Living with a changing river and desert landscape at Amara West

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NUBIA IN THE NEW KINGDOM

Lived experience, pharaonic control and indigenous traditions

edited by

Neal SPENCER, Anna STEVENS and Michaela BINDER
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LIVING WITH A CHANGING RIVER AND DESERT LANDSCAPE AT AMARA WEST

Jamie Woodward, Mark Macklin, Neal Spencer, Michaela Binder, Matthew Dalton, Sophie Hay and Andrew Hardy

Abstract

The arid environment and lack of modern development around Amara West has preserved distinctive and high-resolution records of changing Holocene river behaviour, both in a palaeochannel immediately adjacent to the town, and in one 2km further north. Combining optically stimulated luminescence and 14C dating, alongside investigation of channel morphology and reach-scale flood inundation simulation, a chronological framework for the dynamic riverine environment in this part of the Nile Valley is reconstructed for the 2nd and 1st millennia BC. The palaeogeographical setting of Amara West changed dramatically and rapidly after the founding of the town as channels dried out and the riparian zone contracted. Evidence from excavations in the town and cemeteries, alongside micromorphological analyses of sedimentary deposits from the settlement and bioarchaeological study of the human remains, is deployed to explore how the ancient inhabitants experienced, and sought to mitigate the effects of, these environmental challenges.

* * *

Pharaonic Egypt conquered Upper Nubia, the area between the Second and Third Nile Cataracts, around 1500 BC, ushering in a period of colonial rule that lasted until around 1070 BC (Smith 2003, 83–96). In the reign of Seti I (c. 1306–1290 BC), a new town was founded at Amara West downstream of the Third Cataract, with a town wall enclosing a cult temple, a Residence of the Deputy of Kush, large-scale storage facilities and a number of houses. An ongoing British Museum research project has revealed how the nature of the town changed across the ensuing 200 years of occupation, with small-scale dwellings replacing many of the formal buildings, the creation of extramural housing areas and developments in the range of material culture found within the town, perhaps suggesting an increasing prevalence of individual or household agency over state planning (N. Spencer 2014a; 2014b; N. Spencer, Stevens and Binder 2014; N. Spencer 2015; and papers in this volume: Dalton, N. Spencer, Stevens, Vandenbeusch).

The end of occupation at the site has typically been associated with Egypt’s retreat from Kush at the end of the New Kingdom, around 1100–1070 BC (P. Spencer 1997, 220–1), with ‘later inhabitants’ facing increasing inputs of windborne sand (Alexander 1998, 250). However, renewed excavations in the cemeteries have revealed their use for burials into at least the 8th century BC (Binder 2014a) and ceramics of this date have been noted across the southern area of the town. It remains challenging to identify architecture post-dating the New Kingdom within the urban area, though a series of dry stone walls reveal the original presence of substantial structures along the southern and western edges of the town mound; these remain to be investigated and their date is currently unknown. Northerly winds, and the sand they carry, have resulted in severe deflation of deposits, and truncation of architectural phases, across the town mound. In some places this truncation has been exacerbated, and deposits disturbed, by digging of mud-brick material for re-use in agriculture or new building projects, whether in ancient or more recent times.

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1 The enclosure wall includes bricks stamped with the name of Seti I (P. Spencer 1997, 15–17, pl. 8).
The current Amara West research project foregrounds the investigation of lived experience, necessitating the creation of an environmental framework for the ancient town, through faunal and botanical studies, but also a consideration of the ancient riverine landscape of multiple channels and islands within which the new town was located. The opportunity to export samples from Sudan for laboratory analyses, alongside the excellent preservation of architecture, sedimentary deposits and skeletal remains, offers the potential to situate the study of environmental change in the past relative to the experiences of those who lived through it. Such an approach has not been previously deployed for an ancient Nile Valley settlement. This paper thus combines data that establish a chronological framework and topography for the ancient river channels north of the town, geoarchaeological and environmental data from the town itself and information obtained from the study of skeletal remains, not only to document an increasingly hostile environment, but also to elucidate how this affected lived experience and prompted measures and responses to mitigate these challenges.

The local environment

In Northern Sudan, immediately downstream of Sai Island, the Nile turns eastward at Abri and flows in that direction for almost 20km. Amara West is located in this reach — on the left bank of the modern river — just downstream of Ernetta Island (Fig. 1; see also N. Spencer, this volume, fig. 1). This configuration is important because the prevailing northerly winds transport large amounts of sand towards the Nile, resulting in the left bank of this west–east reach being flanked by a steeply inclined ramp of riparian dunes (Fig. 2), clearly marked as ‘Sand Hills’ on the map of 1886 (see Fig. 1). These orange dunes, colonised by a variety of plants including tamarisk and acacia, commonly exceed 15m in height,2 and form a prominent topographic barrier along the channel margin (Figs 3–4). On the steeper, southern side of the dunes, orange sands cascade down to the modern river. Exposures in the bank reveal stacked sequences of distinctive orange sands alternating with grey Nile silts (Fig. 5): a graphic illustration of a much longer history of interaction between desert and river in this reach. The ancient settlement of Amara West lies immediately to the north of the riparian dunes, with a well-preserved palaeochannel on the other side (north) of the walled town (Figs 2, 6). This is the Amara West palaeochannel. A wider and longer channel — the Northern palaeochannel — lies further to the north, beyond the escarpment and cemeteries, approximately 2km from the modern Nile (see Fig. 2). The riparian dune complex is an important component of the modern landscape in which Amara West now lies: one can no longer see the Nile from the town because the line of sight is blocked by the highest parts of these dunes (see Figs 3–4).

A key aim of the geomorphological research in the vicinity of Amara West is to build a robust chronological framework for the history of this complex of channels and islands, and particularly to establish when the channels to the north of the town mound ceased to flow permanently. Once these river channels dried out, the most effective obstacle to the transport of wind-blown sand into the town from the north would have been removed. It is notable that modern settlements in this sector of the Nile Valley are located on the south bank of the river, or on islands such as Ernetta, where they are sheltered from the worst effects of blown sand from the north. Satellite imagery shows very clearly this marked contrast in the present-day landscape north and south of the river (see Fig. 6): the former landscape is blanketed by windblown sand whilst ephemeral wadi channel networks dominate the latter. The archaeobotanical evidence indicates that the inhabitants of Amara West had access, presumably in the immediate environs, to sycomore fig, acacia, tamarisk, dom palm, sedges and rushes, alongside a range of cultivars, for example emmer, barley, lentils and legumes (Ryan, Cartwright and N. Spencer 2012). This evidence suggests a more diverse and verdant environment than present-day Amara West.

Building upon an independently dated record of river channel change, detailed below, it is possible to establish the environmental setting of this reach of

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2 One dune top was measured as 15.9m above the Nile water surface level in February 2015.
Fig. 1: Detail from a map showing the location of sand hills along the northern (left) bank of the Nile near Amara West (located opposite the village labelled ‘Amara’). Created from surveys undertaken by John Charles Ardagh between 4th and 6th January 1886. Sudan Archaeological Research Society archive.
the Nile during the New Kingdom, particularly during the founding and abandonment of the town site of Amara West. This investigation of local and regional landscape dynamics is framed by the following questions:

- Was the town of Amara West founded on an island and how many channels in the immediate hinterland were active at this time?
- When did flow in these channels cease to be permanent and when did the dunes that border the modern Nile begin to form?
- Could the abandonment of the town have been related to the failure of these channels and attendant changes to living conditions, and what does the sedimentary record in the town tell us about local and regional landscape change?
- To what extent does the steep modern river bank flanked by vegetated dunes provide a useful analogue for the northern (left) banks of the two palaeochannels when they conveyed permanent flows?
- How do these records of landscape change compare to evidence from elsewhere on the Holocene desert Nile?
Fig. 3: Left bank of the Nile near Amara West, showing riparian sand dunes with associated vegetation.

Fig. 4: View west across riparian sand dunes adjacent to Amara West.

Fig. 5: A section in the modern river bank of the Nile immediately south of Amara West showing layers of orange dune sand intercalated with silts from Nile floods.
Reconstructing the ancient environment

Observations regarding the changing Nile environment in the vicinity of Amara West have long been put forth. H. W. Fairman, director of the Egypt Exploration Society (EES) excavations at Amara West in the late 1930s, noted that the Pharaonic town seemed to have been founded upon an island (P. Spencer 1997, 1), while a series of maps published as part of a survey of this region (Vila 1977, 15–18) record a spread of archaeological sites flanking the Northern palaeochannel 2km away from Amara West, beyond the desert escarpment (see also Fig. 2; and Stevens and Garnett, this volume).

New technologies allow for a more in-depth investigation of the subject. Combining information from topographic data (digital elevation modelling and field survey) and satellite imagery, alongside geophysical survey and flood inundation simulations, it has been possible to create an accurate model for the location and form of these river channels and islands (see Fig. 6). The excavation of sondages (see Fig. 2) within the deposits preserved in the two main palaeochannel systems themselves provided further information on channel sedimentation processes and, of course, the opportunity to extract samples for dating to allow us to construct a chronological framework for key shifts in river channel behaviour and flood frequency in antiquity.

Mapping the palaeochannels and flood inundation modelling

Simulations of floodwater inundation were carried out so as to define the nature and extent of the palaeochannel and palaeoisland network in this part of the Nile Valley. This exercise involved use of a Digital Elevation Model (DEM; derived from the Shuttle Radar Topography Mission, SRTM-2) — with a spatial resolution of 90m — and the hydraulic model HEC-RAS developed by the U.S. Corps of Engineers. The main control on the inundation simulations is the topography of the valley floor. The inundation model uses steady-state simulations of recorded river discharges. First, the mean historical (1912–84) measured discharge of 2,621 m³ s⁻¹ was modelled to ensure that the predicted inundation remained within the perennially occupied channel zone. Second, a steady-state simulation of flood inundation was made using the
The GPR survey was conducted using a GSSI SIR-3000 system with 400 MHz antenna mounted on a cart system with an odometer. Data were collected in transects spanning the width of the palaeochannels at 0.5 m intervals; the information was then visualised as vertical profiles that highlight, in section, the depth, shape and form of the palaeochannels. For the Amara West palaeochannel, a total of twenty-one traverses were recorded with varying lengths between 149 m and 157 m. In the Northern palaeochannel, a total of twenty transects, each 132 m in length, were recorded.
revealed the geometry of the palaeochannel banks and also the interface between vertically — and laterally — stacked fluvial sedimentary units in the subsurface (Fig. 8); all of the features recognised in the GPR data have been observed in section. These GPR reflections are thought to occur at the interface between markedly contrasting deposits in the subsurface. Based on the observed stratigraphic evidence in the 2011 and 2013 pits dug into the Amara West palaeochannel immediately surrounding the town, it is highly likely these horizons mark the boundaries between the distinctive alternating coarse sands and fine-grained silty-clay flood deposits (N. Spencer, Macklin and Woodward 2012, 38, fig. 19) we describe more fully below. The numerous reflections observed at different depths and positions in all of the radargrams indicate the width of the Amara West palaeochannel at certain times in its history, potentially around 65m wide at its greatest extent, narrowing to 30m over time. To the east of the settlement, further downstream on the same channel, the GPR transects also reveal a channel width of up to 65m.

There is a strong correlation between modern topographic breaks in slope and the margins of the ancient river channels. The left (north) bank of the Amara West palaeochannel shows a very steep vertical bank not dis-
similar to the left bank of the modern Nile. In places, the Amara West channel displays an asymmetrical form, and there is clear evidence for a more gently sloping channel margin on the town (south) side in both the GPR data and section exposures. This was obvious in the large section exposed in 2013, where it formed a very distinctive palaeosurface lined with fragments of pottery dipping towards the channel. The GPR data suggest that the position of the Amara West channel has not changed significantly since the founding of the town. When this channel conveyed permanent flows it would have been deep enough for navigation, probably all the year round.

A sondage (no. 3; see Fig. 2) in the Amara West palaeochannel fill revealed a 1.1m-thick deposit of orange windblown sand at the top of the sequence (Fig. 9). This dune sand capped a very well-preserved sedimentary record that reached a depth of almost 4m below the modern land surface and yielded evidence of seven Nile floods (A to G; N. Spencer, Macklin and Woodward 2012). These flood deposits possess a distinctive desert Nile palaeochannel sedimentology that has been observed previously in the Northern Dongola Reach (Woodward, Macklin and Welsby 2001; Macklin et al. 2013) and elucidates the nature of the local environment when these deposits were laid down. Each flood unit consists of a thick blown sandy facies capped by a much thinner bed of grey Nile silty clays (Fig. 10) that was formed as each inundation gently reworked the aeolian sand that lined the dry channel bed. This suggests flows that were probably quite shallow, but with enough suspended sediment to leave a capping — just a few centimetres in thickness — of typical fine-grained Nile silt and clay to complete each flood unit. Field observations and thin section studies using a petrological microscope reveal fine laminations in the silty-clay units. The presence of sand grains embedded in the upper surface of these units indicates that sand was blown onto the wet mud on the bed of the channel as the system dried out. With further drying, the muds often cracked before they were completely buried by the next influx of orange aeolian sand: the mud cracks at the top of flood unit D, for example, are filled with this sand (see Fig. 10). The flood units shown in Fig. 9 form a neatly stacked record of exceptional Nile floods that were large enough to generate flow in this channel.

The very low energy of these inundations is demonstrated quite beautifully by the gentle entrainment of small (mm-scale) lumps of clayey-silt from the cracked and fissile upper layers of each flood unit. Once
A large trench (sondage 5, see Figs 2 and 13) was also excavated in the deposits filling the upper part of the Northern palaeochannel in January 2013. This trench revealed steeply dipping beds of windblown sand alternating with thick units of Nile sediments (Fig. 14). These deposits show an ephemeral channel system that was flooded very infrequently and filled with orange windblown sand for extended periods. The steeply dipping beds suggest a progressive decrease in channel capacity as flood flows waned and the channel became choked with windblown sand. These channel contraction features can also be observed in the GPR profile but they are especially clear in the left bank of the GPR profile for the Amara West palaeochannel (see Fig. 8).

A chronological framework for the riverine changes at Amara West

To establish the age of these flood events and to determine a minimum age for the end of permanent flows in the two palaeochannels, samples from sand units in the sondages were collected for optically stimulated luminescence dating (OSL). This dating method can be summarised as follows. All sediments are exposed to low-level natural background radiation during their burial history. Grains of quartz and feldspar absorb this radiation and store trapped electrons in their crystal structure — they therefore behave as dosimeters as the signal builds up over time. Exposure to sunlight releases this energy and resets the geological clock: the signal is zeroed. By sampling ancient sediments in sealed tubes we can prevent exposure to sunlight and estimate the duration of their burial from the build-up of radiation. When mineral grains are exposed to light under laboratory conditions they emit a signal known as luminescence. If the natural rate of background radiation can be established for a given sampling location, the intensity of the luminescence signal from a sample of deposited sediment can be used to estimate the time elapsed since the sample was buried — in other words, when it was last zeroed by sunlight. When the laboratory stimulus is a light source, the method is known as

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4 The OSL analyses were carried out by Dr Jean-Luc Schwenninger in the Luminescence Dating Laboratory at the Research Laboratory for Archaeology and the History of Art, University of Oxford, following the procedures set out in Briant et al. 2006.
In terms of the Amara West palaeochannel, the OSL ages indicate that six of the flood events (A–F; in sondage 3, see Fig. 2) probably took place within a period of about 1,100 years from c. 1300 to 200 BC (see Fig. 9). As each inundation took place under low-energy conditions as the main Nile rose slowly during the summer flood season, later floods are unlikely to have eroded away earlier flood horizons. Given this,
OSL ages are typically expressed as ka but BC/AD dates are employed here to allow easier cross-referencing with cultural periods and historical events described in this volume.

Calibrated 14C dates provided by Beta Analytic Inc. (1380–1130 cal. BC), and from an overlying archaeological deposit (1260–1010 cal. BC, 1210–1000 cal. BC) separated by blown sand, supports the OSL chronology from sondage 3. The sedimentary records from sondages 3 and 4 indicate that the channel has remained dry since this time, apart from very brief low-energy and probably shallow (<1m) inundations during times of very high floods of the main Nile.

These Amara West results can be contextualised against analyses being undertaken elsewhere in the Nile Valley. The period around 1300 BC was associated with a major contraction of the channel network in the desert Nile that has been observed in both the palaeochannel deposits and archaeological record of and the excellent preservation of the section through the flood deposits, we can be confident that a complete record of exceptionally high Nile floods over this time period is represented in this sondage. The uppermost OSL age, in the orange windblown sands, shows that the sands 50cm below the surface have not been reworked by wind action since around 205 BC: the channel has not been affected by later floods. The long trench up to the edge of the town mound (sondage 4, see Figs 2, 15) provided further dating evidence. Here, radiocarbon dates indicate perennial/seasonal flows ceased sometime between 1380 and 1260 cal. BC. Radiocarbon dating of charcoal associated with archaeological material on the ancient channel bed (1380–1130 cal. BC), and from an overlying archaeological deposit (1260–1010 cal. BC, 1210–1000 cal. BC) separated by blown sand, supports the OSL chronology from sondage 3. The sedimentary records from sondages 3 and 4 indicate that the channel has remained dry since this time, apart from very brief low-energy and probably shallow (<1m) inundations during times of very high floods of the main Nile.

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6 Calibrated 14C dates provided by Beta Analytic Inc.
the Northern Dongola Reach, an area which commences 160km upstream of Amara West (Welsby, Macklin and Woodward 2002; Macklin et al. 2013); culminating in a 200-year-long drought centred on c. 1000 BC (Macklin et al. 2015). A period of exceptionally high floods is also observable in the Dongola Reach during the 8th century BC, suggesting that this was a period of exceptionally high floods in the desert Nile. More broadly, a recent meta-analysis of a large number of published OSL and radiocarbon dates from multiple sites in the Nile basin has identified a series of pronounced valley-floor contractions in the channel network during the course of the Holocene (Macklin et al. 2015). These contractions were associated with a decrease in the number of active channels in a given reach following falls in Nile discharge. In wide alluvial reaches that were formerly characterised by multiple channels and islands, channel network contraction to a single dominant channel was common. This major hydrological change around 1300 BC meant that many channel margins lost their riparian vegetation and former islands became part of the desert landscape and were therefore much more exposed to the transport of blown sand.

Thus Amara West was founded at a time of significant hydrological and geomorphological change in the Nile Valley. When the town was established around 1300 BC it was founded on an island; the fluvial sedimentary record shows that the Amara West palaeochannel flowed at this time along the northern side of
the town. By c. 1270 BC (age range 1485–1055 BC), however — within only a generation of the town’s creation — river flow was no longer perennial and the typical annual summer flood was not large enough to inundate this channel.

All of the channels in this reach to the north of the modern Nile had become strongly ephemeral — they were inundated very briefly and only during exceptionally large flood events, perhaps separated by one to two centuries. The local riverine landscape to the north of the town mound had been radically and rapidly transformed. This transformation would have a lasting impact: there is little evidence for substantial occupation around Amara West from the mid-1st millennium BC onwards, until the arrival of mechanised irrigation in the second half of the 20th century and the construction of a new tarmac road in 2013. It is also now clear that the island upon which Amara West was founded was just one part of a much wider active valley floor with multiple river channels and larger islands. OSL dates from the larger Northern palaeochannel approximately 2km further north of Amara West reveal major flood events between 910 (± 350) and 520 (± 255) BC that fall in the time period between flood units F and C exposed in sondage 3 (see Fig. 2). These dated floods from the Northern palaeochannel may correlate with flood units E and D recorded in the 2011 sondage (see Fig. 9). It is also of interest to note that these flood units are of a similar age to those recorded in the Alfreda Nile palaeochannel on the eastern side of the Northern Dongola Reach (Macklin et al. 2013). Although we have not yet observed sediments demonstrating permanent flows in the Northern palaeochannel (they must lie deeper in the record), as far as the palaeogeography of Amara West is concerned, on the basis of the elevation of the two palaeochannels, the flow inundation simulations, and the OSL chronology, it is highly likely that these channels share a common history and were perennial and then ephemeral at the same time.

The ancient town of Amara West was therefore located on a small island at the upstream end of a much larger island — a strategically important position and vantage point in the middle of the active valley floor between the two major branches of the Nile in this reach (see Figs 2, 6). It is very likely that the left bank of the Northern palaeochannel was lined with prominent riparian dunes during this period. Archaeological survey in the area around Amara West in the 1970s led to the discovery of a series of prehistoric and more recent sites flanking this large channel (Vila 1977), which have recently been confirmed as being Middle Stone Age, Khartoum Variant and Pre-Kerma/Abkan (Garcea et al. 2011); site 2-R-19 and 2-R-19A is of Kerma Moyen date. A chronological sequence of maps (Vila 1977, 15–18) shows a decrease in the number of sites and this is particularly marked from the New Kingdom onwards. Vila dated three sites to the New Kingdom, i.e. within the time period during which channel flows were occurring only occasionally in this desert palaeochannel. Site 2-R-58 is a Kerma Ancien/ Moyen cemetery with at least one Egyptian-style grave (Vila 1977, 65–71, fig. 27.1); the two other sites were the subject of renewed survey in 2014, allowing a refinement to the dating of their occupation (Stevens and Garnett, this volume). Both 2-R-65, a site located upon a rocky outcrop on the south bank of the river channel, and 2-R-18 — possibly a midden associated with the former site — yielded ceramics of Dynasty 18, with no clear evidence of activity after c. 1450 BC. Site 2-R-65 features both stone and mud-brick architecture, and may have been associated with resource extraction (quartz, gold?) and/or the monitoring of desert traffic. It may not have supported year-round occupation, and

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7 The upper (earlier) date of 1485 BC within the age range for the end of perennial flow is here discounted, given the orientation of the town, and particularly temple, to the palaeochannel (Fig. 16).

8 Site 2-S-37 (Vila 1977, 111–14) was surveyed again in 2014, yielding X-Group and early Christian pottery (see Stevens and Garnett, this volume). The three sites around the early Nile channel indicated on the survey map (Vila 1977, 18) comprise two of uncertain date (2-R-59 and 2-R-72) and a rock art site.

9 Vila 1977, 47–51. The pottery dating is provided by Anna Garnett (pers. comm.), on the basis of material from sondages undertaken by the Amara West project in 2015, under the direction of Anna Stevens.

10 The pottery illustrated by Vila correlates well with that from early Dynasty 18 deposits at Sai and site 2-R-65 (Anna Garnett, pers. comm.).
The 7th-century BC temple enclosure wall at Tell el-Balamun had clearly weathered and deteriorated over several centuries by the time it was replaced in the 4th century BC, see A. J. Spencer 1999, 57–8.

Increasing sand ingress: geoarchaeological analyses of outdoor deposits

The existence of deep and often long-lived outdoor sedimentary sequences within the town of Amara West may allow us to associate variations in channel flow to the lived experience of its inhabitants over time. The quantity of aeolian desert sand within these deposits is likely to be strongly correlated to the ability of the Amara West (palaeo)channels, or lack thereof, to hinder the ingress of these sediments. Meanwhile, the relationship of sand-rich outdoor deposits to architectural phases allows their formation to be linked to the site’s chronology, based on stratigraphy, ceramics and inscriptive evidence.

To examine this record, a sequence of deposit samples was collected in 2012 from a deep sondage through the fills within one part of the walled town (E13.12, an alley along the western side of excavation grid E13: Fig. 17; see N. Spencer 2015, 183 fig. 8.13). In 2014, a comparative sample set was taken from an open space (D12.10) between houses in the western suburb, a residential area that developed outside the town wall (see N. Spencer 2015). The alley deposits span the occupation of Amara West, from around 1300 BC to the late 1st millennium BC, while the deposits in the extramural area probably date to the second half of that period. Targeted intact sediment blocks were collected from the alley sequence, exported to the United Kingdom and processed into large micromorphological thin sections (see Dalton, this volume, for methodology); deposits from the extramural open space were too unconsolidated to allow intact sampling. Loose bulk sediment samples were taken from both sequences for supporting Laser Particle Size Analysis (LPSA).

Alley E13.12

Situated c. 18–25m south of the town’s enclosure wall, E13.12 is a roughly east–west alley, bounded by a dense neighbourhood of small and moderately sized houses to the north, and the large Deputy’s Residence (E.13.2) to the south. These houses belonged to phase II–III, or c. 1210–1140 BC. The alley functioned as a narrow thoroughfare from (at latest) the foundation of house E13.7, and probably since the levelling around 1250 BC of the town’s original architecture (phase IA) that underlies it (wall 4958, see Fig. 17; see N. Spencer, this volume, with table 1 for phase dates). It thus remained in use for around two centuries. Surrounding buildings would have stood to one or perhaps two storeys, and we assume that the alley was relatively protected from direct northern winds by this adjacent architecture and the monumental town wall. The town wall must have trapped considerable amounts of sand against its northern face, partly reflected by the thick band of white visible in the magnetometry data (not apparent on the western or southern walls; see Fig. 16). During the occupation of the town, the top of the wall may have degraded and been subject to truncation, resulting in more sand ingress.\footnote{The 7th-century BC temple enclosure wall at Tell el-Balamun had clearly weathered and deteriorated over several centuries by the time it was replaced in the 4th century BC, see A. J. Spencer 1999, 57–8.}

Within E13.12, sedimentary deposition seems to have remained fairly stable from the end of phase IA through to the start of phase IIIA (c. 1300–1180 BC; deposits 4941 through 4921). These earlier fills consist...
of poorly consolidated silt-dominated deposits with common randomly oriented micro-inclusions of bone, charcoal and well-rounded 0.5–5mm mud-brick aggregates. Fine to coarse sand grains comprise 25–35% of these deposits (see Table 1). These size fractions are not a significant component of most architectural materials at Amara West (Dalton, this volume), and are therefore unlikely to have eroded from surrounding mud buildings. They are dominated by rounded to well-rounded quartz, with common well-rounded, spherical calcium carbonate sands, probably eroded and transported from Egyptian Western Desert limestones to the north. These sand grains were almost certainly deposited by the wind, and derive either from the adjacent desert or dried river channel.

Table 1: Results of LPSA (Malvern Instruments Mastersizer 2000) of deposits from alley E13.12, with percentages of silt/clay (<63μm), very fine sand (63–100μm), fine sand (100–200μm), medium–coarse sand (200–1000μm) and total fine–coarse sand. Contexts arranged in descending order from youngest to oldest. * Sample taken elsewhere in E13.12 and not shown in Fig. 17. For details on the phasing, see N. Spencer, this volume, table 1.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Phase</th>
<th>Context</th>
<th>Silt/clay %</th>
<th>Very fine sand %</th>
<th>Fine sand %</th>
<th>Medium to coarse sand %</th>
<th>Total fine to coarse sand %</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS315</td>
<td>III/IV (1180–1100 BC)</td>
<td>4817</td>
<td>27.3</td>
<td>9.2</td>
<td>51.6</td>
<td>12.1</td>
<td>63.7</td>
</tr>
<tr>
<td>AS327</td>
<td></td>
<td>4824</td>
<td>36.7</td>
<td>13.3</td>
<td>44.9</td>
<td>5.5</td>
<td>50.4</td>
</tr>
<tr>
<td>AS416*</td>
<td>II</td>
<td>4921</td>
<td>58.8</td>
<td>14.9</td>
<td>23.1</td>
<td>3.5</td>
<td>26.6</td>
</tr>
<tr>
<td>AS418</td>
<td>(1210–1180 BC)</td>
<td>4921</td>
<td>48.2</td>
<td>16.9</td>
<td>28.6</td>
<td>6.7</td>
<td>35.3</td>
</tr>
<tr>
<td>AS419</td>
<td></td>
<td>4922</td>
<td>62.5</td>
<td>13.2</td>
<td>21.3</td>
<td>3.3</td>
<td>24.6</td>
</tr>
<tr>
<td>AS421</td>
<td></td>
<td>4923</td>
<td>56.2</td>
<td>14.5</td>
<td>25.5</td>
<td>4.1</td>
<td>29.6</td>
</tr>
<tr>
<td>AS433</td>
<td>I (1300–1210 BC)</td>
<td>4941</td>
<td>50.0</td>
<td>16.1</td>
<td>29.2</td>
<td>5.1</td>
<td>34.3</td>
</tr>
</tbody>
</table>
The unstructured micro-fabric of these soft deposits is probably a factor of their thorough mixing by foot traffic. This blurring has destroyed any microstratigraphic evidence of sand deposition, and it is thus generally difficult to estimate the rates or frequency of different sedimentation regimes in the early part of this sequence. The good preservation of a c. 5m long, very fragile water-laid silty crust (4924), formed by an ephemeral flowing drain in the alley, suggests that rapid sedimentation (and the covering of older deposits) did occur at times.

The general dominance of silt over sand-sized sediments nevertheless implies that in these periods of the town’s history, the erosion of mud buildings or outdoor disposal of sweepings and rubbish from inside houses contributed more than aeolian sand accumulation to the formation of this sequence. It is worth noting, however, that sand may have been deliberately removed, an activity that need not leave any clear evidence in the stratigraphic record. Rising street levels at this time clearly did sometimes necessitate reconfiguration of architecture, as is suggested by the demolition of the
phase II A house E13.7 and its replacement in phase IIIA by E13.4+9 at a much higher level (see Fig. 17 and N. Spencer 2015, 177–82).

The latest preserved fills, dating to after c. 1180 BC, in alley E13.12 tell a very different story: Table 1 shows the c. 15–40% increase of total fine to coarse sand, starting from deposit 4824 and reaching its peak in 4817. These sandier deposits formed against phase IIIA houses such as E13.4+9, at a time when the architectural responses to sand ingress became prevalent (see below).

Even at the upper level of 4817, the sandiest fill in alley E13.12, there are still traces of human activity, such as recurring incidents of flowing and standing water, likely thrown over the alley surface to mitigate dust (Fig. 18; and see Dalton, this volume, for this type of activity inside houses). A final patchy layer of mud plaster was also laid down over 4817, perhaps to serve the same purpose. At some point after this, a thick deposit of pure, well-sorted aeolian sand (4815) completely filled E13.12. All contemporaneous adjacent houses are filled with admixtures of wall and ceiling collapse interleaved by the same clean aeolian sand. These are the final preserved deposits in these spaces.

The clean windblown sand deposits need not have formed simultaneously, or indeed during a single large depositional event. They do, however, indicate that no attempt was made to remove sand as it accumulated in the alley and its adjacent, now abandoned, houses. This correlates with the cessation of any other archaeologically identifiable New Kingdom human activity in the area. We should allow that later buildings and deposits may have eroded away, although there is little trace of later pottery, stone artefacts and other materials on the surface of the site. This sand was therefore very likely deposited during a great disjuncture in the occupation of this neighbourhood, possibly its final abandonment.

Open area D12.10

In the town’s western suburb, a c. 90cm sedimentary sequence was sampled in open area D12.10, adjacent to a frequently renovated neighbouring house, D12.7. The earliest deposit exposed here was the ground surface upon which this house and many others in the suburb appear to have been built (12230, associated with nearby garden plots). Early on, D12.7 had a kitchen suite added to it and, later, an enclosed courtyard (D12.7.6; see Fig. 19 and below). Both were fully built over fills in D12.10, providing a localised relative chronology that can be tied to neighbouring houses.

Samples from this sequence tell a rather different story to those from E13.12; instead of increasing steadily over time, fine to coarse windblown sand levels appear to have fluctuated but remained consistently high in sediments post-dating the construction of D12.7 (see Table 2). Many of these fills contain significantly more fine to coarse sand than the sandiest deposits in E13.12 (cf. Tables 1 and 2). This is likely to be due to the western suburb’s more exposed nature, compared to the semi-protected location of alley E13.12 within the town walls. Chronology likely also plays an important role here: the western suburb was built relatively late in the town’s history (preliminary dating of the first large houses in this area places them in phase III; N. Spencer 2015, table 8.1), around the time that sand ingress in E13.12 seems to have begun its dramatic increase. This sequence may thus span approximately the same period of time as deposits 4824/4817 in E13.12.

These data suggest that at some point (soon?) after its inception and then throughout the remainder of its inhabitation, the western suburb faced consistent and significant problems of sand ingress.

Living with wind and sand: architectural solutions

At the time of its foundation, Amara West was located on an island, with the attendant protection from the majority of the windblown sand. The current
such, it is unsurprising that the present-day traditional houses of Ernetta Island, typically featuring jalis or mud-brick walls, and without fitted glass windows, include few specific architectural features aimed at mitigating windblown sand. South- or west-facing doorways are common, but these may reflect a desire to provide protection from the northerly winds rather than sand.

situation on Ernetta Island provides some idea of the setting of the ancient town: an island protected by the water-channel but also the dunes and vegetation on the left bank of the main Nile (Fig. 20). Palm trees and cultivated land along the northern edge of the island provide further protection to the present-day houses: only with very strong winds does one find noticeable accumulations of desert sand and other debris. As

Table 2: Results of LPSA of deposits from open area D12.10 (see Fig. 19), with percentages of different sediment types (see Table 1 for size fractions). Contexts arranged in descending order from youngest to oldest.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Context</th>
<th>Silt/clay %</th>
<th>V. fine sand %</th>
<th>Fine sand %</th>
<th>Medium to coarse sand %</th>
<th>Total fine to coarse sand %</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS984</td>
<td>12209.1</td>
<td>20.8</td>
<td>13.3</td>
<td>55.3</td>
<td>10.9</td>
<td>66.3</td>
</tr>
<tr>
<td>AS985</td>
<td>12209.2</td>
<td>18.6</td>
<td>12.1</td>
<td>58.4</td>
<td>11.1</td>
<td>69.5</td>
</tr>
<tr>
<td>AS986</td>
<td>12209.3</td>
<td>12.5</td>
<td>11.6</td>
<td>66.2</td>
<td>9.8</td>
<td>76.1</td>
</tr>
<tr>
<td>AS987</td>
<td>12209.4</td>
<td>8.0</td>
<td>10.5</td>
<td>71.9</td>
<td>9.7</td>
<td>81.6</td>
</tr>
<tr>
<td>AS1058</td>
<td>12212.1</td>
<td>10.8</td>
<td>11.2</td>
<td>67.4</td>
<td>10.7</td>
<td>78.1</td>
</tr>
<tr>
<td>AS1059</td>
<td>12212.2</td>
<td>31.8</td>
<td>15.3</td>
<td>48.5</td>
<td>4.7</td>
<td>53.2</td>
</tr>
<tr>
<td>AS1060</td>
<td>11212.3</td>
<td>19.5</td>
<td>12.3</td>
<td>58.2</td>
<td>10.2</td>
<td>68.4</td>
</tr>
<tr>
<td>AS1334</td>
<td>12215.1</td>
<td>30.9</td>
<td>15.1</td>
<td>45.8</td>
<td>8.6</td>
<td>54.4</td>
</tr>
<tr>
<td>AS1335</td>
<td>12215.2</td>
<td>25.2</td>
<td>14.4</td>
<td>48.6</td>
<td>12.1</td>
<td>60.7</td>
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<td>12219.1</td>
<td>39.7</td>
<td>16.9</td>
<td>38.0</td>
<td>5.7</td>
<td>43.7</td>
</tr>
<tr>
<td>AS1337</td>
<td>12219.2</td>
<td>34.6</td>
<td>18.4</td>
<td>40.4</td>
<td>7.0</td>
<td>47.4</td>
</tr>
<tr>
<td>AS1338</td>
<td>12230</td>
<td>63.1</td>
<td>16.1</td>
<td>21.2</td>
<td>0.1</td>
<td>21.3</td>
</tr>
</tbody>
</table>

Fig. 19: North-facing section of deposits in open area D12.10 with architecture of adjacent house D12.7 (see Fig. 23), showing location of bulk geoarchaeological samples (small black boxes).
What does the architecture at Amara West inform us about the ancient experience of these northerly winds? The walled town, with its buttresses and corner towers, follows a template favoured by state planners of the Ramesside Period, as found at contemporary sites in the Nile Delta and Nubia (N. Spencer 2014a, 44–5; N. Spencer, this volume). The town was, in many ways, oriented to the north, with a gate in the town wall, and a forecourt extending north of the temple, overlooking the Amara West (palaeo)channel. Is this an example of centralised planning without direct reference to the local environment? This seems unlikely, given the presence of Pharaonic representatives in this area for nearly 200 years prior to construction of Amara West, and the collective experience accumulated at Sai, the Pharaonic town just 14km upstream (by river; see Budka, this volume) and indeed the desert sites around Amara West (Stevens and Garnett, this volume). However, few windblown sand deposits are noted at Sai, which has remained an island, and in any case the layout of the formal buildings at Amara West may only have become problematic with the failure of the northern channel, which occurred soon after the town was founded (see above).

The main northern town gate was blocked with a brick wall, interpreted as post-dating the use of the temple (P. Spencer 1997, 17, pl. 7 [c–d]). The main temple entrance, and the north and west gates into its forecourt, were also fitted with architectural blockings (P. Spencer 1997, pls 23, 66–7). As the examples below illustrate, blockings were often necessary to maintain access through a doorway, and an increase in sand ingestion may have prompted their construction (detailed records of these blockings were not made by the excavators). During excavation, the forecourt of the temple was found to have filled up in antiquity with...
nearly 2m of windblown desert sand (P. Spencer 1997, 29); while this is likely to date to after the abandonment of the building, it nonetheless illustrates the challenges posed by the local environment.

The northern side of the town is delineated by a dry stone wall built of undressed schist in front of the mud-brick enclosure wall (see Fig. 16; P. Spencer 1997, 76, pl. 65 [c–d]). Though not possible to date with accuracy, this wall is almost certainly contemporary with the main period of occupation. Beyond the temple forecourt lies a smaller dry stone wall, extending 9m to the east, and 12m to the west, of the forecourt door. Were some, or all, of these walls constructed to mitigate the effects of windborne sand: perhaps not blocking sand as much as providing a protection to the base of the mud-brick walls? Across eight years of excavation since 2009, the undermining of mud-brick wall bases is the most striking consequence of wind erosion upon architecture left exposed to northerly winds. The walls, built close to the town wall and following its alignment, may also have provided shelter for those walking around the perimeter.

Area E13, immediately north of the Deputy’s Residence and alley E13.12 discussed above, is particularly informative in terms of household responses to increasing sand ingestion. Some time after 1187 BC, this area had been transformed into a block of eight houses, with another two opening off the west side of alley E13.11 (N. Spencer 2014b; 2015). One of these, house E13.3-S, was fitted with a roughly constructed staircase leading down into the front room from the front door (E13.3.25; N. Spencer 2014b, 472, pl. 14). The floor level of this room remained at a lower level due to the ongoing cleaning out of rubbish and deposits blown in through doorways and the stairwell but also through the permeable mud and matting roofs employed in these houses (see Vandenbeusch, this volume). Of the five other front doorways that were excavated by the current project, four had similar structures built out into the street. The structures appended to the front of house E13.4 provide a good example: a small rectangular construction of 170 × 75cm (Figs 21–2), refurnished several times, including original mud-brick walls lined with recycled stones (grindstones, a near-complete sandstone door lintel). These measures are concurrent with the increase in aeolian sand ingestion within alley E12.12, discussed above.

Rapid accumulations of sand are attested elsewhere in the ancient town. An area of housing south of the temple, still within the town walls, was excavated by the EES in the late 1940s, where up to 1m of windblown sand was encountered between architectural phases. The 5m-high ‘mound B’ investigated by the EES, outside the southeast corner of the walled town, featured thick layers of windblown sand interleaved between deposits of New Kingdom rubbish (P. Spencer 1997, 204–5, pl. 143a–b), suggesting sand accumulations formed within the New Kingdom occupation of Amara West, obviating any need to posit a lengthy period of abandonment.

In the extramural housing area, or western suburb, beyond the West Gate (see Fig. 16), it seems likely that the northerly wind would be more keenly felt by inhabitants, who were not afforded the protection of a thick, high enclosure wall. All the evidence suggests that the inhabitants of this informal neighbourhood laid out their houses to maximise protection from the effects of the northerly winds, and the micromorphological analysis presented above (area D12.10) underlines the prevalence of aeolian sand in the deposits in and around these houses. Table 3 presents a summary of the orientation of house doors, and subsequent blockings and adjustments to those entrances:

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12 Fairman suggested that the walls date to late in the occupation of the site, due to their lying over earlier brick walls. Yet undressed schist was employed across the ancient town during the New Kingdom, for example as paving, in door lintels and thresholds, and to provide protection to exterior wall corners. It was also occasionally used within mud-brick walls.

13 On the basis of a scarab of Ramses III found buried in the first floor of house E13.3-S (N. Spencer 2014b, 471, fig. 8).

14 An example, in front of house E13.3, is illustrated in N. Spencer 2015, 193–4, fig. 8.22.

15 It was proposed that layers of windblown sand between architectural phases represent a hiatus in occupation, perhaps between the 11th and 8th centuries BC (see P. Spencer 1997, 218–19). However, the construction of new buildings upon levelled earlier walls, above packed-down deposits of rubble and even deposits of windblown sand, is encountered across newly excavated areas (e.g. area E13, N. Spencer 2015), where we have no clear evidence of a long interval of abandonment. Both the architectural refurbishments and modifications, and the accumulation of sand, can happen within a very short time frame.
A similar approach can be seen in late Ptolemaic settlements in the Fayum (Marouard 2008, 123–4, fig. 2).

The earlier house immediately to the south (D12.7; Fig. 23), despite its south-facing entrance, was fitted with a curving wall (12031), inside which lay a staircase (12091) to facilitate access down into the house (Fig. 24). As with the examples described above, this staircase was an expedient structure: schist slabs, mud bricks and fragments thereof, all mortared together. These overlay an earlier blocking wall (12139) with prepared staircase/slope (12120). Again, despite the extension of the house with room D12.7.6, creating a new west-facing street entrance, the same problem of sand ingress persisted, addressed with another structure (12024) of re-used stonework, mud brick and mortar (Fig. 25).

From this sample of twelve houses (out of an estimated total of twenty in the western suburb), it is striking that only one features a north-facing entrance — house D12.8 — and this was a short-lived alteration to the original plan, created after the extension of the house with a courtyard (D12.8.14). A north door may have been the only option, due to whatever was located to the west: garden plots are a feature of many parts of the western suburb, later overbuilt by houses. In any case, the provision of a northern door prompted a sequence of measures likely intended to mitigate against sand ingestion (Fig. 26). These included a porch-like extension in front of the northern door, which created an east-facing entrance to the house, subsequently blocked, necessitating steps for access. At a later date, a larger room was created in front of the north door, before this too was blocked with brickwork and a re-used sandstone block, presumably in tandem with the creation of a west-facing door in the courtyard D12.8.14: a new access route into the house. The architecture outside the old north door was then repurposed, creating a single space within which distinctive organic deposits accumulated. This might reflect its use as a place for sheltering animals, with direct access from the street rather than from the interior of house D12.8.

The consistent picture that emerges from the blocking structures before front doors, allied with the data on increasing proportions of aeolian sand within the street deposits (see above), is of increasingly frequent measures taken to combat this nuisance. Such architectural measures are more common in

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16 A similar approach can be seen in late Ptolemaic settlements in the Fayum (Marouard 2008, 123–4, fig. 2).
Fig. 21: Area E13 (walled town). Structure 4823 (late phase) built outside front door to house E13.4. Photo: Amara West project (British Museum).

Fig. 22: Area E13 (walled town). Structure 4823 (early phase) built outside front door to house E13.4. Photo: Amara West project (British Museum).
the later phase buildings at the site, dating to late Dynasty 19 and 20, from around 1200 BC. Other details of the layout of individual houses may have been implemented in response to the northerly winds, and the aeolian sand they carry. Despite their different orientation, villas E12.10 (N. Spencer 2009, 50–4) and D12.5 both located their sizeable food processing facilities (ovens, grain-grinding emplacements and storage bins) in the southern part of the building, perhaps to ensure smoke, chaff and other debris was not carried through other areas of the house by wind.

The western suburb was not a planned neighbourhood; thus individuals and households had to create solutions within available space, perhaps necessitating both negotiation and compromise with neighbours and other users of the areas. The location of ovens north of the front room of small house D11.2 may not have been desirable, though the large house to the north would have afforded some protection from the northerly winds. House D12.7 and D12.8 managed to locate their ovens in spaces where the prevailing wind would not have carried excessive amounts of ash and smoke into the main parts of the house.

Fig. 23: Western suburb. House D12.7 after excavation, showing sequence of doorways, with area D12.10 outside (base of image). Photo: Amara West project (British Museum).

Fig. 24: Western suburb. Retaining wall and staircase constructed to maintain access into house D12.7 (original front door). Photo: Amara West project (British Museum).
Living with a changing river and desert landscape at Amara West

Upon the health profile of the town’s inhabitants. Skeletal human remains represent an important source of information about the life of past human populations: integrated with archaeological and palaeoenvironmental data, their study allows for insights into life parameters such as health, diet, ancestry, migration or workload. Between 2009 and 2013, excavations in the two contemporaneous, yet socially differentiated, cemeteries at Amara West led to the discovery of 180 bodies (fully or partially intact), dating to the New Kingdom occupation of the site but also to the post-New Kingdom (10th–8th centuries BC; Binder 2011; Binder, this volume; Binder, N. Spencer and Millet 2010; Binder and N. Spencer 2014). In order to gain an insight into health and living conditions in the ancient settlement, and any potential diachronic changes occurring therein, these remains were subject to a systematic, macroscopic, analysis of selected markers of physical stress used as a proxy for disease and malnutrition, as well as skeletal evidence of trauma and joint degeneration.

Even though the results have to be viewed with caution in light of an uneven distribution of sample sizes (thirty-seven New Kingdom individuals; 143 post-New Kingdom individuals) several trends could be detected.

Fig. 25: Western suburb. Retaining wall and staircase constructed to maintain access into house D12.7 (new front door, after house extension). Photo: Amara West project (British Museum).

Living with wind and sand: the bioarchaeological evidence

Building upon the data on the palaeochannels, increasing aeolian sand ingress in the town and associated architectural measures, we sought to question whether such an environment would have impacted

upon the health profile of the town’s inhabitants. Skeletal human remains represent an important source of information about the life of past human populations: integrated with archaeological and palaeoenvironmental data, their study allows for insights into life parameters such as health, diet, ancestry, migration or workload. Between 2009 and 2013, excavations in the two contemporaneous, yet socially differentiated, cemeteries at Amara West led to the discovery of 180 bodies (fully or partially intact), dating to the New Kingdom occupation of the site but also to the post-New Kingdom (10th–8th centuries BC; Binder 2011; Binder, this volume; Binder, N. Spencer and Millet 2010; Binder and N. Spencer 2014). In order to gain an insight into health and living conditions in the ancient settlement, and any potential diachronic changes occurring therein, these remains were subject to a systematic, macroscopic, analysis of selected markers of physical stress used as a proxy for disease and malnutrition, as well as skeletal evidence of trauma and joint degeneration.

Even though the results have to be viewed with caution in light of an uneven distribution of sample sizes (thirty-seven New Kingdom individuals; 143 post-New Kingdom individuals) several trends could be detected.

Fig. 26: Western suburb. Sequence of door blockings and steps in front of north door to house D12.8. Photo: Amara West project (British Museum).
Table 4: Prevalence of selected disease indicators analysed in the Amara West population (n=number of individuals with indicator, N=number of individuals observable for this indicator, *=due to uneven age distribution within the samples and association of indicator with age, values are given for young adults only, **=statistically significant on 0.5 confidence level, sources: Binder 2014b).

<table>
<thead>
<tr>
<th>Disease indicator</th>
<th>NK n/N</th>
<th>%</th>
<th>Post-NK n/N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caries*</td>
<td>3/8</td>
<td>37.5</td>
<td>19/28</td>
<td>67.9</td>
</tr>
<tr>
<td>Intravital tooth loss*</td>
<td>4/8</td>
<td>50.0**</td>
<td>24/29</td>
<td>82.8**</td>
</tr>
<tr>
<td>Dental abscesses*</td>
<td>1/8</td>
<td>12.5**</td>
<td>20/31</td>
<td>67.7**</td>
</tr>
<tr>
<td>Dental enamel hypoplasias</td>
<td>7/20</td>
<td>35.0</td>
<td>31/66</td>
<td>47.0</td>
</tr>
<tr>
<td>New bone formation in the tibiae*</td>
<td>1/7</td>
<td>14.3</td>
<td>11/26</td>
<td>42.6</td>
</tr>
<tr>
<td>Maxillary sinusitis*</td>
<td>5/5</td>
<td>100.0</td>
<td>14/19</td>
<td>73.3</td>
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<tr>
<td>Chronic pulmonary infections*</td>
<td>4/11</td>
<td>36.4**</td>
<td>18/23</td>
<td>78.3**</td>
</tr>
<tr>
<td>Osteoarthritis (knee)*</td>
<td>9/36</td>
<td>27.8</td>
<td>45/116</td>
<td>38.8%</td>
</tr>
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Age-at-death is generally assumed to represent a robust marker of living conditions, and at Amara West life expectancy appears to have been generally poor throughout the time of occupation of the site, with the majority of adults dying below the age of thirty-five. While it remains impossible to establish the exact causes of death of the people at Amara West, the natural and built environment provides ample evidence for a wide variety of different factors which would have all led to challenging, unhealthy living conditions. These factors include the close proximity of people and animals, which would have facilitated the spread of infectious diseases such as gastro-intestinal disease or tuberculosis; and the presence of rubbish dumps within the settlement, which would have created an ideal breeding habitat for bugs transmitting diseases. In addition, the Nile channel may have acted as a vector for malaria or bilharzia.

Considerable differences could be observed, however, between the New Kingdom and post-New Kingdom groups (Table 4), including the frequency of dental disease and linear enamel hypoplasia (disruption of enamel formation due to malnutrition or disease). More significant in relation to environmental change, perhaps, is an increase in infections of the respiratory organs. These are manifested in the human skeleton through new bone formation in the maxillary sinuses and on the inner side of the ribs, resulting from a chronic inflammation of the soft tissue overlying the bony structures (e.g. Roberts 2007; Roberts, Lucy and Manchester 1994). In recent years, clinical research is revealing increasing evidence for a direct correlation between large-scale environmental change and the frequency of respiratory diseases (Bernstein and Rice 2013), as a result of rising temperatures and consequences such as droughts, wildfires or changes to plant cover. All these lead to higher levels of airborne particles and hence environmental pollution, which can further compromise respiratory health through either direct promotion, or aggravation, of respiratory diseases (D’Amato et al. 2014). The main health consequences are rhinosinusitis, asthma, chronic obstructive pulmonary disease and respiratory infections, which could all potentially lead to the skeletal changes observed in the inhabitants of Amara West. Consequently it seems reasonable to suggest that the increasing amount of sand and the architectural changes visible in the settlement bear testimony to the fact that sand, and hence airborne environmental pollution, not only became a significant problem for the living environment but perhaps more importantly to human health. Even though it has to be borne in mind that people living at Amara West would have also been exposed to considerable levels of indoor air pollution through smoke from wood fires in small and confined spaces, such as oven rooms or courts, the sharp rise is nevertheless intriguing and probably indicates additional risk factors during the later stages of occupation. This claim may be supported by the statistically significant increase in the prevalence of caries, periapical lesions and ante-mortem tooth loss already affecting young adult individuals (twenty–thirty–five years) during the post-New Kingdom period. These changes indicate significant alterations in the composition of the diet and/or an increase in the amount of abrasive material in the diet, perhaps coupled with an overall decrease of
immune defence resulting from a general deterioration of living conditions.

Further changes in living conditions are attested by higher levels of trauma and joint degeneration in the post-New Kingdom burials, signifying increasingly strenuous physical activities performed by the people at Amara West. Even though it remains difficult to interpret these alterations in the absence of intact settlement deposits dating to the post-New Kingdom, they may perhaps be attributed to an increasing intensity of labour necessitated by the deteriorating agricultural potential of the area. However, these results again have to be viewed with caution given that the differences in trauma and joint degeneration are not statistically significant and may be somewhat biased due to the smaller sample size of the New Kingdom group. Nevertheless, considering all strands of evidence included in the bioarchaeological analysis of the skeletal human remains from Amara West together, there are certainly indications that living conditions deteriorated considerably during the post-New Kingdom period. Together with the decreasing agricultural potential and sustainability of the settlement, threats to human health may have well been one of the determining factors ultimately leading to the abandonment of the site.

State intentions, environmental change and lived experience

The geomorphological and geophysical survey of the environs of the New Kingdom town at Amara West indicate the one-time existence of a small island separated from a much larger island by a narrow, deeply incised, river channel. OSL dates, supported by 14C dates from charcoal, provide a chronological framework for when Amara West ceased to be an island, and joined the left bank of the Nile. It is clear that by c. 1270 BC, the Amara West channel did not flow perennially, prompting the transformation of the landscape from a Nile island — suitable for agriculture — to an arid desert-edge location not protected from the northerly winds and the aeolian sand they carry.

While the reasons for the foundation of a town at Amara West remain unclear (see N. Spencer, this volume), its island location is consistent with the approach taken by the Pharaonic state at, for example, Kom Firin in the western Delta (N. Spencer 2014a, 25–7), or Per-Ramses in the northeastern Nile Delta (Bietak and Forstner-Müller 2011, 25–6, fig. 2). The architecture is also consistent with that deployed at a number of other colonial/border foundations in the early Ramesside period: Aksha in Nubia, Kom Firin, Tell Abqa’in and Zawyet Umm el-Rakham in the western Delta and Mediterranean coast, or Tell Borg at the edge of Sinai (N. Spencer 2014a, 27–33). Created as a planned town, the settlement’s shifting nature can be traced through its architecture and artefact assemblages (N. Spencer, Stevens, this volume; N. Spencer, Stevens and Binder 2014), a transformation that reflects an increase in community self-organisation, shaped by individual and/or household agency, and perhaps transformations in community requirements as the town became more established, its population expanded, and networks/relationships were created and developed with communities around Amara West. The falling levels of investment in Nubia by the Pharaonic state, at least in terms of formal monuments and inscriptions, is quite striking following the reign of Ramses III (N. Spencer 2014a, 197–8).

This paper argues that climate and hydrological change — resulting in the drying up of the Nile channel that defined the site as an island and the subsequent loss of all the benefits offered by a permanently flowing channel — was a considerable factor in the changing fortunes of this Pharaonic town, from around a generation after the town was first founded. How did the principal protagonists respond to this development? In terms of the Pharaonic state, and its local representatives headed by the Deputy of Kush, the situation was not considered critical enough to warrant an abandonment of the town as an administrative centre: viceroys of Ramses VI and IX are referenced in a small shrine within the temple (P. Spencer 1997, 39, 41), and the official completion of temple decoration may have been marked by the large-scale sunk-relief inscription in the peristyle, in Year 6 (c. 1125 BC) of Ramses IX (P. Spencer 1997, 36–7, pl. 30b–d). Of course, these may be the result of initiatives by the resident elite, rather than reflecting direct state involvement. Elsewhere, considerable investment was needed in response to riverine changes, for example at Tell Borg, where the shifting Nile destroyed part of the fortified walls, leading to the construction of a new walled complex in late Dynasty 18 or early Dynasty 19 (Hoffmeier 2004, 91–103). The construction of a dry stone wall along the exterior of the Amara West north town wall, most likely a measure to reduce the impact of northerly winds on the mud-brick town wall, may have been a project instigated by the Pharaonic state, its local representatives or even a community-driven initiative;
unfortunately, there is not yet sufficient evidence to date its construction.

Beyond the formal buildings, residents struggled with the deteriorating conditions, though houses were occupied through Dynasty 20, it seems. The skeletal evidence reflects a population suffering an increase in respiratory diseases, but also displaying other signs of a decreasing quality of life, some of which may have been the result of a changing environmental context. An increasing effort — in agriculture, fishing, animal husbandry and hunting — may have been needed to sustain subsistence levels,\(^{17}\) while considerable effort was also expended on creating relatively elaborate structures outside the front doors of houses. These made use of what material was to hand — discarded quern-stones, schist slabs and re-used sandstone architectural elements — combined with the construction of new mud-brick retaining walls, designed to maintain access down into the houses, and reduce the amount of exterior debris (including windblown sand) that could enter the inner rooms. Maintaining the living surfaces for as long as possible would postpone the effort needed to raise the walls and roofs (see Vandenbeusch, this volume). The increase in the proportion of aeolian sand in the sediment record, so evident in the later stages of an alley inside the walled town and open space in the western suburb, provide explicit evidence for how outdoor areas were becoming infiltrated with windblown sand.

These extensions to houses were often limited by available space, often being built into alleys where circulation would have been hampered by the new constructions. The ‘porch’-like extensions that are a feature of houses in the western suburb were in most cases part of the original plan of the houses, and are also found inside the walled town (e.g. D.14.1-2-4-5-6; P. Spencer 1997, pl. 77). These ‘porches’ may have had benefits in terms of buffering outside space — with its accumulations of windblown sand, other debris and also strong sunlight and high temperatures — from the interior parts of a house, but in addition could have been destined for specific activities and to create a turn in the axis of entry into houses, with attendant benefits in terms of privacy and the marking out of spatial boundaries.

Once the transformation into a desert-edge environment was complete, maintaining a viable system of agriculture would have become more challenging, something perhaps reflected in an increase in markers of physical stress in the skeletal assemblage; the ability to maintain sustainable herds of livestock may also have been affected, as fodder became less plentiful. The impact of the end of regular river flow in the two channels to the north of the town would not have been immediately catastrophic: in the Dal area today, Nile channels that have not flowed for several years still support seasonal agriculture (P. Ryan, pers. comm.).

The reduction in Pharaonic investment and support — eventually ceasing completely around 1070 BC — has been assumed as the primary factor in the abandonment of Amara West. That burials continued for some time after the Pharaonic state controlled Upper Nubia (Binder 2011; Binder 2014a; Binder and N. Spencer 2014) argues against a sudden retreat of the population to Egypt envisioned previously: ‘the inhabitants ... seem to have taken with them anything of value when they left for Egypt. A deliberate abandonment of the town would help to explain the lack of “fine objects”’ (P. Spencer 1997, 220–1).\(^{18}\)

\(^{17}\) Study of the botanical (for which see Cartwright and Ryan, this volume), faunal and fish remains from Amara West is ongoing.

\(^{18}\) Such a model is problematic in other ways. Firstly, the population is unlikely to have seen itself as solely ‘Egyptian’, but rather comprised a range of individuals who deployed different cultural affiliations as circumstances required, and may have envisaged ‘home’ as the region itself, Egypt or indeed other regions within or beyond the Egyptian empire. Secondly, no matter the cultural or political affiliation of individuals, the inhabitants of a town are rarely in a position to migrate en masse due to a change in political master. Buhen provides an explicit case of local elites shifting allegiance to a Nubian ruler, at the end of Egyptian control of Lower Nubia in the late Middle Kingdom (Edwards 2004, 97). Thirdly, ongoing excavations are revealing continued occupations at town sites, and burials in cemeteries, during the first centuries of the 1st millennium BC, for example at Kawa, Hillat el-Arab, Tombos, Sai and in the southern Dongola Reach (see N. Spencer, Macklin and Woodward 2012, 40). The ‘paucity’ of the artefactual record suggested by the excavators, and echoed by P. Spencer and Alexander (1998, 250) is questionable: the number of artefacts are broadly consistent with that found at other settlement sites, and the small number of fine objects from the temple might simply reflect their potential for re-use, whether for materials (precious stones or metals) or for later sites (witness the Napatan and Meroitic re-use of Pharaonic sculpture, as epitomised by the lions of Amenhotep III, Sourouzian 2001).
Rather, might we envisage a town characterised by increasing numbers of vacant houses and buildings? A dwindling population may have removed stonework from abandoned buildings for use in ever more elaborate architectural measures to halt the flow of sand. The social implications of the model proposed here are also considerable, with the possibility of an ageing demographic, one with a less healthy existence and possibly a reduction in those inhabitants engaged in activities (administration, craft, resource extraction and processing) beyond day-to-day survival and the maintenance of adequate subsistence levels. The process of abandonment may have taken several generations, with periods of re-use of previously empty houses also possible. Pottery scatters and occasional burials in the cemetery attest to people living at, or visiting, Amara West as late as the 8th century BC. The environment witnessed by those people was more like that we see today than that seen by the first inhabitants of the newly founded town of 1300 BC. Research at other New Kingdom towns in the Nile Valley will allow the creation of further site-specific biographies and perhaps reveal whether the phenomena attested at Amara West were common to the wider lived experience of Nubia at this period.

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