Chapter 4

Geology, stratigraphy and site phasing

by Francis Wenban-Smith, Martin Bates, Peter Allen, Richard Bates and John Hutchinson

INTRODUCTION

In the first part of this chapter the landscape setting and geomorphological context of the site are described in more detail than in the general background chapter, including use of borehole records to investigate the subsurface geology. This is followed by details of the deposits in the excavated site area. The disparate sequences recorded in various exposures during the excavation have been integrated into a sequence of eleven phases, 1-11 (Table 4.1). Each phase is discussed in turn, with lithological description and interpretation of its depositional origin. At this stage, depositional interpretation is based primarily on sedimentological character, in conjunction with selected results of micro-morphological and clast lithological analyses, taken from the full specialist reports which are presented separately (Chapters 5 and 6). Results of specialist palaeo-environmental investigations, for deposits where such remains were present, are not taken account of here. Nor indeed are the results of the lithic artefact investigations: refitting, microdebitage distribution and assessment of condition, which likewise have some bearing on deposit formation processes for Phases 6-7, which contained the bulk of the lithic artefactual remains. These are presented subsequently, in Chapters 7 to 12 for palaeo-environmental investigations and Chapters 17 to 19 for the lithic work. Any relevant results are then incorporated into the final discussion and conclusions (Chapter 22).

One of the difficulties, and curiosities, of the site is the extreme geometry and topography of various sediment bodies, as exemplified in the 'skateboard ramp' across its central part (Fig. 3.18). Attempting to understand the causes of this geometry is essential both for developing interpretations of formation processes of the sediments concerned and also for wider understanding of how the sequence of deposits at the site relates to key sequences in the surrounding landscape, such as the Swanscombe 100-ft terrace at Barnfield Pit and the Members of the wider Boyn Hill/Orsett Heath Formation. If the observed geometries relate to the original deposition of the sediments, then they may contribute to interpretation of how the sediments were formed; conversely, if the present-day geometries are post-depositional deformations, then they have wholly different implications (see below).

The final two sections of this chapter then consider the Pleistocene sequence at the site in conjunction with data from borehole and test pit investigations in adjacent areas (Fig. 4.1), identifying correlations with the site phasing sequence and expanding interpretation where possible. This ultimately leads to an overview of the Pleistocene development of the site in its landscape setting.

LANDSCAPE AND GEOLOGICAL CONTEXT

The first key point to keep in mind about the landscape situation and geological context of the site is its drastic alteration over the last 150 years due to the intensity of quarrying around it. Then one must consider how great the geomorphological alterations to the local landscape might have been between the era of its main early Palaeolithic occupation, in the Hoxnian interglacial (see Chapter 22 for a review of dating evidence) and the pre-quarrying landscape of the 19th century. Finally, one must try and incorporate ideas about the palaeo-landscape, its topography and the distribution of resources such as lithic raw material into understanding of the hominin occupational evidence.

In the early 19th century the Ebbsfleet was a small tidal stream less than 3km long, running northward from Springhead to join the Thames, passing between the villages of Swanscombe and Northfleet located on the high ground above the valley sides. As shown on the pre-quarrying geological mapping (Fig. 2.3), the Ebbsfleet passed to the east of a now-quarried spur of chalk (the Associated Portland Cement Manufacturers' Southfleet Pit, excavated between 1907 and 1912) before making a sharp right-angle turn to the west and then curving round to resume a northward course as it enters the Thames. The Southfleet Road elephant site was located at *c* 29m OD (prior to the removal of several metres of deposits by groundworks and archaeological excavation) on the western side of the southern end of this chalk spur. Prior to quarrying this would have been about one third way up the western flank of this part of the Ebbsfleet Valley, which rose westwards for about 1km to the summit of Swanscombe Park at *c* 90m OD. The northern side of the Swanscombe Park hill was quarried away in the second half of the 20th century, contained within Blue Circle's Eastern Quarry as it expanded eastwards and southward from the tunnel linking it with the older Barnfield Pit (Fig. 2.4).

Table 4.1 Stratigraphy and phasing: final version cross-referenced with initial post-evaluation scheme and published interim report (Wenban-Smith *et al.* 2006)

Phase - final	*Sub-phase*	*Interim report (Jan 2006)*	*Initial phasing (Dec 2003)*	*Description*	*Main contexts*
11 - Not *in situ*	-	-	-	Out-of-context, or in made ground	0, 40001, 40012
10 - Holocene	-	-	-	Holocene features and layers	-
9 - Brickearth bank	9b	Unit 6	9 - Brickearth	Reddish-brown brickearth, with occ. sandy/gravelly beds	40053, 40075, 40087
	9a	Unit 6	8 - Sand	Sand/gravel bed at base of main brickearth	40051, 40052
8 - Sandy gravel	8c	Unit 5	7 - Gravel	Bedded sand/gravel	40018, 40048, 40049, 40050, 40071, 40102
	8b	Unit 5	7 - Gravel	Bedded sand/gravel, with sandy/ clayey patches	40047
	8a	Unit 5	7 - Gravel	Bedded sand/gravel, with sand beds	40098
7-8 Transition	-	-	-	Remnant, truncated clayey/sandy gravel beds that interdigitate with base of overlying Phase 8 gravels	40044, 40045, 40046
7 - Mixed clay/gravel (syncline infill)	-	Unit 4	6 - Mixed Clay/Sand/ Gravel	Silts, sands, massive structureless gravelly clay and sandy/clayey gravel	40041, 40042, 40043, 40101, 40164, 40166, 40167
6 - Grey clay, with brown organic-rich beds and tufaceous channel-fill deposits	6	Unit 3	5 - Clay with dark, brecciated upper part	Grey clay, with reddish-brown stained horizons, including v dark humic horizons in north central part of site	40039 (to N of elephant), 40068, 40074, 40078, 40100, 40158
				Lower grey clay, (central part of site)	40099, 40160, 40161, 40162
	6b	Unit 3	5 - Clay	Tufaceous channel fill	40070, 40143, 40144
	6a	Unit 3	5 - Clay	Basal clay horizons	40039 (in central and southern parts of site), 40040 (taken as transitional to Ph 6), 40103
5 - Clay-laminated sand	-	Unit 2	4 - Clay-laminated sands	Fluvially bedded yellow sands with clay-silt laminae, very wavy and contorted in places, and occ. gravel-rich beds	40025, 40066, 40067, 40072, 40163
4 – Sandy/gravelly clay	-	-	3 - Clay, clay-silt	Clay/silty clay beds, stained in yellowish, brownish and greyish bands, gravel/sand rich in places	40026, 40027
3 – Chalky/silty / gravelly sand	-	Unit 1	2 - Clayey/silty sand with flint and chalk pebbles	Grey clay-silty sand with chalk and flint pebbles, rich in derived Tertiary shell fragments	40028, 40061, 40062, 40063 (decalcified), 40159
2 – Parallel-bedded sand/clay	2b	-	-	Alternating beds of silty clay and sand, dipping to west	40060, 40064, 40065
	2a	-	-	Sandy chalk/flint rubble	40077
1 – Tilted block	-	-	-	Block of translocated/disrupted bedrock with steeply dipping beds of Chalk, Bullhead flint bed and Thanet Sand, then darker zone in upper part of Thanet Sand grading into structureless silty sand	40054, 40055, 40056, 40057, 40058, 40059

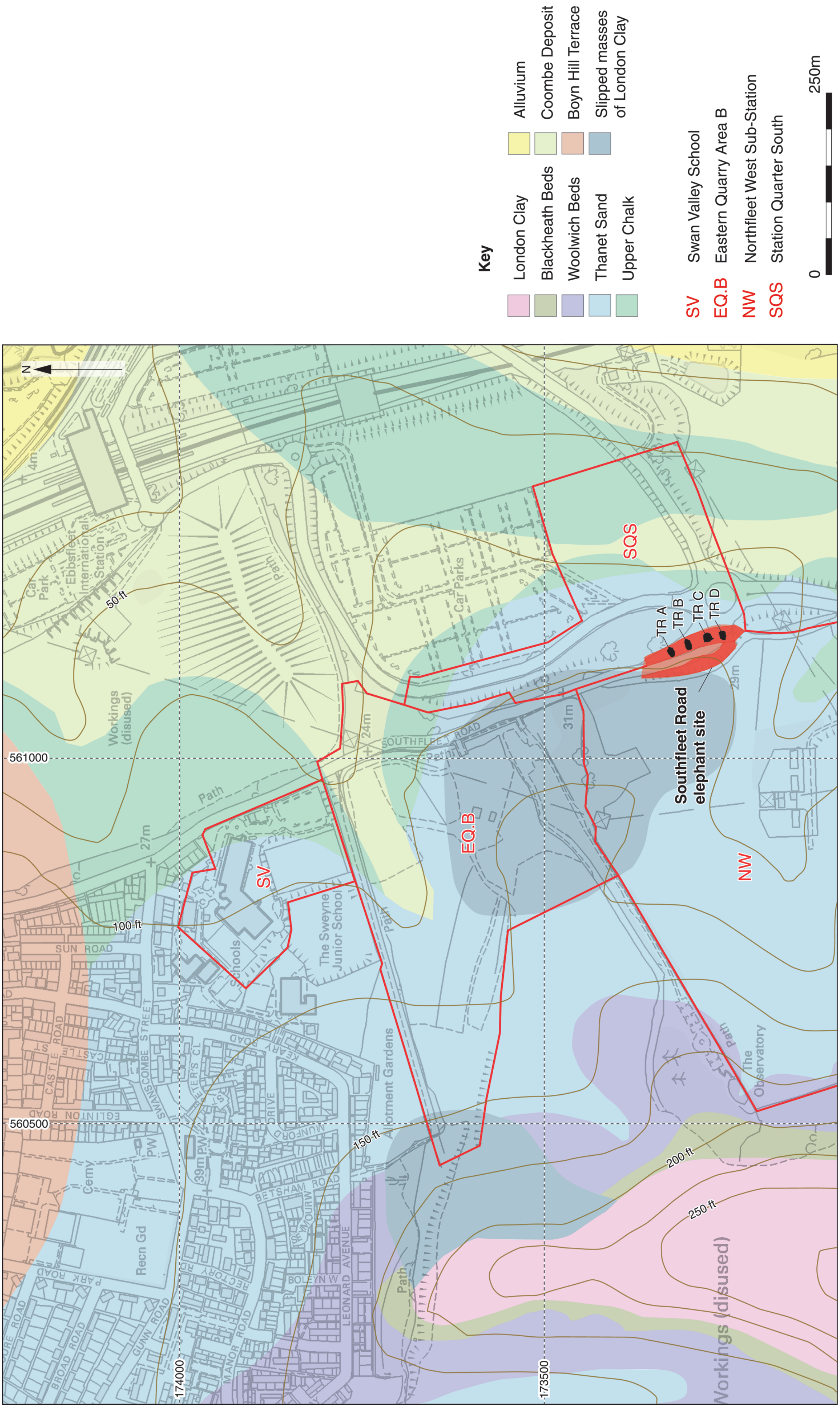

Figure 4.1 Location of non-HS1 interventions around the site: Northfleet West Sub-station; Station Quarter South; Eastern Quarry Area B and Swan Valley Community School [pre-quarrying base geology follows 1922 Geological Survey mapping, 6" sheet X, NW]

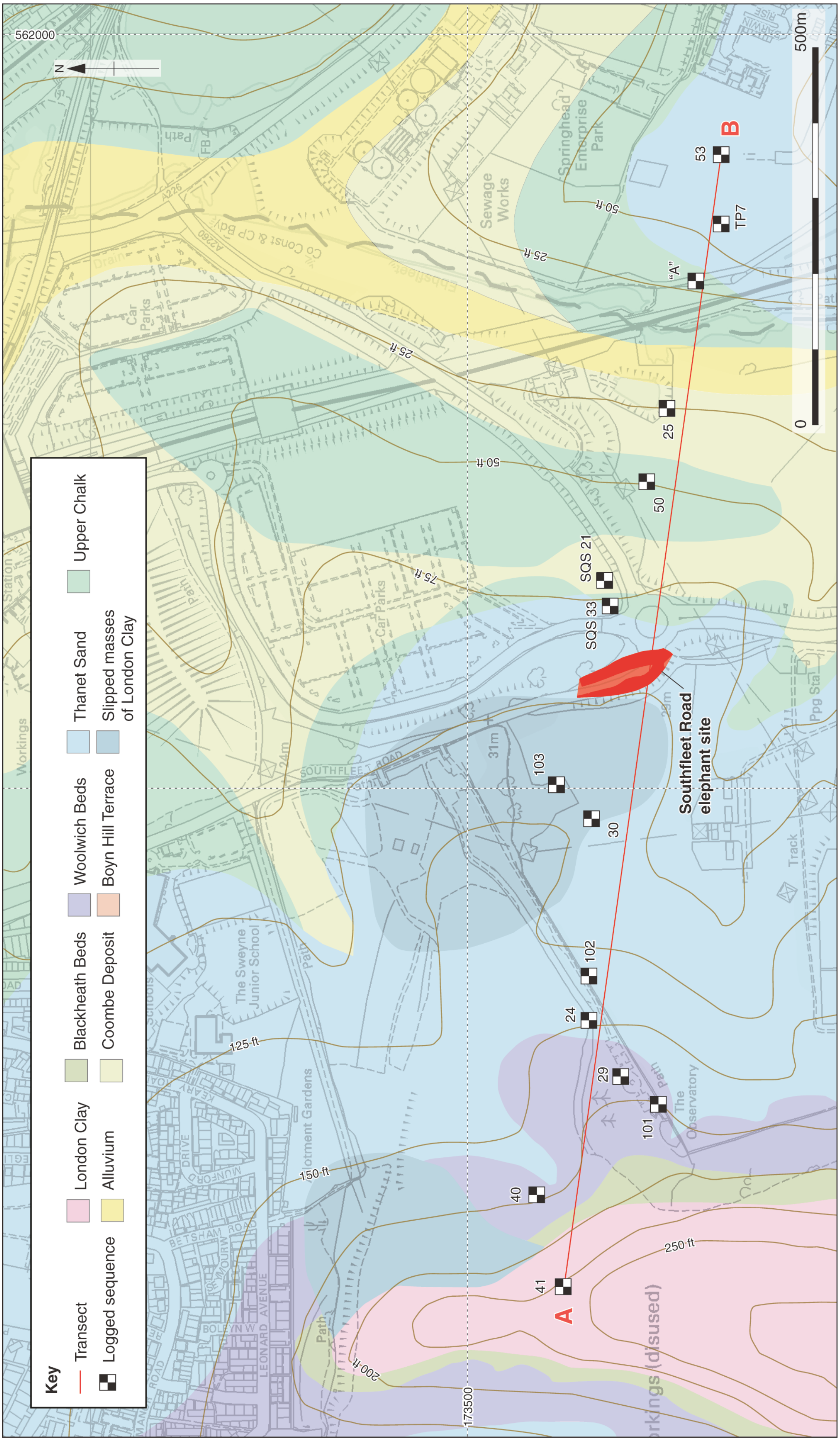

Figure 4.2 Site in geomorphological context, with east-west transect AB points, see Figure 4.3 [pre-quarrying base geology follows 1922 Geological Survey mapping, 6" sheet X, NW]

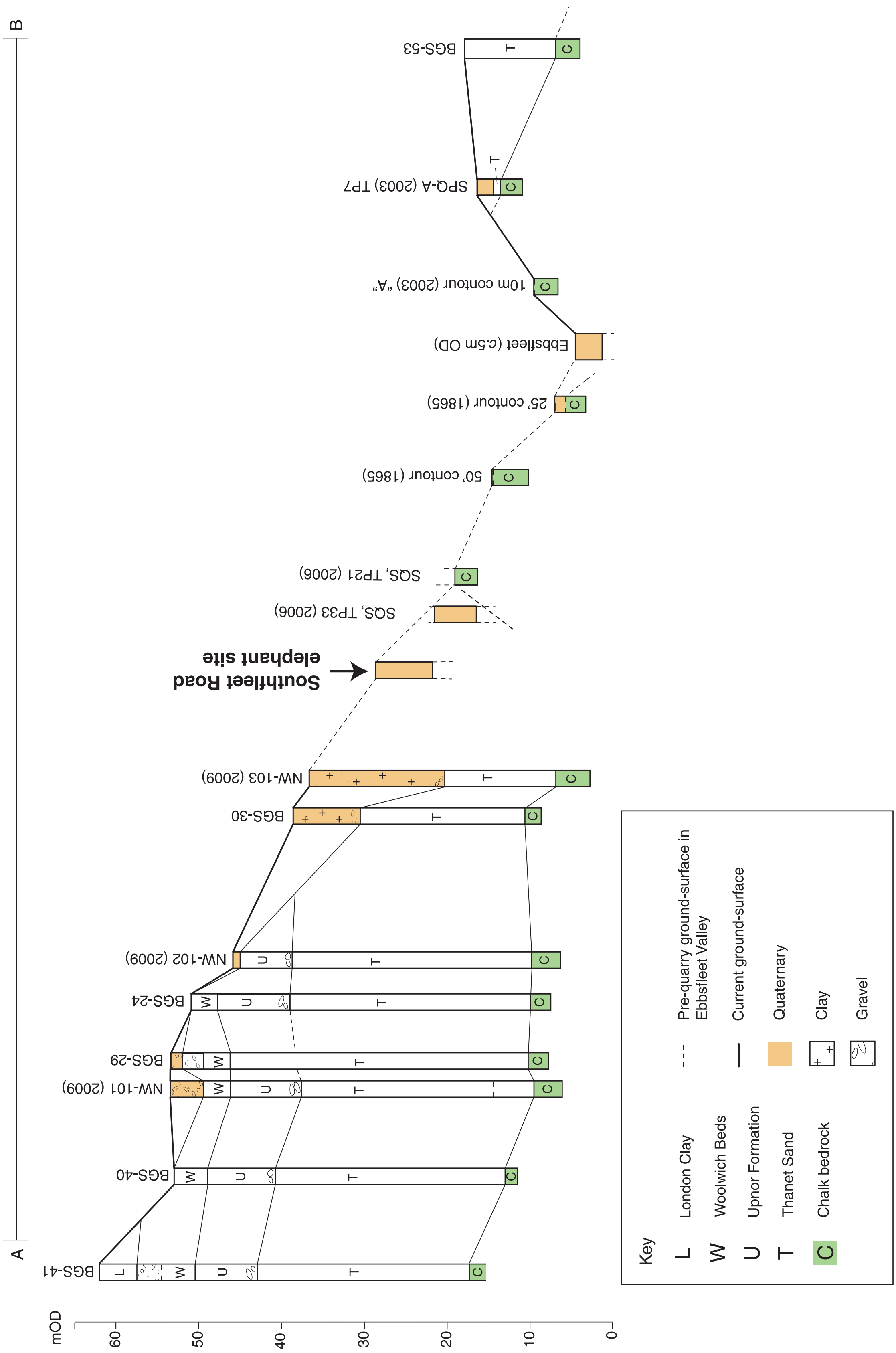

Figure 4.3 East-west geomorphological transect AB across Ebbsfleet Valley and through the site

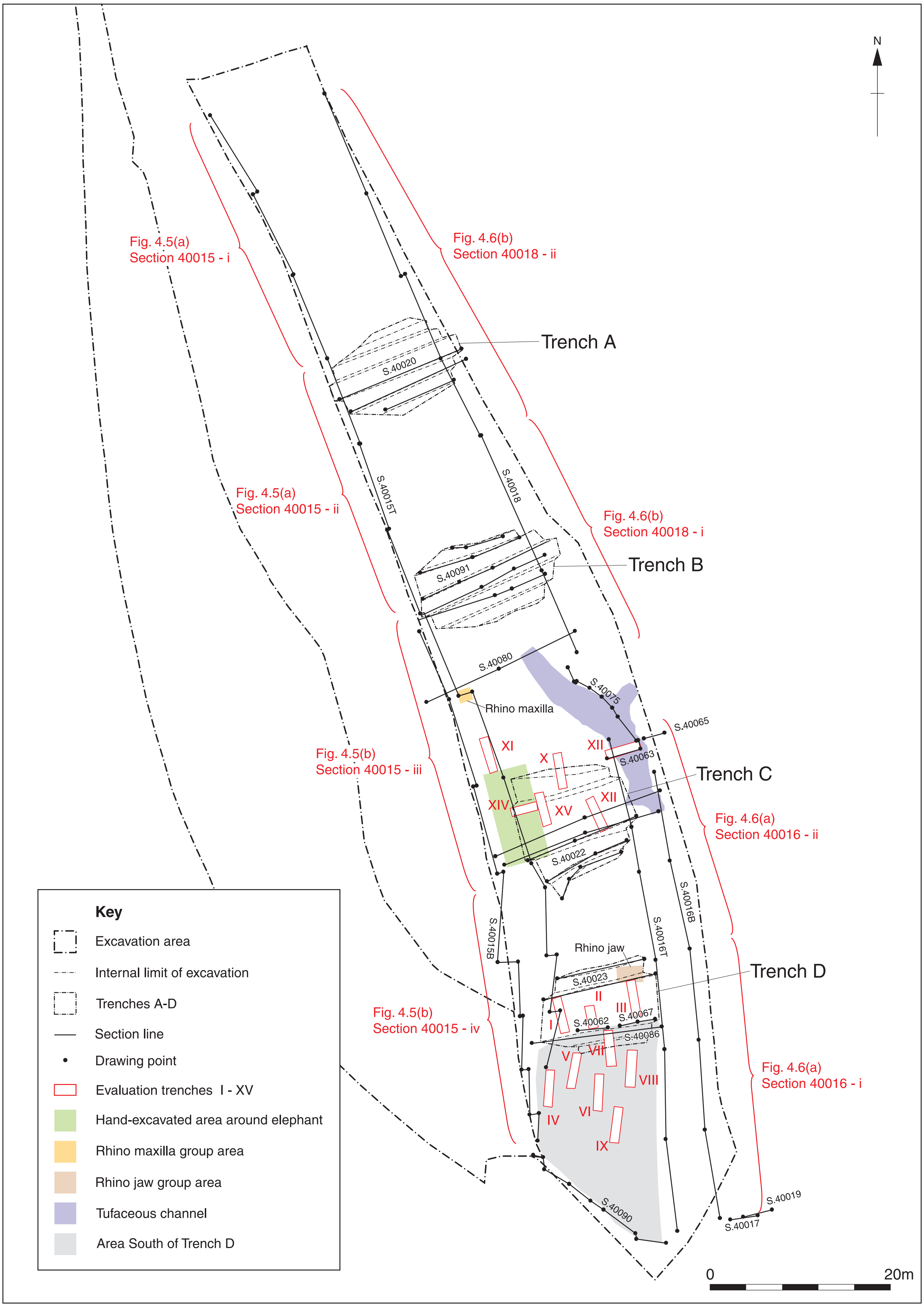

Figure 4.4 Site layout with key section-line drawing points

Pre-quarrying borehole records (Fig. 4.3, borehole BGS-41) show that the Chalk that was the main target of quarrying was overlain by up to 40m of relatively worthless fine-grained deposits, which provides an insight into just how desirable a mineral resource the deeper lying Chalk was. Geological mapping of the late 19th century shows that the Swanscombe Park hill was capped by London Clay, and then progressively older Palaeocene deposits (Woolwich Beds, Upnor Formation and Thanet Sand) were exposed down the eastern slope towards the site (Fig. 2.3 and Fig. 4.2). The geological mapping also identified two 'slipped masses' of mainly London Clay, one close to the summit of the hill and the other half way down the eastern side, with its eastern edge just encroaching over the site's location. This latter 'slipped mass' is at the foot of a spur that extends eastward downslope from the summit of Swanscombe Hill towards the base of the Ebbsfleet Valley. It widens slightly as it descends, suggesting a fan of clay-rich deposits having slipped downslope to the east, originating from the Woolwich Beds and London Clay capping Swanscombe Hill.

A plot of land approximately 30ha in area immediately to the west of the site, bounded to the south by the A2, remains unquarried and currently contains the Northfleet West electricity substation, surrounded by arable fields (Fig. 4.1, area 'NW'). The ground surface within this area is uneven, with steep-sloping dry valleys incised into the soft Tertiary sands that outcrop across most of the area. This plot has recently undergone a range of geotechnical and geo-archaeological investigations (Museum of London Archaeology 2011). These new records, combined with pre-existing records held by the British Geological Survey and results of other recent geotechnical investigations in Station Quarter South to the east of the site (Fig. 4.1, area 'SQS'; Wessex Archaeology 2006b) and Springhead Quarter, further to the east of the Ebbsfleet (CgMs Consulting and Wenban-Smith 2003) allow an east-west transect to be constructed. This shows the site within the context of ground-surface topography and subsurface bedrock geology (Fig. 4.3).

This east-west transect shows that the Chalk bedrock surface is approximately horizontal at *c*10m OD to the west of the site, but rises sharply to over 20m OD immediately to its east, forming the southern end of the spur of Chalk excavated as Southfleet Pit (Fig. 4.3, SQS, TP 21). The eastern side of this chalk spur is then erosionally truncated by the current ground surface of the Ebbsfleet Valley, dipping towards the Ebbsfleet floodplain. The next eastward conformable boundary with the overlying Thanet Sand occurs at *c* 14m OD in the Springhead Quarter (Fig. 4.3, SPQ-A, TP 7). There is thus, immediately to the east of the site, a sharp and anomalous rise in the upper surface of the Chalk bedrock, which then dips steeply eastward, as reflected in the most easterly borehole record of the transect (Fig. 4.3, borehole BGS-53).

The Pleistocene deposits at the site and in its immediate vicinity are discussed in more detail below. It is, however, apparent from this east-west bedrock transect that they fill a pronounced trough to the west of this Southfleet Pit chalk spur, halfway up the west slope of the Ebbsfleet Valley.

Investigation of the wider geometry of the Chalk bedrock surface, where conformably overlain by the Bullhead (flint) Bed and Thanet Sand rather than erosionally truncated, shows that it rises steadily north-west towards Swanscombe. Here it outcrops beneath the Boyn Hill/Orsett Heath Formation deposits of the Swanscombe 100-ft terrace at *c* 27m OD at the Swan Valley Community School almost 1km away (Wenban-Smith and Bridgland 2001). Apart from the anomalous Southfleet Pit Chalk-high, the site is located in a minor east-west trending depression of the Chalk surface, which also rises to the south, as shown by British Geological Survey mapping (Fig. 2.2).

DEPOSITS AT THE SITE

The full sequence and geometry of deposits at the site was pieced together from section exposures recorded throughout the excavation process. The main sections contributing to this synthesis are the extended north-south sections along each side of the rectangular spine of deposits that formed the main site (see Fig. 4.4 for their locations). These include Section 40015 on its west side (Fig. 4.5) and Section 40016-40018 on its east side (Fig. 4.6) as well as the evenly spaced east-west sections transversely across the site associated with Trenches A-D (Fig. 4.7 – Tr A, Section 40020; Fig. 4.8 – Tr B, Section 40091; Fig. 4.9 – Tr C, Sections 40022 and 40085; Fig. 4.10 – Tr D, Section 40023; and Fig. 4.11 – Tr D, Sections 40062, 40067 and 40086) which provide lithological correlations between the two main north-south sections.

Other important sections include an additional transverse east-west section between Trenches B and C (Fig. 4.12 – Section 40080) and sections associated with the tufaceous channel, namely Section 40064 (Fig. 4.13) and Section 40075 (Fig. 4.14) parallel with its main axis, as well as those recorded transversely across it in and around Trench XIII, the north-facing Section 40063 (Fig. 4.15a). Also, the south-facing composite of Section 40065, 40068 and 40074 (Fig. 4.15b), a small off-set section through the basal phase of deposits at the south-east corner of the site (Fig. 4.16 – Composite Section 40017-40019). Finally, the main north-east-facing Section 40090 (Fig. 4.17), marking the southern boundary of the hand-excavated area south of Trench D.

As will become clear from the descriptions below, and also as is shown in many of the photos in the preceding chapter on excavation progress and methods (Chapter 3), many deposits were extremely uneven in their 3-dimensional topography. In order to try and represent this and to investigate relationships across the site, all sections were integrated as panels into a 3-D site model using the software package Fledermaus (Fig. 4.18) and excerpts from this model are also used as figures where appropriate below.

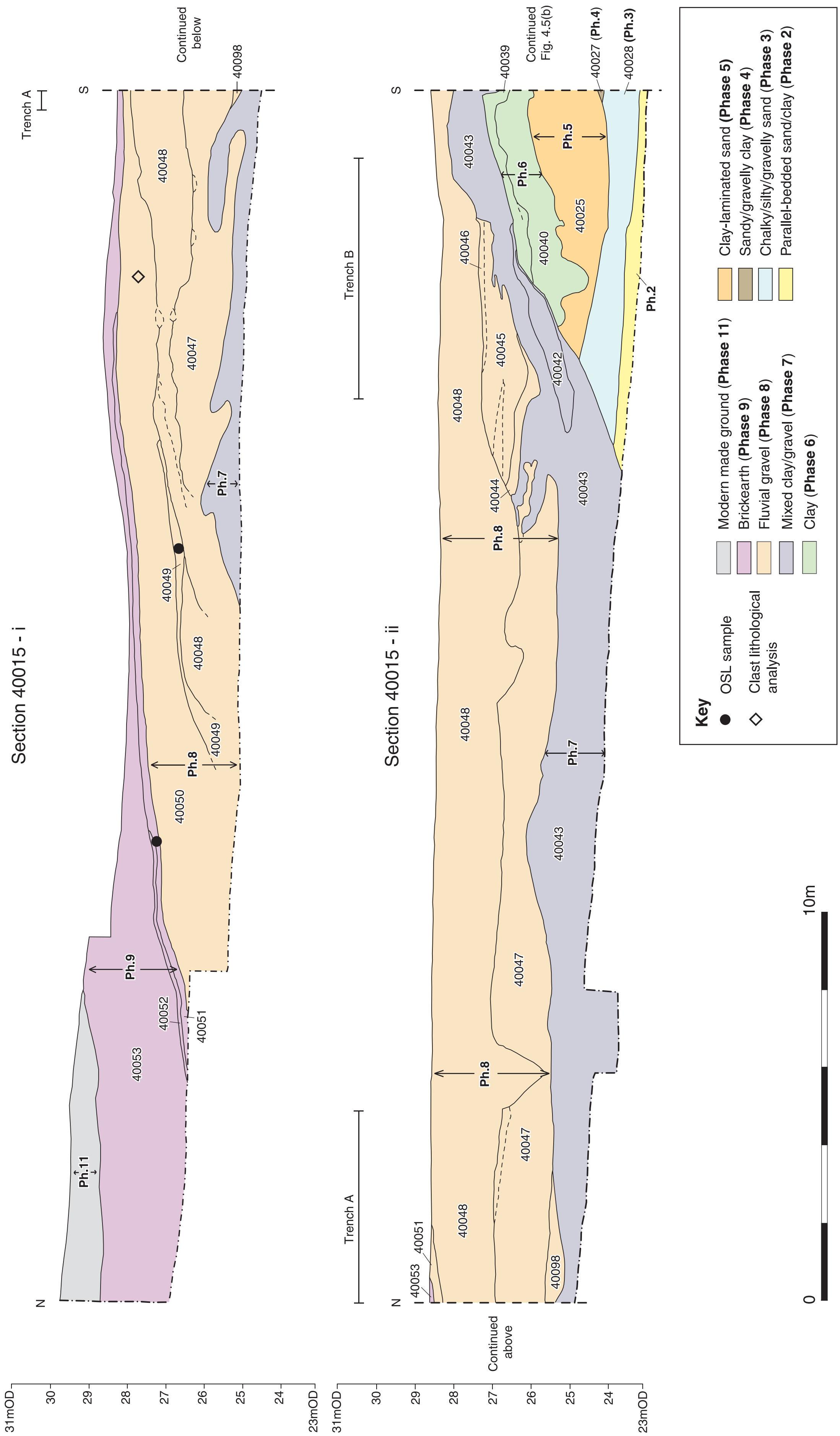

Figure 4.5a Main west-facing section (no. 40015), northern end

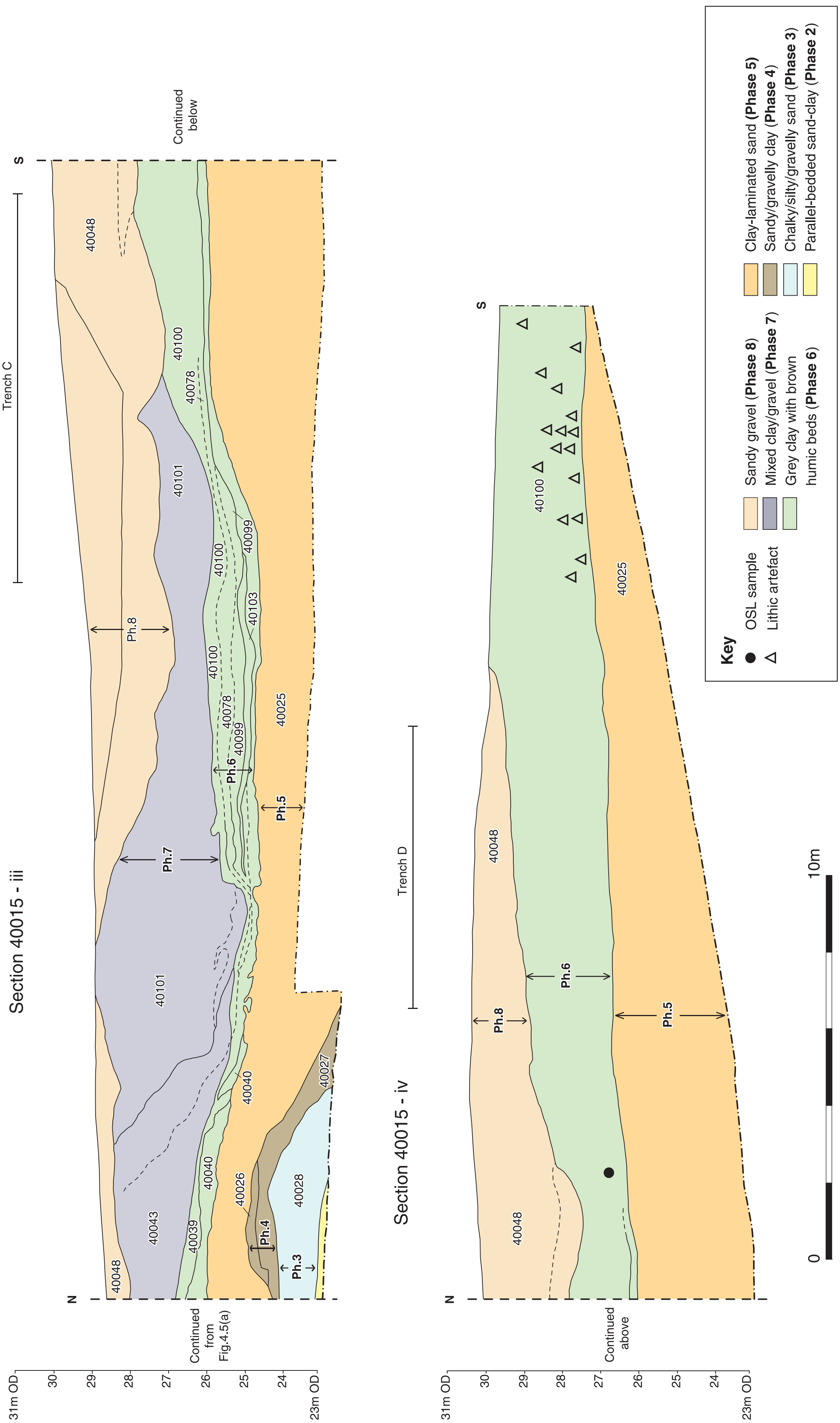

Figure 4.5b Main west-facing section (no. 40015), southern end

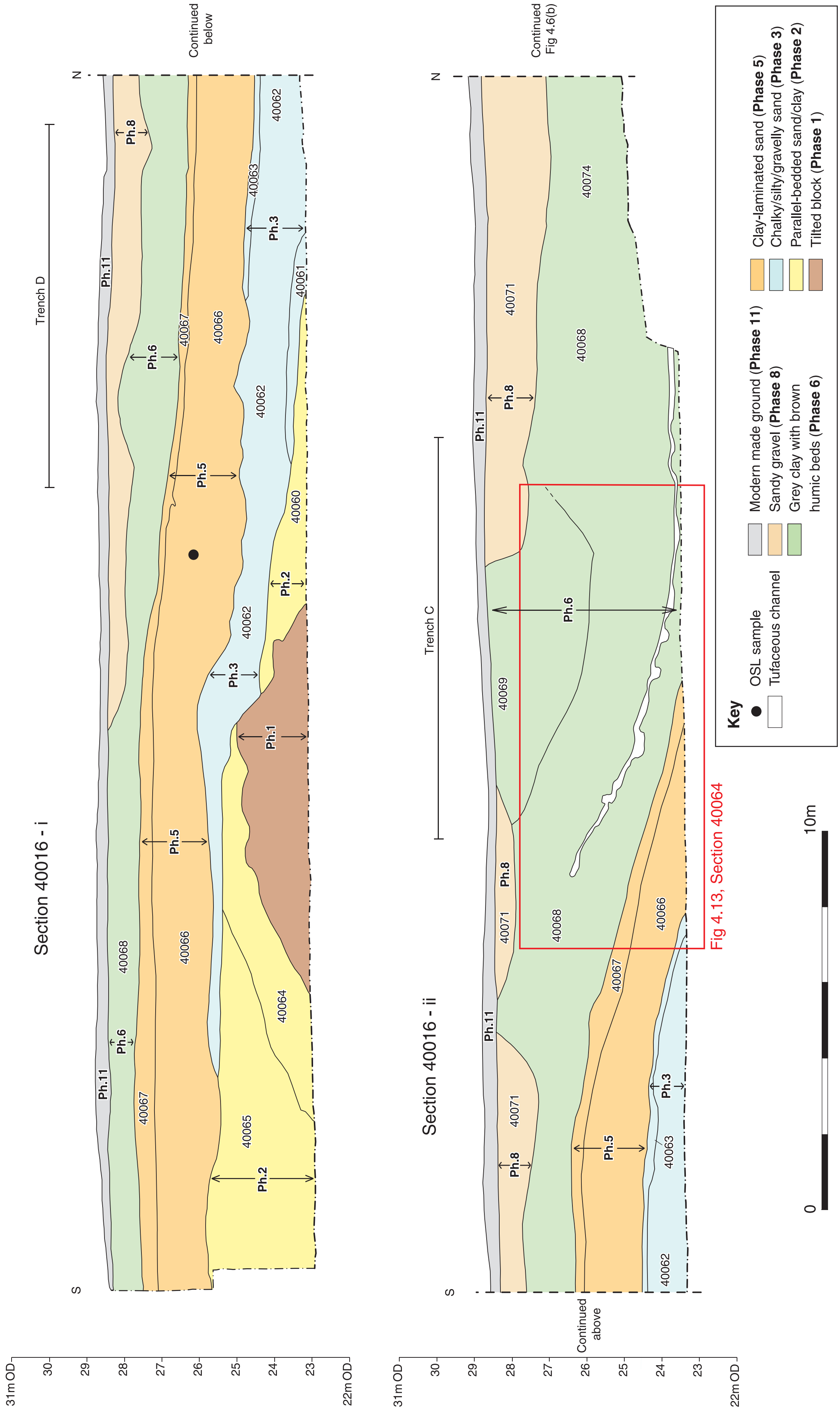

Figure 4.6a Main east-facing section (no. 40016), southern end

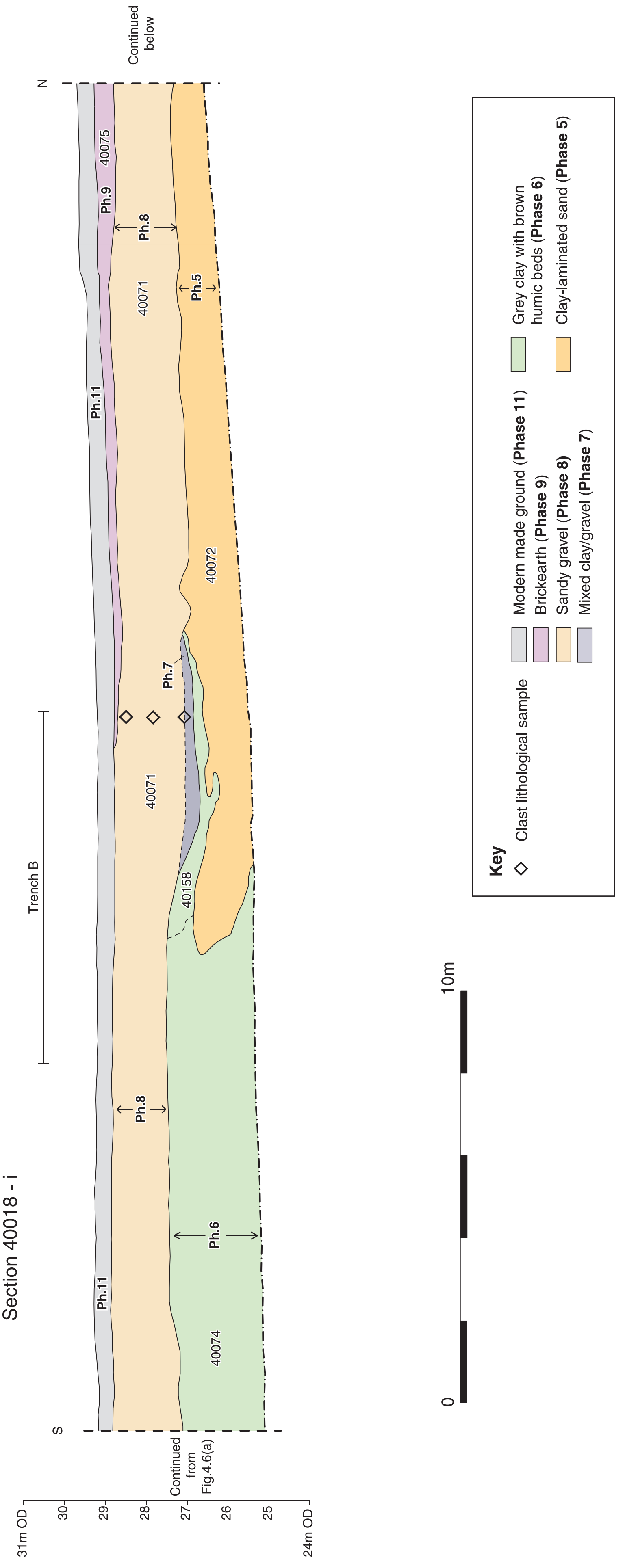

Figure 4.6b Main east-facing section (no. 40018), middle

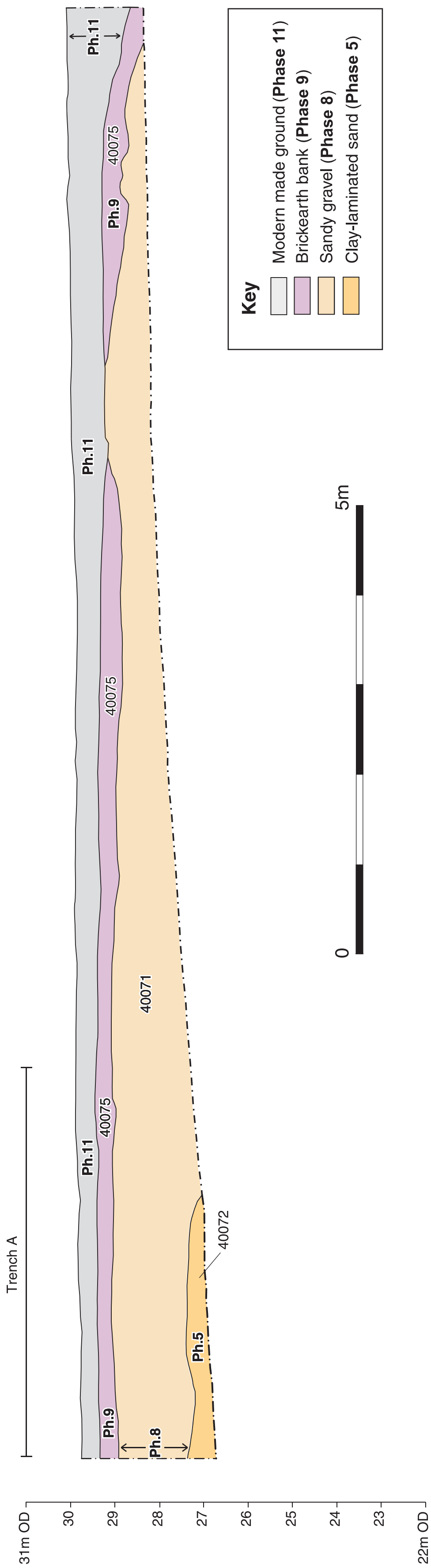

Figure 4.6c Main east-facing section (no. 40018), northern end

Eleven deposit phases were recognised (Table 4.1), from Phase 1 at the base of the sequence to Phase 11 at the top, representing modern made ground and out-of-context finds. This phasing represents an expansion of, and evolution from, previous stratigraphic summaries, mostly presented in unpublished internal site documents (ie Oxford Archaeology 2004a; b and 2005), but also published in the preliminary report (Wenban-Smith *et al.* 2006). This new phasing summary table shows the final version, cross-referenced with (a) the initial phasing summary from the geo-archaeological field evaluation in December 2003 (Oxford Archaeology 2004a) and (b) the published preliminary version of 2006. It also specifies sub-divisions of phases, where relevant, and lists the main archaeological context numbers associated.

No solid bedrock was encountered in course of the project, so the sequence at the site is not securely bottomed. Deposits from the two basal phases, Phases 1 and 2, are of uncertain date and not even necessarily Pleistocene. Those from subsequent phases, Phases 3 through to 8, are unequivocally Middle Pleistocene, and, as explained throughout the remainder of this volume, can be reliably associated with the Hoxnian interglacial, in MIS 11. Phase 9 is of uncertain date; it may follow closely on from Phase 8, or be from the later Middle or Late Pleistocene, or may even include multiple post-MIS 11 depositional phases. Phase 10, the final pre-modern phase, represents anthropogenic deposits associated with late prehistoric (or later) occupation layers and archaeological features from the later Holocene. These last deposits (Phase 10), and associated later prehistoric archaeological material, are not considered further in this volume, which focuses upon the earlier Palaeolithic evidence from the site. They are, however, incorporated in the wider analysis of later prehistoric activity in the Ebbsfleet Valley in the companion *Prehistoric Ebbsfleet* volume (Wenban-Smith *et al.* forthcoming). Phase 11 represents out-of-context artefacts and modern made ground. This chapter, and the remainder of this book, focus therefore upon Phases 1-9, and material recovered from these deposits, with one addition, namely the curious presence of an 18th century gunflint industry from the made ground capping the sequence (Chapter 21).

Phase 1. Tilted Block

An isolated series of steeply dipping sedimentary units christened the 'tilted block' was identified at the base of the sequence, in the southern end of the main east-facing section no. 40016 (Fig. 4.6; Fig. 3.8). These continued south-east beyond the site area, as seen in the lower section forming the southern site boundary (Fig. 4.16). In the main section, the internal unit boundaries appeared to dip vertically, but a better understanding of their geometry resulting from wider exposures (Fig. 4.19) revealed that they in fact dipped steeply to the ENE, *c* 60° down from horizontal. The Phase 1 sediments can be divided into two groups consisting of:

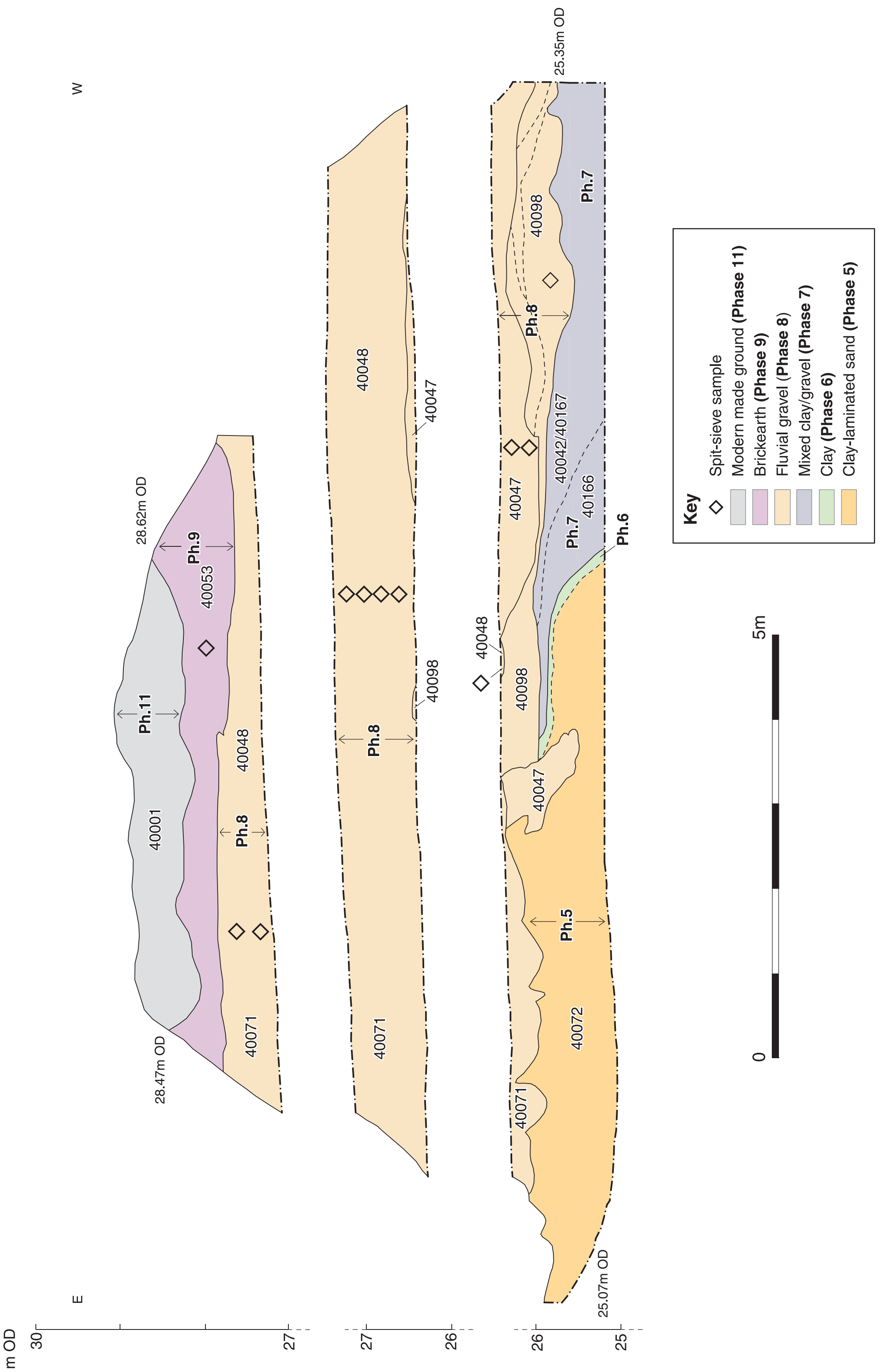

Figure 4.7 Trench A, north-facing section (no. 40020)

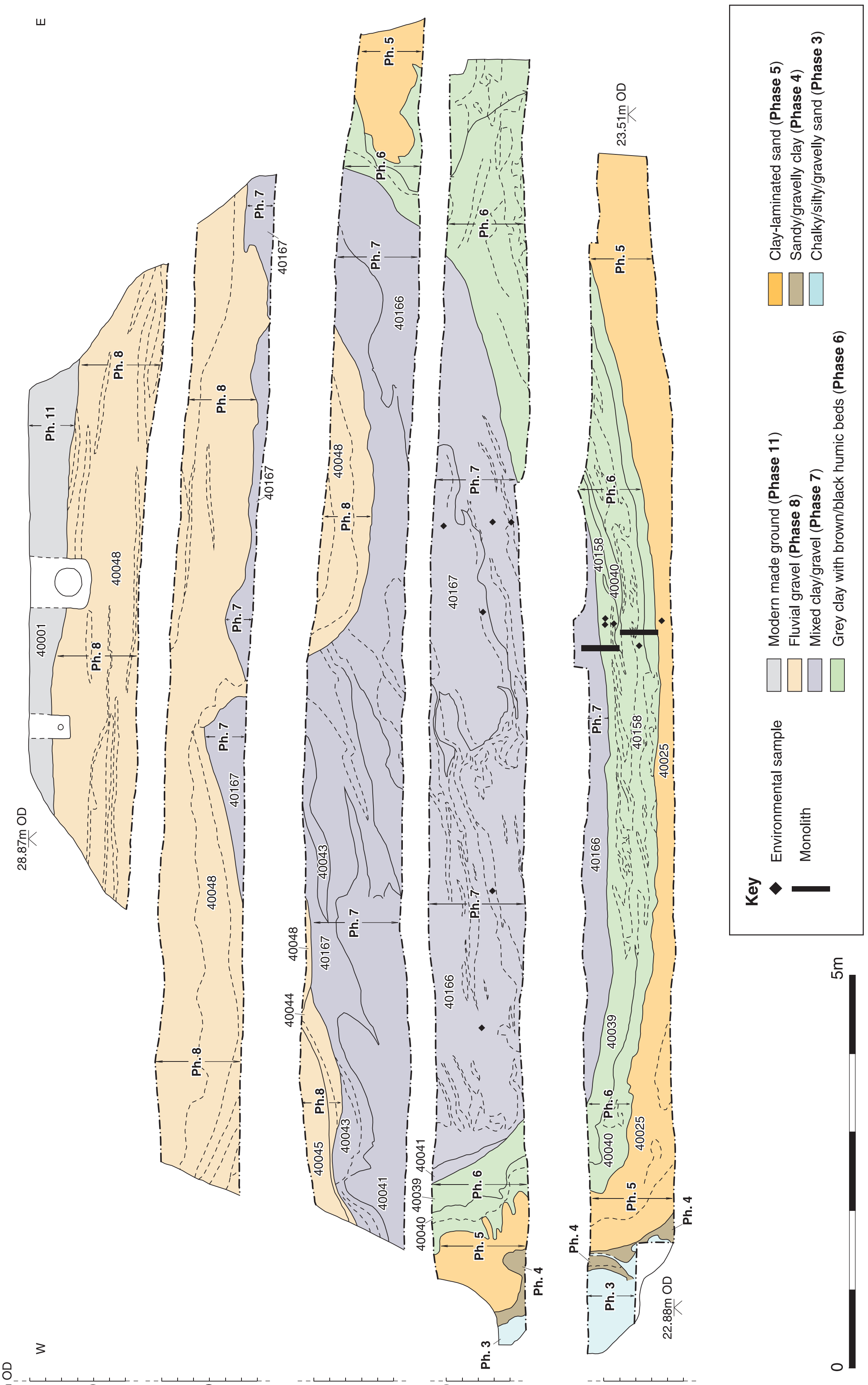

Figure 4.8 Trench B, south-facing section (no. 40091)

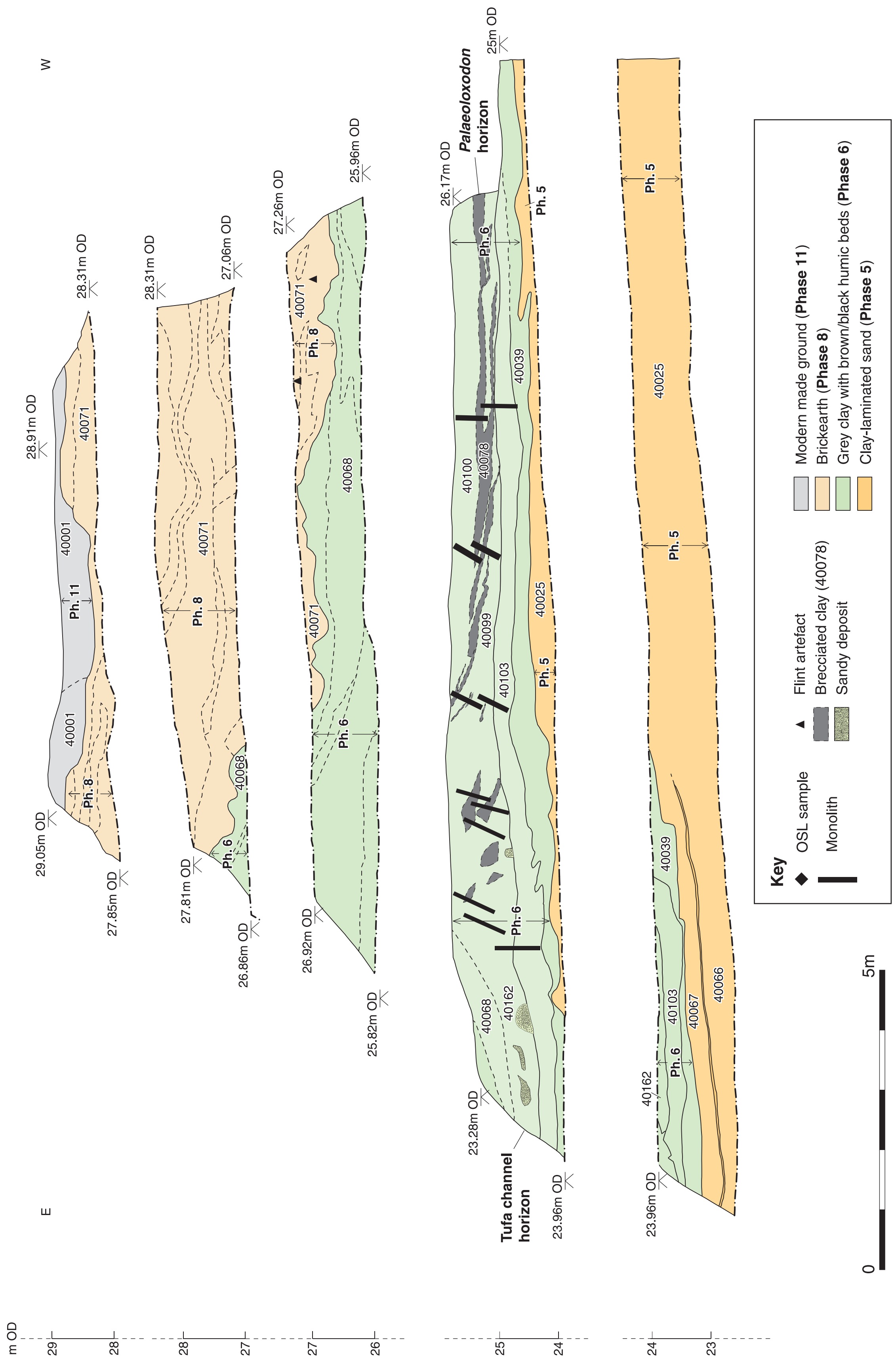

Figure 4.9 Trench C, north-facing sections (nos 40085, 40022)

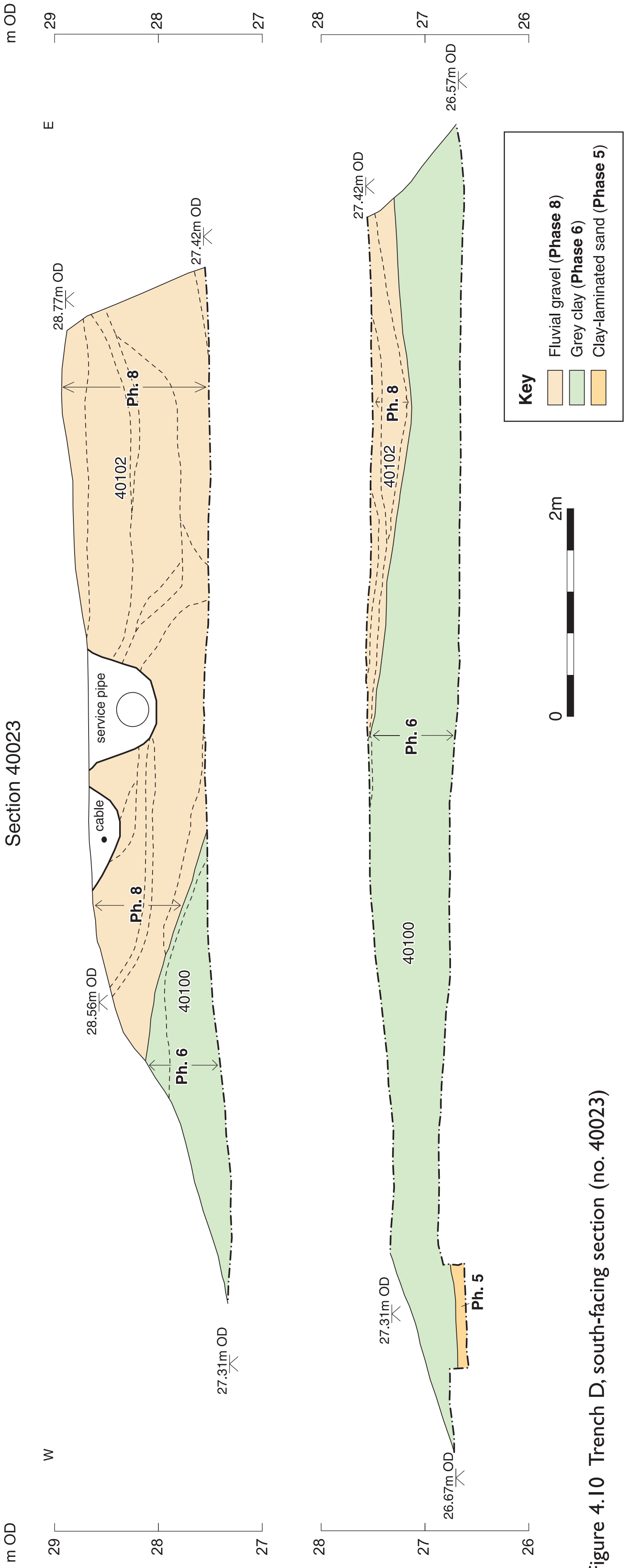

Figure 4.10 Trench D, south-facing section (no. 40023)

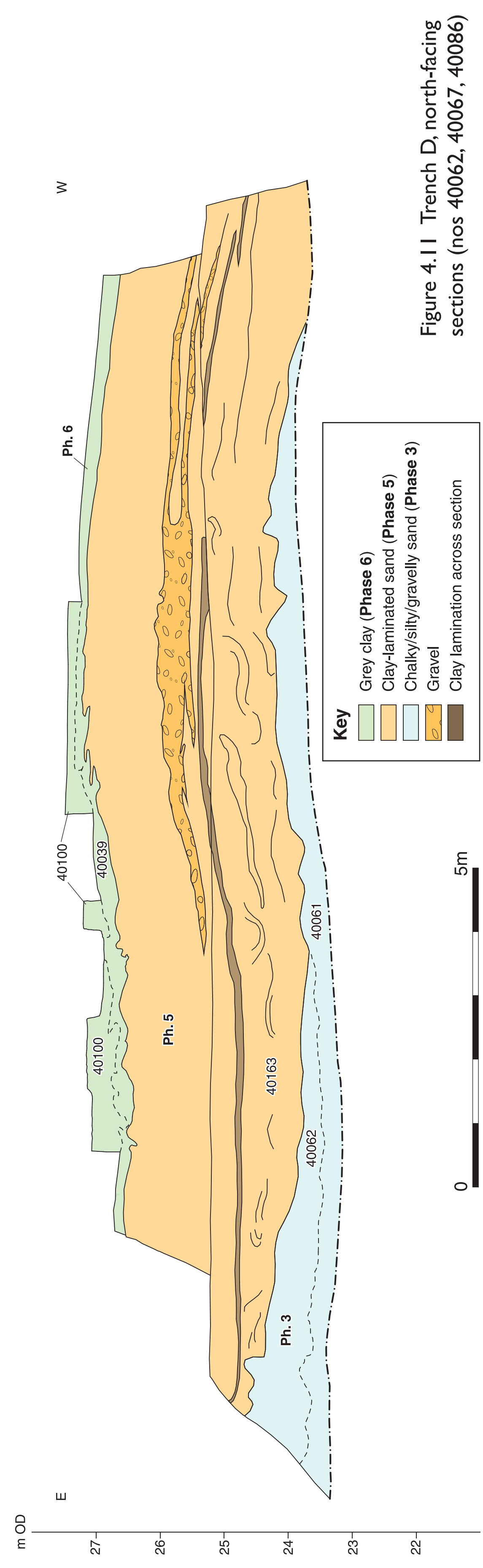

Figure 4.11 Trench D, north-facing sections (nos 40062, 40067, 40086)

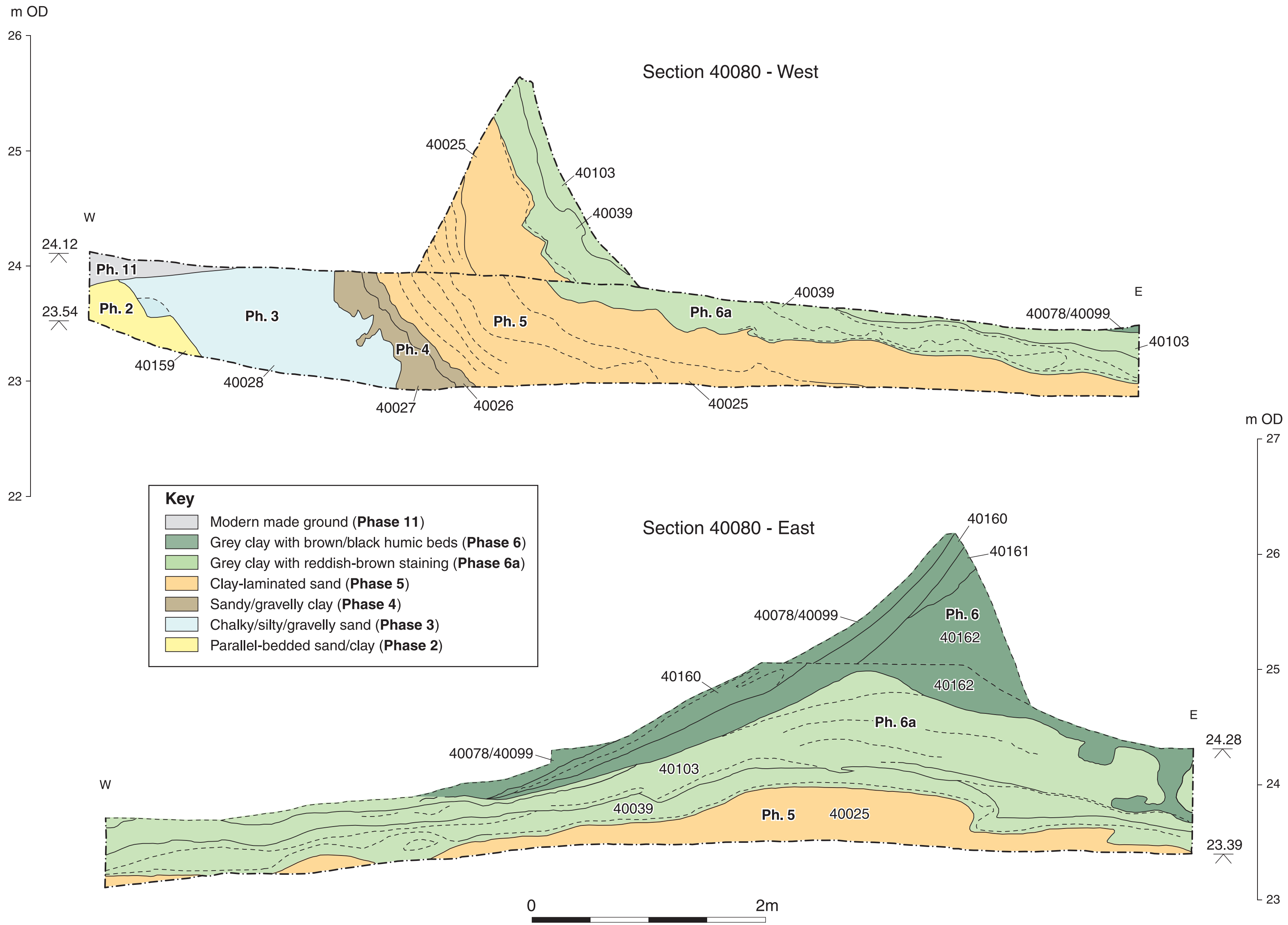

Figure 4.12 Section 40080, south-facing ('skateboard ramp')

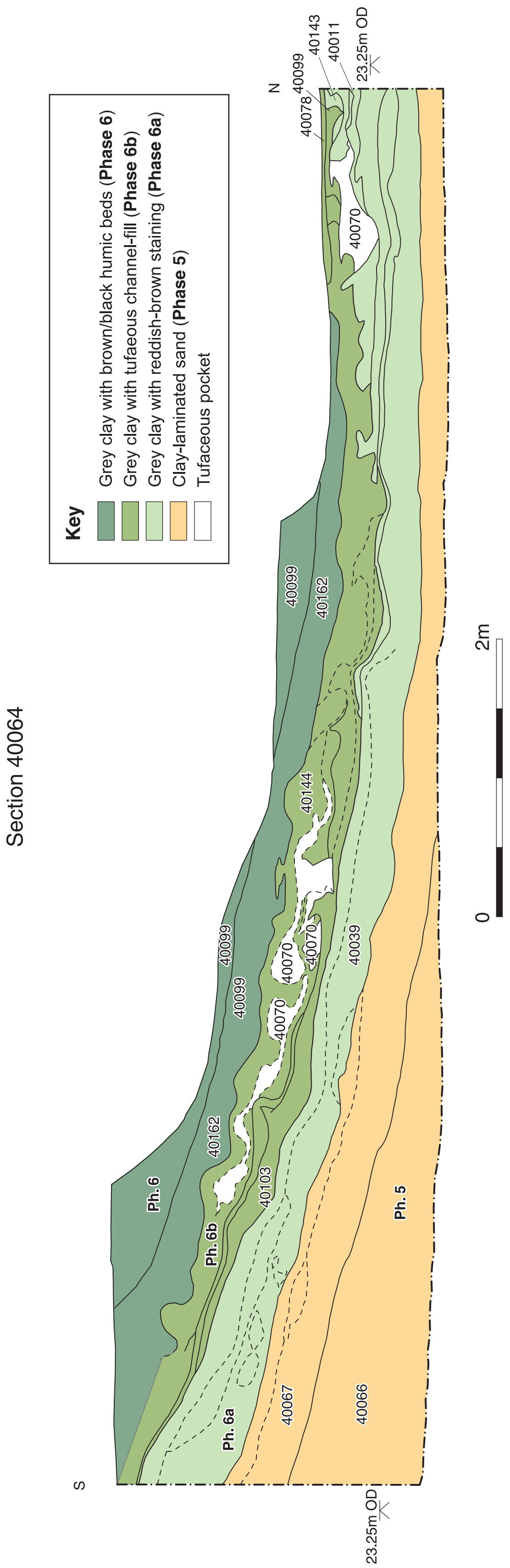

Figure 4.13 Section 40064, showing tufaceous pockets (context 40070) rich in mollusc and small vertebrate remains

- At the base, fractured Chalk (40054), clayey greenish-grey sand with dark-green stained flint nodules with an orange-stained band just beneath their cortical surface (Bullhead flint bed) (40055) and a massive, slightly clayey greenish/greyish-brown sand (Thanet Beds) (40056).
- A series of three overlying sand-dominated sediments, contexts 40057-40059. The deposits within this block are unconformably overlain by the Phase 2 sequence.

The basal three contexts, 40054-40056, appear to represent a body of bedrock moved and re-orientated from the local nearly sub-horizontal junction of the Chalk with the overlying Tertiary beds. Particularly puzzling is the fact that the surface of the Chalk in this tilted block dips steeply in precisely the direction where it is known from previous records that Chalk was present close-by in an anomalously high position in Southfleet Pit (Fig. 4.3). These lower units of the 'tilted block' have clearly been detached *en masse* from regional bedrock; but how this has happened, and from where the block originates, remain entirely unknown. This evidence of disruption may, however, be related to the larger scale disruption reflected in the anomalous chalk-high of Southfleet Pit. Whatever the explanation, the observed effect is that Chalk outcrops, tilted or otherwise, are present in the local landscape in anomalous positions. This has implications for hominin activity, since these Chalk outcrops, or detached masses, provide a source of flint raw material; this matter is returned to subsequently (Chapter 22).

The overlying series of sediments is dominated by sands and clays. Context 40057 consists of a fine to medium sand with a grey black colour possibly associated with weathering and pedogenic activity. Flecking parallel with the lower boundary suggests the possibility that this context was once laminated and the presence of root tubules supports the notion of localised pedogenic activity. The overlying clayey sands (40058, 40059) are characterised by brecciation and shearing, possibly indicative of deposition in low-energy conditions followed by drying out and sub-aerial weathering. The shearing may have occurred in conjunction with overturning of the full block sequence. Although the stratigraphic relationship between the two groups of sediments within the tilted block is clear, the temporal relationship between the two is difficult to resolve, and no environmental or dating evidence was recovered to address this further.

Phase 1-2 transition. Chalk/flint rubble

A single bed (context 40077) exists at the junction between the 'tilted block' sequence and the overlying alternating beds of sand/clay-silt that constitute Phase 2 of the site sequence (Fig. 4.16, section composite 40017-40019). This bed consists of very poorly sorted chalk and flint rubble in a sandy/clayey matrix with solid lumps of greenish-greyish sand clearly derived from context 40056. The bed dips very steeply (*c* 50^{o}) west, therefore

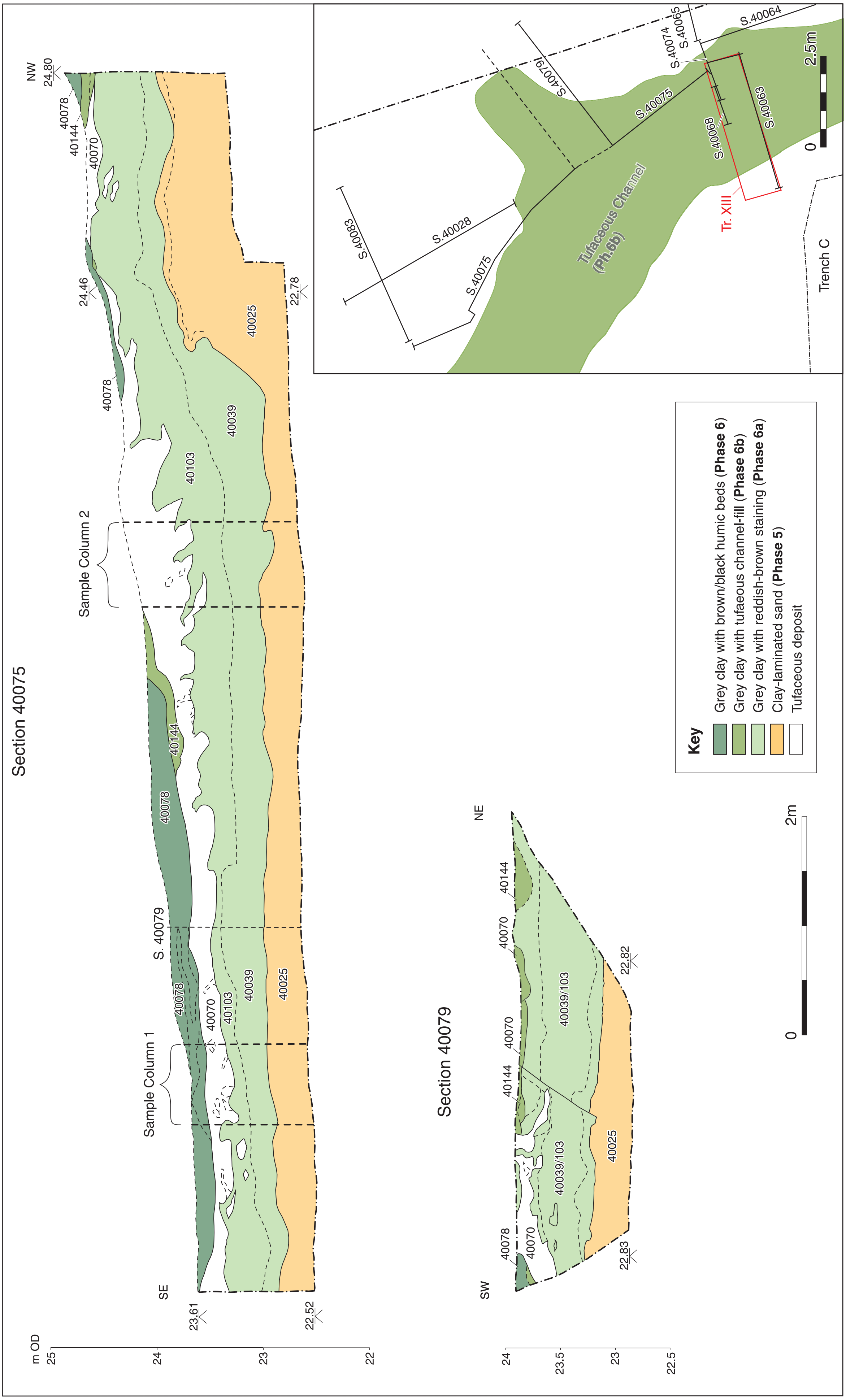

Figure 4.14 Tufaceous channel, main longitudinal section, east-facing (nos 40075, 40082)

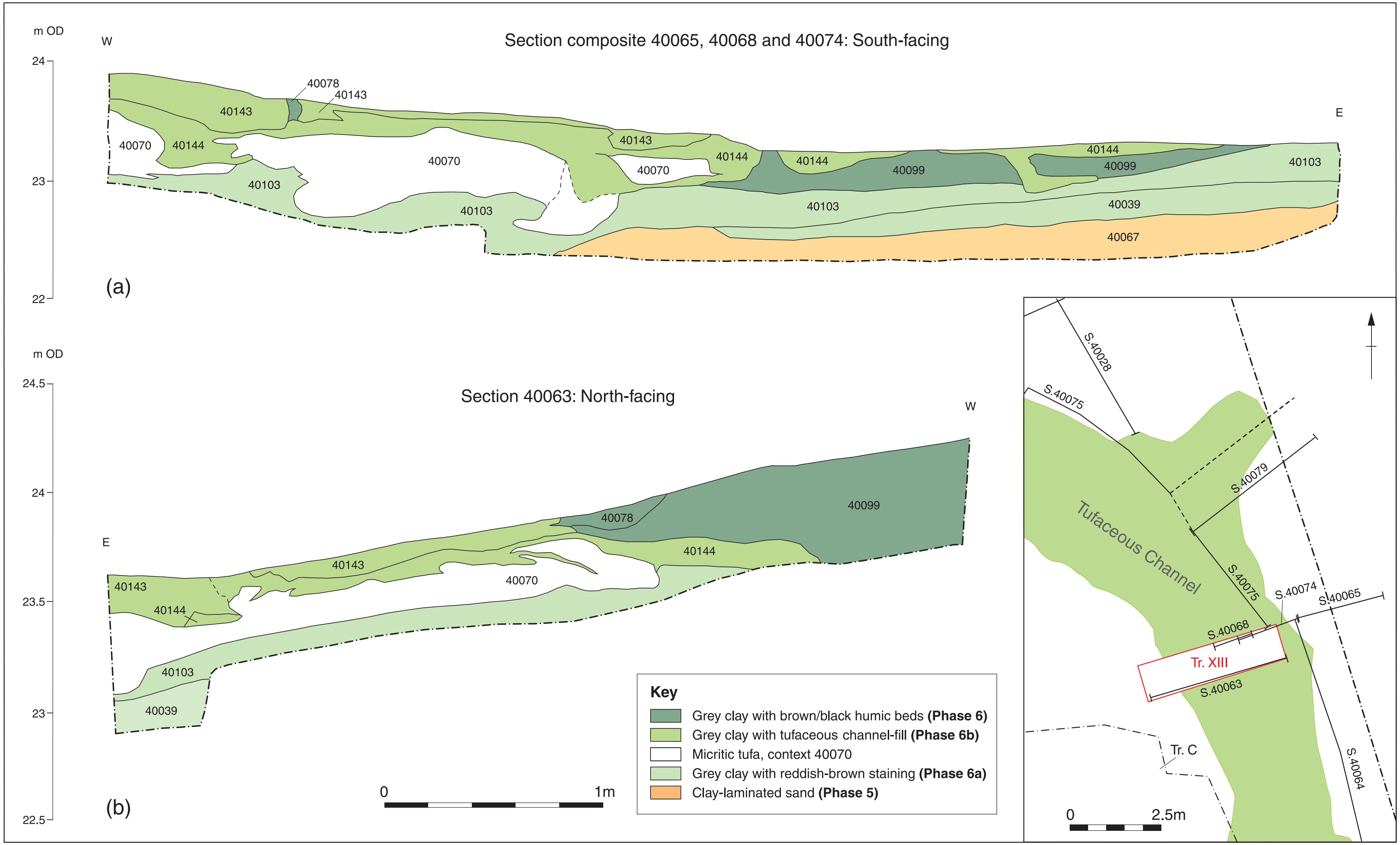

Figure 4.15 Tufaceous channel, cross-sections

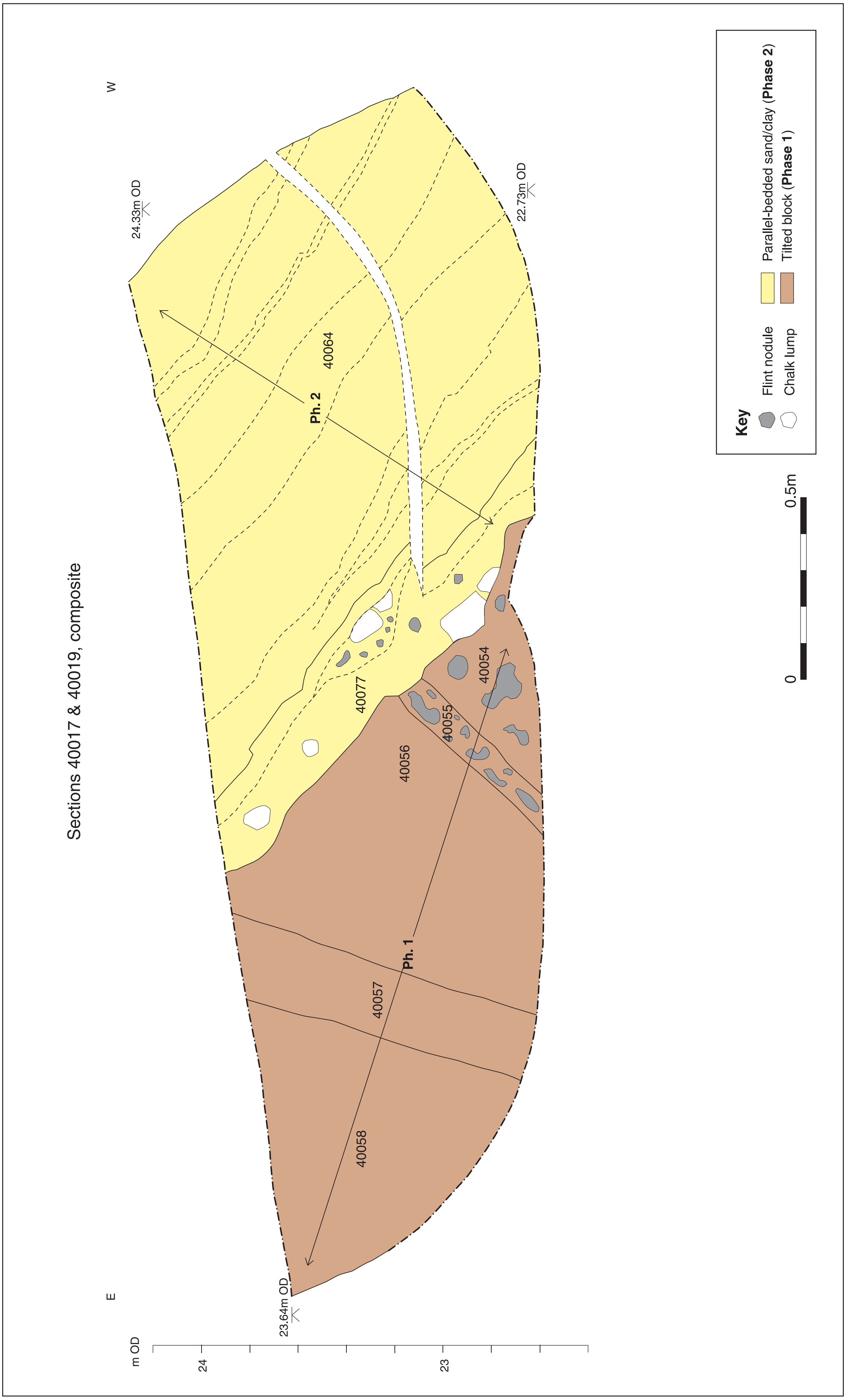

Figure 4.16 Composite section (40017-40019) showing Phase 1-2 junction in south-east of site

Figure 4.17 Section 40090, north-east facing (southern end of excavated area south of Trench D)

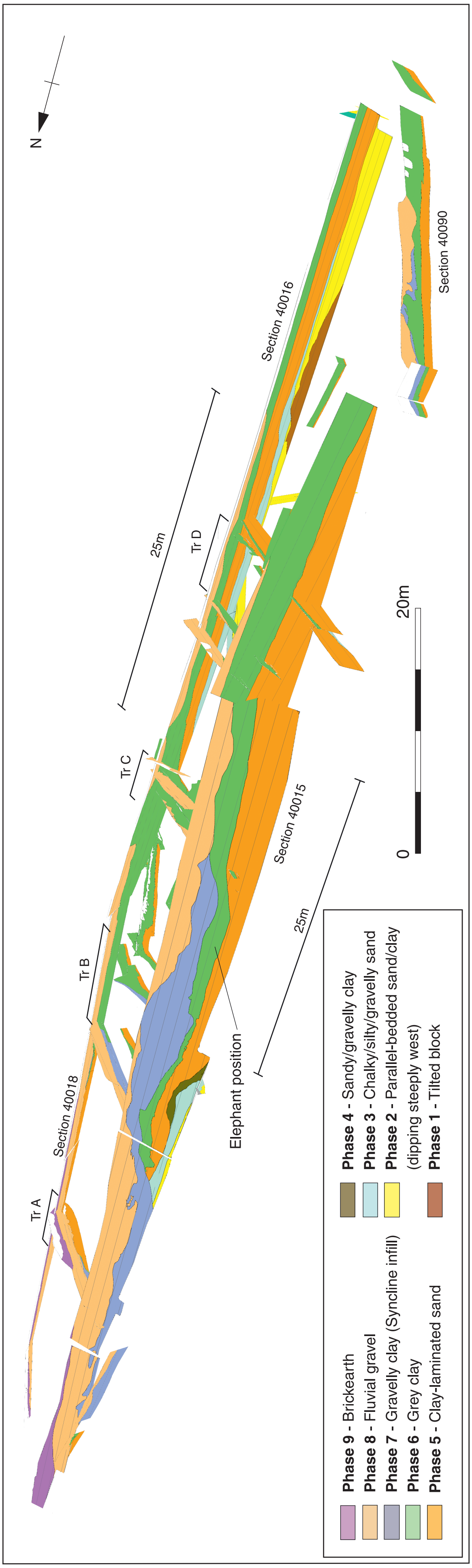

Figure 4.18 Overview of site 3D model, using section drawings as integrated panels coloured by sequence phase (looking north-east)

unconformably cuts across the strata of the 'tilted block', while providing a conformable base for the overlying Phase 2 deposits. The chalk clasts vary from small pebbles to cobbles, between angular and sub-angular in shape, and slightly to moderately abraded. Lateral variation is noted in the context, with greater sorting in places. This appears to be either a slopewash or solifluction deposit developed over the tilted block, or a gravel erosion lag. Crucial to its understanding is consideration of whether its current geometry corresponds with the situation when it was formed, or whether there has been subsequent reorientation of deposits *in situ*. The former seems more likely, as subsequent reorientation would have affected overlying deposits that, however, retain undisrupted parallel bedding. Therefore this transitional bed can best be explained as slopewash deposits descending down a steep slope to the west, filling a depression in that direction, with infilling continued with the Phase 2 deposits.

Phase 2. Parallel-bedded sand and clay

Deposits of this phase are only present in the lower levels of the south-east quadrant of the site, at the southern end of the main east-facing section, no. 40016 (Fig. 4.6a) and in the north-facing sections, nos. 40017 and 40019 (Fig. 4.16). The deposits occur in two lithostratigraphically unconnected groups, one on the northern side of the 'tilted block' (context 40060) and the other to its south (contexts 40064 and 40065). The more northerly unit (40060) is dominated by alternating beds of fine sand and clayey fine sand becoming coarser upwards. The bedding is essentially planar and dipping to the north-west. The more southerly units (contexts 40064 and 40065) likewise exhibit parallel sand and silty-clay interbeds, dipping steeply west and conformably overlying the chalk/flint rubble of the Phase 1-2 transitional context 40077. This can be seen at the southern end of site, in the background of the photo of the 'tilted block' in section (Fig. 3.8a).

Phase 3. Clayey/silty sand with flint and chalk gravel

The upper parts of sediments of this phase outcropped at the base of exposures in various locations, namely:

- At the southern end of the main east-facing section, above the more northerly unit (context 40060) of the Phase 2 deposits (Fig. 4.6a, contexts 40061, 40062 and 40063).
- In the central part of the main west-facing section, at the base of the sequence (Fig. 4.5b, context 40028; Fig. 3.4, Log 40011).
- In the stripped surface to the west of the main west-facing section, where they formed (in plan view) a pale chalk-rich elongated patch oriented north-west to south-east (Fig. 4.20).

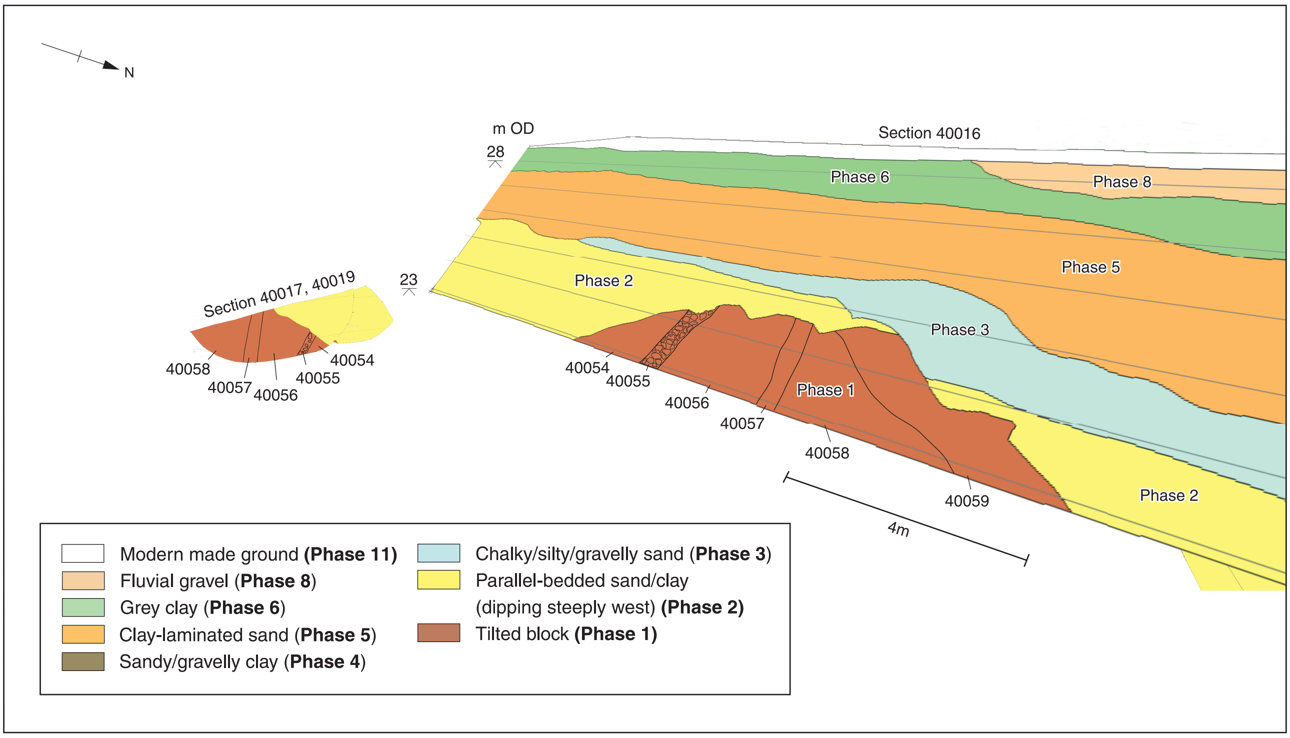

Figure 4.19 Phase 1: 'Tilted block' (looking south-west)

Figure 4.20 Stripped surface to the west of the main west-facing Section 40015 (looking north)

Although not directly recorded in a continuous section, it became clear during the deeper excavations between Trenches B and D that there was a direct sedimentary connection between context 40028 on the east side of the site and 40062 on the west side (Fig. 4.21). This allowed these deposits to be confidently grouped in the same phase, on lithostratigraphic grounds as well as lithological similarities. Phase 3 deposits were also observed at the western ends of the east-west sections 40080 and 40091, between Trenches B and C (Fig. 4.12; Fig. 4.8).

The upper surface of the Phase 3 deposits was observed to pass sub-horizontally east-west across the site at the bottom of Trench D (Fig. 4.11). However, this was probably an unconformable erosional boundary formed by the base of the Phase 5 deposits, and so not indicative of the geometry of the Phase 3 group. The base of the Phase 3 sediments was rarely seen and may also have been affected by the same post-depositional deformation in the central part of the site as the overlying sediments of Phases 4, 5 and 6 (discussed below). Hence their original geometry remains uncertain, as does their conformability with the underlying Phase 2 sediments. At the southern end of the site, it appears in the bottom part of the main east-facing section that context 40061 at the base of Phase 3 is near-conformable with the top of the Phase 2 sequence (Fig. 4.6a). Further west, however, the Phase 3 deposits of contexts 40062 and 40063, higher up the Phase 3 sequence, lack bedding structures and are unconformable with the well-bedded contexts 40064 and 40065 of Phase 2.

When excavated, the Phase 3 sediments in the central part of the site, between Trenches B and D, formed the basal horizons at the west side of the markedly U-shaped synclinal 'skateboard ramp' feature (Fig. 3.18; Fig. 4.8; Fig. 4.22). Further west, the Phase 3 sediments were exposed in plan, along the route of the cutting for the

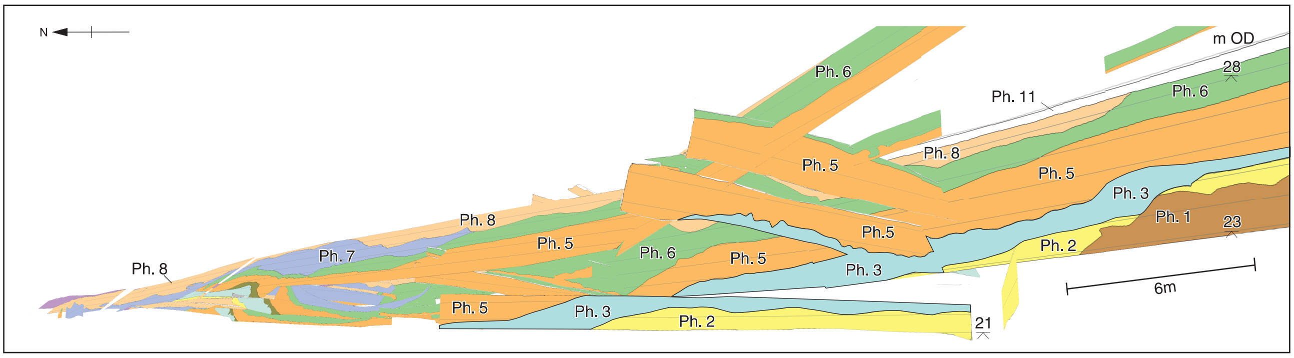

Figure 4.21 Phase 3 (looking up, north-east)

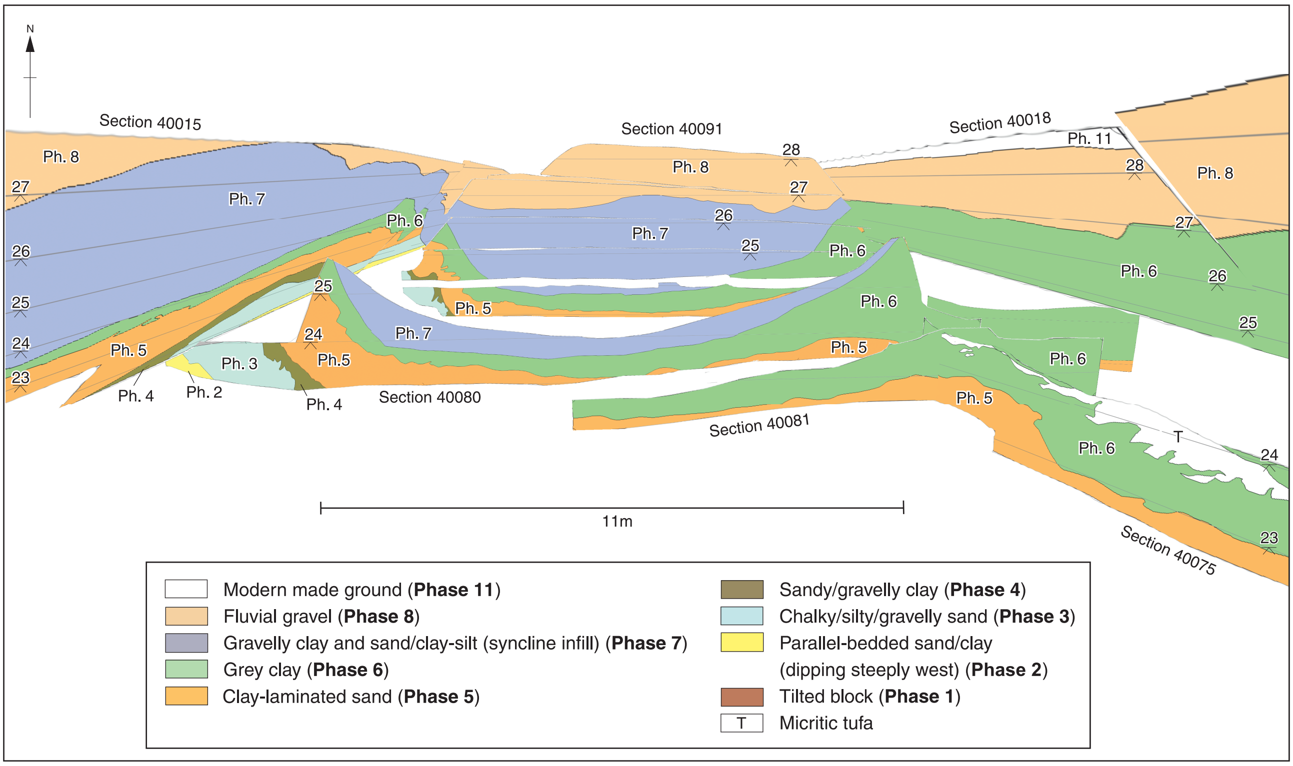

Figure 4.22 Syncline infill, aka 'skateboard ramp' (looking north)

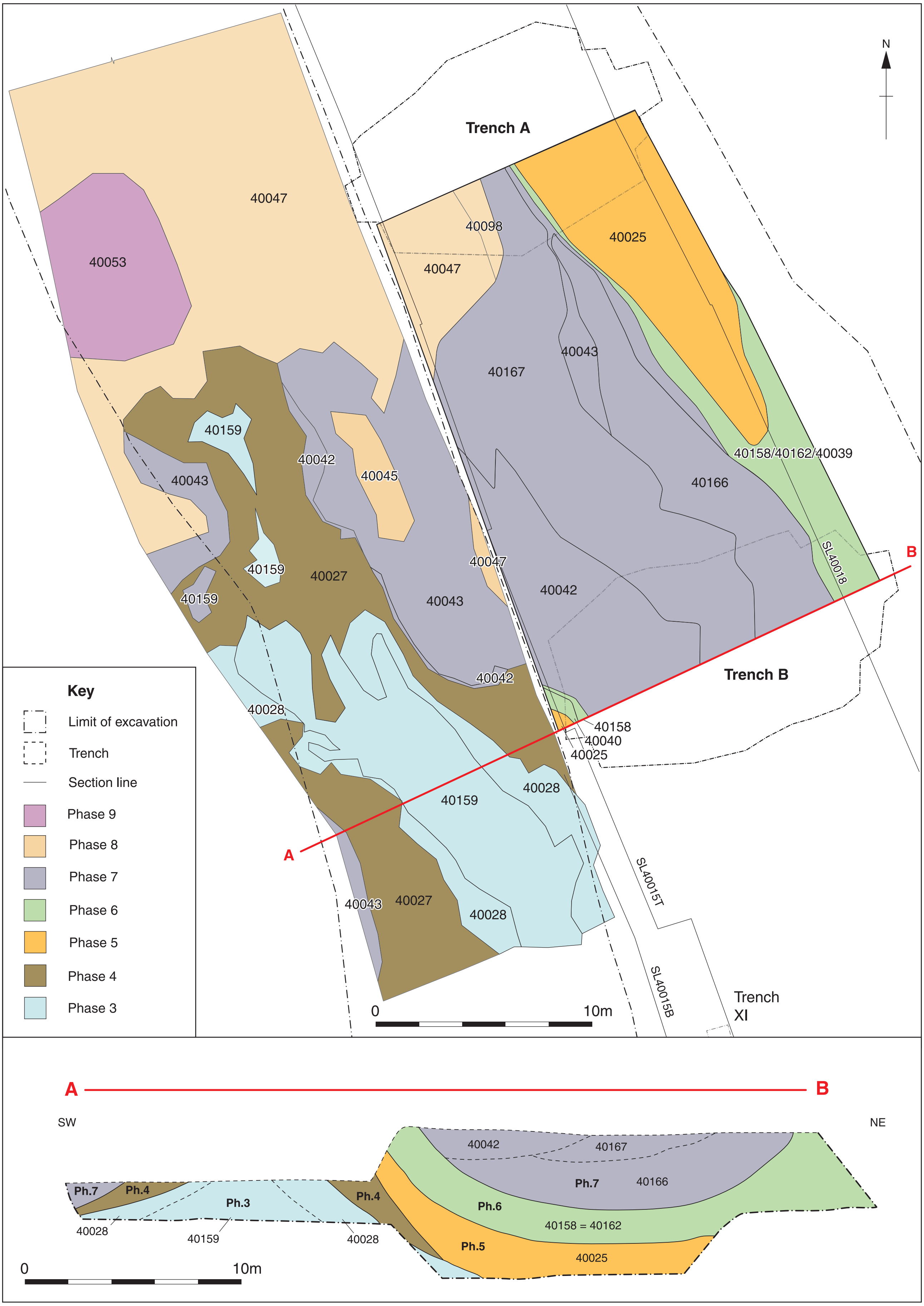

Figure 4.23 Stripped surface to the west of the main west-facing section: plan view showing phasing and diagrammatic cross-section

new Southfleet Road link. Here they formed an elongated tongue oriented roughly north-west to south-east, with the upper surface dipping away again on the west side (Fig. 4.23).

There were two groups of Phase 3 sediments. The upper group (contexts 40028, 40062 and 40063) typically consisted of grey-brown structureless clayey/ silty sand with flint and chalk pebbles, the latter decreasing in size and less common eastward across the site. These deposits mostly had a moderately high presence of Tertiary shell fragments, apart from in their upper parts in the main east-facing section, where in places the sediments were decalcified and also lacking chalk clasts (Fig. 4.6, context 40063). The lower group (context 40061) comprised flint gravel beds with common chalk clasts in a silty/sandy matrix rich in Tertiary shell fragments.

Evidence of frost-pitting and sub-angular spalls was noted to be common amongst the flint clasts. Although not bedded, some contexts (for example 40061, which was more gravel-rich) contained evidence of the sub-horizontal alignment of shell fragment and flint pebble long-axes. Minor erosional unconformities were noted in places, for example at the base of 40062. Patches of included sand were noted in some contexts (eg 40063). This phase of deposition is interpreted as an inter-mixing of overbank and slope deposits, forming clay-sand-silt sediments rich in flint and chalk clasts and derived Tertiary shell fragments. The coarse lower bed (40061) may represent a short-lived high-energy fluvial event at the base of the sequence or a narrow torrent of gravelly material washing down the valley side from the west.

Sediments regarded as probably equivalent to Phase 3 were also recorded in subsequent test pits to the east of the site, excavated as part of the field evaluation of Station Quarter South (Wessex Archaeology 2006b). They were also seen to the west of the site as part of the field evaluation of Northfleet West Sub-station (Museum of London Archaeology 2011) (Fig. 4.1). These provided important additional information on the distribution and geometry of Phase 3 deposits, discussed in the following section, below. Furthermore, some important faunal evidence was recovered from Phase 3 deposits, including large vertebrate specimens, *Bithynia* opercula and a rich ostracod fauna. These are discussed subsequently (Chapters 7, 9, 11 and 13) and have additional bearing on the interpretation of the sediments (Chapter 22).

Phase 4. Sandy-gravelly clay

Deposits of this phase were very restricted at the main site, being only present towards the base of the central part of the main west-facing section (Fig. 4.5a, b), shown more closely in Log 40011 (Fig. 3.4). The basal part of this phase consists of a fine clayey sand with some flints (context 40027) passing upwards to a massive grey/brown clay (context 40026). A possible bimodal grain size in the basal unit may be interpreted as a marginal fluvial sand with occasional stronger flows importing clasts giving way up-profile to a very low energy deposition of clays in a small water body with possible admixtures of colluvially derived material. Mixing across the boundary between the two contexts indicates the sediments were probably saturated after deposition. These sediments dip steeply eastwards, being towards the base, and at the western side, of the series of deposits appearing in a marked synclinal U-shape between Trenches B and C – the 'skateboard ramp' (Fig 3.18; Fig. 4.22). This geometry is regarded as post-depositional (see discussion below), and so has no bearing on interpretation of formation processes with regard to the Phase 4 sediments. Phase 4 sediments did not re-appear on the east side of the skateboard ramp', but a much greater thickness of probably equivalent sediments was observed further east in test pits dug in 2006 (Fig. 4.1) during field evaluation of the Station Quarter South area (Wessex Archaeology 2006b). These are discussed below.

Phase 5. Clay-laminated sands

These sediments (contexts 40025, 40066, 40067 and 40072) were widespread across the site, being the main basal deposit, almost three metres thick, in the southern side of the main west-facing section (Fig. 4.5a, b), and a significant presence in the southern and central parts of the main east-facing section (Fig. 4.6a, b). The links across the site between these two exposures were also directly seen in the transverse east-west sections of Trenches B (Fig. 4.8) and C (Fig. 4.9) and section 40080 (Fig. 4.12; Fig. 4.24). The sediments linked to this phase varied somewhat across the site but typically were brownish-yellow sand with grey clay or clay-silt interbeds, with some reworked Tertiary shell fragments and occasional thin beds of flint pebbles. The sand was planar-bedded, dipping to the north parallel with the junction of their upper surface with the base of the Phase 6 clay deposits, suggesting a broadly conformable relationship between these two sets of deposits. Small ripples were noted in places, along with a number of reactivation surfaces indicating breaks in sedimentation. The silty-clay interbeds were thicker and more frequent higher in the sequence (40067), where they were often highly deformed by loading, suggesting saturated conditions. Gravity folding (*boudinage*), representing soft-sediment deformation under the influence of gravity, was also observed in the central part of the main west-facing section (Fig. 4.5; Fig. 3.4) where the sediments dipped steeply east, forming the western end of the U-shaped 'skateboard ramp' (Fig. 4.22), suggesting post-depositional deformation in a saturated, fluid state.

This sequence appears to reflect local deltaic conditions with alternating sediment supply sources at the edge of a water body. The planar bedding (with occasional ripples) and reactivation surfaces suggest alluvial fan or delta aggradation in a fluctuating fluvial environment with input from overbank colluvial slopewash and surface run-off. The flint pebble beds reflect short-lived episodes of higher fluvial energy alternating with periods of quiet water. Progression

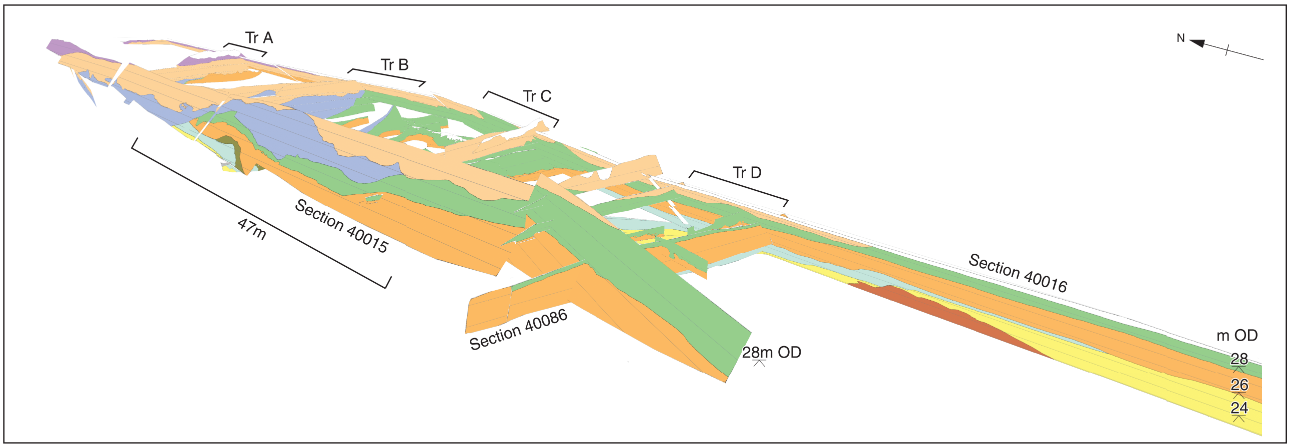

Figure 4.24 Phase 5 sediments (looking down, north-east)

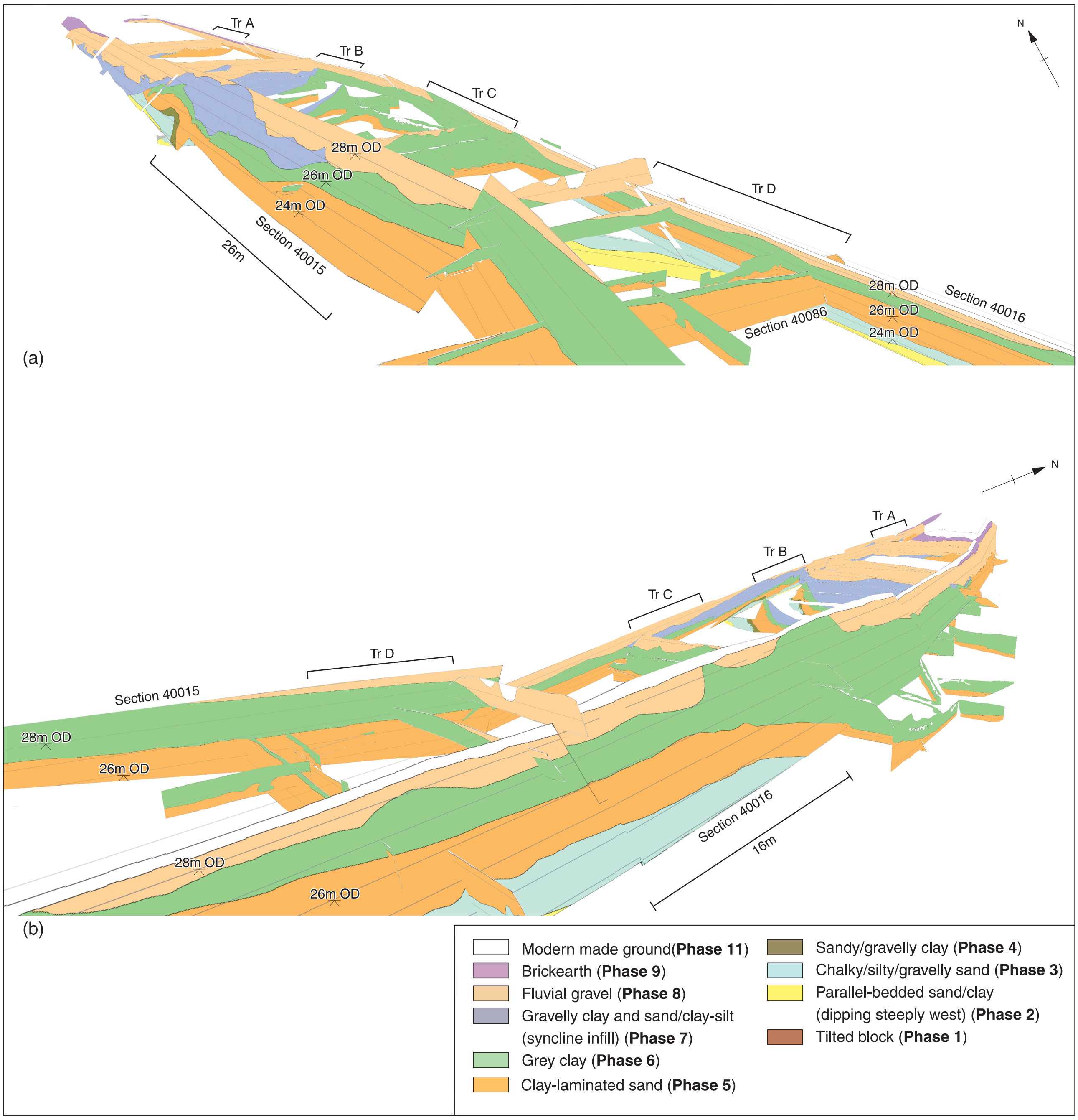

Figure 4.25 Phase 6 sediments: (a) looking down, north-east; (b) looking down, north-west

towards the increased occurrence of low energy conditions are indicated by the presence of the thicker, more frequent fine-grained units upwards. This may also suggest the development of a more extensive low energy water feature in the landscape, such as a very quiet river, or even a lake.

Phase 6. Grey clay with brown humic beds

The sediments associated with this phase (Table 4.1; Table 4.2) are geometrically complex (Fig. 4.25a,b) and also vary laterally. They predominantly consist of grey brecciated clay, often with areas of minor slickenside faulting, and with undulating, intersecting thin oxidised iron-rich silty bands around 10mm thick in their lower parts in the centre of the site. The clay includes various sandier and siltier facies. These sediments are often associated with colour variations from pale grey to reddish and brownish, almost black in places. The more brownish and black beds are concentrated in the lower parts of the sediments in the centre of the site, where the elephant skeleton was found and associated with organic-rich beds with visible fragments of rotted plant macrofossils. The Phase 6 clay also included (besides concentrations of lithic artefacts) a range of natural flint clasts. These were very rare through most of the deposit, but increasingly common (and generally larger) in the area of the lithic concentration south of Trench D, varying in size from fine gravel to small cobbles, and generally considerably abraded. The depositional and site-formation implications of this are discussed more fully below, in conjunction with the refitting and lithic artefact distributional data (Chapters 17 and 18). The presence of large natural clasts clearly reflects at least some colluvial and/or slopewash input, although, as discussed below, the Phase 6 deposits are thought predominantly to represent deposition in quiet or standing water, with periods of desiccation and the regular exposure of palaeo-landsurfaces.

The Phase 6 sediments form a significant element in the southern parts of the main east- and west-facing sections (Fig. 4.5; Fig. 4.6; Fig. 4.27; Fig. 4.28), and in the transverse east-west sections of Trenches B, C and D between these faces (Fig. 4.8; Fig. 4.9; Fig. 4.10). In general, the Phase 6 sediments wedge out from south to north between Trench D and A. They become significantly deformed in their thinner, northern part into the U-shaped 'skateboard ramp' between Trench C and B, and fade away further north to become a vestigial layer about 10mm thick at Trench A (Fig. 4.7). These sediments contained many of the most important remains found at the site, including the *Palaeoloxodon* skeleton and its associated flint artefacts,the tufaceous channel and its rich micro-faunal remains (Fig. 3.9; Fig. 4.29) and the dense concentration of (mostly) mint condition artefacts found south of Trench D (Fig. 4.26). Therefore their internal stratigraphy and the use of various context numbers within Phase 6 are presented here in some detail.

Description and interpretation of the internal sequence of contexts within Phase 6 is complicated by the varying thickness of the deposits and the use of different numbers for the same sediment in different parts of the site. Additionally, local sedimentary variations were given their own context numbers within the great clayey mass of the Phase 6 deposits (Table 4.2). Context 40039 was used for the full thickness of the Phase 6 deposits when first encountered; a relatively thin (*c* 250mm) dark brown brecciated clay bed in the central part of the main west-facing section (Fig. 4.5a, b). This number was also used, probably erroneously, to represent the strong brown clay at the base of the much thicker grey clay (context 40100) that constituted the Phase 6 deposits in the southern part of the site in the west-facing section. Different context numbers (40068 and 40069) were then used for the same grey clay in the main east-facing section (Fig. 4.6a), and for finer stratigraphic sub-division of the even thicker grey clay with intervening brown humic beds where the *Palaeoloxodon* was found (upwards through the sequence: contexts 40103, 40099, 40078 and 40100 – see Fig. 4.9, west end and Fig. 4.30).

A suite of additional numbers (from the base: 40070, 40144 and 40143) was then used for the sequence of deposits associated with the tufaceous channel, which was contained within the lower part of the Phase 6 grey clay (40068) on the eastern side of the site (Fig. 4.13, section 40064). As shown in Table 4.2, Fig. 4.9 and Fig. 4.22, it is important to note that, while there is no direct lithostratigraphic link between the elephant horizon and the tufaceous channel sequence, they both occurred in equivalent stratigraphic positions, within the bottom part of the Phase 6 clay. Most importantly, recovery of one of the elephant's foot bones from within the tufaceous channel sequence (Chapter 8) also established true contemporaneity of the elephant (and its associated hominin activity) with the rich environmental remains from the tufaceous channel.

Towards the end of the excavation, it was found that the dark brown brecciated clay originally identified as 40039 thinned northward and became almost black, and here it was given a new context number (40158), as seen in the final south-facing section of Trench B (Fig. 4.8: section 40091). Finally, three further context numbers (40160, 40161 and 40162) were later applied to distinct sandy and silty beds within the Phase 6 grey clay in the central eastern part of the site (Fig. 4.12, section 40080).

Two subsidiary phases were identified within Phase 6 (Table 4.2). These were:

1. A basal Phase 6a, representing 40039 (in the central and southern parts of the site where this context did not represent the full thickness of Phase 6), 40040 and 40103.

2. Phase 6b, representing the three contexts of the tufaceous channel-fill sequence (40070, 40144 and 40143).

Table 4.2 Phase 6 contexts, showing relationships and internal phasing across site

Phase	*Trenches A-B*		*Trenches C-D*				*South of Trench D*
6			40100		40160	40069	40100
					40161		
6 – Elephant			40078	40144			
6b				40143	40162	40068	
			40099	40070			
6a	40158	40039	40103 40039				

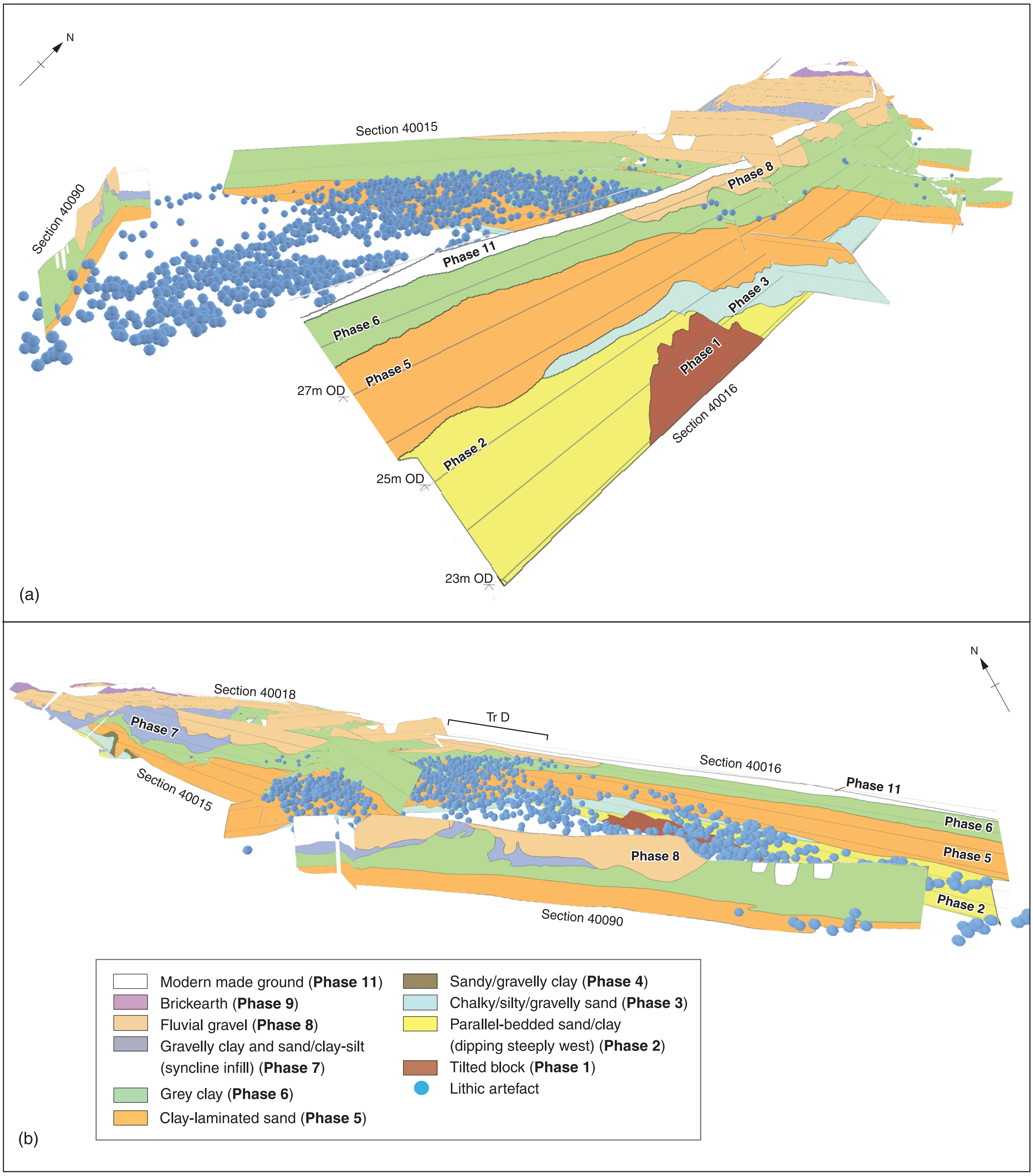

Figure 4.26 Lithic concentration south of Trench D: (a) looking down, north-west; (b) looking down, north-east

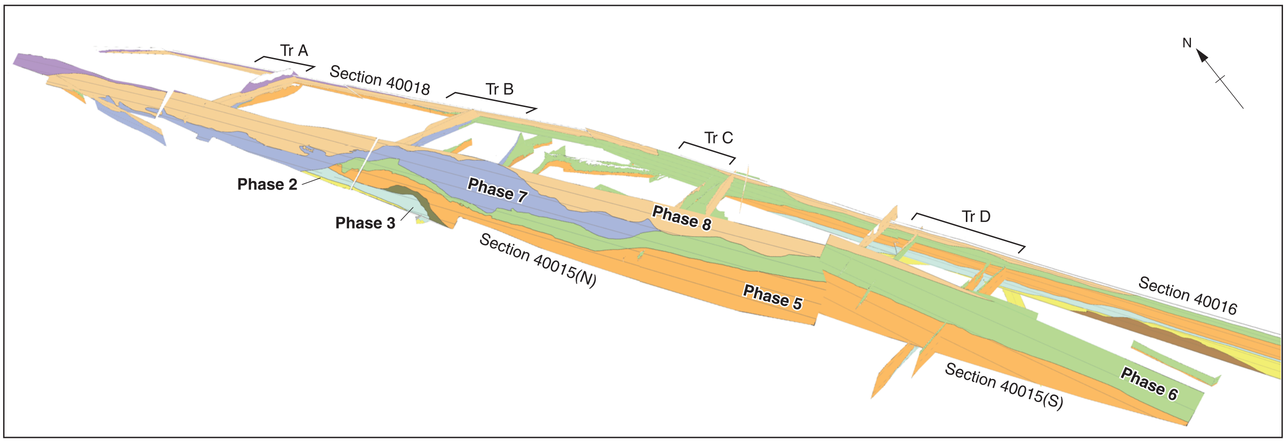

Figure 4.27 Main west-facing section, no. 40015 (looking north-east)

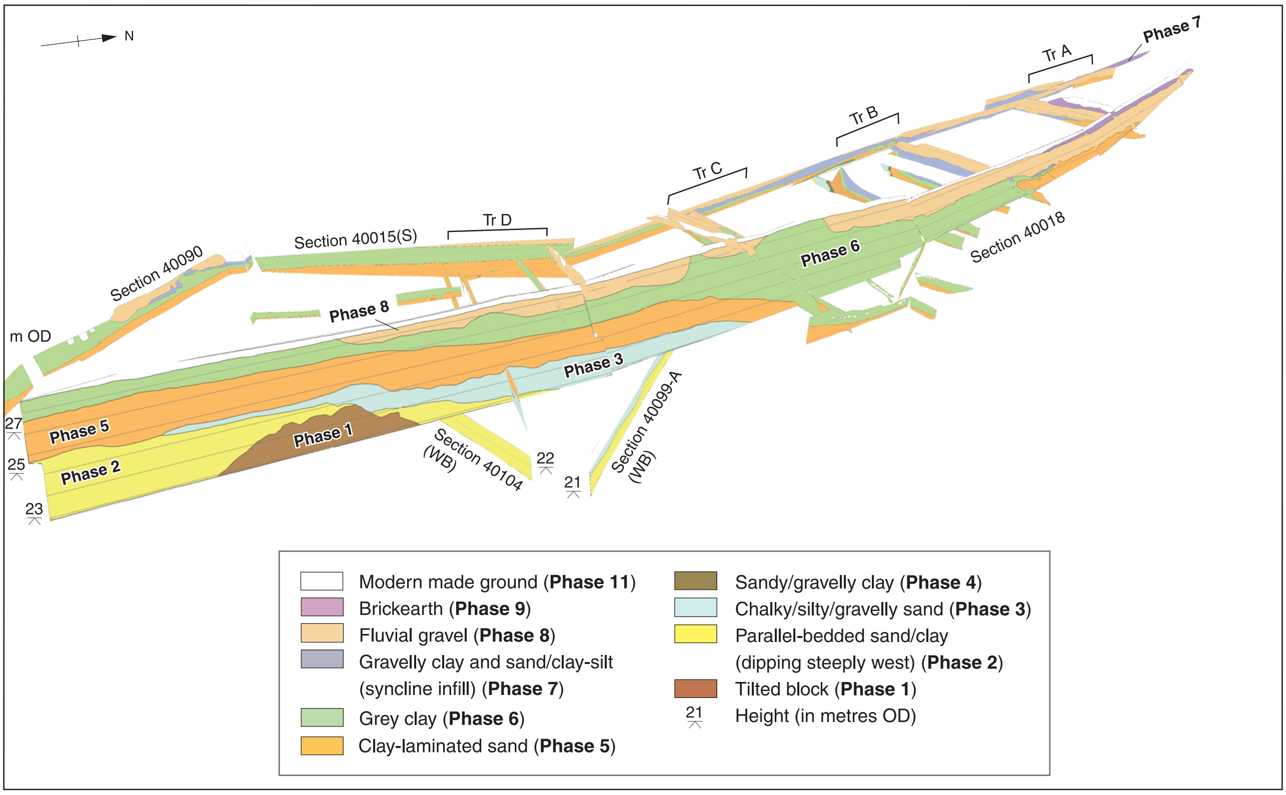

Figure 4.28 Main east-facing section, nos. 40016 and 40018 (looking north-west)

The base of Phase 6 is broadly conformable with, and continues the increasingly clayey upward trend of, the underlying Phase 5 deposits. The basal context (40040) is a mid to dark grey sand and clayey silt with occasional small flint clasts suggesting continuation of fluvial conditions, but with a marked decrease in energy from the underlying Phase 5 sands. As discussed above, the overlying Phase 6 deposits varied in nature and thickness across the site. It was originally thought that the dark brown, almost black in places, brecciated clay (40039; 40158) that overlay this in the central part of the site represented *in situ* pedogenesis and a palaeo-landsurface. Subsequent sedimentary and thin section micromorphological investigations (Chapter 5) indicated that, rather than there just being one land surface, these darker sediments represent regular influxes of sediment rich in organic remains by a combination of alluvial and colluvial processes interspersed with episodes of desiccation and oxidation. This resulted in the brecciation of the deposit and the periodic exposure of short-lived palaeo-landsurfaces. These processes were evident upwards through the sequence in the central part of the site, near the elephant, with deposition of the grey clay (context 40103). There were sharply-defined undulating sub-horizontal bands of reddish-brown (iron-enriched) silt, with the top of this context being defined by a particularly well-defined reddish iron-rich band that extended across the site (Fig. 4.9; Fig. 4.30). This layer showed greater signs of soil development and may represent a longer-lived palaeo-landsurface, although no particular archaeological remains are associated with it.

Overlying this, and still in the central part of the site, occur the grey clays with browner, organic-rich beds associated with the area of the elephant skeleton. These

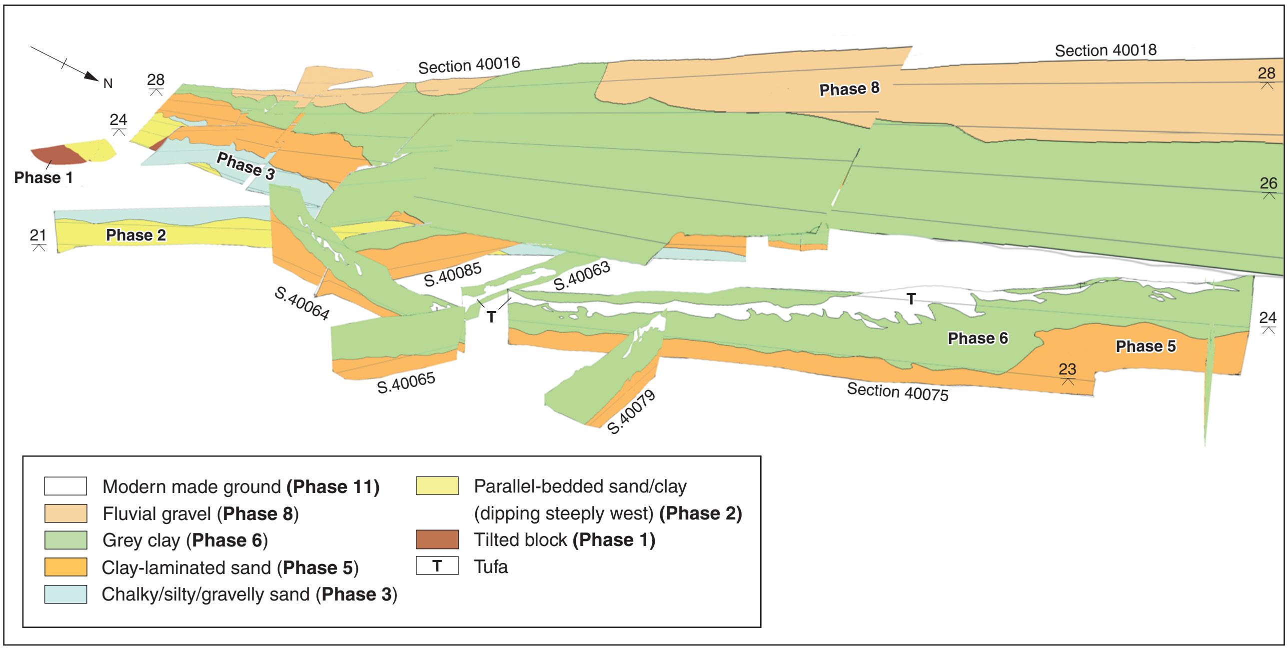

Figure 4.29 Tufaceous channel towards base of Phase 6 (looking south-west)

were best recorded in the west-facing section 40043 beside the elephant skeleton (Fig. 4.30), and at the west end of Trench C in the north-facing section 40085 (Fig. 4.9). The elephant skeleton was mostly contained in one particular brown organic-rich bed (context 40078), which dipped gently north, thickening from 20mm thick at its southernmost manifestation (in the west end of Trench C, Fig. 4.9) to about 150mm thick to the north of the elephant skeleton. At the elephant skeleton, 40078 was divided from the top of the underlying context (40103) by a thin pale grey clay bed (40099), and was overlain by the main body of the Phase 6 grey clay (40100), which rose and thinned southwards (Fig. 4.5). The flints associated with the elephant skeleton were also mostly recovered from the same context (40078) (Fig. 3.17), although several (and also several of the elephant bones) were embedded at their base in the underlying grey clay (40099).

After excavation of the elephant was finished, Trench C was deepened through the deposits to the east of the elephant. It was found that the lower Phase 6 deposits in the vicinity of the elephant were characterised by numerous different brown organic-rich beds, which rose and thinned to the south-east, often merging together as they did so (Fig. 4.9; Fig. 3.21). The apparent presence within these beds of rotted plant macrofossil remains was later complemented by the demonstration of increased loss-on-ignition (Chapter 5) and the recovery of pollen and an *Azolla* spore (Chapter 12), confirming they were associated with enhanced organic preservation. The soil micromorphological studies (Chapter 5) indicated a combination of alluvial and colluvial deposition, perhaps often into standing water, with the formation of peaty beds, now substantially decayed, and periodic desiccation.

Taken together, the evidence suggests that the elephant died (or was killed? – see Chapter 22) in a zone near the edge of a quiet or still water-body, where fluctuating water levels led to the exposure of dry land alternating with the presence of shallow water and muddy, marshy/swampy conditions. There was some sedimentary input by colluvial slopewash processes from high ground capped by Tertiary sands, clays and gravels to the west. The sediments under the elephant skeleton are not disrupted and its bones, which are often weathered (Chapter 8), were all found within a relatively narrow horizon, certainly when compared to the thickness an intact skeleton could occupy. Consequently it seems likely that the elephant died on a firm palaeo-landsurface that was then shallowly inundated for long enough for the skeleton to be buried by fine-grained clays/silts with various plant remains and peat development.

Another important feature seen in the central part of the site, on its east side, was a small channel (Fig. 3.6; Fig. 4.13, section 40064). This was filled at its base with a very pale brown mollusc-rich sandy/silt (context 40070) overlain by a brownish-grey sandy silt (context 40144), which was capped in places by a thin, very intermittent white silt layer (context 40143). This feature (Fig. 3.9; Fig. 4.29) became known as the 'tufaceous channel' and is allocated to Phase 6b of the site sequence. The main, basal context (40070) consisted of fragments of tufa and micritic tufa, mixed with pale grey silts. Its base was very uneven, forming contorted pockets in places, and interdigitating with the underlying clay, indicating post-depositional deformation. The slightly coarser nature of the sediment in this feature, compared to the remainder of Phase 6, suggests higher energy conditions and that a small stream channel was developed across a dried out surface developed in the underlying sediments. The origin of the source of the fragmented tufa was probably a spring system, perhaps in cascades to the south, with subsequent erosion and transportation of the detritus from primary context and

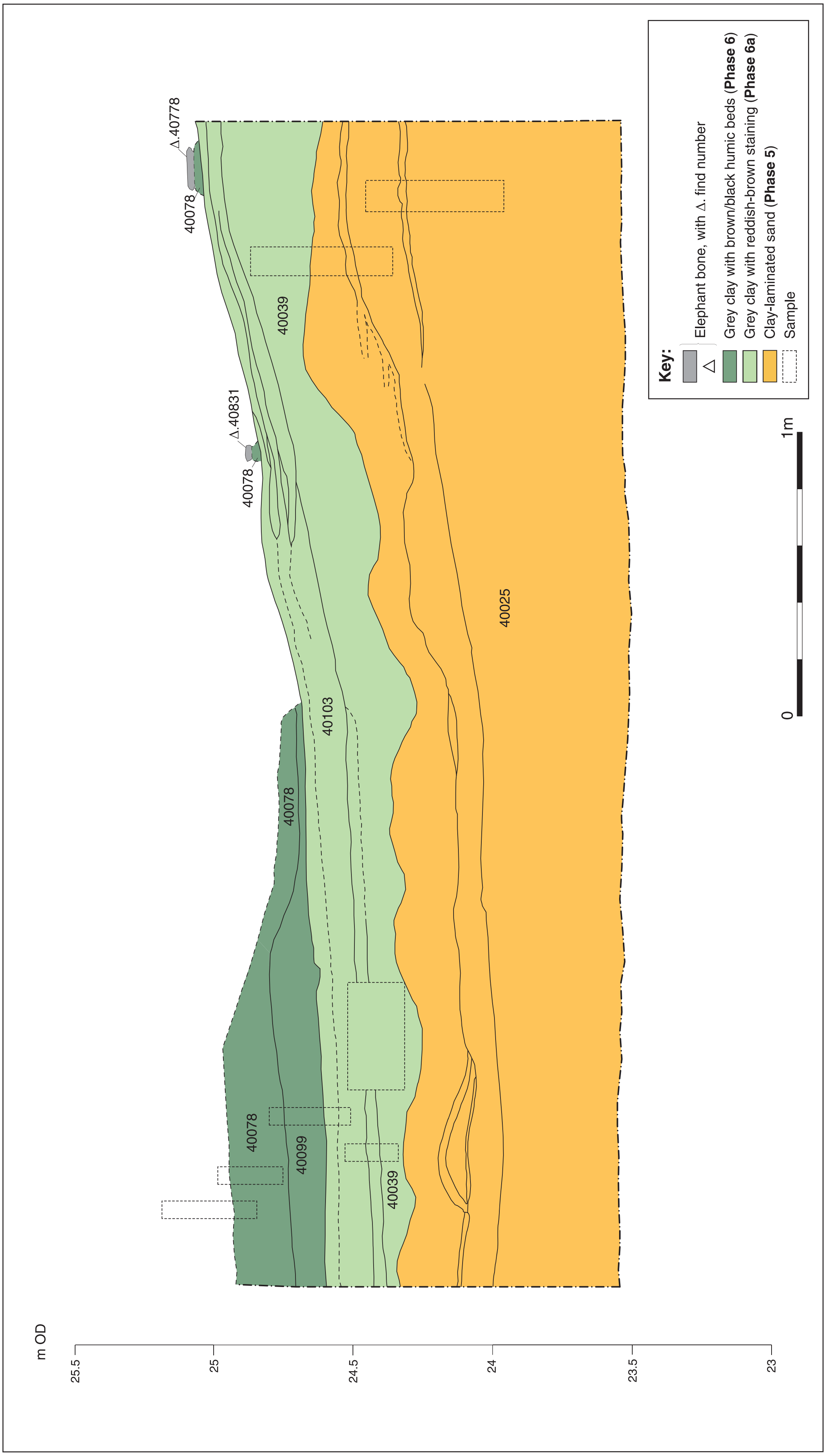

Figure 4.30 Section 40043, closer view of stratigraphy at *Palaeoloxodon* skeleton findspot

its redeposition in the channel. The tufaceous channel deposits were rich in molluscan and small vertebrate remains (Chapters 7, 9 and 10) and there were also ostracods in the overlying white silt of context 40143 (Chapter 11), making it of high importance for biostratigraphic, palaeo-environmental and palaeo-climatic interpretation. There was no direct lithostratigraphic relationship with context 40078 within which the elephant skeleton was found, but both context 40078 and the tufaceous channel occurred in equivalent levels in the bottom part of Phase 6 (Fig. 4.9). Both were above the palaeo-landsurface at the top of context 40103, and both were buried by the main body of clay (contexts 40068; 40100), so they were confidently regarded as broadly contemporary from a Pleistocene stratigraphical viewpoint. Subsequent identification of one of the elephant's well-preserved foot bones from within the tufaceous channel-fill sequence then established true landscape contemporaneity, suggesting the channel-fill was forming at the same time as the elephant carcass was decaying (Chapter 8).

The upper parts of the Phase 6 clays that bury the tufaceous channel and the elephant skeleton rise and extend south across the remainder of the site, thinning in their southern part where they contain the dense lithic concentration south of Trench D (Fig. 4.26). The sedimentological variations that give rise to the complex context sequences in the central part of the site are absent further south. Here there is a very simple sequence of a basal strong-brown-stained context (allocated context number 40039, as it initially appeared in the main west-facing section to be a direct lateral continuation of the original 40039, in Log 40011, Fig. 3.4) overlain by a homogenous brecciated grey clay (40100). This latter context included some slightly sandier beds and some very faint reddish and yellowish stained sub-horizontal bands, which were not allocated individual context numbers. This suggests build-up in a muddy lacustrine or quiet fluvial backwater environment, with regular colluvial input and frequent desiccation indicated by textural variation and fine brecciation throughout the sequence. The presence of dipping browner beds associated with more abundant larger, coarser natural clasts in section 40090 at the south-west end of the site perhaps indicates that this part of the site is further up the valley-side bank. It may therefore perhaps be more prone to a higher colluvial/slopewash input as well as being slightly more amenable for hominin occupation. As discussed subsequently (Chapter 18), the evidence of the lithic refitting and distribution in this area suggests some minor spatial disturbance and movement, with artefacts having slumped in, or been re-arranged, *en masse* by colluvial/slopewash input from the south/south-west.

Phase 7. Mixed clays and gravels

Although there is generally a sharp boundary between the top of Phase 6 and the base of Phase 7, this is nowhere erosive and unconformable, suggesting no major hiatus between deposition of Phases 6 and 7. The sediments associated with Phase 7 were predominantly represented in the central part of the main west-facing section, no. 40015 (Fig. 4.5; Fig. 4.27) and the south-

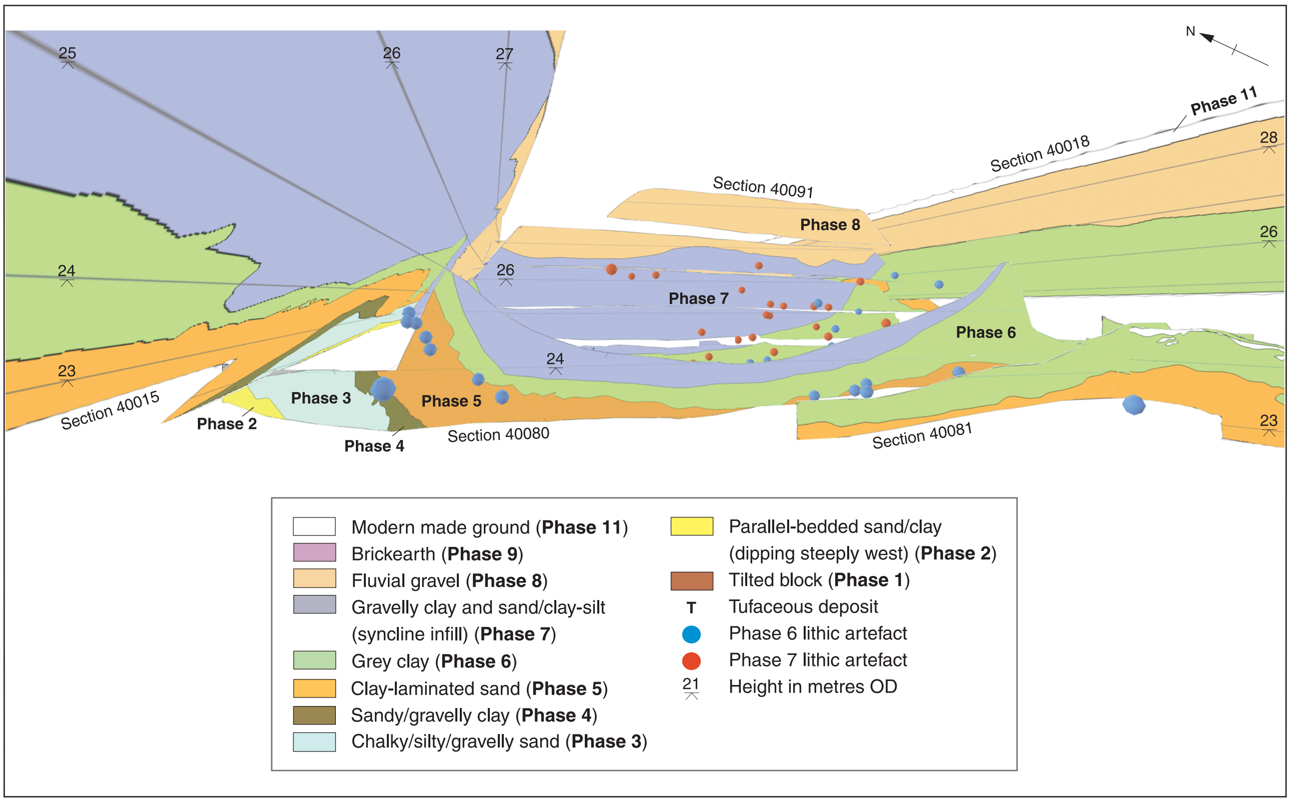

Figure 4.31 Trench B, south-facing Section 40091, also showing flints from Phase 7 (looking north)

facing section, no. 40091 of Trench B (Fig.4.8; Fig. 4.31). In Section 40015 they mostly consisted of variably gravelly greenish/greyish-brown brecciated clay (contexts 40043 and 40101), with minor gravelly and silty beds in places at its base (contexts 40042 and 40041). These deposits were well represented and several metres thick in the central part of the section, but were absent at its northern and southern ends, where the Phase 8 gravel that unconformably overlay them had cut right down to the Phase 6 clay. In the east-west transverse section, 40091 of Trench B, it can be seen that the infill of the synclinal 'skateboard ramp' is dominated by Phase 7 sediments. Here they mostly consisted of a distinct lower facies (context 40166) that is a fine yellowish-brown sandy/clayey silt with contorted clay beds in places, equivalent to context 40041 in the west-facing section 40015. Context 40166 is overlain by contorted clayey gravel (40167), which is equivalent to contexts 40042 and 40043 of Section 40015. As discussed previously (Chapter 3) context 40167 contained occasional concentrations of what looked like rotted and charred plant macro-remains and produced an assemblage of variably stained/abraded lithic artefacts (Chapter 19).

As discussed below, sediments of this phase continue to the west and north-west of the site, extending upslope as a substantial clayey/gravelly mass. This is interpreted as a local mass movement deposit, originating from west or north-west of the site.

Phase 8. Sandy gravel

Passing unconformably across the underlying sequence was a deposit of moderately well-sorted medium-to-coarse gravel with sand lenses, best represented in the main west-facing section no. 40015 (Fig. 4.5; Fig. 4.27) and in the 3-D Fledermaus model (Fig. 4.32a, b). The gravel deposits comprising Phase 8 were given different context numbers in different parts of the site at different stages of the excavation (Table 4.3). Although some might complain that this is typically awkward, in line with the variety of different context numbers used for the same horizons in other phases of the sequence (eg Phase 6, see Table 4.2), this was in fact important and beneficial. It meant that subsidiary stratigraphic phasing within the gravels that only became apparent when wider continuous exposures were seen later in the excavation could be reconstructed and preserved with suitable amalgamations of context numbers. This enabled the meaningful attribution of clast lithological samples and artefact assemblages to specific subsidiary phases within the build-up of gravel. Three sub-phases of the gravel were identified: 8a, 8b and 8c. The main gravel body was represented by Phase 8c (contexts 40048=40071=40102) which extended all across the site, and the two earlier Phases 8a and 8b were only present in the northern half of the site.

The base level of the main Phase 8c gravel beds was at *c* 27.2m OD at the south end of the site, where it cut directly into Phase 6 clays south of Trench D. It then dipped gently down to the north as it passed over the central part of the site, where its base was at *c* 26.5m OD. It truncated the Phase 7 deposits that featured here, and which in turn here overlay the Phase 6 sediments containing the *Palaeoloxodon* skeleton (Fig. 4.5). Further north, however, although the Phase 8c gravel continued its gentle northward dip, it was underlain by additional fluvial gravel beds (from the base, contexts 40098 and 40047, attributed to Phase 8a and 8b respectively) with the base of the Phase 8a bed seen at 25.2m OD at Trench A. After that it disappeared beneath the ground surface which rose up north of this point. Clast lithological analyses (Chapter 6) and orientation studies established that the gravel was a fluvial deposit laid down by a northward-flowing palaeo-Ebbsfleet.

The Phase 8a gravel (40098) was sandier than the other gravel beds, with the thicker sand beds (for which the grain size was fine-medium) often displaying foresets dipping north/north-west (indicating flow in that direction). Overlying this, the Phase 8b gravel (40047) consisted mostly of well-rounded dark grey gravel clasts (derived from Tertiary deposits) with a medium sand matrix. Occasional clasts of sub-angular flint from Chalk were also noted. The sandy matrix became less clayey from south to north. Clasts were imbricated and dipping to the south, confirming the south-to-north flow direction indicated by the foresets in the Phase 8a gravel. The upper surface of 40047 was channelled and infilled with sediment from 40048, the basal deposit of Phase

Table 4.3 Phase 8 contexts, showing numbering correlations, internal phasing and clast analyses

Phase	*Main site sequence*	*Clast analyses*	*Logs 40001-40004*	*Logs 40005-40006*
8c	40050	<40004> - lithology	-	40018
	40049 - sand lens	-	-	
	40048=40071=40102 [=40002]	<40001> - lithology	40006	
		<40002> - lithology	40007	
		<40016> - orientation	40008	
		<40017> - orientation	40009 - upper	
8b	40047	-	-	
8a	40098	-	-	-

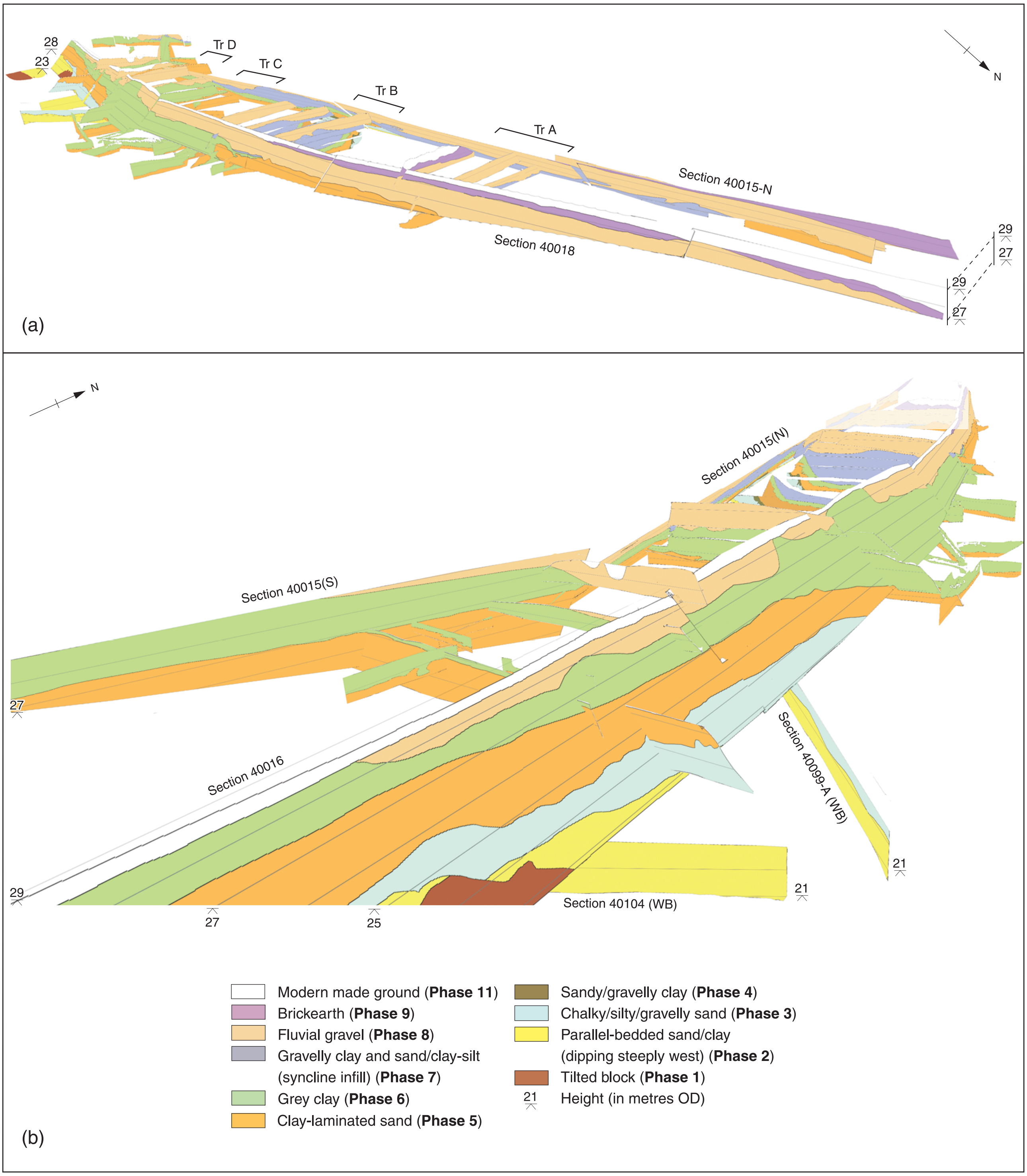

Figure 4.32 Phase 8 sediments: (a) looking south-west; (b) looking north-west

8c, and this junction was also characterised by occasional quite large patches, about 1m long by 0.75m high in section (Fig. 4.5) of clayey sand. Context 40048 was similar to the underlying context 40047, but contained a greater quantity of Chalk-derived flint. Additionally the gravel appeared to exhibit a series of packages of fining upwards sequences that sometimes ended in sands. In the southern part of the site, bedding was sub-horizontal and poorly developed with some bar-edge dipping beds noted. Large scale cross-bedding was noted further to the north.

The Phase 8 sequence appears to show an initial phase of rapid deposition being superseded by the development of a series of superimposed braid bars. Two macro-fabric studies (samples <40016> and <40017>) from the west side of the main site showed a predominant dip to the south (120–230º) with a minor mode to the north-west (285-335º), considered to represent imbricate deposition, with flow to the north. The clasts were predominantly flint, from both the Chalk and the Thanet Sand. There were only a few southern Greensand lithologies (such as chert or sandstone) and too few exotics associable with Thames deposits (such as vein quartz and quartzite) for a Thames origin to be feasible. The top bed of the gravel sequence (context 40050) was characterised by a flint gravel with a medium sand matrix dominated by Tertiary-derived flint with a lesser component of uncertain origin and occasional Chalk-derived flint. Again the clasts exhibit imbrications to the south. This is interpreted as braided fluvial deposition, perhaps prograding on a gentle deltaic front as the channel approaches the point of confluence with the much larger Thames, a short distance to the north.

Phase 9. Reddish-brown clay-silts, 'Brickearth'

The northern part of the gravels, as their upper surface dipped to the north at the north end of section 40015 (Fig. 4.5), was overlain by moderately firm, cohesive and pliable yellowish to reddish-brown sandy/silty clay, locally recognised as 'brickearth'. At its base, this brickearth has a thin bed (context 40051) with thin, continuous, parallel sand/silt laminae. These become coarser upward, grading into a thin reddish-brown gravel bed with poorly sorted flint clasts (context 40052). This is in turn was overlain by the main body of the brickearth, a thick sandy clay-silt (context 40053, also equivalent to 40075), which contained occasional faint sandier beds and gravel trails, as well as patches of intrusive recent rooting. Occasional isolated small gravel clasts were also present. These deposits are likely to predominantly represent slopewash and sheet-wash deposits, including reworked aeolian sediment from upslope.

These sediments are without doubt equivalent to the 'ferruginous loam' reported by Carreck (1972, 61) exposed in the quarry faces to the east of Southfleet Road over a stretch of several hundred metres to the north of the site (Fig. 2.4, site 16). As well as the exposures seen in Transects 1-3 to the north of the main site, the northward continuation of the brickearth was investigated in numerous test pits in Station Quarter South and Eastern Quarry Area B between 2005 and 2008, and this work is discussed below.

GEOMETRY OF THE SEQUENCE AT THE SITE

The sediments exhibited a complex 3-dimensional geometry. The primary bedding structures in the main fluvially lain deposits of Phases 5 and 8 dipped northwards suggesting an underlying trend of progradation from south to north. These sedimentary phases were interspersed with sediments from Phases 3, 4, 6 and 7, which are thought to have been laid down by a combination of colluvial slopewash and surface run-off processes, feeding into fluctuating (and periodically drying out) bodies of standing or very quiet water. However, superimposed upon this, a number of other features and trends can be seen. The sandwich of Phases 3-6 formed an asymmetric north-south trending synclinal basin in the central part of the site, about 18m across east-west and with a preserved depth of at least three metres (Fig. 3.18; Fig. 4.12). This was flanked to the west by a corresponding anticlinal fold of the same sediments, with a core formed by the north-west to south-east trending Phase 3 chalk-rich sediments, recorded in plan (Fig. 4.20-21). The eastward continuation of the site had been excavated away by HS1 groundworks and so could not be observed. However, faint bedding in the upper Phase 6 sediments in the upper east end of the main north-facing section of Trench C dipped to the east (Fig. 4.9), and it was thought that the main east-facing section of the site contained faulting parallel with its sloping face, suggesting that the upward curve of sediments at the eastern side of the synclinal basin was reversed downward a short distance further east. North of Trench B, the sediments of Phase 6 within the main synclinal basin continued their northward thinning trend in Trench A, persisting here as a vestigial bed about 10mm thick, but the synclinal structure remained, with its eastern limb recorded in plan once the overlying sediments had been machined away (Fig. 4.33).

Synclinal folding was also observed at the east end of Transect 2, *c* 150m to the north of Trench B (Fig. 4.34). This group of contexts could not be tied in with the main phased site sequence, although there were superficial similarities of some beds with Phases 3 (context 40093) and 6 (contexts 40089 and 40091). It is uncertain whether this is the northward continuation of the same synclinal structure as seen at the site, or a different one; it does, however, demonstrate the persistence of sedimentary folding beyond the immediate main site area.

The explanation for these basin features is problematic. Dips in the Solid geology of the central and eastern parts of the London Basin are very low, generally not exceeding a few degrees. Against this background, the high dips observed in some of the Southfleet Road excavations, both in the Chalk and in the overlying Pleistocene deposits, are remarkable and apparently anomalous. A number of possible explanations exist for these features:

1. *Tectonic activity*. Dips in the Chalk as high as 55° occur on the southern limb of the London Basin at the Hog's Back (Sumbler 1996) and, further south, approach the vertical on the south side of the Hampshire Tertiary Basin in the Isle of Wight. This is however an unlikely explanation because of its location in an area of sub-horizontal dip, the very local nature of the feature and the apparent absence of hinge structures between the two basins. Also, there has been no suggestion that any folding has been active during the Pleistocene. As Pleistocene sediments are involved, the deformation must be post-Tertiary and must post-date these regional tectonic structures.

2. *Superficial valley disturbances.* A wide variety of superficial valley disturbances exist, which have been reviewed by Hutchinson (1991 and 1992). These can

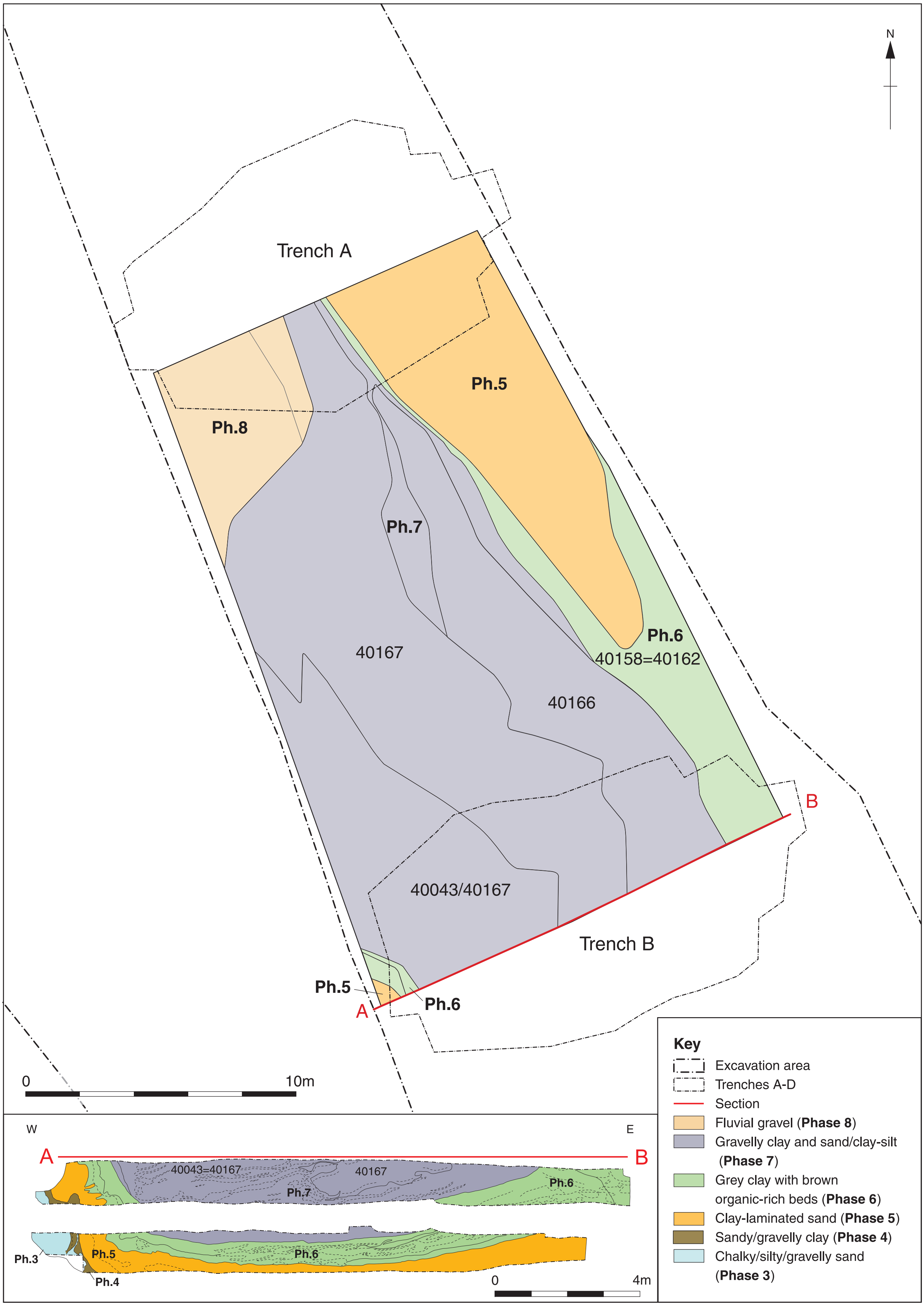

Figure 4.33 Stripped surface between Trenches A and B, showing east side of synclinal basin in plan

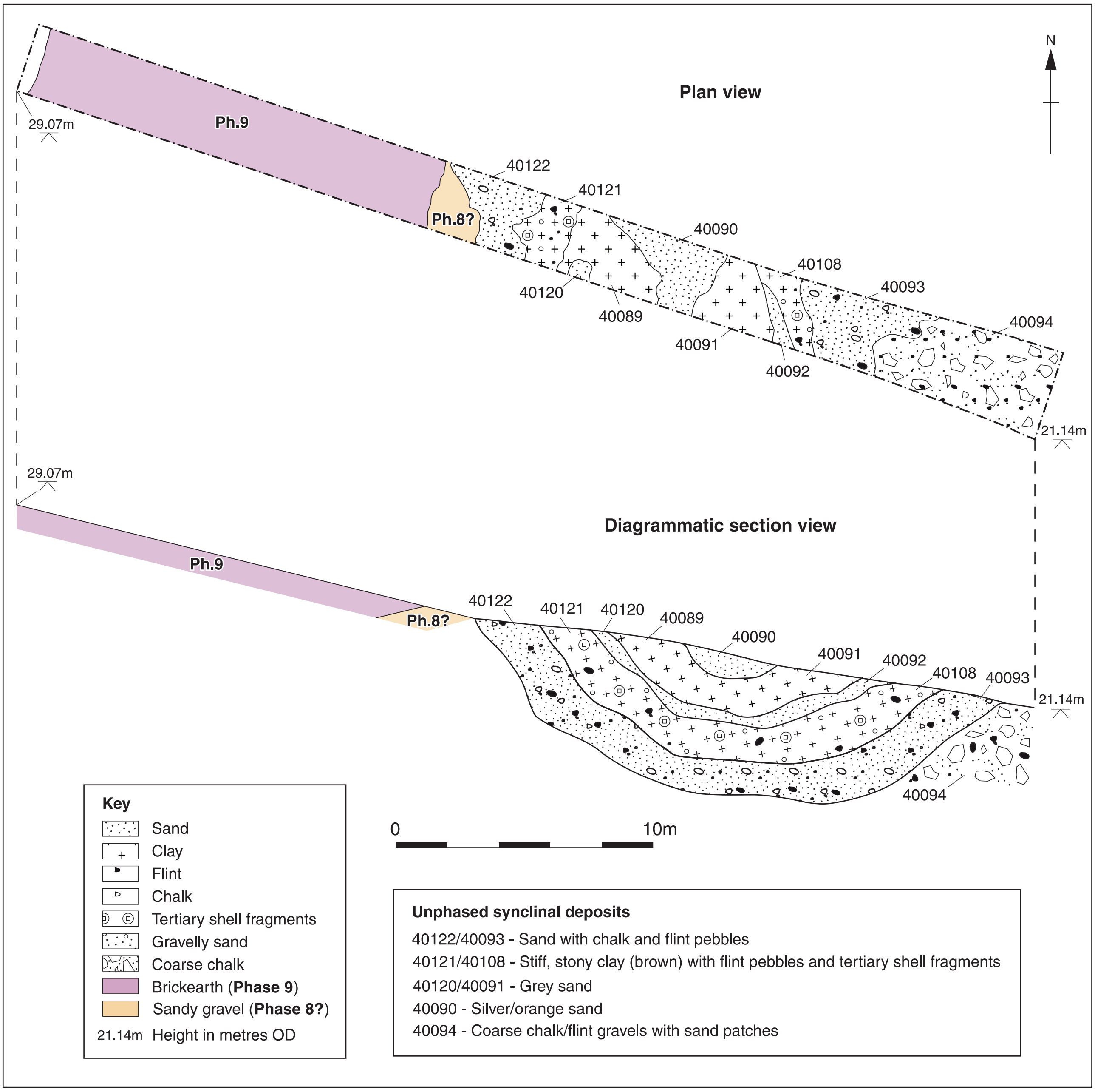

Figure 4.34 Synclinal folding at the east end of Transect 2

produce local dips of 70° or more in valley bulges and are widely distributed in the Jurassic outcrop of central England and in the Weald. However, they require the valley to be underlain by a thick argillaceous stratum. The absence of such a stratum beneath the Southfleet Road site, its location away from the axis of the local valley and the very local nature of the observed anomalous features rule out an explanation depending upon the above mechanisms.

3. *Pingos.* Relict pingos, chiefly of open type and generally (but not always) more or less circular or oval in plan, are common in southern England and Wales. Some are reported to have diapiric structures in their lower parts that can result in steep dips. Pingos are frequently found in clusters towards the foot of slopes, particularly if artesian groundwater pressure is present. While some of these criteria may be fulfilled at Southfleet Road, the continuity of the beds across the basins and the absence of boggy, peaty infills argue strongly against a pingo origin.

4. *Frost heave and periglacial solifluction.* While both these processes can result in considerable deformation of the ground, they are too shallow to explain the Southfleet Road structures.

5. *Solution of the Chalk.* Solution pipes, swallow holes and solution dolines are numerous in the Chalk, especially around the margin of London Clay capped hills (the umbrella effect). The work of Higginbottom and Fookes (1970) and Jones (1981) indicate that

the extent and magnitude of solution effects in the Chalk have been underestimated. Both this background and the detailed local geology point to the solution of Chalk as a possible mechanism producing the features at the site. Indeed it is not abnormal to have two solution features adjoining each other or for them to have a linear tendency. However, this does not explain the folding of the surrounding beds, nor the marked asymmetry of the basin, which seems suggestive of lateral pressure from the west.

6. *Landsliding*. British Geological Survey mapping shows the site to lie at the lower edge of a landslipped area. Pressure exerted downslope or by the toe of a landslide can produce deformation, folding and faulting of its lower parts and of the resisting ground, although faulting would be less likely to occur in the case of saturated sediments,which would behave in a more fluid manner (Allen 1991). An example at Lyme Regis is described by Hutchinson and Hight (1987), the effects extending no more than about 5m below ground level, which is compatible with the sequences seen here at the Southfleet Road site. The presence of gravity folding, elongation of folds and *boudinage* in Phase 6 especially in section 40091 (Fig. 4.8) and 40085/400285/2 (Fig. 4.9), indicates deformation of sediments in a saturated, fluid state, due to pressure from the west, which lends support to landsliding as a deformative process.

On present evidence, the deformation of the sediments is interpreted as a result of lateral pressure caused by downslope movement of a substantial mass of clay-dominated colluvial deposits from the west, perhaps in conjunction with underlying subsidence caused by solution of the Chalk bedrock. This deformation and landsliding post-dated Phase 6, and pre-dated Phase 8, the sediments of which overlie the deformed sediments unconformably and are not affected. Although the sediments of Phase 7 conformably overlie those of Phase 6 and show some signs of internal deformation, they do not themselves show evidence of having been entirely in place and deformed together with the underlying sequence. Rather, it is suggested that the Phase 7 sediments may themselves have been the source of this pressure, slipping down from the west and both deforming and over-riding the sequence already in place in the valley floor. As is seen in the next section below, the Phase 7 sediments at the site can be correlated with a major body of similar clayey and gravelly sediments that extend upslope to the west and north-west.

Finally an explanation for the nature of the basal parts of the sequence remains elusive. The Phase 1 sediments, ie the intact 'tilted block' of bedrock, and the overlying sediments of Phase 2, remain difficult to explain and insufficient evidence exists to address this convincingly. However, it is likely that the slope failures postulated as responsible for the creation of the synclinal basins discussed above would have had a long history in the Ebbsfleet Valley and that such processes may also be partly responsible for the formation of this earlier part of the sequence. The 'skateboard ramp', Phase 6 (Fig. 4.12), seems to represent an extreme response to lateral pressures from the west, given the scale of the deformations in sections 40091, 40020, 40085/40022; possibly the steeply dipping sediments of Phases 1 and 2 are also related to this.

DEPOSITS IN THE SITE VICINITY

Since 2004 when the elephant excavation took place, the neighbouring areas have been subject to numerous field investigations that have provided new information on the Pleistocene sequences around the elephant site (Fig. 4.1). In particular:

1. Around 70 deep test pits (TP) and 5m window-sample boreholes have been excavated in the field in the north-east quadrant of the Northfleet West electricity substation plot, immediately to the west of the site (Museum of London Archaeology 2011).

2. Some 35 test pits and boreholes have been excavated in the Station Quarter South development plot, immediately to the north and east of the site (Wessex Archaeology 2006b).

3. Approximately 100 deep test pits have been excavated in the north-east unquarried quadrant ('Area B') of Eastern Quarry to the north-west of the site (Wessex Archaeology 2006a; Wessex Archaeology 2009a). Amongst this huge body of work, several interventions have revealed deposit sequences, and on occasion faunal and artefactual remains, that complement the work at the elephant site. These works both expand our understanding of local Pleistocene lithostratigraphy and geometry beyond the relatively restricted area of the elephant site and enhance the scope of the site's interpretation. Key interventions relevant to the elephant site are listed (Table 4.4), with descriptions and photographs of their deposit sequences provided as digital appendices (D1-D4).

Three Transects EF, GH and IJK were constructed using some of the most informative investigations in the closer vicinity of the site (Fig. 4.35). Two of these, EF and GH (Fig. 4.36a; b), cross east-west through the site, and the third, IJK (Fig. 4.36c) originates to the south-west of the site, then passes northward through it.

The west ends of Transects EF and GH both show Thanet Sand bedrock occurring much higher than at the site, at above 30m OD, from which its (erosionally truncated) surface dips steeply eastward to an unknown level (but below 20m OD) less than 100m away at the site. To the west of the site (Northfleet sub-station TPs 235-237, 242-244, 255 and window sample WS 106) the basal group of Pleistocene deposits consist of chalk rubble and chalk-rich sands and flint gravels. These

Table 4.4 Key field interventions in project areas in the vicinity of the elephant site

Project area	*Project field code*	*Test Pits*	*Section logs*	*Boreholes, window samples*	*Report reference*
Northfleet West Sub-station	KT-SFL 03	227, 235, 236, 237, 242, 243, 244, 255, 256-B	-	WS 106, WS 163	Museum of London Archaeology (MoLA) 2011
Station Quarter South	63542	1, 3, 5, 11, 12, 16, 17, 20, 21, 23, 25, 27, 30, 31, 32, 33	-	-	Wessex Archaeology 2006b
	63544	-	-	BH 201, WS 3	Wessex Archaeology 2007
Eastern Quarry, Area B	61040	2.2, 3.1, 3.2, 4.1, 6.2, 7.2, 16.2, 55.1, 59, 60, 61	-	-	Wessex Archaeology 2006a
	61041	111, 112	-	-	Wessex Archaeology 2008a
	61042	127	-	-	Wessex Archaeology 2008b
Swan Valley School	SCS 97	D, K, E	19/40	-	Wenban-Smith & Bridgland 2001

deposits dip and thicken towards the site, becoming less chalk-rich and with diminishing chalk-clast size as they do so, and are here interpreted as equivalent to Phase 3 of the site sequence.

These deposits thus both underlie, and also form the western valley-side bank of, deposits of Phase 5-9 at the site, which contain the principal archaeological remains. An important, and very puzzling aspect of these deposits is their abundant chalk content, and by association their nodular flint content, which is probably fundamental to the prolific lithic knapping remains found at the site. Flint nodules would probably have been exposed both in the west side of the (periodically dry) stream/marsh/lake environment of the valley floor, and also in colluvial/slopewash fans slumping down the valley sides towards the valley floor, providing a ready source of flint raw material for hominins at this time.

It is, however, difficult to see, when considering the local geological mapping (Fig. 4.2) and sub-surface solid geology (Fig. 2.2; Fig. 2.3), where the Chalk bedrock source was from which the chalk and flint content of the western valley-side originated. It does not appear feasible that these could have originated from north, south or west, leaving only (however improbable) east as the most likely source direction. As discussed above, there is 'something funny going on' with respect to the chalk bedrock, as evidenced by both the 'tilted block' of the Phase 1 sediment, and the anomalous Chalk high at Southfleet Pit to the east of the site (Fig. 4.3). The most feasible scenario is perhaps that there was originally a pinnacle or cliff of chalk to the east of the site, the westward collapse of which fed chalk rubble and flint nodules into the area that later became the western side of the valley.

There is then a significant hiatus in the depositional sequence to the west of the site, with the Phase 3 sediments there being directly overlain by gravelly clays identical, and interpreted as equivalent, to the Phase 7 deposits at the site. These gravelly clay deposits extend further north and west, and correspond with the protruding lump of higher ground mapped as 'slipped clay' in the early 20th century (Fig. 4.2). Thus it seems clear that the Phase 7 sediments at the site directly originated from the Tertiary deposits capping the high ground to the west, and that these have slipped down to the east, over-riding the Phase 6 clays. As discussed above, it is suggested here that this landsliding has also caused deformation of the underlying sequence at the toe of the landslip, where it over-rides the site area, forming the synclinal basin of the 'skateboard ramp'.

These slipped gravelly clays are in turn overlain by very homogenous reddish-brown clayey silts (present in the top half of the sequence in Northfleet West Sub-station TPs 244 and 255). These pass laterally into the Phase 9 deposits preserved at the top of the Pleistocene sequence in the northern half of the site. Here they overlie the Phase 8 fluvial gravels. The northward continuation of these two deposits is discussed in more detail further below (and see Fig. 4.41).

To the east of the site, chalk-rich sands and gravels interpreted as equivalent to Phase 3 of the site sequence occur at the base of the sequence in Station Quarter South TPs 31-33 at the east end of the transect GH (Fig. 4.36 b), between *c* 17 and 20m OD (with their base not reached). Clast lithological sampling from a gravelly bed of the Phase 3 deposits in the base of TP 32 indicated that here they included fluvially deposited Ebbsfleet gravels (Chapter 6). A distinctive interglacial ostracod fauna, similar to that from the Phase 3 deposits at the site, was also recovered from sand/silt beds (3304 and 3306) at the top of deposits regarded as equivalent to Phase 3 in TP 33 (Chapter 11).

In contrast, only a short distance to the north, at the eastern end of Transect EF (Fig. 4.36a), the Phase 3 chalky sands/gravels were thinner, and were underlain (in Station Quarter South TPs 16 and 17) by a firm laminated sand/silt deposit. This was interpreted as most likely equivalent to Phase 2 in the site sequence, seen

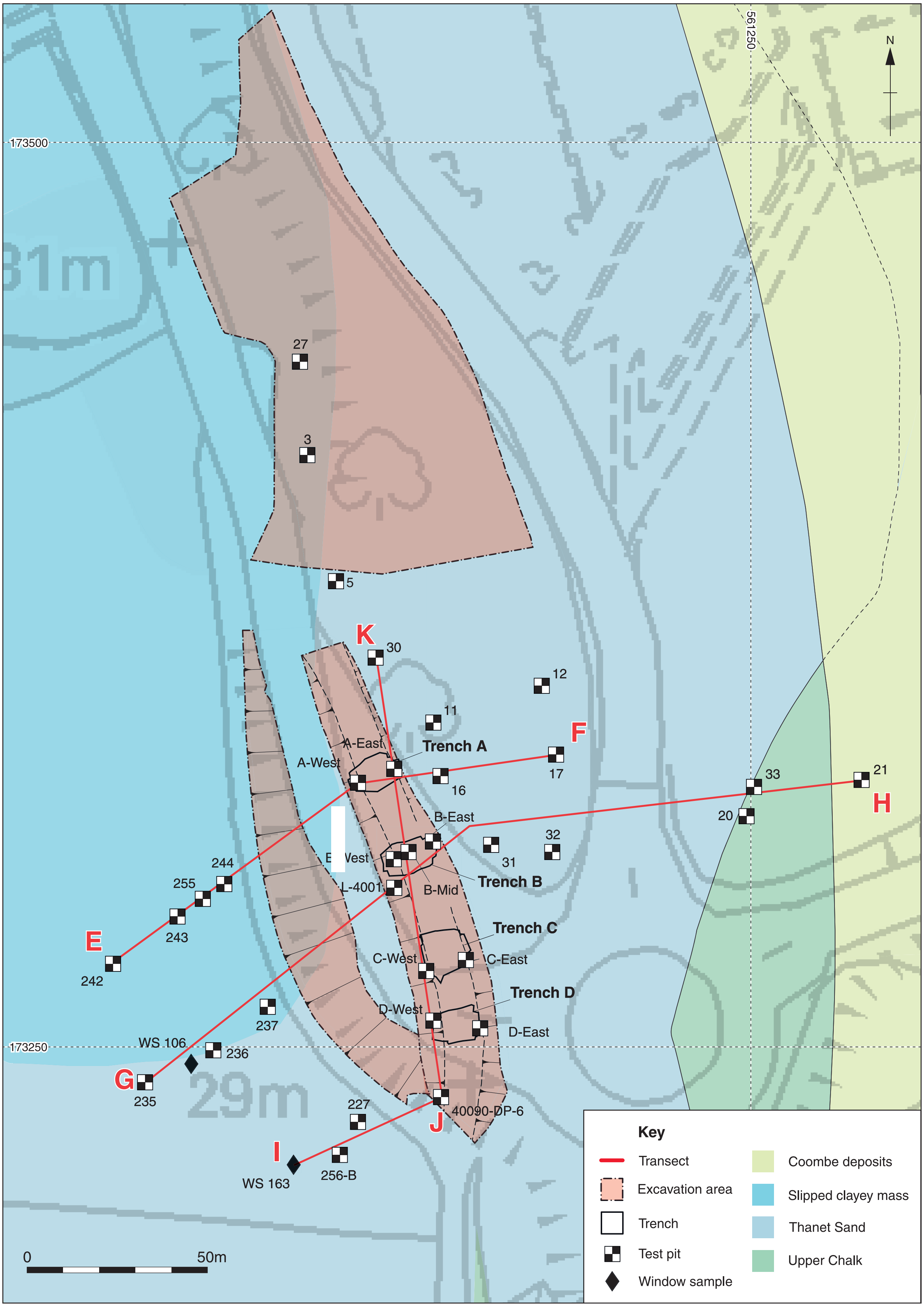

Figure 4.35 Location plan of area around the site, with key interventions from non-HS1 fieldwork and locations of representative Transects EF, GH and IJK

outcropping at the base of the southern end of the main east-facing section (Fig. 4.6).

At the eastern ends of both Transects EF and GH, the Phase 3 deposits were overlain by fine homogenous clayey silts, interpreted as standing lacustrine deposits prone to drying out. This is indicated by the clear polygonal cracking, preserved as an oxidised staining pattern (Fig. 4.37) and equivalent to Phase 4 of the site sequence. These deposits were only thinly present in TP 17 at the east end of Transect EF, but were well-developed and 2-3m thick in TPs 31 and 32, where they occurred between *c* 20 and 23m OD only 15m east of the site (Fig. 4.36b). The same distinctive ostracod fauna as was found in the Phase 3 deposits at the site and in TP 33 was recovered from the top of the Phase 4 deposits (3107) in TP 31 (Chapter 11). Pleistocene Mollusca were also present in context 3107, in the same horizon as the ostracod-bearing sample, including shells and opercula of *Bithynia tentaculata* (and possibly *B. troschelii*), *Valvata piscinalis* and *Pisidium nitidum* (RC

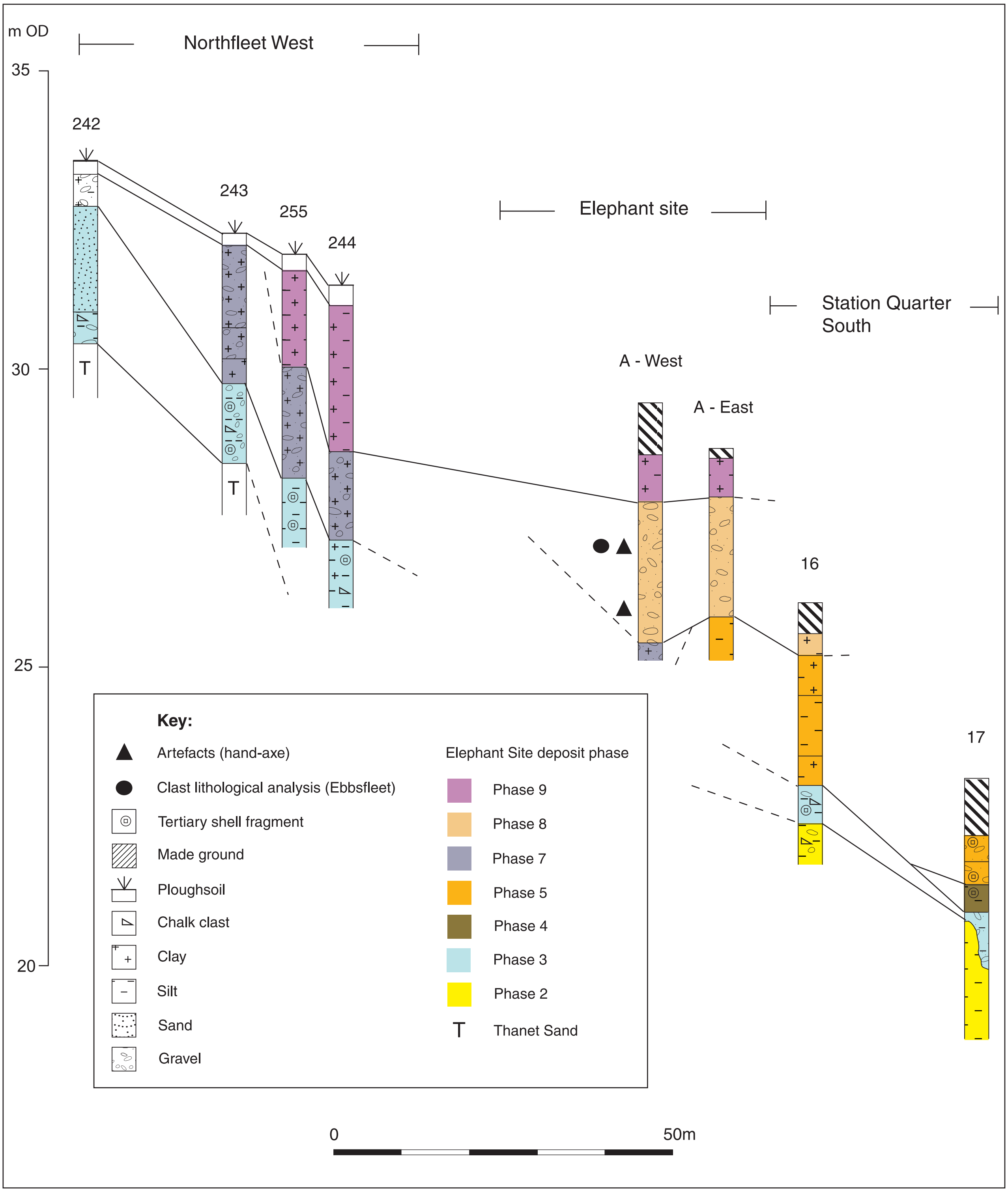

Figure 4.36 Lithostratigraphic transects in the vicinity of the site: (a) EF

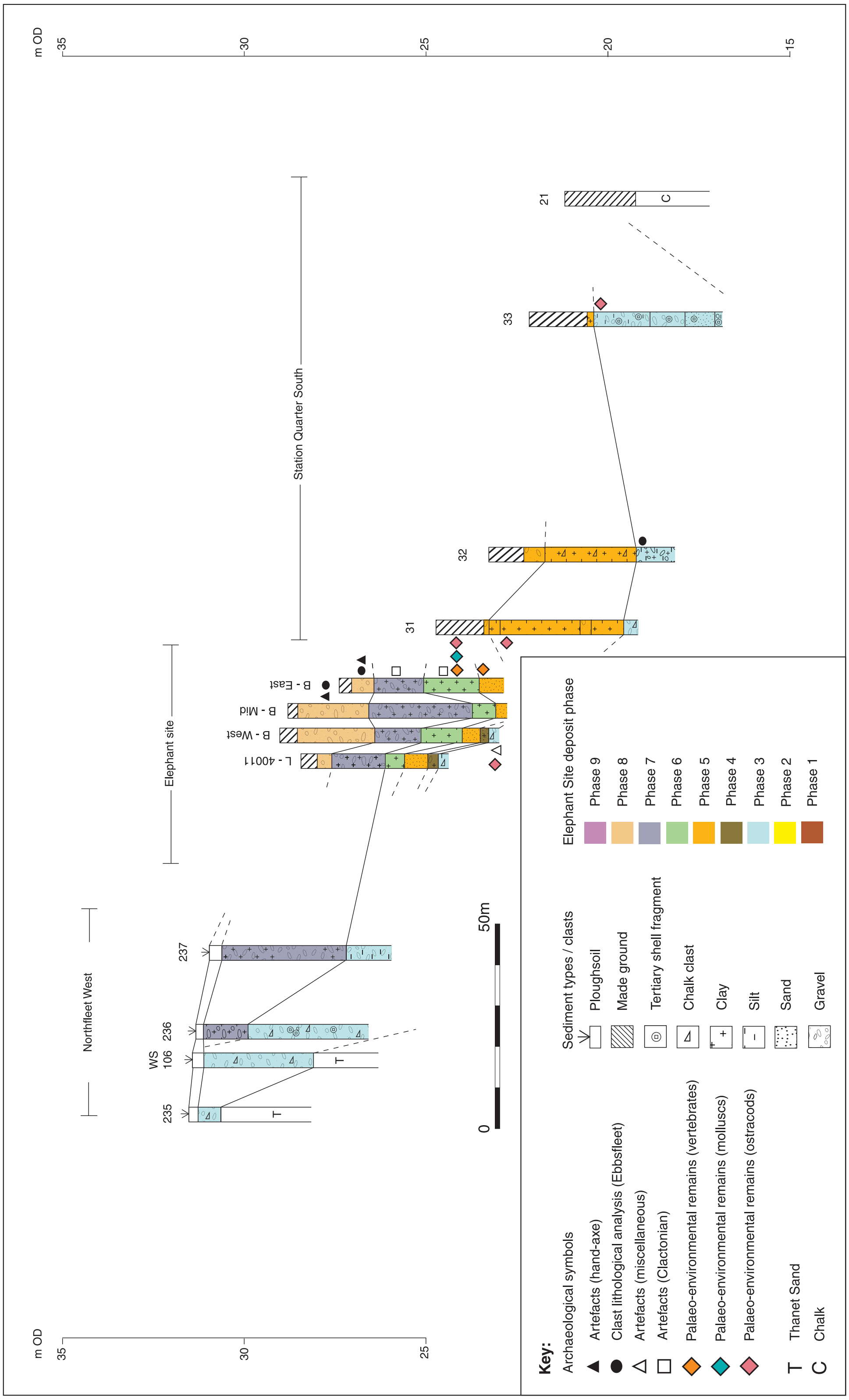

Figure 4.36 Lithostratigraphic transects in the vicinity of the site: (b) GH

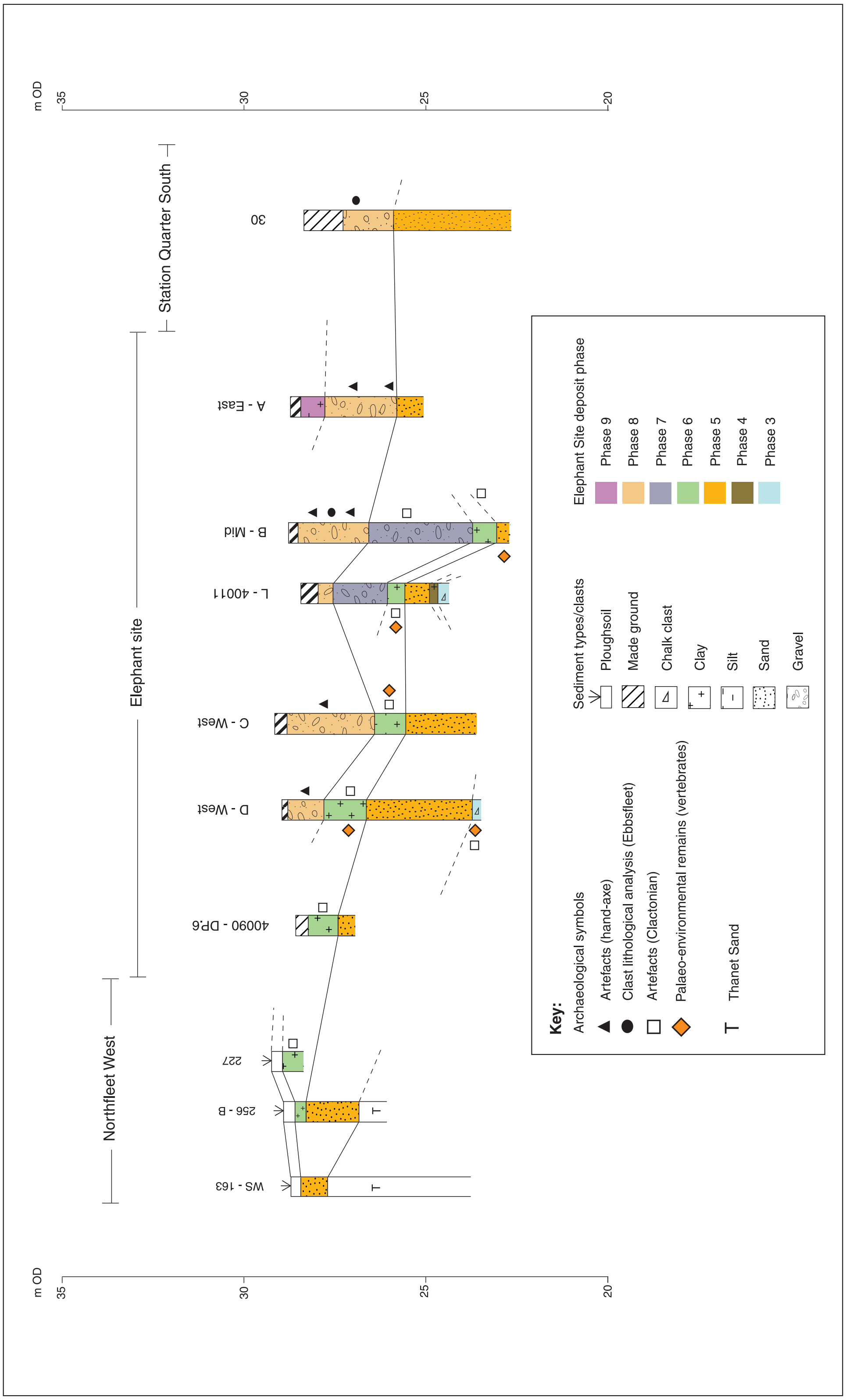

Figure 4.36 Lithostratigraphic transects in the vicinity of the site: (c) IJK

Figure 4.37 (right) Polygonal cracking indicative of desiccated lake-bed sediments (Phase 4) in Station Quarter South, Test Pit 32 [photo Francis Wenban-Smith]

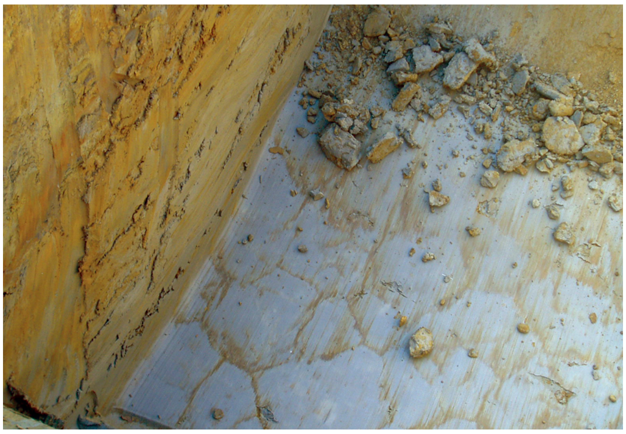

Figure 4.38 (below) Clactonian artefacts *in situ* at Northfleet West Sub-station TP 227: (a) find Δ.1, large flake 0.55m below ground surface; (b) close-up view find Δ.1, showing ventral features and cortical striking platform; (c) close-up view refitting finds Δ.4 and Δ.5, 0.85m below ground surface – note machine smear marks suggesting artefacts were not broken apart by machine bucket [photos Francis Wenban-Smith]

(a)

(b)

(c)

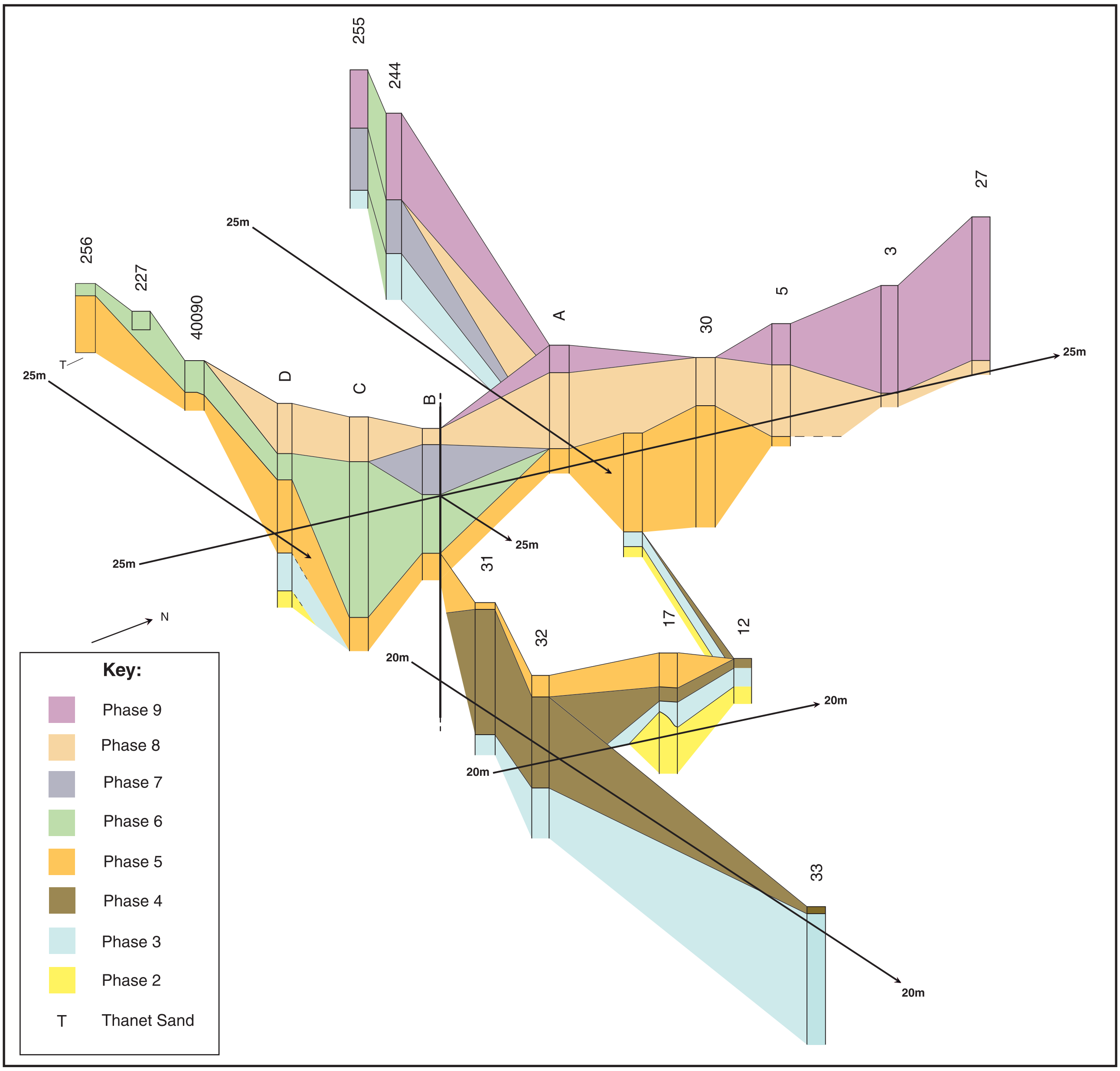

Figure 4.39 Fence diagram showing deposit phases at the site and in the vicinity

Preece, Appendix 3 in Wessex Archaeology 2006b) suggesting a low-energy freshwater habitat.

The Phase 4 sediments are overlain at the east end of Transects EF and GH by clay-laminated sands interpreted as equivalent to Phase 5 of the site sequence (Fig. 4.36a; b). These are mostly present as thin layers at the truncated top of the Pleistocene sequence, overlain by thick deposits of made-up ground, deposited during the HS1 groundworks of 2003-2004. However, thicker Phase 5 deposits were present in TP 16. It can be seen in TP 30 at the northern end of Transect IJK (Fig. 4.36c) that these persist as a well-developed body 2-3m thick immediately to the north and north-east of the site between *c* 23 and 26m OD. Here deposits of Phase 6 and Phase 7 are absent and the Phase 5 sediments are overlain directly by the Phase 8 fluvial gravels, which are in turn overlain by the Phase 9 brickearth. The northward continuation of the Phase 8 and 9 deposits, and their correlation with the Swanscombe 100-ft terrace deposits at Swan Valley School, Barnfield Pit and other deposits in Eastern Quarry Area B, is discussed further below.

To the south-west of the site, as seen in Transect IJK (Fig. 4.36c), the fluvial clay-laminated sands of Phase 5 were seen to wedge out directly onto Thanet Sand, and were overlain by a continuation of the Phase 6 clay. The base of this clay rose steadily from *c* 27.5m OD at the south-west edge of the site (Section 40090, DP.6) to *c* 28.5m OD at the Northfleet West TP 256-B, where it wedged out beneath the present-day plough-soil. This extension of the Phase 6 clay was, like its counterpoint at the south-west side of the site, still rich in mint condition flint artefacts, several of which were found close beneath the plough-soil in TP 227 (Fig. 4.38).

The relationships, geometry and phasing of deposits in the vicinity of the site, as discussed above, is here integrated with those at the site in a fence diagram (Fig. 4.39).

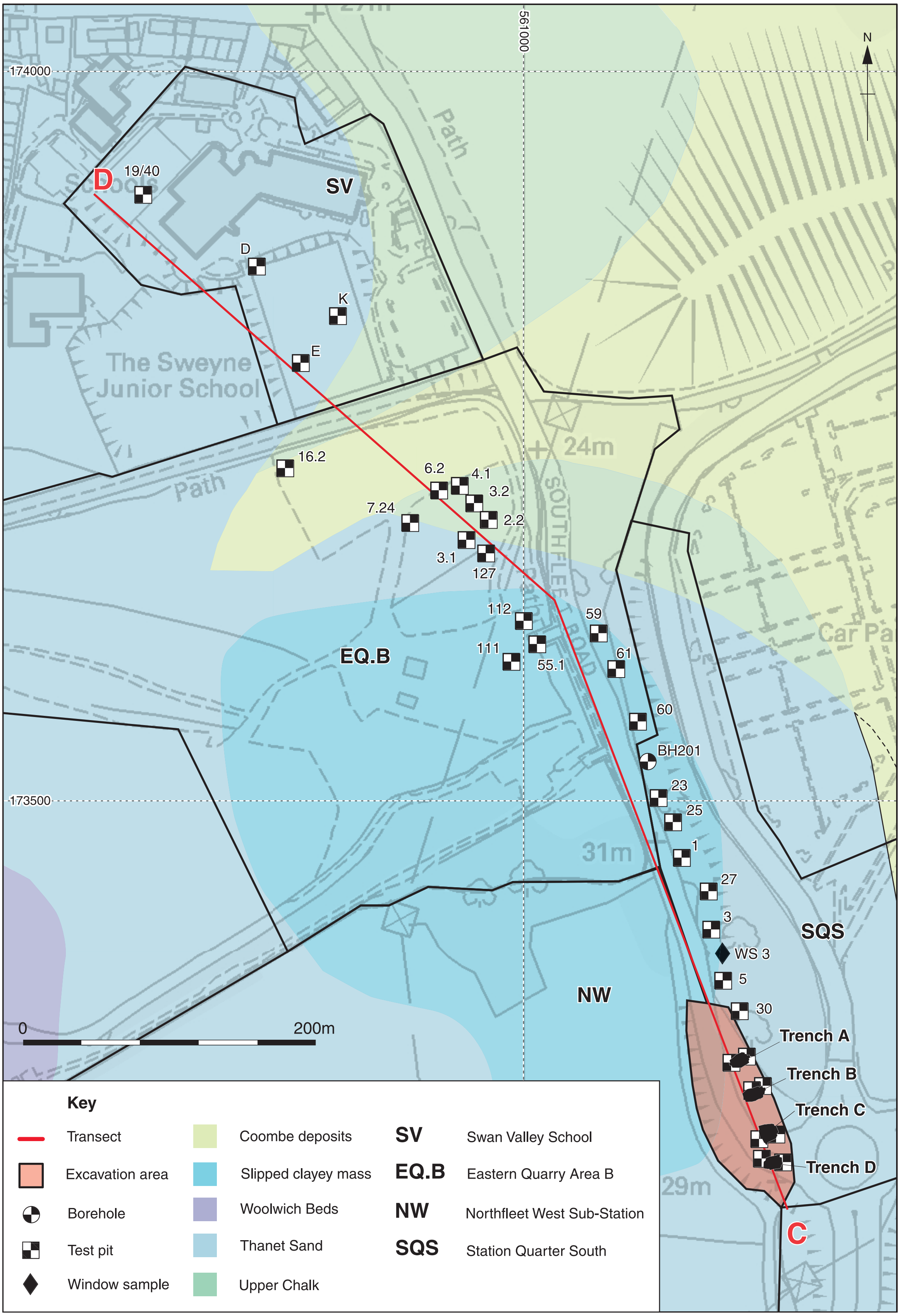

Figure 4.40 Location of north-south Transect CD, Pleistocene sequence between site and Swan Valley School, through Eastern Quarry Area B

As seen in Fig. 4.36c and in the stripped area exposed to the north of the site, deposits of Phases 5, 8 and 9 were seen to extend northward beyond the site. As mentioned previously (Chapter 3), deposits of Phase 9 had earlier been reported by Carreck (1972, 61) as extending several hundred metres further north from the site. There have been a large number of field investigations in various areas to the north and north-west of the site between 2004 and 2008 (Table 4.4; Fig. 4.1). This has provided a wealth of new data that allows correlations of these deposits to be extended northwards towards the proven outcrops of the Swanscombe 100-ft terrace sequence at Swan Valley School and Barnfield Pit. Furthermore, this new work has been accompanied by clast lithological analyses that make a significant addition to our understanding of the course of the Thames and the evolution of the palaeo-landscape during the period represented in these sequences.

From this wealth of new data, the sequences from a relatively small selection (n=26) of field investigations are presented here, distributed along a transect CD that runs broadly north-west from the site to the Swan Valley School, about 700m away (Fig. 4.40). In the southern half of this transect, the dominant deposit is the Phase 9 brickearth (ie Carreck's 'ferruginous loam') which can be traced as far north as TP 112 in Eastern Quarry Area B (Fig. 4.41). This deposit reaches as high as 30m OD in several places, with its base dipping eastward towards the axis of the palaeo-Ebbsfleet valley floor. It is mostly a very homogenous reddish-brown slightly sandy and clayey silt, but contains occasional sandier and fine gravel lenses, also dipping to the east, and more substantial gravel-rich beds as it progresses northward and in its more easterly downslope exposures. This geometry and sedimentology support the notion of the deposits as of colluvial/aeolian origin, although incorporation of a denatured estuarine alluvium perhaps cannot be ruled out. Although mostly lacking in archaeological contents, two mint condition handaxes were recovered *in situ* from this brickearth, including one particularly fine example from TP 25 in the Station Quarter South project area (Fig. 4.42). This find complements the handaxe and accompanying scatter of debitage recovered from the stripped brickearth bank at the west end of Transect 2, and raises the possibility that the Phase 9 brickearth may contain undisturbed, although sparsely distributed, artefactual remains.

The base of the brickearth is underlain along this stretch by a sharp junction with the top of a gravel deposit that is presumed to represent the northward continuation of the Phase 8 gravel. At the southern end of the transect, the gravel was seen at the north end of the site as *c* 2m thick and dipping northward. Further north, the full thickness of the gravel was likewise seen in TPs 30 and 5, where it continued the same northward dip. Between TP 5 and borehole BH 201, deposits thought to be the same gravel were only observable in the inaccessible bases of a series of deep test pits, where its top part was reached beneath deep brickearth deposits. Then, in borehole BH 201, a substantial gravel body was proved between *c* 22 and 25m OD, which continued the steady downward trend from the north end of the site. North of borehole BH 201, the surface of the gravel rises again, being present at 29m OD in the base of TP 112, in Eastern Quarry Area B. Clast lithological analysis of this gravel bed has established that at this point it remained an Ebbsfleet fluvial gravel (Chapter 6). No artefactual remains were recovered along this stretch of gravel. However this is not indicative of any absence of content, but merely reflects the fact that the gravel was unable to be investigated properly due to its inaccessibility, with only its top parts being exposed at the base of deep test pits.

At the north end of Transect CD, the sequences in the Swan Valley School identified and investigated in the late 1990s (in Trenches D, K and E) have been securely confirmed as containing deposits equivalent to the Lower Middle Gravel (and also, in places, the Upper Middle Gravel) of the Swanscombe 100-ft terrace Barnfield Pit sequence, on the basis of both clast lithological analysis and geomorphology (Wenban-Smith and Bridgland 2001). At the time of this work, part of its significance was extending the southern bank of the Thames of this time significantly further south than previously recognised. This work is now superseded by the new results presented here, which extend the southern valley-side bank even further south, well into Eastern Quarry Area B.

Just to the south of the Swan Valley School plot, TP 16.2 in Eastern Quarry Area B contained what is clearly a slightly further southerly extension of the same Lower Middle Gravel. This result is confirmed by clast lithological analysis and reinforced by its appropriate level above OD and its similar archaeological content, namely handaxes and debitage. TP 16.2 is about 150m to the north of TP 112, where, as discussed above, Ebbsfleet fluvial deposits interpreted as a continuation of the Phase 8 gravels at the elephant site are present at a very similar altitude. However, as discussed below, the situation in between these two locations is more complex, and less clear cut.

Immediately to the south of TP 16.2 there is a south-west to north-east trending dry valley that drops down into the Ebbsfleet valley, filled with last glacial and Holocene sediments. This has cut through and removed any earlier sediments and divides TP 16.2 from a cluster of test pits on its southern side, the sequences from several of which are presented here: TPs 2.2, 3.1, 3.2, 4.1, 6.2, 7.2 and 127 (Fig.4.40; Fig.4.41).

These test pits contain a plethora of sandy gravel deposits, fluvial in appearance and rich in artefactual remains, with recovery of numerous small pointed handaxes and debitage, the handaxes often being fairly crude, but sometimes very neatly made (Fig. 4.43). The deposits occur at a variety of levels, extending to an unknown depth below 23m OD in TP 3.2, and with their highest surface level being nearly 29m OD in TP 127. Clast lithological analysis at TPs 4.1 and 127 has firmly established that the gravels in these test pits are of Thames origin, providing a new maximum southern extent of the Boyn Hill/Orsett Heath formation as represented in the Swanscombe 100-ft terrace, very

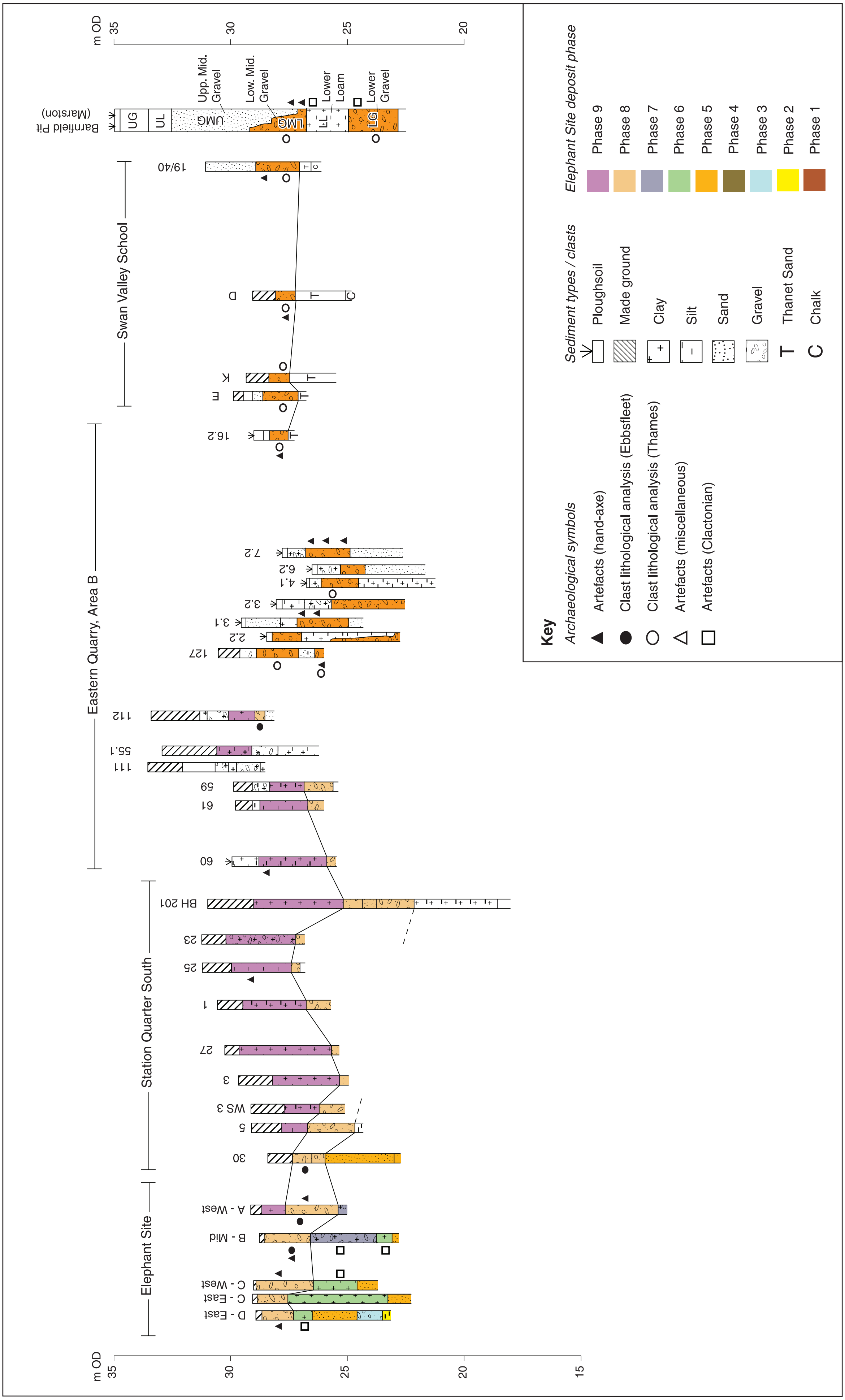

Figure 4.41 (a) North-south Transect CD, lithostratigraphy between the site and the Swanscombe 100-ft terrace at Swan Valley School

(a)

(b)

Figure 4.42 Handaxe from Station Quarter South, Test Pit 25 [photos Francis Wenban-Smith]: (a) as newly discovered in upper part of Phase 9 brickearth; (b) close-up view of handaxe – note imprint in sediment [fine divisions in cm on scale bar]

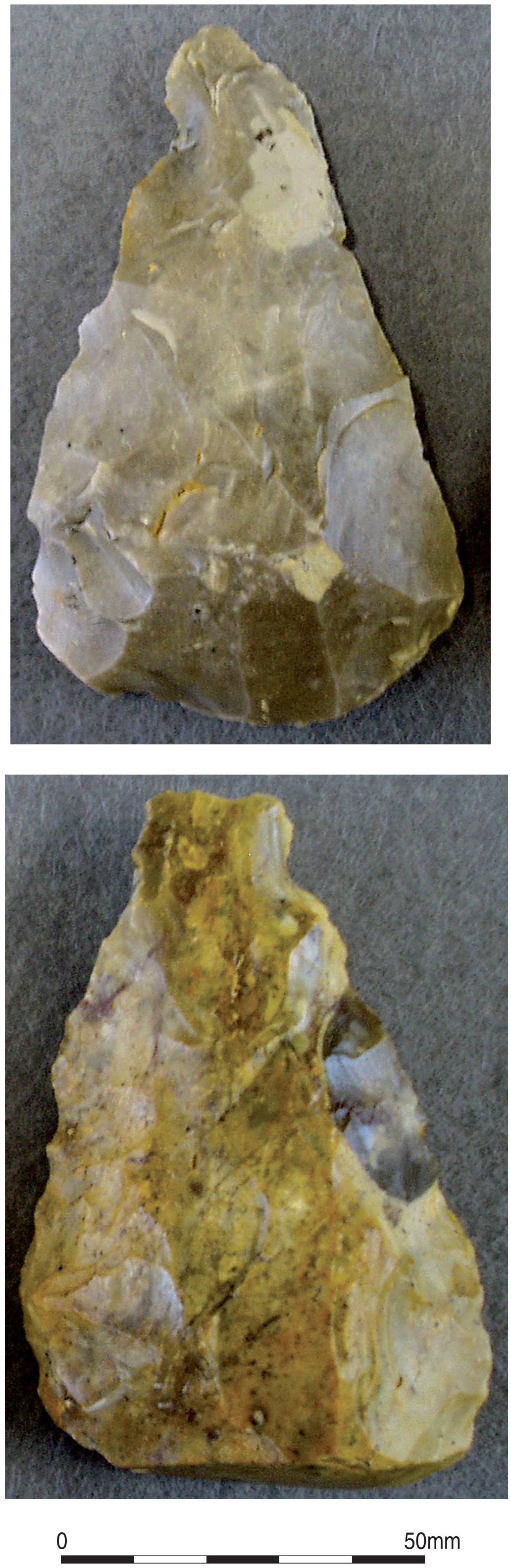

Figure 4.43 Handaxes from Eastern Quarry Area B, Test Pit 127

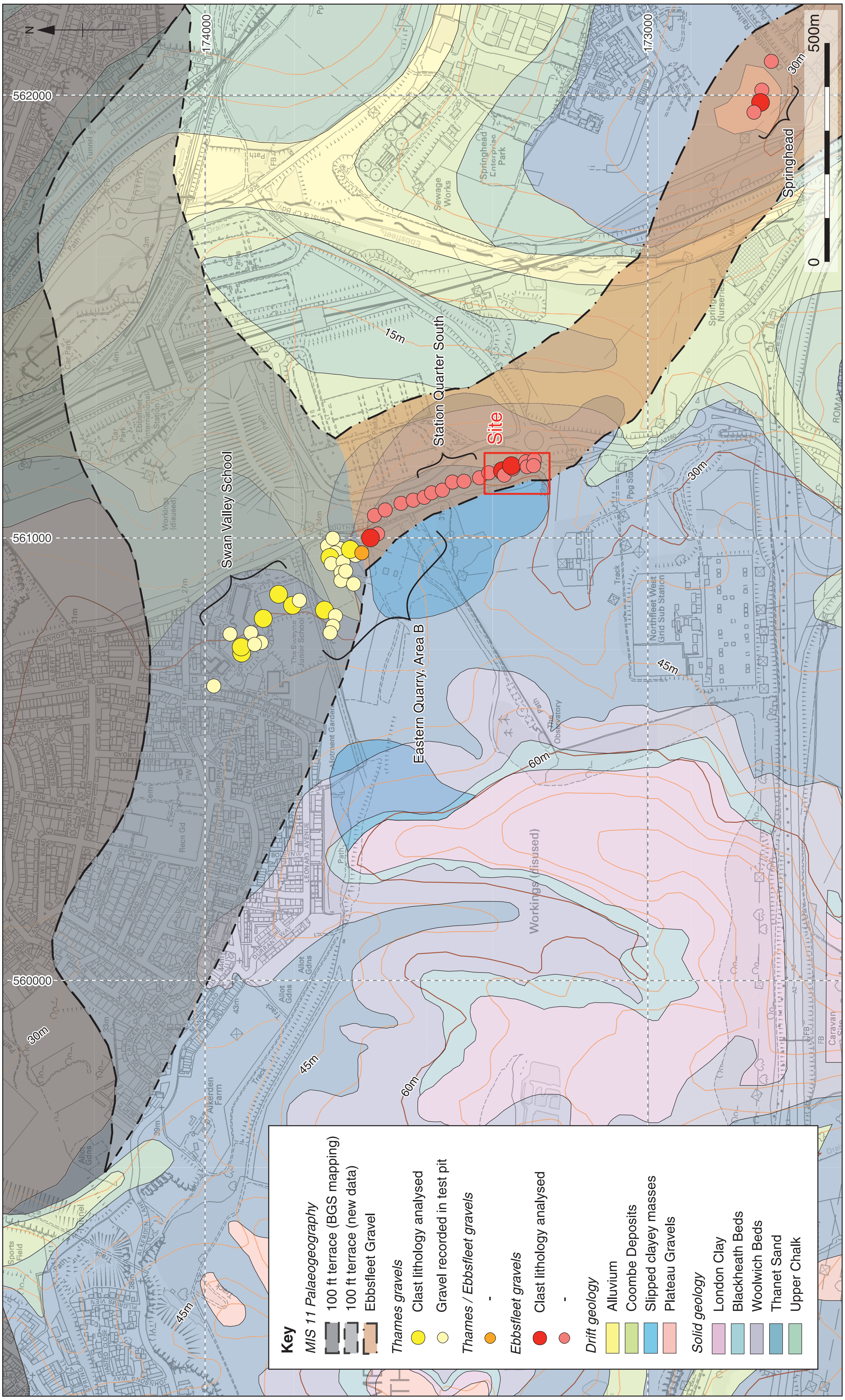

Figure 4.44 Revised palaeo-landscape model of Boyn Hill/Orsett Heath formation (Swanscombe 100-ft terrace outcrop, Phase II) and confluence with the contemporary palaeo-Ebbsfleet (Phase 8)

likely broadly equivalent to the Lower Middle Gravel of the Barnfield Pit sequence.

It was seen in most of these test pits that the base and surface of the gravel beds were not usually horizontal, but dipped in various directions. For example, its upper surface apparently dipped very steeply, declining by several metres to the west in TP 2.2, although it was unclear from the limited exposure whether this was a limited local deformation, caused for instance by underlying solution, or whether indicative of more widespread sediment geometry. This area seems to represent the point of confluence of the palaeo-Ebbsfleet of Phase 8 with the Thames of the Lower Middle Gravel, which would thus on purely geological grounds suggest an MIS II date for the Phase 8 fluvial gravel at the site. The uneven geometry of the gravel, and intervening finer-grain sand/silt beds, at this point is entirely consistent with disturbance relating to a tributary confluence, and with this locale being the furthest outer bend of a large loop of the Thames (Fig. 4.44). There is also, when attempting to interpret the apparent geomorphological geometry of these gravel deposits, the same problem to consider as in interpreting the complex sedimentological geometry at the site, namely: to what extent the present-day geometry represents the original Pleistocene internal position, or whether there have been substantive post-depositional disturbances/events that have altered the deposits, posing extra factors to take account of in their interpretation.

In general, it is suggested here that much of the present-day geometry of the deep Pleistocene sequences, both at the site and along Transect CD between the site and the Thames, has been affected by post-depositional downslope movement (towards the valley floor), and resultant compressional deformation, with possible additional effects from localised chalk solution and vertical collapse. Thus, although broad horizontal correlations remain tenable, particularly when supported by other lines of evidence (such as clast lithological analysis), we would question an undue reliance on more detailed correlation based on very specific altitudes relative to OD and/or interpretation based on apparent sedimentary structures observed in limited exposures, as previously discussed in this chapter.

GEOMORPHOLOGICAL EVOLUTION OF THE SITE LOCALITY

The history of local geomorphological evolution reflected in the sediments in and around the site, discussed above, forms but a small part of the overall geological evolution of the Ebbsfleet Valley from the Middle Pleistocene onwards and elements of this history remain difficult to determine. It is, however, clear that the sediments preserved at the site are the oldest relatively well-understood deposits in the valley and lie at elevations considerably above the recently investigated sequences of deposits associated with the Ebbsfleet International station and its associated works closer to the modern valley floor (Wenban-Smith *et al.* forthcoming).

The overall structure of the sediments, and their fluvial, lacustrine or colluvial origins, suggest that the site would have been close to the valley floor when most of them were deposited, at the foot of the slope of the valley side rising to the west. The contemporary valley side to the east is now missing as a result of the downcutting and eastward shift of the valley axis through subsequent periods of downcutting. The geometry of the sediments indicates progradation of many units from south to north. The associated sedimentological evidence from clast lithology indicates that all fluvial deposits at the site are essentially Ebbsfleet in origin continuing north towards a confluence with the Thames in Eastern Quarry Area B, now pinned down to a narrowly defined area between TPs 112 and 127 (Fig.4.41; Fig. 4.44; Chapter 6). Downcutting and erosion of the valley floor is only indicated with deposition of the final sequence of Pleistocene deposits associated with Phase 9 (the brickearths) that represent valley-side colluvial sequences in the main, perhaps with some aeolian input.

Leaving aside the mysterious earlier history associated with Phase 1 (the 'Tilted Block') and Phase 2 (the 'Primary Sump Infill'), the subsequent history of geomorphological evolution and sediment aggradation seems to reflect the site's position at the junction between valley-side and valley-floor, with alternating cycles of fluvial and colluvial/slopewash deposition. Phase 3 deposits higher up the western valley-side dip and thicken eastward, reflecting slopewash processes. Further east, in the lowest parts of the sequence seen at the site and, especially, in the cluster of Station Quarter South test pits to its east, they contain sand and gravel-rich beds suggesting moderately high energy fluvial deposition. Above this, prior to the deposition of the Phase 8 gravels, the history of landscape development and associated environments of deposition appear to be associated with lower energy water bodies in conjunction with periods of stagnation and drying-out, with variably intense overbank slopewash input.

Although water is implicated in many of the depositional processes associated with Phases 2 to 6, it is probable that deposition occurred in relatively localised bodies of water close to the valley margins at the foot of the valley side rising to the west. Thus local ponds receiving sediment from downslope wash as well as moving bodies of water are likely to have contributed sediments at times. Deltaic conditions have been indicated at times, especially in the well-developed clay-laminated sands of Phase 5, as well as water-edge conditions. However in all cases these are likely to be small-scale local features, probably reflecting minor topographic variations in valley-side fan and valley-floor ponding of water bodies. It is difficult to relate any of these depositional phases to climatic conditions on purely sedimentological grounds, for instance postulating fluvial gravel deposition as a cold/warming or warm/cooling process (cf. Bridgland 2001). Gravel (where present) might easily have been moved/deposited locally by short-lived spate events of little palaeoclimatic significance.

The environment of deposition of the main Phase 6 events associated with the faunal and archaeological remains also reflects this marginal situation between valley side foot and wetter environments on the floodplain. The fine sediments of many of the deposits in this phase clearly indicate deposition under very low energy fluvial, or stagnant marsh/lacustrine, conditions; perhaps in some form of small pond or lake, but where the sediment might have been introduced through downslope washing of sediment into the water body. Drying out of this body is attested to by the brecciation of sediments and various micromorphological features (Chapter 5), as well as the small-channel infilled by reworked tufa (Phase 6b).

After the phase of deposition associated with the Phase 6 sediments, an episode of landsliding occurred, associated with deposition of the major body of gravelly clays that extends upslope to the north-west. This indicates that the site was over-ridden by the toe-end of a major fan of deposits derived from Tertiary deposits capping the high ground to the west. It is suggested here that one possibility for the creation of the asymmetric synclinal 'skateboard ramp' structure between Trenches B and C might be lateral compression by this fan while in a saturated condition, which would have prevented the expected faulting. Other explanations for this structure include localised solution of the underlying Chalk bedrock along north-south joints and the local collapse of organic-rich Phase 6 sediments, although this latter explanation wouldn't address the conformable deformation of the deeper-lying sediments. The massive landslip of Phase 7, along with the nature of the sediments infilling the feature, may indicate that changing local conditions were taking place at this time. Alternatively, it may have been a more unpredictably catastrophic event triggered by an external factor, or by the reaching of an erosional tipping point in the evolutionary history of the local landscape. The Phase 7 sediments are predominantly clay with gravelly patches, although the basal Phase 7 sediments within the heart of the syncline are silts and fine sands (Fig. 4.8). These may be indicative of cold-climate conditions, and the possible inception of minor valley-floor incision at the transition from warm to cold conditions might have destabilised the slope sufficiently to encourage the mass movement of bodies of sediment downslope. The contemporaneous creation and infilling of the syncline would have resulted in conditions necessary for preservation of the feature.

The Phase 7 sediments are unconformably truncated by higher energy fluvial gravels (with sand bars reflecting quieter episodes) of the overlying Phase 8 sequence. Although such gravels are often regarded as reflecting a braided channel environment during cold climatic conditions, this is not necessarily the case. Both the Swanscombe Lower Gravel and Lower Middle Gravel, with the latter of which the Phase 8 gravels are putatively correlated, are both generally accepted as MIS 11 interglacial deposits (eg, Bridgland 1994). The presence of fluvial gravels at this point in the sequence is indicative that any downcutting associated with valley-side destabilisation would only have been of minor, local significance. The cessation of fluvial deposition was followed by the development of the thick sequence of valley-slope brickearths across the site; at this point the fluvial channel may have shifted east, and further downcutting occurred. While one might postulate that this is associated with significant climatic cooling, there is no direct sedimentary structural evidence of this, such as ice-wedge casts. Rather, climatic cooling is only implicit in off-stage downcutting, a small degree of which might be expected to be associated with deterioration of climate at the end of MIS 11 interglacial and the following cold stage MIS 10, followed by more pronounced downcutting at the start of the MIS 10-9-8 cycle associated with formation of the Lynch Hill/ Corbets Tey Formation (Bridgland 2006).