Recent Advances in Archaeological Geophysics

Friday 19th February – hosted online by University of Leeds, School of Earth and Environment

Session 1

1. **Stephen Kay (British School at Rome)** – **online!** - https://youtu.be/aN16AGvNYf0
   Vespasian's baths? Geophysical prospection at the site of Terme di Cotilia, Lazio (Italy)
2. **Duncan Hale (Archaeological Services, Durham University)**
   – **online!** - https://youtu.be/AyQ_WfIKxHI
   Presenting interpretations of complex datasets: examples of recent magnetometer surveys in the Nene Valley, UK
3. ***Bulletin:*** **John Oswin (Bath and Counties Archaeological Society)**
   Looking under church floors – **online!** - https://youtu.be/P0JqRWAP6kg
4. **Michał Pisz (Faculty of Geology, University of Warsaw)** – **online!** - https://youtu.be/U-SO83tzLr8
   Magnetic investigations at the Treblinka II extermination camp

Session 2

1. **Veli Voipio (Aalto University)** – **online!** - https://youtu.be/IlESwRuwjac
   Tilted GPR beam in the ground
2. **Adam Booth (University of Leeds)** – **online!** - https://youtu.be/f2VI97V1Y3A
   Lockdown lessons for drone-based GPR: simulations using a (badly) homemade drone
3. ***Bulletin:*** **Paul Blockley (RA.GA Srl)**
   Geophysical prospection on the site of a Medieval castle in Northern Italy, 2019
4. **Ed Burton (Magnitude Surveys)** – **online!** - https://youtu.be/rJJcZJyCNxA
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5. **Mandana Parsi** (Ludwig-Maximilians-University of Munich) – **online!** - https://youtu.be/tZ8-Z6GH8wU
   Looking beneath Yeha (Ethiopia) with 3D Electrical Resistivity Tomography (ERT)

Session 3

1. **Jonathan Fowler (Saint Mary's University)**
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   Looking for historical graves at the San Ildefonso Cathedral

1.1 Vespasian's baths? Geophysical prospection at the site of Terme di Cotilia, Lazio (Italy)

Stephen Kay (s.kay@bsrome.it; British School at Rome), Elena Pomar (British School at Rome), Myles McCallum (Saint Mary's University Halifax) and Martin Beckmann (McMaster University)

View it online! https://youtu.be/aN16AGvNYf0

The sprawling Roman monumental complex of the 'Terme di Cotilia', located on the Via Salaria 90km northeast of Rome, was first recorded in 1809 however its precise function remains uncertain. In 2020 the British School at Rome undertook the first archaeological prospection at the site, using magnetometry and GPR to principally examine a large terrace adjacent to the ancient consular road. The aim of the survey, undertaken on the behalf of Saint Mary's University Halifax and McMaster University, was to better understand the purpose of the buildings, variously interpreted either as an Imperial bath complex or a religious sanctuary. The multiple technique geophysical survey recorded a range of previously unknown structures that shed new light on the function of this site.

1.2 Presenting interpretations of complex datasets: examples of recent magnetometer surveys in the Nene Valley, UK

Duncan Hale (d.n.hale@durham.ac.uk; Archaeological Services Durham University), Richie Villis, Mark Woolston-Houshold

View it online! https://youtu.be/AyQ_WflKxHI

This presentation will look at three recent high resolution magnetometer surveys conducted in the Nene Valley in the east of the UK. Each survey covered a scheduled monument and served as a window onto the rich archaeological landscapes of the prehistoric and Roman periods. However, from one site to the next, the interpretation of each dataset and how to present the interpretation in a client report became increasingly more challenging, largely due to the high densities of archaeological features detected. At the third site, the Roman small town of Durobrivae, it became clear that our usual method for presenting interpretative plans would not be sufficient, or practical. In this instance, we attempted to separate different types of magnetic anomaly into different 'layers' of interpretation, which could be viewed separately but could also be combined into a composite interpretation. This approach was useful in this instance, where printed copies of reports were required in addition to the digital resources. Similar challenges arise with presenting the results of very large surveys, and in both cases the challenges are best overcome by moving away from the constraints of a more traditional report towards the report being a digital package of resources.

1.3 Looking Under Church Floors

John Oswin (oswinjohnr@gmail.com), Sophie Hawke, Fiona Medland and Rick Buettner (Bath and Counties Archaeological Society)

View it online! https://youtu.be/P0JqRWAP6kg

The development of the TR resistance meter for the Council of Independent Archaeologists (CIA) enabled many amateur societies to have a capability in geophysics at low cost. The meter was

further developed to add a facility for Earth Resistance Tomography (ERT), locally called 'Profiling'. The Bath and Counties Archaeological Society (BACAS) has extended this capability by adding the full RES2DINV processing software and finding a way to work through solid surfaces.

Some large churches have commissioned radar surveys to detect tombs and vaults beneath the floor, but such professional services are beyond the budgets of our small village churches. Two case studies are given here of the ERT method developed by BACAS being used to detect vaults under small village churches.

1.4 Magnetic investigations at the Treblinka II extermination camp

Michal Pisz (michal.pisz@uw.edu.pl; Faculty of Geology, University of Warsaw), Sebastian Różycki (Faculty of Geodesy and Carthography, Warsaw University of Technology)

View it online! https://youtu.be/U-SO83tzLr8

During World War 2, a large population of Jews was brought under the control of Nazi Germany following their invasion of Poland (1939) and Soviet Union (1941). The primary plan of expelling Jews and Roma from Europe evolved into the project of eradication of this population. The planned extermination begun in 1941, however it was in January 1942, during a Wannsee Conference, when the "Final Solution to the Jewish Question" (Ger: *Endlösung der Judenfrage*) was officially presented to and approved by senior government officials. The extermination camp Treblinka II was one such facility, constructed by Germans on Polish land in 1942, as a part of Operation Reinhardt (Ger: *Einsatz Reinhardt*). It is considered that over 800.000 people were murdered in Treblinka II between July 1942 to November 1943, when Operation Reinhardt was ended. Much effort was directed towards covering the traces of these horrific facilities. Many parts of the camp's infrastructure has been successfully erased and, due to restrictions of Halakha, invasive archaeological research cannot be applied to uncover these traces.

This presentation reports achievements of the Polish team which undertook non-destructive research in Treblinka II from 2018, with the main focus on the results of magnetometry survey.

2.1 Tilted GPR beam in the ground https://youtu.be/llESwRuwjac

Veli Voipio (veli-erikki.voipio@aalto.fi; Aalto Univestity, Finland)

View it online! https://youtu.be/llESwRuwjac

In this presentation, I introduce the idea of a tilted beam in GPR. Tilting is now possible due to the relatively narrow beam of my Gopher antenna. The use of a neoprene filling allows for a smooth coupling between the antenna and the ground.

2.2 Lockdown lessons for drone-based GPR: simulations using a (badly) homemade drone

Adam Booth (a.d.booth@leeds.ac.uk), Tiffany Koylass (School of Earth and Environment, University of Leeds)

View it online! https://youtu.be/f2Vl97V1Y3A

Interest is growing in the application of drone-based GPR surveys. Drones offer the potential for increased survey efficiency, access in otherwise inaccessible areas, and risk reduction where the ground is potential hazardous (e.g., UXO). However, guidelines for optimal flight heights remain unclear: for optimal results, should the drone fly as high as possible off the ground (legislation notwithstanding) or as close as possible to it? Flying high limits the degree of refraction at the air-ground interface, but increases the vulnerability to off-line scattering and propagation losses. On the other hand, flying low reduces the amount of spreading, but complicates the wavelet raypaths and thus how subsurface geometries are represented in data.

Here, we simulate drone responses using Matlab and gprMax software, and compare predicted responses to DIY-drone acquisitions made over an urban archaeological target. Simulations involve a drone emitting 1000 MHZ GPR energy, flying at heights up to 3x the nominal GPR wavelength. We suggest that subhorizontal layers can be imaged well, but the appearance of diffraction hyperbolae is heavily distorted with a low flight height. Our real-data acquisitions use a bio-powered polystyrene drone into which Sensors&Software pulseEKKO antennas (1000 MHz centre frequency) are mounted, targeting historical road foundations near to the Leeds-Liverpool canal, at Rodley, Leeds. Clear diffraction hyperbolae, presumably from now-covered road cobbles, are highly distorted when GPR energy is air-launched. Of greater significance than the flight height could be the requirement for antennas with greater directionality, thus limiting the application of standard GPR antennas for a drone-based platform.

More work is of course required with a rather more credible drone!

2.3 Geophysical prospection on the site of a Medieval castle in Northern Italy, 2019

Paul Blockley (archeogeo@gmail.com; RA.GA Srl)

As part of an archaeological research project in the commune of San Ilario d'Enza (Reggio Emilia, Italy), a small geophysical survey of 8500 square metres, was conducted with a Bartington Mag 601-2 gradiometer on the area once occupied by the small medieval castle. The aim of the survey was to confirm the location of the boundary walls, which were visible in aerial photos, look for traces of activity and structures in the internal courtyard, and to check for the presence of a suspected external moat.

The results were very encouraging: the resulting magnetogram revealed parts of the curtain wall and the eastern tower. In the external area, the magnetic signal was flatter, indicating an area without archaeological remains, but the strip immediately outside the defensive wall shows a more variable signal, which could indicate the presence of a backfilled moat. In the courtyard area, many small positive anomalies were visible: possibly ferrous objects or other archaeological material. A linear anomaly with a very variable signal would seem to be the continuation of the road documented in

recent archaeological excavations. On either side of the road, a series of positive, sub-circular, anomalies were visible, which could be the bases of hearths or furnaces.

2.4 Innovation and the Prosumer Revolution

Ed Burton (e.burton@magnitudesurveys.co.uk; Magnitude Surveys)

View it online! https://youtu.be/rJJcZJyCNxA

Over the last decade, advances in IT and manufacturing technology have opened up access to increasingly advanced tools and methods for innovation. This paper examines how Magnitude Surveys has implemented 'prosumer' technologies into its development of bespoke systems and software, with a focus on addressing the needs of large-scale survey designs and on tailoring surveys to different research questions.

This presentation explores two case studies. Firstly, an overview of the development of a modular GPS-positioned magnetometer and EM system, configured to adapt to varying ground conditions while maintaining consistent data quality. Secondly, a detailed account of the ongoing challenges of designing and building a lightweight multi-channel GPR system intended for more efficient data collection in a range of survey environments.

2.5 Looking beneath Yeha (Ethiopia) with 3D Electrical Resistivity Tomography (ERT)

Mandana Parsi (mandana.parsi6@gmail.com; Ludwig-Maximilians-University of Munich (LMU)), Jörg Fassbinder, Sandra Hahn, Iris Gerlach, Sarah Japp

View it online! https://youtu.be/tZ8-Z6GH8wU

We used 3D Electrical Resistivity Tomography (ERT) measurements in Yeha (northeastern Ethiopia) to model a multi-layered underground settlement from pre-Aksumite and Aksumite times (early 1st millennium BCE – 8th century AD). A large-scale magnetometer prospection has been done in this area in 2018 and 2020 by our team. According to the results of the magnetograms and previous excavations, we chose a suitable area for 3D ERT prospection. The 3D models revealed multi-layered interconnected walls with a height of 60 - 120 cm made of stones and proved the continuation of this substructure on the east side of the excavation.

3.1 Is this the church of St-Charles-des-Mines?

Jonathan Fowler (jonathan.fowler@smu.ca; Saint Mary's University)

French colonists established the church of St-Charles-des-Mines at Grand-Pré, Nova Scotia, around 1687, and it served as a place of worship until the community was destroyed in the lead-up to the Seven Years' War. New England troops used the church in 1755 to imprison hundreds of French inhabitants prior to their deportation later that year. Longfellow made the event famous in "Evangeline: A Tale of Acadie" (1847). The field in which the church of St-Charles stood has since become the heart of Grand-Pré National Historic Site of Canada and the Landscape of Grand-Pré UNESCO World Heritage Site. But where are the ruins of the church? Although the site has been

heavily modified by antiquarian diggers and, more recently, by construction activities in the service of official heritage, significant clues remain. For the past 20 years we have studied the area through our annual archaeological field schools and with multi-instrument geophysical surveys. The tight feedback loop combining geophysics with follow-up test excavation has been instructive. This presentation summarizes our key findings and proposes that the ruins of the church may be more evident geophysically than archaeologically.

3.2 Geophysical Survey of Site 14LV425, Leavenworth County, Kansas

Blair Schneider (blair.schneider@ku.edu; Kansas Geological Survey, University of Kansas), Christopher Eck (Natural Resources Conservations Service, United States Department of Agriculture)

Northeastern Kansas is home to the earliest peoples in Kansas, with associated sites spanning 11,500 years. Site 14LV425 is an archaeological site that resides within the Old Kickapoo Reservation (1832-1854). This site was described by Jim Feagins in a Report to the Kansas State Historical Society in 2017 as consisting of a house and several likely Kickapoo burials. The current landowners at this site are working to create a wetland area, which could affect any remaining site features or burials. Geophysical surveys, including magnetics and ground-penetrating radar, were utilized to determine if any features, and in particular burials, remain in the affected area. Three anomalies were detected by the magnetic survey, each appearing to be a unique object that varies in size and magnetic strength. The GPR data detected one anomaly that is consistent with the size and shape of a possible burial. In addition, the GPR data detected an anomalous semi-circular feature that is not visible at the surface. Further investigation is recommended to determine the source of this feature.

3.3 Looking for historical graves at the San Ildefonso Cathedral

Itzayana Bernal Cortés (ibecorts@gmail.com; Faculty of Engineering, Autonomous University of Mexico (FI-UNAM)), Jorge Blancas Vázquez (Institute of Anthropological Research, IIA-UNAM), Luis Barba Pingarrón (Institute of Anthropological Research, IIA-UNAM), Agustín Ortiz Butrón (Institute of Anthropological Research, IIA-UNAM)

View it online! https://youtu.be/7delMsUZgfY

The important finding of a historical document from 1574 during Friar Diego de Landa's Bishopric was the start point of the study of the basement of the Cathedral of San Ildefonso, Mérida Yucatan in Mexico. This document describes the distribution of the funeral spaces in the floor of the cathedral and mentions some names of important figures of Spanish society of this nascent city (Merida), who had been purchasing these spaces. Ground-penetrating radar (GPR), a geophysical method, is appropriate in these spaces, it allows for a large amount of information to be collected from the subsoil near the surface, with high resolution, without excavation or any invasive technique. Covering the largest possible area in a system of grids established inside the Cathedral of San Ildefonso, it was possible to map anomalies, obtaining their distribution, geometries and depth estimates, detecting the presence of possible burial chambers, tombs and other anomalies that suggest the presence of colonial or pre-hispanic structural elements. Finally, those anomalies were pointed out in relation to the information on the graves of the historical document of 1574, complementing the historical and archaeological research.