The Evolution of the Prehistoric Landscape beneath the London Cable Car

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Introduction and methods

Environmental archaeological investigations along the route of the London Cable Car (site code: CAC11) provided an opportunity to explore Holocene depositional environments and vegetation history on both sides of the river in this part of the Lower Thames Valley (Figure 1a). The Cable Car route spans Bugsby's Reach of the tidal River Thames between the North Greenwich 'peninsula' on the south bank and the Royal Victoria Dock on the north bank (National Grid References: from TQ 40111 80696 (north) to 39478 79745 (south). Geotechnical investigations (test pits, window samples, cable percussion boreholes and rotary boreholes) were carried out in five main areas, as follows: North Station (NS); North Intermediate Tower (NIT); North Tower (NT); South Tower (ST), and South Station (SS) (Figure 1b).

The cable percussion and rotary boreholes were monitored so that the sub-surface sediments could be mapped across the site, and significant sequences could be selected for detailed laboratory analysis. Two borehole core samples were retrieved, from the North Intermediate Tower (NT-BH03) and South Station (SS-BH1C) respectively. The sediment sequences were described in detail and sub-samples were extracted from organic-rich units for radiocarbon dating (calibrated using OxCal v4.1 and the IntCal09 atmospheric curve (Bronk Ramsey, 1995, 2001; Reimer *et al*., 2009). Biostratigraphic remains (pollen, diatoms, plant macrofossils (seeds and wood) and insects) were investigated in sub-samples from both boreholes using standard extraction and analysis procedures (Moore *et al*., 1991; Berglund, 1986; Batterbee, 2001; Hather, 2000; Cappers *et al.* 2006).

A note on the radiocarbon chronology

Radiocarbon dates SUERC-41294 and 41295 (Figure 3) are problematic results, possibly resulting from difficulties in coring the lower horizons of borehole NT-BH03 where there was incomplete recovery between -4.95 and -5.45m OD. There are also chronological inconsistencies in the SS-BH1C sequence; in this case SUERC-37825 is considered incorrect, whilst it is unclear whether SUERC-41291 or Beta-301232 is the most reliable date from the base of the sequence.

Geology, sedimentary sequences and geochronology

On both the north and south bank of the river, the site is mapped by the BGS as Alluvium overlain by Made Ground, and thus originally formed part of the natural floodplain of the Thames. Beneath the Alluvium, up to *ca*. 8m of sand and gravel (Shepperton Gravel) is recorded overlying London Clay (Gibbard, 1994). The new sedimentary records along the route of the Cable Car largely confirm this general sequence, with Shepperton Gravel succeeded by various Holocene mineral- and organic-rich deposits (Figure 2). However, in the area of the NIT, the sequence was entirely truncated during construction of the Western Dock Entrance. Here, records from the British Geological Survey borehole archive (NERC) have been used to reconstruct the sedimentary sequence.

The Shepperton Gravel which was deposited within a high-energy braided river environment during the Late Devensian, has an undulating surface. At the SS on the south bank, this surface lies at around -3.0m OD; on the margins of the Thames at the ST, it falls to between *ca*. -7.0 and -10.0m OD. On the opposite bank at the NT and NS, the Shepperton Gravel surface lies between *ca*. -5.0 and -7.5m OD. However, in the area of the NIT a small number of sequences and boreholes from the adjacent site of West Silvertown (Figure 1a, no. 2; Wilkinson *et al*., 2000) indicate a higher gravel surface, between -3.3 and -1.6m OD. These variations in the level of the surface of the Shepperton Gravel are consistent with observations elsewhere in the Thames valley. They indicate that at the beginning of the Holocene (the Early Mesolithic), the surface of the Shepperton Gravel forming the valley floor of the River Thames was characterised by gravel bars aligned approximately parallel with the valley axis and separated by low-water channels. The gravel bars are significant, archaeologically as they represent elevated points on the floodplain (eyots) where prehistoric activity may have taken place. The high points on the gravel surface at the Cable Car site are not as high as those upstream on the Bermondsey ayot and the Horseleydown ayot in Southwark (*ca*. +1m OD; e.g. Sidell *et al*., 2002; Leary *et al*., 2011) or those downstream in the area beneath the Royal Docks Community School (*ca*. +0.5m OD; Figure 1a, number 11; Holder 1998) where archaeological evidence for Mesolithic and Bronze Age activity has been recorded, probably indicative of seasonal exploitation.

However, the surface at the Cable Car site might lie on the western slope of the gravel 'high' recognised beneath the Royal Docks Community School.

The borehole records on both the south and north bank indicate that a variable sequence of mineral- and organic-rich deposits, including peat, overlie the Shepperton Gravel. The mineral-rich sediments are generally fine grained, representing the deposition of alluvium from standing or slow-moving water. In some places, e.g. towards the base of NT-BH03; (Figure 3), this alluvium contained varying quantities of organic detritus resulting from either long distance transportation or *in situ* deposition from plants growing within, or on the margins of an open water-body. Periods of peat formation are representative of the development of a semi-terrestrial land-surface, most likely occupied by fen vegetation; while varying organic matter content values during peat formation indicate a dynamic landscape subject to frequent episodes of flooding. These semi-terrestrial land-surfaces have archaeological significance, representing areas that might have been used by human groups; for example, Neolithic and Bronze Age trackway structures have been recorded in the peat at Fort Street (Figure 1a, no. 3; Wessex Archaeology, 2000) and Bellot Street (Figure 1a, no. 8 & 9; McLean, 1993; Philp, 1993; Branch *et al*., 2005). However, all these changes recorded in the sediment sequences represent evidence of significant spatial and temporal changes in the floodplain landscape, all of which would have impacted upon the potential activities of prehistoric people.

Sedimentation generally began in areas with a lower Shepperton Gravel surface, and migrated upwards and outwards. Thus, the earliest recorded Holocene sediment is in borehole NT-BH03 where accumulation began before 8000 cal BC (8800-8560 cal BC; Early Mesolithic) at a level slightly above -5.68m OD, and began later (sometime between 3940 and 3340 cal BC; Neolithic) in borehole SS-BH1C at the higher level of -3.01m OD. However, there are considerable local variations in the date and level at which Holocene sediment began to accumulate; for example in the nearby West Silvertown BH8 (Figure 1a no. 2; Figure 2; Wilkinson *et al*., 2000), accumulation began around 10,570-9820 cal BC at an elevation of -2.5m OD.

In borehole NT-BH03, two phases of peat formation took place; the first was short-lived, spanning 4900-4720 to 4830-4620 cal BC (Late Mesolithic), the second was longer spanning from 4340-4080 to 1110-920 cal BC (Early Neolithic to Late Bronze Age). This latter period of peat accumulation is comparable with SS-BH1C and other sites nearby such as Preston Road (Branch *et al*., 2007), Canning Town (Stafford *et al*., 2012), 118 Victoria Dock Road (Barnett *et al*., 2011), Prince Regent Lane (Stafford *et al*., 2012) and Greenwich Industrial Estate (Morley, 2003) (Figure 1a no.'s 4, 6, 7 & 10).

Overlying the peat in all sequences (where not truncated) was another unit of alluvium, consisting of well-sorted silt with some evidence of soil forming processes in its upper part and scattered finely-divided detrital plant remains generally present. It is everywhere overlain by Made Ground and has undoubtedly been truncated in some places.

Biostratigraphy

The majority of both NT-BH03 and SS-BH1C contained a high concentration of sub-fossil remains in a good state of preservation. This data, together with the sedimentary and geochronological records has permitted reconstruction of the environmental history (Figures 4 & 5) which is comparable to other investigations from this part of the Lower Thames Valley.

Mesolithic

Reconstruction of environmental history during the Mesolithic is based on the record from NT-BH03 only, as sedimentation did not commence until the Neolithic in SS-BH1C. The results indicate three significant changes in vegetation during this time (NT1-NT3; Figure 4). During NT1 (Early Mesolithic), sedge (Cyperaceae) and reed (Poaceae) swamp occupied the wetland area with lesser quantities of other herbaceous/aquatic plants (e.g. *Ranunculus* and *Sparganium*). Willow (*Salix*) increased over this period, followed by alder (*Alnus*) indicating their invasion of this wetland habitat. Pine (*Pinus*) and birch (*Betula*) occupied the surrounding dryland forming woodland typical of cold climatic conditions. This was later invaded by oak (*Quercus*), lime (*Tilia*), elm (*Ulmus*), ash (*Fraxinus*) and hazel (*Corylus*) reflective of a transition towards warmer conditions.

The transition to NT2 is characterised by a large expansion of pine woodland, reaching its peak sometime before 4900-4720 cal BC (Middle-Late Mesolithic). Oak, hazel, elm, lime and ash rapidly expanded within this pine woodland to form a mixed deciduous-coniferous community in <100 years that continued until 4340-4080 cal BC (Late Mesolithic). This new forest ecosystem developed on the dryland all along the Lower Thames Valley, forming excellent areas for human occupation during the Mesolithic/Neolithic cultural periods, with rich plant and animal resources, including hazel nuts and acorns, and probably *Cervus elaphus* (red deer) and *Bos primigenius* (auroch) (see Thomas & Rackham, 1996; Sidell *et al.,* 2002).

During this period peat temporarily formed on the wetland in the area of NT-BH03 during NT2 and was colonised by sedge and reed swamp, and alder-willow carr woodland. After 4830-4620 cal BC (during NT3), this peat surface was flooded. The combined occurrence of herbs such as thrift (*Armeria maritima* types A & B) and Chenopodiaceae (e.g. *Suaeda maritima* – annual seablite) together with high numbers of polyhalobous and mesohalobous diatom taxa, suggest an estuarine influence during this period of inundation. Despite this however, alder carr expanded on the wetland, perhaps on the margins of the river and in back swamps.

Palaeoenvironmental reconstructions in the Lower Thames Valley during the Mesolithic are fairly rare when compared to that from later cultural periods. This is due to the limited number of sites that accumulated alluvial/peat sediments over this time. The record from NT-BH03 is broadly consistent with these few records, but there are some significant differences in the chronology; most notably that of the peak in pine which is approximately 4000 years later than the Early Holocene age recorded at West Silvertown (between 10,570-9820 and 8810-8350 cal BC) and other sites such as Bramcote Green (Thomas and Rackham, 1996).

Neolithic

Reconstruction of the environmental history during the Neolithic comprises data from both NT-BH03 (NT4) and SS-BH1C (SS1 & SS2). In both sequences, this equates to the main period of Peat accumulation which commenced from *ca*. 4500 cal BC. During this cultural period, evidence from these two boreholes indicates that alder dominated fen carr occupied the peat surface, whilst mixed deciduous woodland grew on the dryland. However, this period incorporates three important events: (1) the decline of elm; (2) the colonisation and decline of yew (*Taxus*), and (3) an expansion of lime.

<u>The elm decline</u>

The NT-BH03 record indicates a decline in elm woodland from *ca.* 4340-4080 cal BC. This event, which is well-documented across the British Isles occurring broadly synchronously between approximately 4400 and 3350 cal BC (Parker *et al*., 2002), was arguably one of the most significant changes in woodland composition and structure during this time. Causal hypotheses for the decline have included climate change to cooler conditions (Smith, 1981), soil deterioration (Peglar & Birks, 1993) and competitive exclusion (Huntley & Birks, 1983), however the most favoured are human interference with natural vegetation (e.g. Scaife, 1988; Lamb & Thompson, 2005) and disease (e.g. Perry & Moore, 1987; Girling, 1988).

The argument for a human induced decline centres on the fact that the decline occurs around the transition from the Mesolithic to Neolithic and is often accompanied by pollen and/or insect evidence of temporary clearance for cultivation or animal husbandry (e.g. Girling & Grieg, 1985; Scaife, 1988). However, the evidence for a human caused decline is circumstantial with no definitive archaeological proof for the direct exploitation of elm (Garbett, 1981; Rasmussen, 1989a,b), and arguments that the human population at this time would have been too small to cause a long-term reduction in woodland (Moe & Rackham, 1992). The alternative argument for a disease caused decline has resulted from the discovery of the bark beetle *Scolytus scolytus* (which caused the present elm disease) at or near to a decline in elm in pollen in other records (e.g. Girling & Grieg; 1985; Girling, 1988; Batchelor *et al*., unpublished data). Further support for this hypothesis includes the discovery of microscopic anatomical features suggestive of disease in elm wood (Rasmussen & Christensen, 1997), and rapid, large-scale declines of elm in both recent and Middle Holocene pollen-stratigraphic records (Perry & Moore, 1987; Peglar & Birks, 1993).

More recently it is been argued that the decline was caused by the interaction of human activity and disease. Whether farming facilitated the spread of the disease by creating opportunities for its easier transmission through woodland, or whether disease created woodland glades suitable for cultivation, or pastoralism, may have varied spatially (Parker *et al*., 2002). The new record from NT-BH03 does not contain evidence of human activity or disease, and thus does not contribute further to the debate.

However, the decline does occur at the onset of peat formation, perhaps suggesting that local environmental changes on the wetland influenced the rate of its decline.

The colonisation and decline of yew

The pollen-stratigraphic records indicate that yew colonised the alder-dominated fen carr on the peat surface shortly after the decline of elm. Pollen values are low and no waterlogged wood was recorded, but several other sites have demonstrated the growth of this woodland community around this time along the Lower Thames Valley (e.g. Seel, 2001; Batchelor, 2009; Branch *et al.,* 2012). In particular, high concentrations of yew wood and pollen have been recorded at a number of sites in the Newham area (Batchelor *et al*. in prep). The recording of yew pollen in the vicinity of SS-BH1C however, represents a new find in this area of the floodplain. The growth of yew on peat has both palaeoecological and cultural significance.

Palaeoecology. The modern day ecology of yew is for dry and basic conditions such as chalk downland and limestone geology (Thomas & Polwart, 2003). Its occurrence on peat during the Middle Holocene is therefore somewhat surprising.
Culture. Yew is of great cultural significance and has been utilised from the Palaeolithic through to the modern day. The prehistoric importance of yew is demonstrated by its use in: (i) creating weapons and tools such as spears, swords, bows, knives and musical pipes (e.g. Clark, 1963; Coles *et al.*, 1978; Sheridan, 2005), and (ii) constructing trackways, platforms and boats (Coles & Hibbert, 1968; Coles *et al.*, 1978; Wright *et al.*, 1965, 2001).

Recent investigations (Batchelor, 2009, Branch *et al*., 2012; Batchelor *et al*, in prep) indicate that yew colonised and declined from the peat surface during the Late Neolithic (this frequent occurrence is therefore another reason why radiocarbon date SUERC-41291 in SS-BH1C is considered to be incorrect). These same investigations also indicate that a dry peat surface was almost certainly required to enable the growth of yew, however, more favourable climatic conditions, and human disturbance may also have had an influence. The decline of yew is most often often related to wetter peat surface conditions, consequent of rising relative sea level. It is also considered likely that human activity had a far greater influence on the decline of yew, than on its expansion; it is notable that the decline occurs at the transition from the Neolithic to Bronze Age. A return towards a more continental climate may also have contributed to the yew decline from the wetland.

Both new records from the Cable Car support the developing model. The initial expansion of yew occurred at a time when the other lithostratigraphic and bioarchaeological records indicate a drier surface conditions, and a more mature fen woodland community. Similarly, a decline in organic matter content contemporaneous with the fall in *Taxus* pollen values suggests increased inundation may have led to the departure of yew from the floodplain surface. There are no indicators to suggest that human activity may have caused the decline of yew at either site.

The expansion of lime

An unusual feature of both the new pollen-stratigraphic diagrams is the increase of *Tilia* (lime) percentage values towards the top of NT4 (2850-2470 cal BC) and SS1 (3940-3660 cal BC). Unlike most arboreal taxa, the pollen from lime is entomophilous (insect pollinated), and thus does not travel far from source. Therefore the high concentrations of lime suggest that it was growing nearby on areas of dryland at these times.

Bronze Age

It is difficult to establish the precise environmental history during the Bronze Age due to a combination of poor pollen concentration and chronological uncertainties. However, in both boreholes alder dominated fen carr began to decline from the wetland, and in borehole SS-BH1C was replaced by vegetation indicative of wetter conditions and estuarine inundation. The transition to these zones is also marked by a decrease in dryland woodland pollen taxa (e.g. *Quercus* and *Tilia*) and the occurrence of an array of herbaceous pollen taxa, probably (at least in part) indicative of Bronze Age land clearance for settlement and/or farming purposes. The occurrence of alder and ash charcoal at the boundary into SS3 may also indicate an anthropogenic influence on the peat surface sometime before 1440-1220 cal BC. Definitive archaeological evidence for human activity on the peat surface during the Bronze Age is also recorded at a number of local sites in the form of wooden trackways.

The contemporaneous decline of woodland on both the wetland and dryland is striking and suggests a strong link between the two environments and possible causes. Indeed, it is considered probable that the increased rate of relative sea level (RSL) rise that brought about environmental change on the floodplain, also contributed to the decline of mixed deciduous woodland on the dryland in two different ways. Firstly, RSL rise may have caused the expansion of wetland onto areas of former dryland, and/or the saturation of dryland soils. This would have caused the retreat of dryland woodland away from the sampling point. Secondly, the wetter conditions and estuarine inundation that caused the eventual abandonment of the wetland by Bronze Age people, most likely led to the concentration of anthropogenic activity (and thus clearance) on the neighbouring dryland edge. There seems little doubt that these RSL driven processes could have influenced the rate of woodland decline on the dryland; however, the precise temporal and spatial relationships between RSL change, soil deterioration, human activity and dryland woodland decline remain very difficult to measure.

Conclusions

The investigations along the cable car route have revealed variation in the thickness of alluvial and peat deposits overlying an undulating gravel surface. However at both locations both fine-coarse grained mineral-rich deposits and peat are recorded overlying sands and gravel of the Shepperton Gravel. Transitions between these units represent significant changes in landscape from alluvial/estuarine to semi-terrestrial environments. Collectively, the sedimentary sequences from the two core sequences analysed represent deposition between the Early Mesolithic and Bronze Age cultural periods. During this time, the biostratigraphic records indicate the a transition from birch and pine woodland growing under cold climatic conditions to the growth of mixed deciduous woodland on the dryland and alder fen carr on the floodplain during the later Mesolithic and Neolithic, before a decline during the Bronze Age in response to relative sea level change and woodland clearance for settlement and agricultural purposes.

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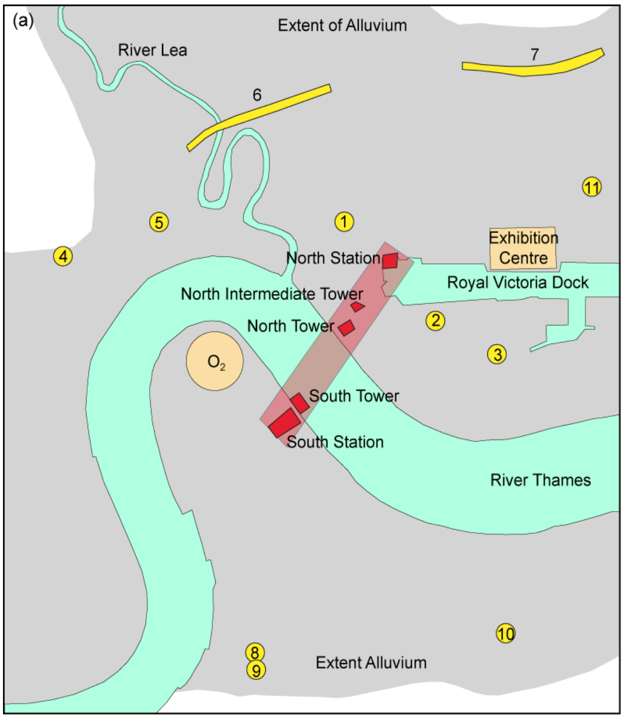

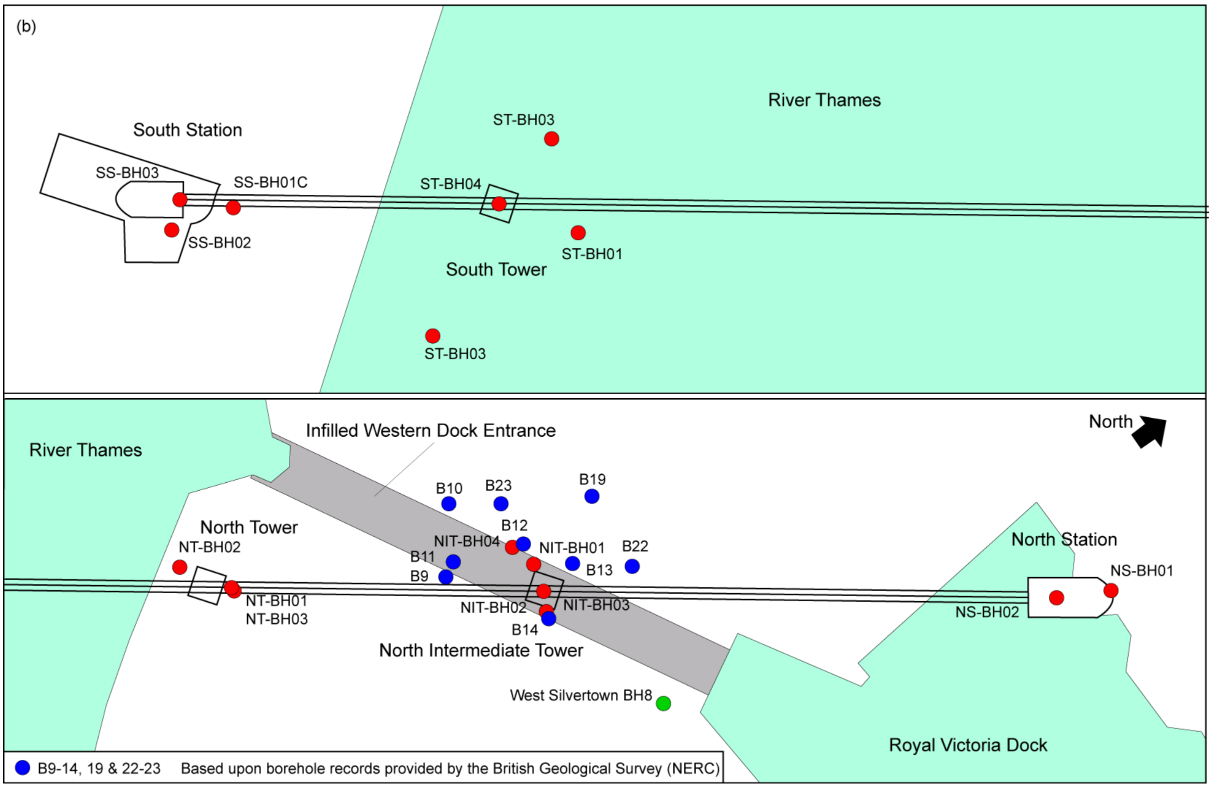

Figure 1: (a) Location of the Cable Car route and other nearby sites of interest; (b) Location of boreholes at the: (A) North Station; (B) North Intermediate Tower; (C) North Tower; (D) South Tower; (E) South Station

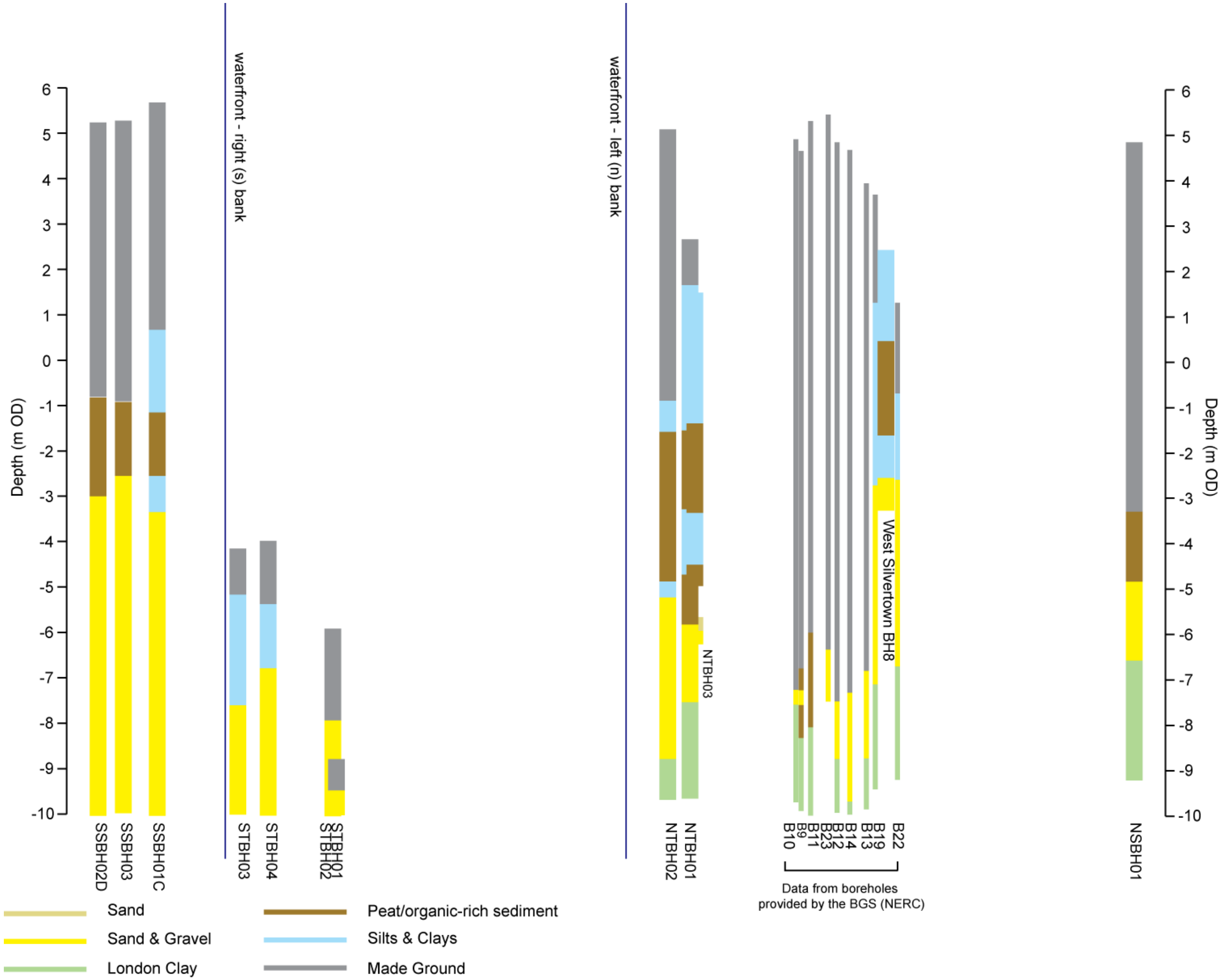

Figure 2: Transect of selected sedimentary logs across the Cable Car route

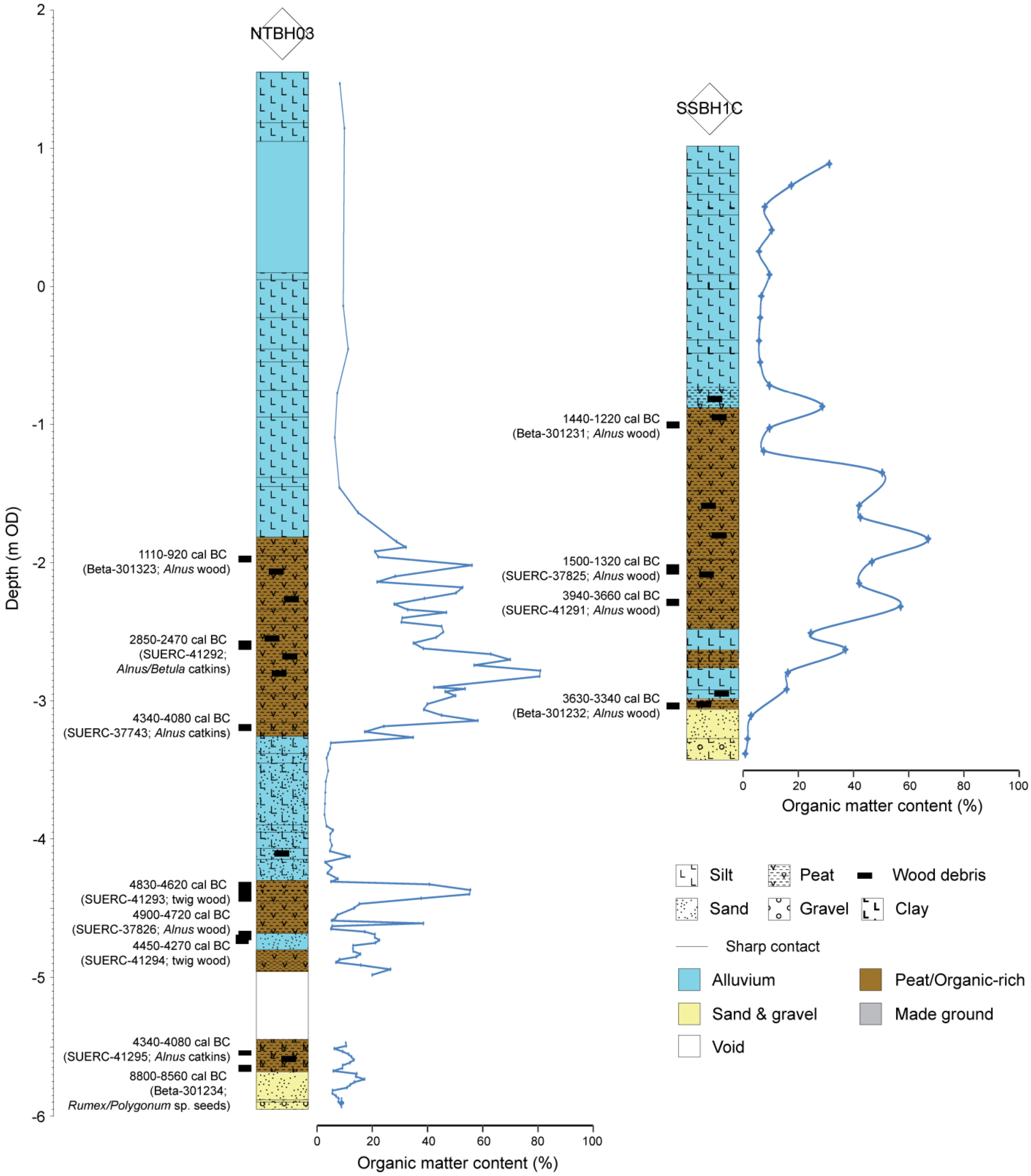

Figure 3: North Intermediate Tower and South Station detailed sedimentary records and radiocarbon dates

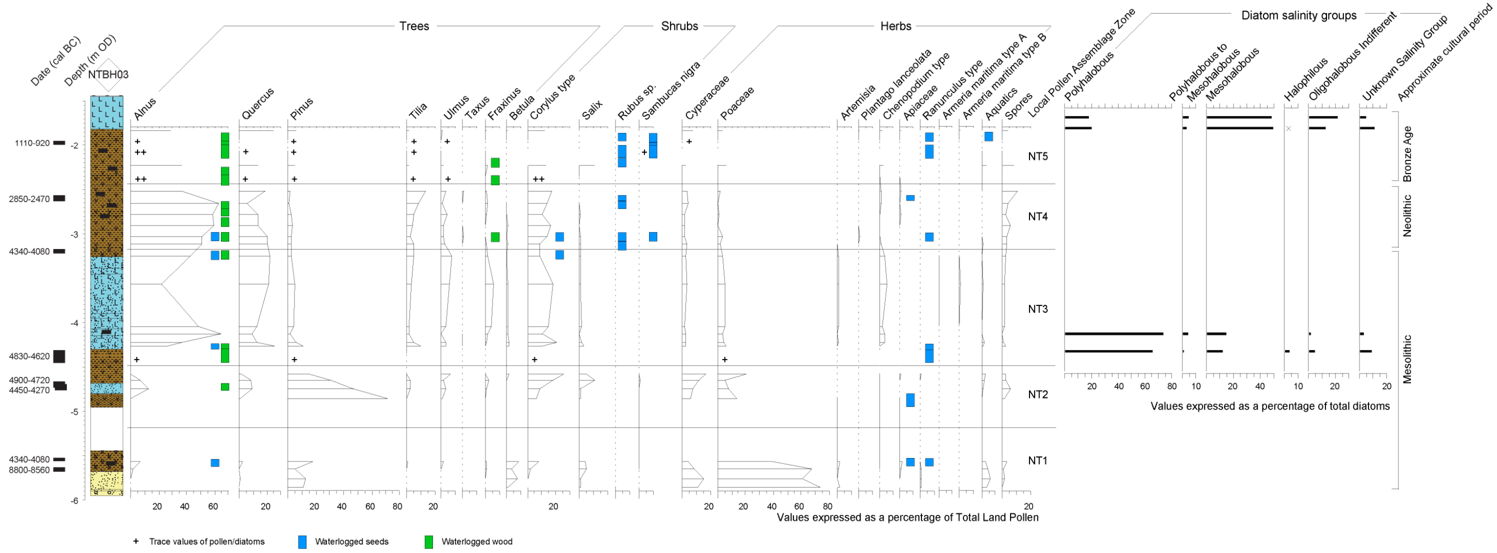

Figure 4: North Intermediate Tower summary biostratigraphic diagram

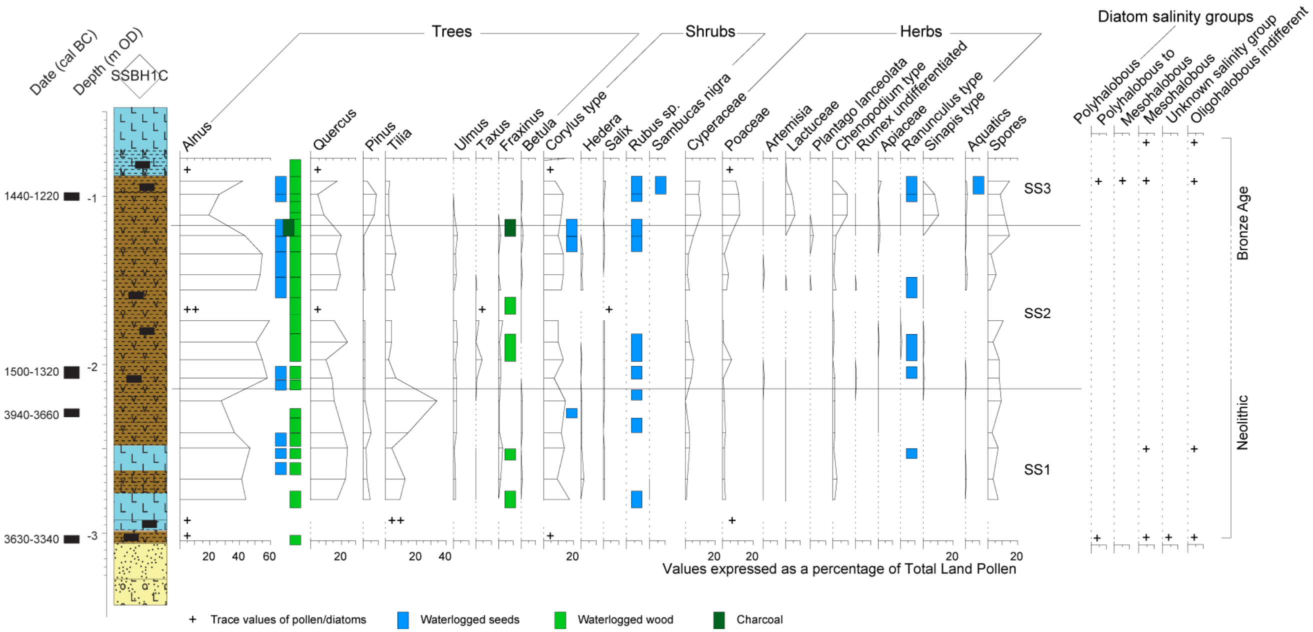

Figure 5: South Station summary biostratigraphic diagram