S23 Needles in the haystack: Geophysical methods in challenging conditions

Lars Gustavsen, Christer Tonning, Arne Anderson Stamnes, Erich Nau, Monica Kristiansen

The development of geophysical techniques for archaeological purposes has largely taken place in areas where archaeological features tend to be pronounced, well-defined and, arguably, easily detected by geophysical instruments. Often, however, we are faced with archaeological features which do not readily lend themselves to detection by these methods. This is sometimes compounded by local geomorphological and pedological conditions, which may obscure or mask the archaeological features. This calls for different approaches to how geophysical methods are applied, and it requires comprehensive field observation regimes to verify and understand the geophysical properties of the archaeology.

In this session we wish to focus on projects where adverse geological, geomorphological, pedological and archaeological conditions have been encountered. We want to explore how these conditions have affected the geophysical survey results and their archaeological interpretability, to see how these phenomena have been observed through archaeological feedback, and how the results have influenced subsequent field procedures.

S23-01 Magnetic geophysical prospection on prehistoric iron production sites in cultivated contexts: The case of Ånestad, Hedmark in Norway

Christian Løchsen Rødsrud, Arne Anderson Stamnes, Kristin Eriksen

In 2010 Hedmark County Council uncovered ten furnaces at two sites, dated to the Merovingian period (600–800 AD) in a cultivated field at Ånestad, Løten, Hedmark. In 2015 the Museum of Cultural History conducted excavations of the sites. In a preliminary phase a geophysical survey was completed, using topsoil magnetic susceptibility mapping and gradiometer surveys, to clarify the extent of the production sites.

The geophysics resulted in many anomalies interpreted as possible furnaces. While several proved to be furnaces, a range of geophysical anomalies proved to be of a quite different nature (stones, clay, etc.) when compared with the excavation evidence.

In this paper we will discuss what was done methodically and present our experiences on how the geophysical data were put to use and affected the strategy of the excavation, as seen both from the geophysical surveyors and the excavator's point of view. We will also discuss how the archaeological feedback helped altering the initial archaeological interpretation of the geophysical data, and potentials and pitfalls associated with such a cross-disciplinary collaboration. Finally, we will see this survey from a heritage management and planning perspective, and discuss the value of the geophysical prospecting opposed to the "regular" survey of the County Council. Did the magnetic geophysical surveys contribute with additional data preliminary to the field work at this site? And generally; is more methodical work needed before geophysics is applicable in rescue archaeology of similar sites? We believe the Ånestad–results will act as a contribution to further refinement of the field methodologies and improved understanding of magnetic geophysical data of similar sites in the future.

S23-02 Understanding contrast at Busayra: Geophysical surveys of an Iron Age settlement in Southwest Jordan

Christine Markussen, Katie Simon, Benjamin Porter, Stephanie Brown

In 2014 geophysical surveys were conducted at Busayra, southwest Jordan, as part of collaboration between and the University of California, Berkeley and the University of Arkansas' SPARC (Spatial Archaeometry Research Collaborations) program. The settlement of Busayra is suspected of being the capital of the Iron Age polity of Edom. British excavations in the 1970s revealed monumental buildings, fortifications, and domestic residences on Busayra's acropolis that confirm the settlement's stature as an administrative

center. With the objective to further investigate Busayra's sub-surface features, Ground Penetrating Radar (GPR) and Magnetic Gradiometry were employed to survey the site's unexcavated areas and yielded interesting results about the settlement's layout and primary construction materials. While few Gradiometery surveys in southwest Jordan have yielded notable results or have even been attempted, the data from Busayra provides an understanding of the settlement's design and highlights the need for multi–method approaches in the region. Underlying limestone architecture contrasts strongly with surrounding soil in the magnetic data set, but the GPR varied in success in identifying the same architectural features. The differences between the results from the two methods can provide insight into the geologic and geomorphologic properties of the features and soils at the site. In addition to understanding soil contrasts at Busayra, questions regarding "empty spaces" where little to no contrast can be identified in the current geophysical data invites suggestions for what further methods could provide results at the site.

S23-03 Opportunities and limitations of archaeological geophysical prospection on the example Uppåkra in Sweden

Manuel Gabler

The archaeological site Uppåkra is Sweden's largest and long lasted Iron Age settlement. In the years 2010 – 2013 the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) conducted large scale archaeological geophysical measurements with motorized magnetic systems and ground penetrating radar (GPR–MIRA from Malå). The Riksantikvarieämbetet and the University Lund conducted targeted excavations based on the prospection results. Although the underlying geology is the same, the results differ extremely within the investigated area. At the central part of the settlement the prospection data could be perfectly confirmed. Just a few hundred meters south from that place large magnetic anomalies could not be hit by excavations. At another place north of the central area a large amount of archaeological remains could not be located with magnetic at all.

Ghost features (anomalies in prospection data which could not be confirmed by excavation) or non-detectable features are known phenomena in archaeological prospection. Anyway the results from Uppåkra with different results within the same geological environment are a good example for the possibilities and limitations of archaeological prospection methods in Sweden. In many cases it is very complicated to distinguish between archaeological and geological structures and only additional information makes it possible to understand the data. As large areas have been investigated with magnetic GPR, a high amount of comparable data is available. It can be clear demonstrated that the interpretation and reliability with just one prospection method is limited and combined prospection methods should be applied wherever possible. The data which will be presented highlights the opportunities of large scale prospection as well the limitations which have to be taken in consideration when it comes to a planned investigation of archaeological landscapes.

S23-04 Looking through the rocks. Geophysical research on the agora of the ancient city: Nea Paphos—A case study

Martina Siefert, Ewdoksia Papuci-Władyka, Tomasz Kalicki, Sebastian Adlung, Michaelis Antonakis, Nikola Babucic, Joanna Krupa, Artur Buszek, Sławomir Chwałek, Dawid Święch, Tomasz Herbich, Łukasz Miszk

Ancient Paphos was given enhanced protection status in November 2010 by UNESCO's Committee for the Protection of Cultural Property. Sustaining the outstanding universal value of the site, the (re)construction of the cityscape for example is one of the prominent issues in archaeological fieldwork. Hard terrain, tightly compacted layers of rubble mixed with the

ground, stone debris, an unclarified modern context without a mapping of recent building activities and infrastructural supply are part of the complicated local setting. The paper under discussion will present a work-in-progress case study of a combined archaeological, geological and geophysical research at Nea Paphos in Cyprus. Special emphasis will be laid on the ongoing process of finding methods as well as practical solutions and outlining workflows in a surrounding of forced public and scientific interest. Due to permission, money and time, non-invasive geophysical methods get more and more important to calculate workloads and, at least, the financial budget for archaeological research. In 2011, the Jagiellonian University in Kraków, Poland, started the PAPHOS AGORA PROJECT aiming to work out the urban plan of the site mainly focusing e.g. on the localization and spatial organization of the ancient agora, both in Hellenistic and Roman times. For the present interdisciplinary work of an international team include the prospection of the terrain with geoelectricity, georadar and geomagnetic. One of the main problems is to separate stone structures–so artificial walls from the natural level of rocks on the bottom and the pebbles layers over the built structures in an area known for field cultivation and used for an English military road.

S23-05 A geoarchaeological approach to selected issues in Norwegian archaeological geophysical prospection

Petra Schneidhofer, Erich Nau, Christer Tonning, Immo Trinks

Until recently, large-scale, high-resolution geophysical archaeological prospection had not been applied in Norway, mostly due to the challenging environmental conditions. New developments regarding motorized data acquisition, data processing and visualisation as well as the use of complementary prospection techniques have been able to provide promising solutions to some of these issues. Since 2010, research and development carried out by the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) and its Norwegian partners, Vestfold County Administration (Vestfold fylkeskommune) and the Norwegian Institute for Cultural Heritage Research (NIKU), have been focusing on selected Viking Age landscapes in Vestfold County (http://lbi-archpro.org/cs/vestfold/). The vast amount of geophysical archaeological prospection data collected during this period has highlighted a range of issues, including those caused by shallow magnetic bedrock and unsorted glacial and fine-grained marine sediments, which are inherent to the diverse and dynamic character of the Norwegian environment. These environmental characteristics considerably affect the interpretation of ground penetrating-radar and magnetometry data sets, prompting a more detailed investigation. Targeted in-situ measurements of physical properties of soils and sediments (dielectric permittivity, electrical conductivity, magnetic susceptibility) were conducted in order to enhance the quality of geophysical archaeological prospection data interpretation, to establish a comparative knowledge base for future investigations, and not least to render the large- scale prospection approach more reliable. Methodology and results of several geoarchaeological evaluation studies from Norway are presented.

S23-06 Picking needles from a magnet: Obstacles and (hidden) opportunities of magnetic prospection in challenging environments

Tuna Kalayci, Apostolos Sarris

Magnetic prospection can be considered as the main arsenal of archaeologists due to its sensitive response to anthropogenic variations. It is a rapid approach, becoming the fastest one compared to other techniques due to the multiple sensor arrays, enabling a landscape approach to archaeological problems. Nevertheless, the foundational physics behind this technique limits its use for particular conditions; e.g. magnetic clutter, magnetic contrast between background soil and material culture. Feasibility of the survey is also determined by

the conditions of the study area; e.g. lack of modern features, absence of diffused archaeological material and relatively smooth topography. Complex Mediterranean landscapes, however, provides immediate challenges, both for the physics and the feasibility of magnetic prospection.
Various parameters can influence the success of a magnetic survey and a number of magnetic anomalies either remain masked or are difficult to interpret. Dense distribution of tiles in the Roman Nikopolis (Epirus) severely hindered the actual archaeological targets (roads and structural remains). The hematite ores in the vicinity of the ancient settlement of Hyettos (Boeotia) were indicative of the parent soil deposits of the area that made the magnetic survey an impossible task. In Palaepaphos, Cyprus, extreme values of vertical magnetic gradient were encountered over large patches without being able to be further verified through GPR or soil magnetic susceptibility measurements. Drawing from the examples of Naxos, Sicily and Therasia Island, Cyclades, it becomes clear that volcanic and volcano–sedimentary formations present further challenges in data collection, processing, and interpretation efforts.
This paper is a manifestation of some of the problematic situations encountered in the magnetic prospection of archaeological sites in the Mediterranean region. However, other geophysical methods are also discussed for further illumination of the magnetic prospection in magnetically enriched contexts. Results of this comparison highlight the importance of a priori information on the archaeology of sites and the employment of multi–sensor approach.

POSTER

S23-P1 Comparing 3D Ground–Penetrating Radar visualization methods: A case study from Austria

Christine Markussen

Collecting, interpreting, and visualizing Ground-Penetrating Radar (GPR) data is fundamentally a three–dimensional process. Closely spaced GPR transects have the potential to be interpolated into a true three–dimensional data block placing archaeological features into near surface geologic context as well as identifying and recording strata within the archaeological context. However, most archaeological interpretation of GPR data is carried out in two dimensions on individual horizontal slices limited to a certain depth or range of depths. Archaeological interpretations of GPR data are also often limited to computer specifications and program capabilities. In 2012 the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) collected high-resolution GPR data (8cm sample spacing) across approximately 10 hectares of the site Flavia Solva, a Roman town in Austria along the Mur River dating from the 1st to 5th centuries A.D. This high–resolution data set provides accurate details of sub–surface properties ideal for 3D visualizations of archaeological features. This project analyzes multiple methods of 3D visualizations including vector extrusions, time-slice animations, iso–surface renderings, and voxel and point–cloud representations for the high–resolution data set.