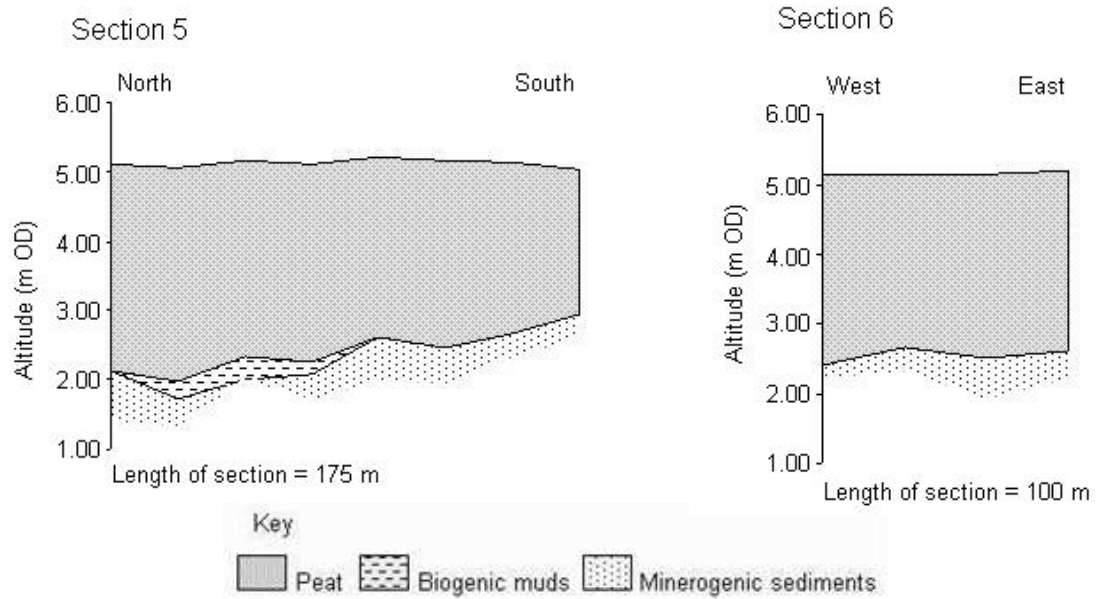


Figure 5.12: Sections 5 and 6

## Section 6

Section 6 demonstrates west-east down-valley depositional changes on the southern part of Weston Moor, and as such represents the deposits of the extreme southern edge of valley floor. It crosses Section 5, providing a cross-section through the southern part of that section. Here, just west of the middle of the section, the minerogenic surface rises slightly to form a low amplitude (~ 0.3 m) hummock. There are no biogenic mud deposits.

### 5.5.5 Interpretation of Weston Moor (South) sections

The geometries of the southern valley sections reveal a southern continuation of the undulating surfaces of Weston Moor. Shallow depressions in the minerogenic surface are again more pronounced in an east-west direction, suggesting possible surface water channels. In this part of the southern valley the minerogenic sediments form a shallow basin, approximately 100 m wide, which has provided accommodation space for biogenic mud accumulation.

### 5.5.6 Description of Clapton Moor sections

Sections 7 and 8 (Figure 5.13) provide information about the geometries of sediments on Clapton Moor, just east of Weston Drove.

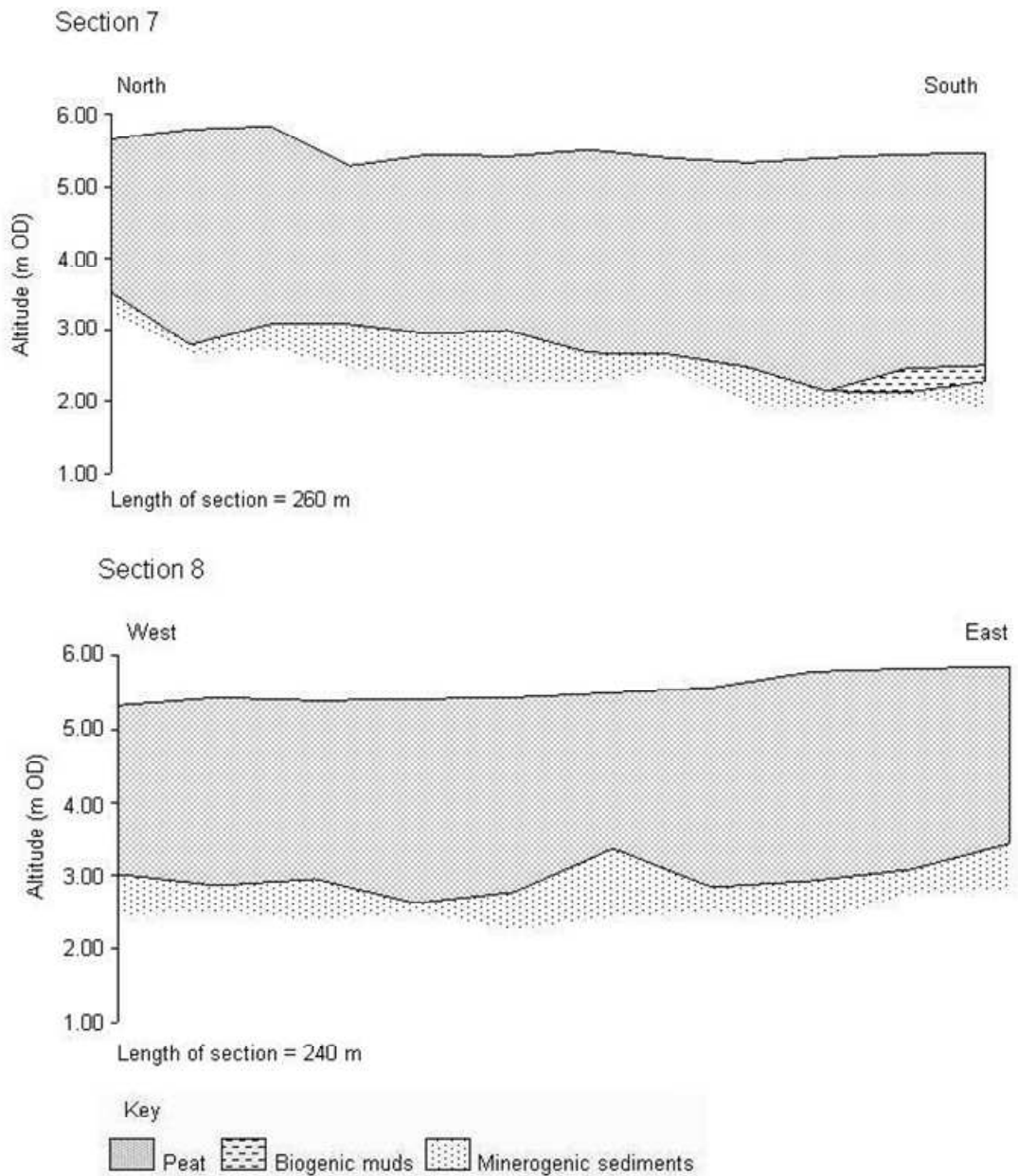


Figure 5.13: Sections 7 and 8

## **Section 7**

Section 7 is a long cross-valley section of Clapton Moor, providing information about the geometries, thickness and lateral changes in deposits east of Weston Drove. In this section peat has accumulated either directly on the undulating surface of the minerogenic sediments or on a thin deposit of biogenic mud. The section displays very shallow depressions in the minerogenic surface, the northernmost depression being the deepest. The surface gradually falls away towards the south, where a thin deposit of biogenic mud has accumulated in a surface depression. This appears to taper out against the south face of the depression although in reality it probably fills the depression.

## **Section 8**

Section 8 bisects Section 7 and forms a long down-valley section of Clapton Moor, providing information about the geometries, thickness and lateral changes in deposits from adjacent to, and eastwards, of Weston Drove. There are two very shallow depressions at the west of the section, a large hummock (amplitude ~ 0.40 m) in the centre and the sediments then rise towards the east.

### **5.5.7 Interpretation of Clapton Moor sections**

The geometries of the Clapton Moor sections are summarised in Figure 5.14. This shows the undulating surfaces of Clapton Moor, with shallow depressions in the minerogenic surface. In contrast to Weston Moor (North) these are more pronounced on the north-south than east-west section; again, possible surface water channels are suggested. Biogenic mud has accumulated in a shallow basin the southern part of the moor.

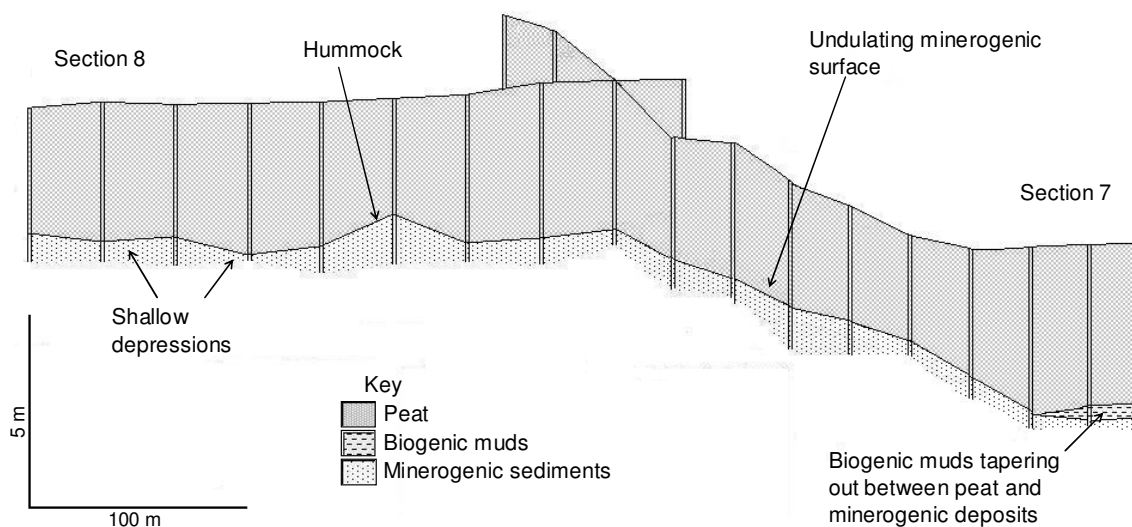


Figure 5.14: Summary fence diagram of Sections 7 and 8 showing main geometries of Clapton Moor sediments. Narrow vertical lines represent locations of manual cores

## 5.6 Summary of aerial extent, surface morphology and geometry of the Gordano Valley Pleistocene minerogenic sediments

The known extent of Pleistocene minerogenic sediments has been mapped and their surface morphology determined. Additional mapping of overlying biogenic mud deposits and their depositional variations has allowed their inter-relationships and their relationship to the geometry and morphology of the minerogenic sediments to be determined. Sand is more extensive than gravel, and is more common on, although not restricted to, Weston Moor, whilst gravel patches are more common on Clapton Moor.

Surface morphology of the minerogenic deposits indicates a minerogenic surface with an irregular, hummocky surface; there also appears to be evidence of slumping of material onto the valley floor. Overall, the surface morphology suggests a number of poorly drained hollows separated by better drained hummocks.

The broad geometries of the sections also reveal a pattern of undulation; depressions with high width to depth ratios run in north-south and east-west directions, are more pronounced towards the west and trend east-west on Weston Moor, possibly indicating channelling of surface water in a down-valley direction, whilst those of Clapton Moor trend north-south, suggesting cross-valley channelling of surface water.

These findings have contributed to a fuller understanding of the aerial extent, surface morphology and geometries of the valley floor minerogenic sediments. This



information was subsequently used to determine suitable locations for cores used for further analysis of the Pleistocene minerogenic sediments. The stratigraphy and sedimentology of these are presented in the next chapter.