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THEBAN HARBOURS AND WATERSCAPES SURVEY, 2013*

By A. GRAHAM, K. D. STRUTT, V. L. EMERY, S. JONES *and* D. S. BARKER

Report on the 2013 season of the Theban Harbours and Waterscapes Survey.

The 2013 season ran from 16 January to 6 February 2013. The team consisted of Dominic Barker (field technician, University of Southampton), Virginia Emery (Egyptology PhD candidate, University of Chicago), Angus Graham (field director, University College London), Sarah Jones (topographer and head of geomatics, Museum of London Archaeology) and Kristian Strutt (assistant director and geophysical researcher, University of Southampton), with Reis Alaa Farouk and Reis Omar Farouk managing our local team of workmen. Our MSA inspectors were Abeer Sayed Mohammed (Karnak) and Elazab Rageb Ahmed Abd Rabu (West Bank).

Aims of the survey

Following on from our work in 2012,[1] the work this season focussed on three main areas of investigation: Karnak, the Birket Habu, and the Royal Cult Temple of Amenhotep III (Kom el-Hetan), with some additional work in and around the Royal

* The Theban Harbours and Waterscapes Survey (THaWS) runs under the auspices of the Egypt Exploration Society and is funded by the EES Excavation Fund. For their support, we would like to thank: former EES Representative in Cairo Faten Saleh; Mohammed Ismail and Hani Ahmed Abu El Azm at the MSA; Mansour Boraik (director general of Luxor antiquities), Mohammed Abd el-Aziz (director of the West Bank, Luxor), Fathi Yasseen (director of the central area of the West Bank, Luxor), Abd el-Nasser Havez (director of the southern area of the West Bank, Luxor) and Mohammed Hamdan; our MSA Inspectors Abeer Sayed Mohammed (Karnak) and Elazab Rageb Ahmed Abd Rabu (West Bank); Christophe Thiers (director of CFEETK), Ibrahim Suleiman (director of Karnak), Amin Amr (chief of inspectors at Karnak), and Saleh el-Masekh; Ray Johnson and Brett McClain of the Epigraphic Survey, Chicago House; Hourig Sourouzian and Rainer Stadelmann for their collaboration around Kom el-Hetan, and all in the 'Memnon team', particularly Christian Perzlmeier, Josef Dorner, and Eriko Kamimata; the Joint Expedition to Malkata for their collaboration: Diana Craig Patch, Peter Lacovara, Catharine Roehrig, and Joel Paulson; Alban-Brice Pimpaud for his continued collaboration on the topography of the West Bank; Elizabeth Richley for assisting with GPR data processing during the season remotely at University of Southampton; John Shearman and Andrew Bednarski (ARCE Luxor) for sharing Quickbird satellite data of the Theban area; François Larché for discussions of the First Court and Hypostyle Hall at Karnak; Reis Alaa Farouk and Reis Omar Farouk and team, for their conscientious work with us this season. Finally, thanks are owed to all the farmers/landowners for allowing access to their paths and fields.

[1] A. Graham, 'Investigating the Theban West Bank floodplain', *EA* 41 (2012), 21–4; A. Graham, K. D. Strutt, M. A. Hunter, S. Jones, A. Masson, M. Millet, and B. T. Pennington, 'Theban Harbours and Waterscapes Survey, 2012', *JEA* 98 (2012); A. Graham, K. D. Strutt, M. A. Hunter, S. Jones, A. Masson, M. Millet, and B. T. Pennington, 'Reconstructing Landscapes and Waterscapes in Thebes, Egypt', in W. Bebermeier, R. Hebenstreit, E. Kaiser, and J. Krause (eds), *Landscape Archaeology: Proceedings of the International Conference Held in Berlin, 6th–8th June 2012* (eTopoi Special Volume 3; Berlin, 2012), available online: <http://journal.topoi.org/index.php/etopoi>; A. Graham and K. D. Strutt, 'The Theban Harbours and Waterscapes Survey: Recent Fieldwork to Investigate the Canals and Harbours on the West and East Banks at Ancient Thebes (Luxor), Egypt', *ISAP News: The Newsletter of the International Society for Archaeological Prospection* 31 (2012), 6–7.

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Cult Temple of Thutmose III and along the dirt track to the south of the Ramesseum. This season we employed Ground Penetrating Radar (GPR) in addition to Electrical Resistivity Tomography (ERT) and magnetometry, all methods that we used in 2012.

At the Birket Habu, we aimed to collect data that might enable us to begin to interpret the size and depth of the basin, to investigate the extent of the spoil mounds and to decipher any link between a basin and the river through the 'entrance' spoil heaps now occupied by the villages of Naj' Raml al-Aqaltah on the south mound and Kom al-Bi'irat on the north mound.[2] At Kom el-Hetan we aimed further to explore and clarify the position of a channel located in the Second Court of the temple (P13, 2012) and a possible channel to the east of the temple (P7 and 8, 2012).[3] At Karnak, our aim was to cover all the 2008 and 2012 ERT profiles using GPR and further test the results of ERT and hand augering around the Amun-Re temple and at North Karnak.[4]

Survey methodology

In order to collect data from below the surface of the floodplain, we have used a variety of geophysical techniques to facilitate comparison between different datasets.[5] Normally we follow this up by hand augering along the geophysical profiles in order to ground-truth the geophysics results. However, this season as team members were not available to study sediments and artefacts we limited our augering to one auger (AS41) on the West Bank to test new gouge augering equipment. The geophysical methods used in the 2013 season are all non-invasive.

Topographic survey

All site survey work for the 2013 season was carried out using a Leica Viva GNSS (using GPS and GLONASS satellites) base-rover system, incorporating a GS10 base sensor and a GS15 rover sensor,[6] collecting data in WGS84 UTM36N (Universal Transverse Mercator 36 North) coordinates (in metric units).

Base station control points were established for carrying out project work, with a station on the West Bank situated on the top of Reis Ali Farouk's house (located between Medinet Habu and the North Palace at Malkata), and a station on the East Bank on the roof of Chicago House. The latter point was established and located using the GPS rover, while the base was set up on the former control point, in order to

[2] Graham et al., *JEA* 98, 37.

[3] Graham et al., *JEA* 98, 34–5.

[4] Graham et al., *JEA* 98, 36; J. M. Bunbury, A. Graham, and M. A. Hunter, 'Stratigraphic Landscape Analysis: Charting the Holocene Movements of the Nile at Karnak through Ancient Egyptian Time', *Geoarchaeology* 23/3 (2008), 351–73; A. Graham, 'Islands in the Nile: A Geoarchaeological Approach to Settlement Locations in the Egyptian Nile Valley and the Case of Karnak', in M. Bietak, E. Czerny, and I. Forstner-Müller (eds), *Cities and Urbanism in Ancient Egypt: Papers from a Workshop in November 2006 at the Austrian Academy of Sciences* (DGÖAW 60 = UZK 35; Vienna, 2010), 125–43; A. Graham, 'Ancient Landscapes around the Opet Temple, Karnak', *EA* 36 (2010), 25–8; A. Graham and J. M. Bunbury, 'The Ancient Landscapes and Waterscapes of Karnak', *EA* 27 (2005), 17–19.

[5] K. Strutt and S. Keay, 'The Role of Integrated Geophysical Survey Methods in the Assessment of Archaeological Landscapes: The Case of Portus', in R. Lasaponara and N. Masini (eds), *Advances on Remote Sensing for Archaeology and Cultural Heritage Management: Proceedings of the 1st International EARSeL Workshop CNR, Rome, September 30 – October 4* (Rome, 2008), 121–4; S. Keay, G. Earl, S. Hay, S. Kay, J. Ogden, and K. Strutt, 'The Role of Integrated Geophysical Survey Methods in the Assessment of Archaeological Landscapes: The Case of Portus', *Archaeological Prospection* 16 (2009), 159–60, 162.

[6] For a detailed description of the function of GPS, see S. Ainsworth and B. Thomason, *Where on Earth are We? The Global Positioning System (GPS) in Archaeological Field Survey* (Swindon, 2003).

establish both base control points in relation to each other. These base control points were established in the hope that they can be reused by THaWS as well as by other projects and colleagues in the future.

Base raw data was collected over each base-control point for a minimum of 7 hours, and was then exported and uploaded as RINEX data to the Opus post processing website <http://www.ngs.noaa.gov/OPUS/#> in order to maximise and improve overall locational accuracy. All topographic survey data collected using these base-control points were globally adjusted using the post-processed control values. All GNSS data recording is intrinsically 3D.

GNSS recording of the ERT transects involved individual location of start and end points, of intermediate measuring-tape-end and peg locations, and continuous Real-Time Kinematic (RTK) survey along the transect ground surface, with readings taken at 1 m spacing or at 0.2 m height differentials. GPR transects were recorded similarly, and the ground surface values along each transect (whether ERT or GPR) were exported and entered into the respective modelling software for each type of data, in order to model and interpret the sub-surface features in relation to the ground surface variation.

Area GPR or magnetometer surveys were variously staked out, and their boundaries or baselines were located using the GNSS. Where possible, the GNSS was also used to pick up permanent control points used by THaWS in the 2012 season, as previously it had only been possible to locate these using a total station or by referencing control points from other project grid and co-ordinate systems (e.g. Theban Mapping Project controls at the Temple of Merenptah, or Karnak CFEETK supplied control points). In addition, some Survey of Egypt (SoE) benchmarks on the West Bank were also recorded using the GNSS, in order to relate datum values and UTM36N co-ordinates in the THaWS ArcGIS project environment.

Quickbird panchromatic satellite imagery in WGS84, transformed into UTM36N, has kindly been given to THaWS by the American Research Center in Egypt (ARCE) Luxor office to aid our topographic and survey work. The imagery covers the area of the Birket Habu and the floodplain in front of the Royal Cult temples as far north as that of Seti I on the West Bank and from the Eighth Pylon at Karnak to the former ETAP Hotel to the south on the East Bank corresponding to a north-west location of latitude 25.74480336N and longitude 32.56478827E, and a south-east location of latitude 25.68454062N and longitude 32.66806540E. The resolution of the data is 0.6 m per pixel.

Electrical Resistivity Tomography (ERT) survey

Our Electrical Resistivity Tomography (ERT) survey continued using the same methodology, processing software and equipment, namely the Allied Associates Tigre 64-probe resistivity system as in 2012.[7] For the 2013 season, we restricted the maximum depth of measurements on the West Bank and at Karnak to 19.5m below the ground surface, as this was sufficient for the research questions posed. The 14 ERT profiles covered a total distance of 3.2 km over the ground.

Ground Penetrating Radar (GPR) survey

Ground Penetrating Radar (GPR) was used extensively this season to assess the presence of ancient deposits comprising river sediment and building material, and the potential

7 Graham et al., *JEA* 98, 28–9.

relationship between floodplain deposits and anthropogenic deposits associated with the ancient landscape. The speed with which it can be carried out meant that the 33 GPR profiles conducted covered a distance of *c.* 18.7 km. The seven small area surveys covering over 2 hectares in different locations were designed to assess the pattern and form of potential archaeological remains.

GPR survey is based on the use of an electromagnetic radar wave propagated through the soil to search for changes in soil composition and the presence of structures, measuring the time in nanoseconds (ns) taken for the radar wave to be sent and the reflected wave to return. The propagation of the signal is dependent on the Relative Dielectric Permittivity (RDP) of the buried material.[8] The electromagnetic radar waves pass through most materials and therefore 'hard' surface layers such as stone paving slabs and Tarmac surfaces have a limited effect on carrying out GPR survey. It was thought that this method would provide a useful complementary technique to Electrical Resistance Tomography (ERT) survey and therefore the same ERT profile transects were sampled using GPR and many of those ERT profiles from the 2012 West Bank season and all the previous Karnak ERT profiles from 2008 and 2012. GPR was also used to carry out area surveys in order to investigate specific areas with associated structures and interiors of possible archaeological interest, in conjunction with magnetometer survey where appropriate.

The GPR survey was conducted using a GSSI 200 Mhz antenna, with the frequency of the antenna propagating a signal to a maximum depth of 6–8 m. The area surveys were carried out using traverses recorded at 0.5 m intervals. GPR transects were run along the same lines as the ERT profiles in order to recover comparative data. Long transects were split into shorter lengths in order to reduce the possibility of a large cumulative error due to the mechanical properties of the odometer wheel and localised rough terrain. The GPR data were processed in Reflex2DQuick and GPR Slice software. All profiles were processed to remove background noise, and a regain function was applied to strengthen the deeper responses to the radar signal. All data were then sliced and resampled to produce a series of timeslices through the site.

Magnetometer survey

Magnetometer survey was conducted to provide survey data in selected areas associated with specific structures and features located in the landscape or from historic map data using the same equipment, software, and procedures as in 2012.[9] This technique was chosen as a relatively time-saving and efficient survey technique[10] suitable for detecting burials, pits, kilns, hearths, ovens, and ditches; however, in areas of modern disturbance the technique is limited by ferrous (iron) material.[11]

Archaeological features such as brick walls, hearths, kilns, and disturbed building material can be represented in the results, as well as more ephemeral changes in

[8] L. B. Conyers, E. G. Ernenwein, M. Grealy, and K. M. Lowe, 'Electromagnetic Conductivity Mapping for Site Prediction in Meandering River Floodplains', *Archaeological Prospection* 15/2 (2008), 81–91; L. B. Conyers, *Ground-penetrating Radar for Archaeology* (Oxford, 2004); L. B. Conyers and D. Goodman, *Ground-penetrating Radar: An Introduction for Archaeologists* (London, 1997).

[9] Graham et al., *JEA* 98, 29.

[10] C. Gaffney, J. Gater, and S. Ovenden, *The Use of Geophysical Survey Techniques in Archaeological Evaluations* (IFA Technical Paper 9; Birmingham, 1991), 6.

[11] A. Clark, *Seeing Beneath the Soil: Prospecting Methods in Archaeology* (2nd edn; London, 1996); I. Scollar, *Archaeological Prospecting and Remote Sensing* (Cambridge, 1990), 362.

soil, allowing the potential locations of foundation trenches, pits, and ditches to be determined. Results are, however, extremely dependent on the geology of the particular area and on whether the archaeological remains are derived from the same materials. The magnetometer survey was complemented with an area GPR survey in order to compare and contrast the differing strengths of each technique. In contrast to both GPR and ERT, magnetometry is limited by the nature of the technique to collecting data to only 1.5 to 2 m below the surface. Only one magnetometer survey area was conducted this season on the West Bank in front of the pylon of the Royal Cult Temple of Thutmose III.

Geoarchaeological methodology

The geoarchaeological work was restricted to a single hand auger (AS41) using the same methodology as laid out in our 2012 report,[12] in order to test three new 0.5 m long gouge auger[13] heads that allow for the retrieval of continuous cores of sediment by pushing the auger into softer sediments. As anticipated the gouge heads were found to work well in softer sediments, but the auger heads were necessary for the stiffer sediments.

Results

This season 10 ERT profiles (P18–27) (table 1), 15 GPR profiles (G001–G015), three GPR area surveys (AG01–AG03), one magnetometer area survey (M2), and one hand auger (AS41) were carried out on the West Bank. At Karnak, a further four ERT profiles (P28–31), 18 GPR profiles (G016–G033), and four GPR area surveys (AG04–AG07) were conducted. No hand augering took place at Karnak this season.

TABLE 1 *Electrical Resistivity Tomography profiles, length, depth, and resolution*

ERT Profile No.	Surface length of profile (m)	Spacing of probes (m)	No. of levels	Approx. depth of profile (m)
P18	414	3	13	19.5
P19	264	3	13	19.5
P20	714	3	13	19.5
P21	95	1	16	8.0
P22	92	1	16	8.0
P23	126	2	16	16.0
P24	63	1	16	8.0
P25	63	1	16	8.0
P26	63	1	16	8.0
P27	63	1	16	16.0
P28	242	2	16	16.0
P29	255	3	13	19.5
P30	414	3	13	19.5
P31	318	2	16	16.0

[12] Graham et al., *JEA* 98, 30.

[13] We are very grateful to EES members, Fraser and Anne Mathews, for their generous donation that enabled the purchase of this new equipment to add to our existing hand augering kit.

Royal Cult Temple of Thutmose III

Magnetometry (M2) and GPR (AG02) were carried out in a small (64 m × 56 m) area directly in front of the mudbrick pylon of the Royal Cult Temple of Thutmose III in order to complement our ERT (P9) results of 2012, which detected a resistivity anomaly that matched the location of the northernmost feature marked as 'm2' on Wilkinson's 1830 map.[14]

Results of the magnetometry indicated the presence of possible wall structures to either side of the temple axis, although these seemed to be in relatively poor repair. Two positive discrete anomalies, measuring 4–5 m across, indicated possible plinth bases, with two smaller dipolar anomalies measuring *c.* 2 m across indicating possible plinth bases in granite or a similar volcanic stone (fig. 1).

A similar pattern of results was visible in the GPR. A linear high amplitude feature on the south-western edge of the area survey, which runs into the fields to the east, appears to be closely aligned to the axis of the secondary (southern) entrance leading from the outer court to a staircase ramp of limestone and sandstone.[15] A strong anomaly on the line of the central temple axis also indicates a possible extension of a central processional way into the fields (fig. 2). Further extension of this work is necessary (particularly given the closeness of the southern linear feature to the edge of the geophysical survey area) to clarify whether we may have two processional ways to the two entrances in the temple enclosure wall prior to the construction of the mudbrick temple pylon later in Thutmose III's reign, or whether the southern linear feature represents architecture associated with the central axis.

Royal Cult Temple of Amenhotep III

Further work was undertaken at the Royal Cult Temple of Amenhotep III (Kom el-Hetan) in collaboration with Hourig Sourouzian and the 'Colossi of Memnon and Amenhotep III Temple Conservation Project' team. Three ERT profiles (P21, P22, P23) were carried out across the central axis within and to the east of the temple proper in an effort to collect data coordinating with and connecting to channel deposits identified in the Second Court in 2012 (P13) and the excavations of the Memnon team[16] (fig. 3). GPR profile G012 was carried out from south to north along ERT profile P13 to compare results directly with the 'cut and fill' feature seen in P13. Similarly, GPR profile G013 was carried out from south to north along the line of the ERT profile P22 to offer a direct comparison with the ERT results. As with the ERT profiles, both GPR profiles aimed to identify any data that would provide evidence of either a channel or a processional way along the temple axis. GPR area survey AG01 was conducted in the First Court and comprised of thirty-one 80 m long traverses situated to pick up any evidence of a channel below the First Court and/or the processional way.

Results from ERT profile P13 (2012)[17] and the GPR profile G012 (fig. 4) indicated the presence of a substantial cut in the western part of the profiles, between 10 m and 30 m along the profile, with the edge of the cut showing clearly in the GPR, and

[14] Graham et al., *JEA* 98, 34.

[15] H. Ricke, *Der Totentempel Thutmosis' III. Baugeschichtliche Untersuchung* (BÄBA 3/1; Cairo, 1939), figs. 4, 5; P. Laskowski, 'Monumental Architecture and the Royal Building Program of Thutmose III', in E. H. Cline and David O'Connor (eds), *Thutmose III: A New Biography* (Ann Arbor, 2006), 208.

[16] Graham et al., *JEA* 98, 34; Graham, *EA*, 22, 24.

[17] Graham, *EA*, 22.

Fig. 1. Results of magnetometry area survey (M2) immediately east of the mud-brick pylon of the Royal Cult Temple of Thutmose III (background image © Google Earth).

Fig. 2. Results of the GPR area survey (AG02) immediately east of the mud-brick pylon of the Royal Cult Temple of Thutmose III (background image © Google Earth).

FIG. 3. Location of the ERT and GPR profiles and GPR survey area undertaken during 2012 (in italics) and 2013 and around Kom el-Hetan.

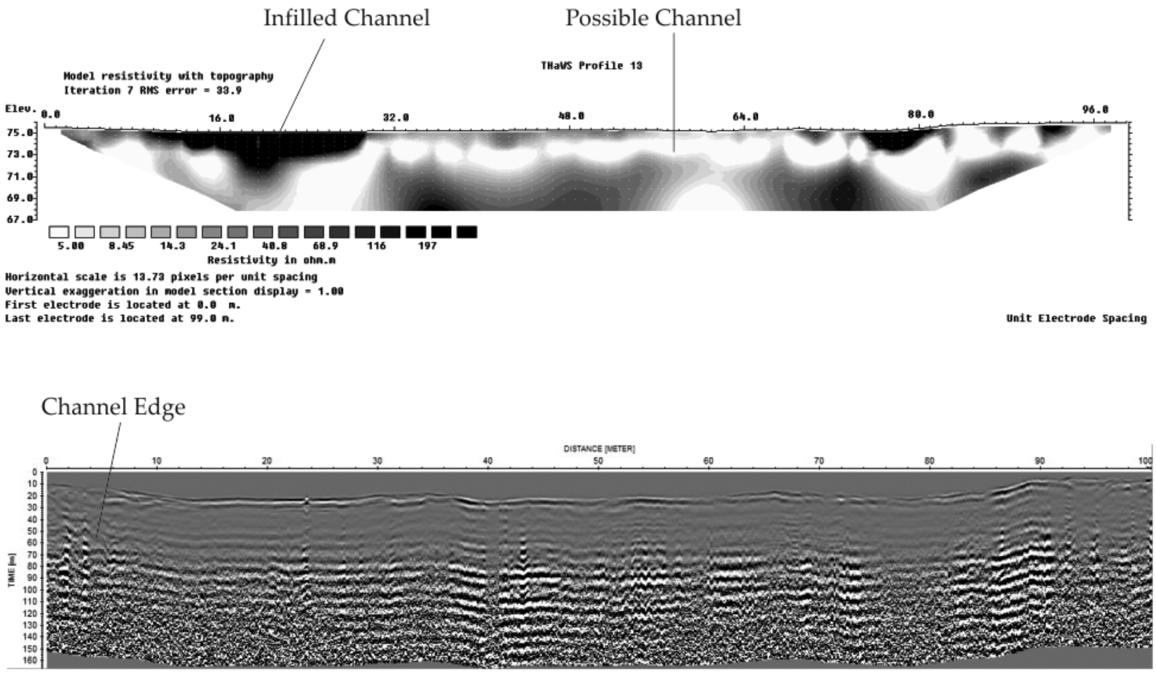

FIG. 4. Annotated results of ERT Profile P13 (2012) (above) and GPR profile G012 (below) in the Second Court of the Royal Cult Temple of Amenhotep III, showing the south side of the axis to the left and the north to the right.

the high resistivity fill showing in the ERT. This feature seems to be aligned on the centre of the temple axis. Low resistivity readings to the north may indicate a possible channel running alongside the colossi. Many of the lower sequences in the GPR, below a depth of 3–4 m, are affected by the salinity of the soil, with stronger reflections of the signal occurring from this depth.

ERT profiles P21, in the First Court, and P22,[18] in front of the Colossi of Amenhotep III, both suggest a possible channel. Between 16 m and 64 m along profile P21, an area of low resistivity most likely representing fine floodplain sediments is suggestive of a cut made into the surrounding higher resistance material. The centre of this is approximately aligned to the northern colossus, Memnon. The depth of the cut goes below the 66 m a.s.l. base of our ERT profile. Between 32 m and 48 m, it seems to have a lag of higher resistance material, perhaps fine sands, extending to 68 m. Excavations by Sourouzian's team revealed that the whitewashed floor in the First Court lies at 73.2 m a.s.l. If this is understood to be a channel to facilitate the delivery of the earlier pairs of colossi standing in front of the second and third pylons, then the depth is certainly sufficient for this process if the statues were transported during the period of inundation. Using a number of different hull dimensions and thicknesses of planking and estimates of the waterline beam at both 20 m and 24 m, the draft of a barge carrying one or both of the First Pylon colossi, estimated at 720 tonnes each, has been calculated to be less than 2.5 m.[19]

ERT profile P22 has a similar deep area of low resistance readings centred on the 48 m mark along the profile, but with a far less obvious cut outside the area of 48 m–58 m along the profile (fig. 5). A 10 m wide channel is certainly not sufficiently wide for barges delivering colossal statues to navigate. What is immediately obvious is that this situation of a possible cut into high resistance material with a fill of low resistance (Nile mud) is the exact opposite of the case of the 2012 ERT profile P13 in the Second Court, where we have a clear cut into Nile muds with a high resistance fill of rubble as observed in section in the excavations in front of the Third Pylon.[20] Thus, if we are to interpret the data in P21 and P22 as a channel cut into the temple, it would seem to indicate that the channel was either left open to fill naturally over time with Nile muds or the ancient Egyptians filled it with Nile mud (silts and clays) from the surrounding cultivable land. It is not easy to envisage either of these scenarios given the working nature of the temple. We will test these hypotheses by carrying out augering or coring to retrieve sediments in order to interpret the ERT data with greater clarity.

Profile P23 located to the east of the Colossi also seems to indicate the presence of a channel on the axis of the temple. In this instance there appears to be a channel some 13–15 m across between *c.*14–28 m along the profile, and 11 m deep from the modern ground surface to *c.*64–65 m a.s.l., in-filled with low resistivity sediments, possibly from the Nile, and with a later, shallower high resistivity infilling, possibly associated with rubble.

[18] See A. Graham and K. Strutt, 'Ancient Theban Temple and Palace Landscapes', *EA* 43 (2013) for colour images of ERT profiles P21 and P22.

[19] J. V. Wehausen, A. Mansour, M. C. Ximenes, and F. Stross, 'The Colossi of Memnon and Egyptian Barges', *IJNA* 17/4 (1988), 296–7.

[20] Graham et al., *JEA* 98, 34.

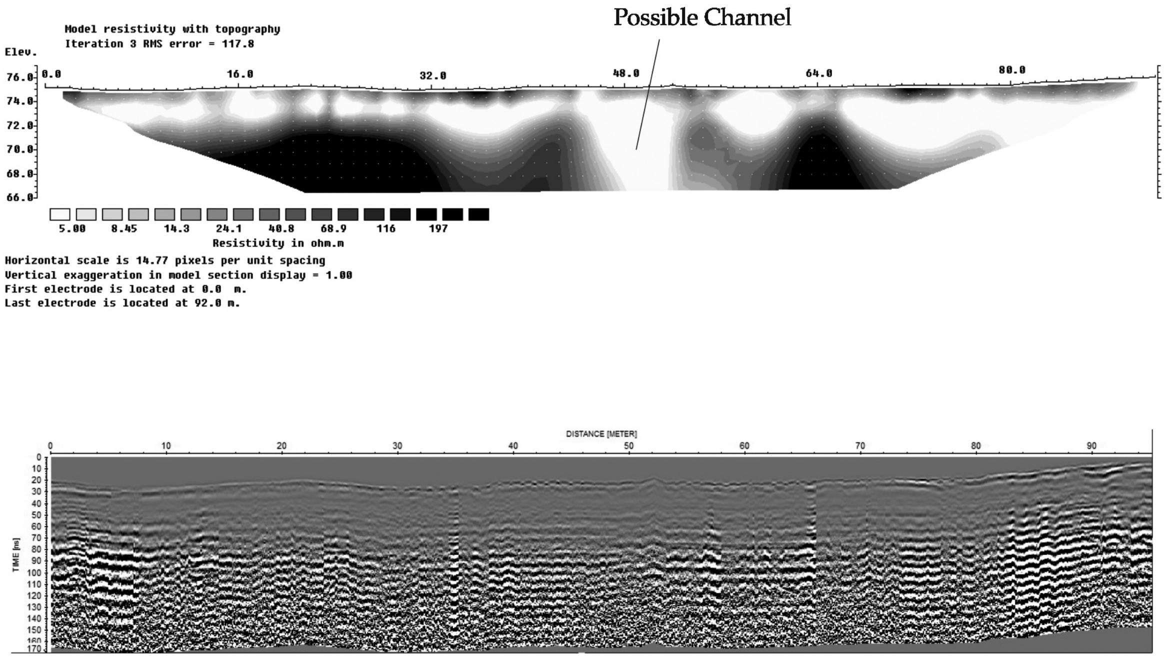

FIG. 5. Results of ERT Profile P22 (above) and GPR profile G013 (below) east of the Colossi of Memnon showing the south side of the axis to the left and the north to the right.

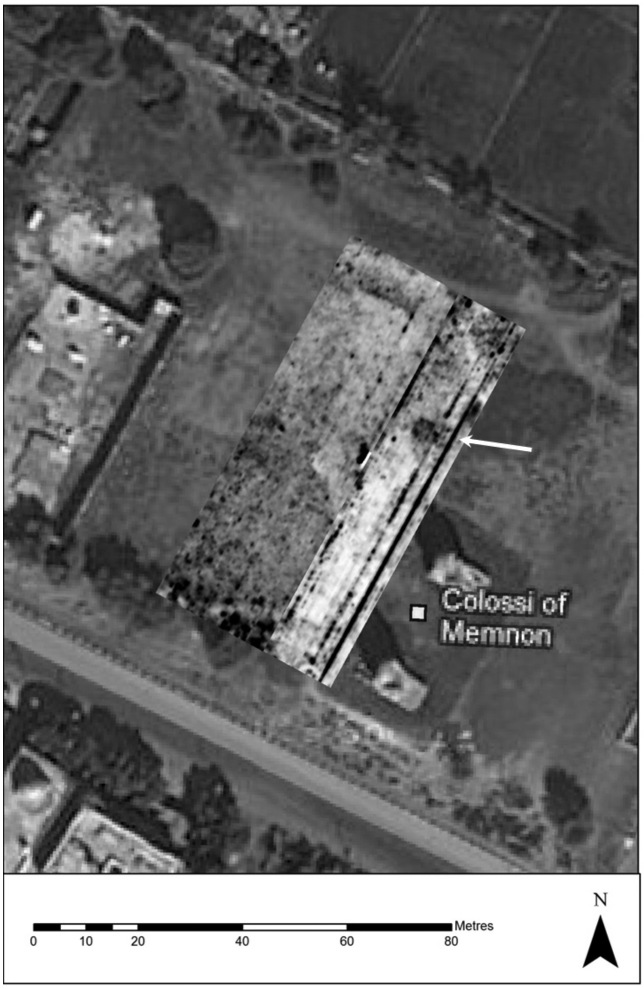

FIG. 6. Results of GPR area survey AG01 in the First Court of the Royal Cult Temple of Amenhotep III. The pit is marked by the white arrow (background image © Google Earth).

In addition to the GPR and ERT profiles at Kom el-Hetan, an area GPR survey (AG01) was conducted to the west of the Colossi to provide evidence of any possible structural remains in plan at the site. Results of the survey indicate the presence of a possible wall or court enclosure to the north of the Colossi, with sides of a possible route or axis running behind each of the monuments. Other large stone rubble is visible in a possible pit measuring some 5 m across to the north of the Colossus of Memnon (fig. 6).

A further hypothesis that will be tested in the future is the notion that the Colossi of Memnon were delivered through the Birket Habu to the south.[21] However, suggestions that long ramps were required to erect these statues[22] must be questioned given the techniques employed by Sourouzian's team to erect the Second Pylon colossi.[23]

Birket Habu

Building on the work of 2012, three ERT profiles (P18, P19, and P20) and 11 GPR profiles (G001–G011) were conducted in and around the area of the Birket Habu, continuing the investigation of the location of the ancient lake within, the position of its entrance canal, and the extent and location of the mounds surrounding it (fig. 7). A number of these profiles still require processing and detailed study.

Fig. 7. Locations of ERT profiles P18, P19, and P20, and GPR profiles G001–G011 in and around the area of Birket Habu (background image © Google Earth).

[21] R. F. Heizer, F. Stross, T. R. Hester, A. Albee, I. Perlman, F. Asaro, and H. Bowman, 'The Colossi of Memnon Revisited', *Science* 182 (1973), 1221.

[22] Heizer et al., *Science* 182, 1221.

[23] H. Sourouzian and R. Stadelmann, 'Ein Koloss aus Quarzit steht wieder: Die Aufrichtung des nördlichen Kolosses des Zweiten Pylons am Totentempel des Amenophis' III.', *Antike Welt* 44/1 (2013), 59–61, figs 1–5.

GPR profile G001 began just south of the Pennsylvania (now French/Ramesseum) dig house and went over the south side of spoil mound B3, clipping the lower south edge of mound A3[24] before passing the front of the local village mosque to end at the mudbrick wall delimiting the fields on the west side of Tir'at (Canal) Ramsis. The results clearly show tip lines on the east and west sides of mound B3. This GPR data coordinates with similar tip lines observed in Barry Kemp's excavations in the avenue between rows A and B (trench M13) and also on the west side of mound B1 (site E, trench ab–ag)[25] (fig. 8). The GPR also reveals evidence of two terraces within the mound, one of which could be seen eroding out of the west side of the mound, providing clear evidence of the value of GPR for our work. The indications of internal terraces and of tip lines offer additional evidence of the physical structure of the Birket Habu mounds, features which highlight the organisational infrastructure used in the construction of these mounds.

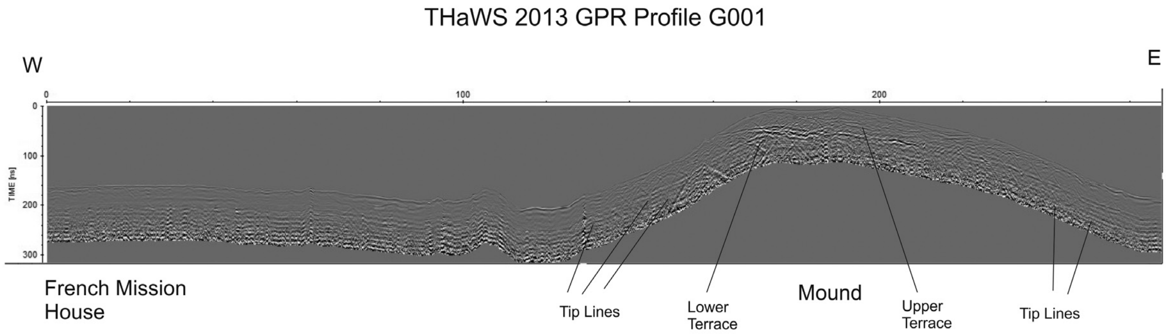

FIG. 8. The annotated results of the western section of G001 going over mound B3 and just into the avenue between B3 and A3.

Three short GPR profiles (G005–G007) were conducted along the dirt tracks leading through the village of Ezbet Basili[26] to gain insight into the archaeology of the area and, considered together with GPR profile G008, to aid the understanding of the relationship between the palaces and temples of Malkata and the area of Birket Habu. G005 and G006 were both conducted in the area of the North Palace, and G007 to the north-east of the palace (figs 9, 10). GPR profile G005 reveals a sloping interface between 57 m and 70 m along the profile. At a depth of some 3 m to 6 m in the profile, between 74 m and 71 m a.s.l. Both GPR profiles G006 and G007 have recorded data that suggest possible mound structures below the ground, potentially providing indications of ancient features whose existence has been questioned based on the modern state of preservation in and around the northwest corner of the Birket Habu.[27] Anomalies within both profiles appear to correspond approximately with the expected location of a northerly extension of the western edge of the B row of mounds, suggesting the potential for an additional mound to the west of mound X and north of mound B1 that has previously not been documented. However, there is no evidence of an eastern

[24] B. J. Kemp and D. O'Connor, 'An Ancient Nile Harbour: University Museum Excavations at the "Birket Habu"', *IJNA* 3/1 (1974), figs 4, 8.
[25] Kemp and O'Connor, *IJNA* 3/1, figs 11, 12A.
[26] Kemp and O'Connor *IJNA* 3/1, fig. 8. The village is also known locally as Ezbet al-Qummus.
[27] Kemp and O'Connor *IJNA* 3/1, 116–17.

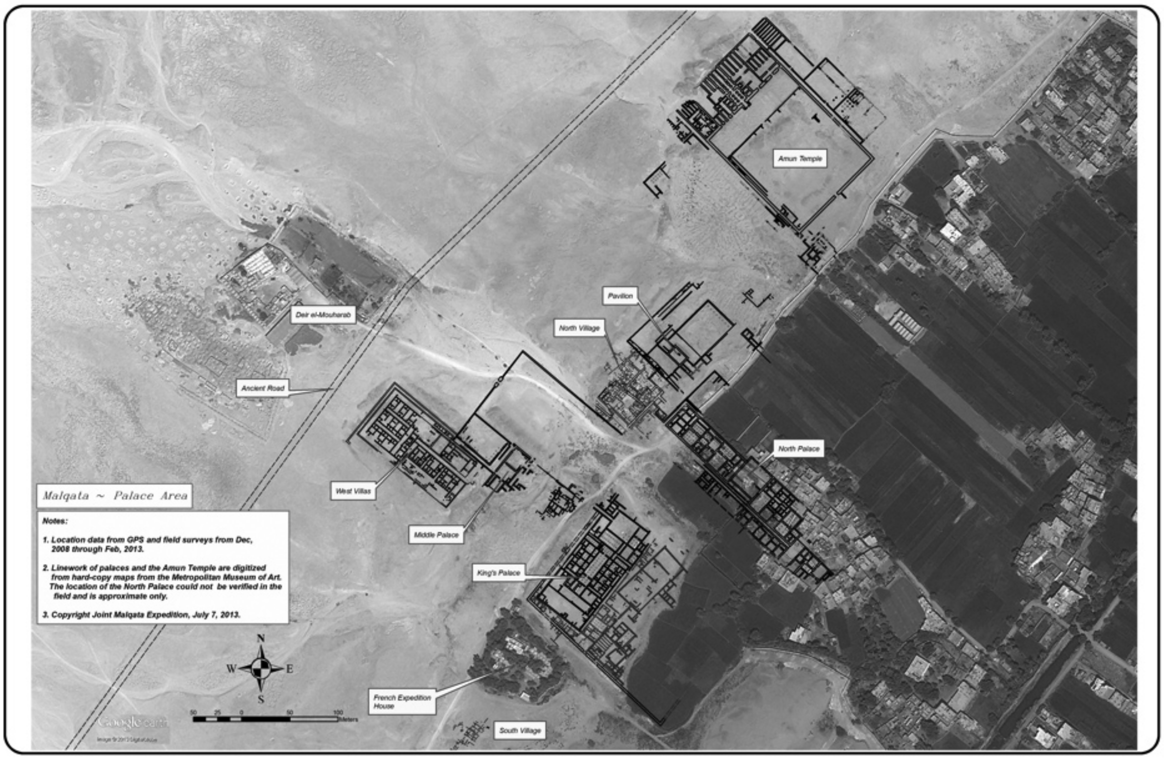

FIG. 9. The location of the complex of Malkata palaces, temples, and settlement (background image © Google Earth). Image by Joel Paulson, Joint Expedition to Malkata (JEM) topographer. Thanks are due to JEM for permission to reproduce it.

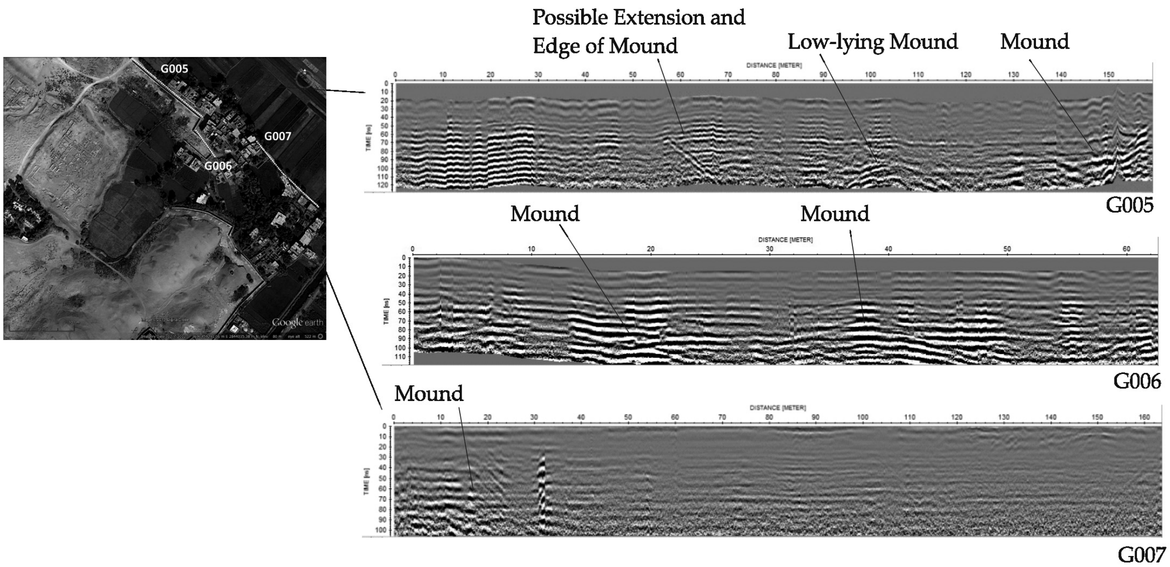

FIG. 10. The location and annotated results of GPR profiles G005, G006, and G007 in the area of the 'North Palace' at Malkata (background image © Google Earth).

edge of this mound in G007, though hopefully further work in the area will clarify this interpretation.

GPR profile G008 runs along the dirt and then tarmac road from Ezbet Basili across the Birket Habu and into the village of Kom al-Bi'irat on the east side of the birket. The profile crosses Tir'at Ramsis (Canal Ramesses), which can clearly be seen centred around the 60 m mark on the profile. It crosses Masraf Farhānah (Farhānah Drain) centred around 850 m along the profile. Anomalies suggest the presence of a possible mound below the road *c.*100–150 m east of the Tir'at Ramsis. Two further possible mounds to the east of the Masraf Farhānah may be part of the construction of the L-shaped 'D mound' now occupied by the village of Kom al-Bi'irat. However, the first of these is only 100m east of the Farhānah Drain, whereas the edge of D mound marked by Wilkinson (geo-rectified by Alban) is 160 m from the centre of the drain. This could be an additional element of the construction of the birket, possibly associated with a series of smaller mounds in the birket. The hyperbolae and reflections along the length of the profile, particularly at 40 m, 100 m, and 200 m along G008, may indicate deposits associated with the northern edge of a terrace constructed under the North Palace.

The GPR and ERT surveys across the entrance of Birket Habu (G004 and P20) show some interesting variations. Much of the southern portion of the GPR profile is affected by noise derived from modern structures along the survey line. A clear area in the results *c.*350–400 m along the profile is visible, together with reflections at 750–790 m along the profile, indicating mound deposits associated with the spoil heaps of the Birket. In the ERT profile some possible channels are visible in the centre of the profile, with a high resistivity anomaly some 240–280 m along the traverse and some 6 m deep, running down to the base of the profile. Both P20 and G004 pass over one of Wilkinson's (1830) mounds in the entrance to Birket Habu at *c.*245–280 m along their profiles, based upon the geo-rectification of his map, and this seems to be supported by this latter anomaly.

ERT profile P18 stretched south–north across the very easternmost edge of mound F[28] (the southern row of mounds) as mapped by Gardner Wilkinson.[29] GPR profile G002 started at the same point and covered the same ground as P18, but continues a further 2 km into the birket. Wilkinson observed a mound 300 m wide whereas today the area above the cultivation upon which the village of Hajir al-Aqaltah sits is only 150–200 m wide. The reclamation of the mound as fields is particularly clear in the field patterns on the inside of the birket. The eastern end of the mound has also been truncated by the cutting of the Farhānah Drain. We aimed to investigate the depth and extent of the mound below the surface, and possibly identify a southern edge of the basin.

P18 cuts across Wilkinson's geo-rectified mound F at *c.*230–320 m along the profile. The large body of higher resistance material lying at *c.*190–290 m along the profile broadly corresponds to this. The appearance of these high resistance readings down 19 m below the current ground level may suggest the presence of a natural feature in the landscape opportunistically used by Amenhotep III's engineers as they excavated the lake basin within the Birket Habu and created the mounds around it. This hints at

[28] Kemp and O'Connor, *IJNA* 3/1, fig. 4.

[29] J. G. Wilkinson, *Topographical Survey of Thebes, Tape, Thaba, or Diospolis Magna* (London, 1830).

some of the practical aspects of the mound creation, though it represents only an initial hypothesis that requires further future investigation through augering or coring.

A channel marked on Wilkinson's (1830) map lies at *c.*141–165 m along P18 and G002. In P18 a fill of low-resistance (Nile muds) between higher resistance deposits appears to align with such a channel. Reflections in the GPR profile G002 suggest possible sediments linked to mound or kom remains to the north of such a channel. Any channel deposits themselves do not provide a strong contrast. No traces of the further channel marked on Wilkinson's plan, some 430 m along the G002 profile, were located, although further processing of the data may reveal other anomalies.

Karnak

The 18 GPR profiles carried out at Karnak this season totalled 5.4 km in length. Many were conducted to compare directly with ERT profiles from 2008 (P01–03) and 2012 (P14–15), as well as those from 2013 (P28–31). GPR profiles were also carried out where ERT was more problematic due to paving (e.g. G017, G022, G023, and G025), again demonstrating the value of employing the GPR in addition to the ERT. Four GPR survey areas were conducted: AG04 in the Hypostyle Hall of the Amun-Re temple; AG05 in the First Court of the Amun-Re temple; AG06 at the bottom of the ramps in front of the First Pylon; and AG07 in front of the North Karnak Tribune (fig. 11).

The aim of the small GPR area survey AG05 between the columns erected by Taharqa in the First Court was to see if we could identify a *c.*1.5 m wide channel-like feature running through the First Court along the central axis.[30] In fact the GPR survey seems to indicate the presence of two parallel high amplitude anomalies running from north to south across the court, rather in the direction of the principal axis of the temple.

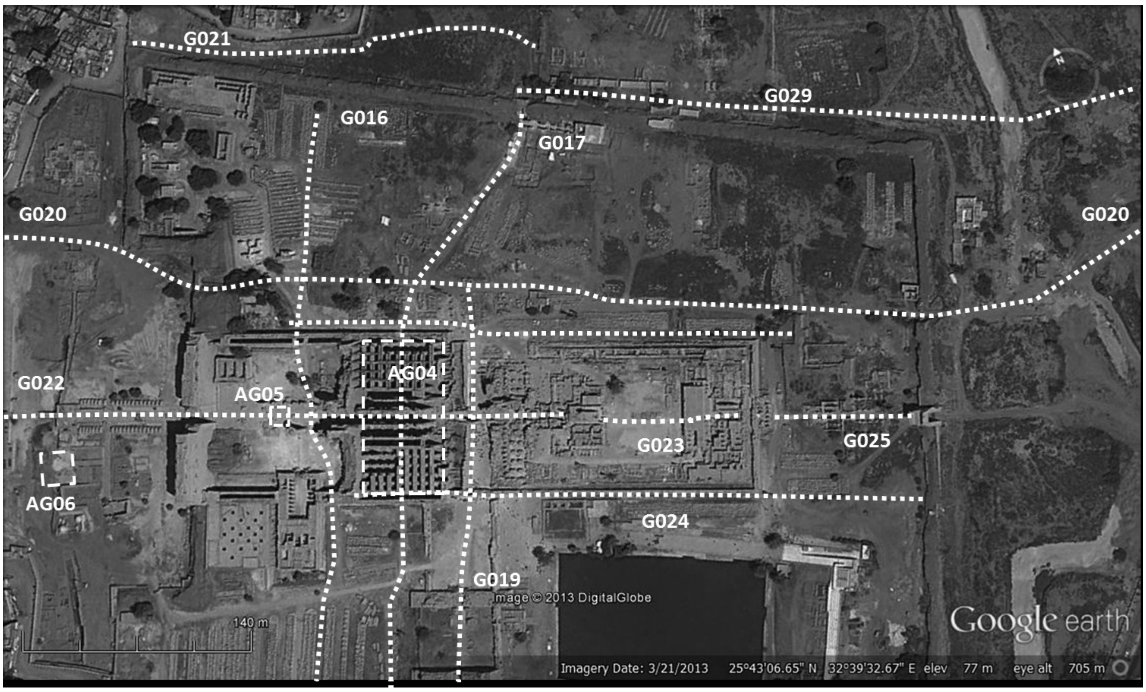

FIG. 11. Location of 2013 GPR profiles and area surveys in the central Karnak area (background image © Google Earth).

[30] This feature consisting of two parallel mudbrick walls was filled with water when excavated by J. Lauffray: F. Larché, *La cour à portique de Thoutmosis IV* (Paris, 2013), pl. 13.

A quiet area in the main features may indicate the path of the axis; however, the two parallel anomalies together with a third, fainter linear anomaly running from north to south further to the east, are more indicative of a path or channel, plus possible buildings, running on a north–south axis.

The aim of GPR area survey AG06 at the bottom of the ramps lying to the south of the tribune/reception platform in front of the First Pylon was to see if we could detect whether they extended further west below the excavated ground level.[31] The GPR identified 6 linear features in line with the central ramp, dated to the reign of Taharqa,[32] that suggest the ramp extended further westwards beyond the line of the tribune and quayside walls (fig. 12). The northern wall of the extant ramp is visible in the results running for at least a further 5 m west, and a linear anomaly, in line with the southern edge of the extant ramp, runs from part way across the survey area west–east for a distance of 7 m. This seems to indicate the southern edge of the ramp, although its eastern extent is not visible. Several other linear anomalies suggest the presence of other possible ramps to the south of the main ramp, and possible structures and further ramp features to the north of the main structure. Further processing of the preliminary data will enable the team to elucidate further the nature of these anomalies. However the data raises the question of how far the ramp extended and to what height above sea level it descended. It is clear from the steps set within the quayside walls both north and

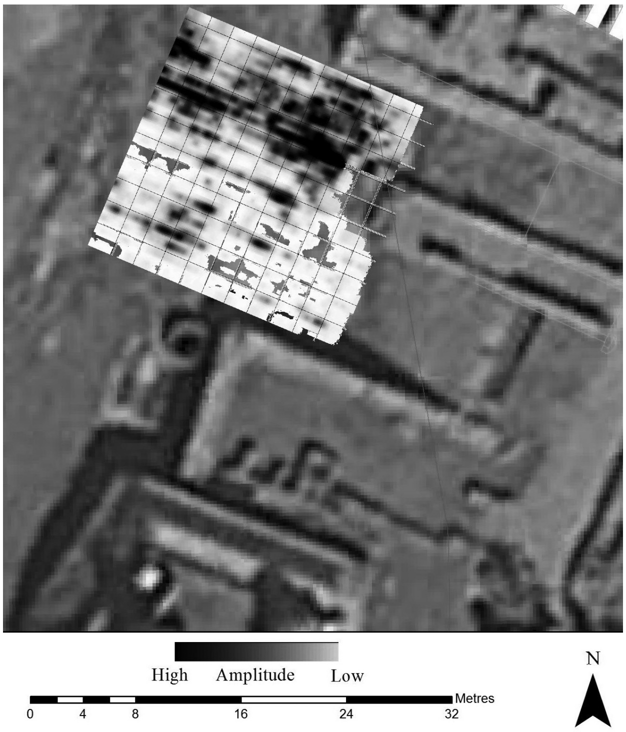

Fig. 12. Results of the GPR area survey AG06 at the bottom of the ramps in front of the First Pylon at Karnak (background image © Google Earth).

[31] AG06 was carried out at the invitation of Mansour Boraik (director general of Luxor antiquities, MSA), who directs the research into the ramps and quayside in front of the First Pylon.

[32] J. Lauffray, 'Abords occidentaux du premier pylône de Karnak: Le dromos, la tribune et les aménagements portuaires', *Kêmi* 21 (1971); C. Traunecker, 'Les rites de l'eau à Karnak d'après les textes de la rampe de Taharqa', *BIFAO* 72 (1972); M. Boraik, 'Excavations of the Quays and the Embankment in front of Karnak Temples: Preliminary Report', in Centre franco-égyptien d'étude des temples de Karnak, *Cahiers de Karnak*, XIII (Paris, 2010), 70.

south of the tribune, with mooring loops at different heights, that they were designed to enable large processional boats to moor alongside at different heights within the annual Nile cycle.[33] These narrow steps would not have facilitated the loading or unloading from a shrine on a barque by the priesthood to the processional boat. Is it possible that this central ramp was constructed to do just that?

Conclusions

The ERT profile data in particular has suggested a number of in-filled cut features. In some instances, e.g. P18 this season and P4 (2012),[34] these correspond to recent channels in the West Bank floodplain mapped by Gardner Wilkinson in the 1820s. Others may well be ancient channels contemporary with the temples they are associated with e.g. the Royal Cult Temple of Amenhotep III, perhaps used for the construction of the temple and possibly also later deliveries and festival processions. They still require verification or otherwise by augering. At this stage we have not yet covered enough ground on West Bank to provide conclusive evidence of an intra-temple canal system.

At the Birket Habu we have begun to provide further evidence of the construction techniques and locations of the enormous spoil mounds bounding the birket area. In the area of the north-west corner, the GPR profile G001 provides evidence illuminating the process of the creation of the mounds, suggesting that, at least in some cases, internal terraces were constructed. Tip lines were revealed in this GPR profile supporting the observations in Kemp's 1971 and 1973 excavations. The GPR profiles across the area of the North Palace and extending across the interior of the Birket Habu (G005–08) provide initial indications that the western row of mounds extended further north than has been observed or assumed until now. The work has also enabled the coordination of data from Wilkinson's early modern map of the area. Results from ERT profile P18 across the southern line of mounds also appears to reveal features noted on Wilkinson's map. It is hoped that further geophysical survey in the area north of the A and B mounds in the northwest corner and between mounds F and E will assess the possibility that the rows of mounds continued, producing a landscape with a more enclosed Birket Habu than has previously been assumed. With continued work at the Birket Habu and the Royal Cult Temple of Amenhotep III we hope to provide clarity to the interpretations of Amenhotep III's building programme in the Theban area as presenting the cosmos on earth.[35] We also aim to test the hypothesis that the location of Amenhotep III's royal cult temple was positioned to accord with cosmogonical reasoning such that it would be intentionally flooded by the waters of Nun, the annual inundation, with the royal colossi being seated on the 'primeval mound'.[36] Whilst in recent times the inundation has been observed around the Colossi of Memnon,[37] it remains to be determined if the inundation levels during the reign of Amenhotep III reached heights sufficient to flood his royal cult temple.

[33] H. Chevrier, 'Rapport sur les travaux de Karnak', *ASAE* 46 (1947); Boraik, *Cahiers de Karnak* XIII, 72.

[34] Graham et al., *JEA* 98, 32.

[35] D. O'Connor, 'The City and the World: Worldview and Built Forms in the Reign of Amenhotep III', in D. O'Connor and E. H. Cline (eds), *Amenhotep III: Perspectives on his Reign* (Ann Arbor, 1998), 154–72.

[36] O'Connor, in O'Connor and Cline (eds), *Amenhotep III*, 160; B. M. Bryan, 'Designing the Cosmos: Temples and Temple Decoration', in A. P. Kozloff and B. M. Bryan (eds), *Egypt's Dazzling Sun: Amenhotep III and his World* (Bloomington, 1992), 93.

[37] See e.g. D. Arnold, *Lexikon der ägyptischen Baukunst* (Düsseldorf, 1994), 153.

The geophysical results in front of the mudbrick pylon of the Royal Cult Temple of Thutmose III clearly reveal the temple complex extending into the floodplain. This is not surprising given our understanding of processional ways and tribunes of temple complexes.[38] It will require further work in the floodplain east of the temple to see if there once was a connection to a reception platform, basin and canal as suggested by the scene in the tomb of Khons (TT31).[39]

At Karnak we have continued to elucidate the complex history of the site with the apparent structures perpendicular to and crossing the central axis in the First Court and the probable extension of Taharqa's ramp in front of the First Pylon that may have been a key part of the festival processions departing from and arriving at Karnak.

Despite a season on the ground of only three weeks, we collected an enormous amount of geophysical data, much of which still requires processing and study. The study of this data will in part help to clarify some of the interpretations made to date. However, what is necessary to illuminate our interpretations still further is to extend the geophysical survey areas at a number of locations to provide further context to the work undertaken thus far. It is also essential to ground-truth the geophysics through augering and coring of sediments to test the hypotheses of a number of channels seen in the ERT profiles.

In time we hope to contribute to the discussions of the itinerary and mode of travel of the weekly procession of Amenemopet from Luxor temple to the 'Genuine Mound of the West' on the site of Medinet Habu in a ritual recreation of the cosmos[40] and Amun-Re in the Valley Festival from Karnak to the royal cult temples and necropolis on the West Bank[41] celebrated by all in ancient Thebes.

[38] A. Cabrol, *Les voies processionnelles de Thèbes* (OLA 97; Leuven, 2001); H. Jaritz, 'Die Tribünen vor ägyptischen Tempeln der 18. Dynastie bis zur Römerzeit: Ein Deutungsversuch zur Funktion', in P. Jánosi, (ed.), *Structure and Significance: Thoughts on Ancient Egyptian Architecture* (DGÖAW 33=UZK 25; Vienna, 2005), 341–400.

[39] W. Wreszinski, *Atlas zur altägyptischen Kulturgeschichte*, I (Leipzig, 1923), pl. 128; R. Stadelmann, 'Totentempel und Millionenjahrhaus in Theben', *MDAIK* 35 (1979), 306; Jaritz, in Jánosi (ed.), *Structure and Significance*, 345 n. 27.

[40] W. J. Murnane, United with Eternity: A Concise Guide to the Monuments of Medinet Habu (Chicago, 1980), 76–7; O'Connor, in O'Connor and Cline (eds), Amenhotep III, 168–9.

[41] U. Rummel, 'Ramesside Tomb-temples at Dra Abu el-Naga', *EA* 42 (2013), 17; J. Budka, *Bestattungsbrauchtum und Friedhofsstruktur im Asasif: Eine Untersuchung der spätzeitlichen Befunde anhand der Ergebnisse der österreichischen Ausgrabungen in den Jahren 1969–1977* (DGÖAW 59=UZK 34; Vienna, 2010), 479–85; L. Bell, 'The New Kingdom "Divine" Temple: The Example of Luxor', in B. E. Shafer (ed.), *Temples of Ancient Egypt* (New York, 1997), 136–7; E. Graefe, 'Talfest', in *LÄ* VI, 187–9; C. F. Nims, *Thebes of the Pharaohs: Pattern for Every City* (London, 1965), 138–9; G. Foucart, 'Études thébaines: La belle fête de la vallée', *BIFAO* 24 (1924), 1–209.