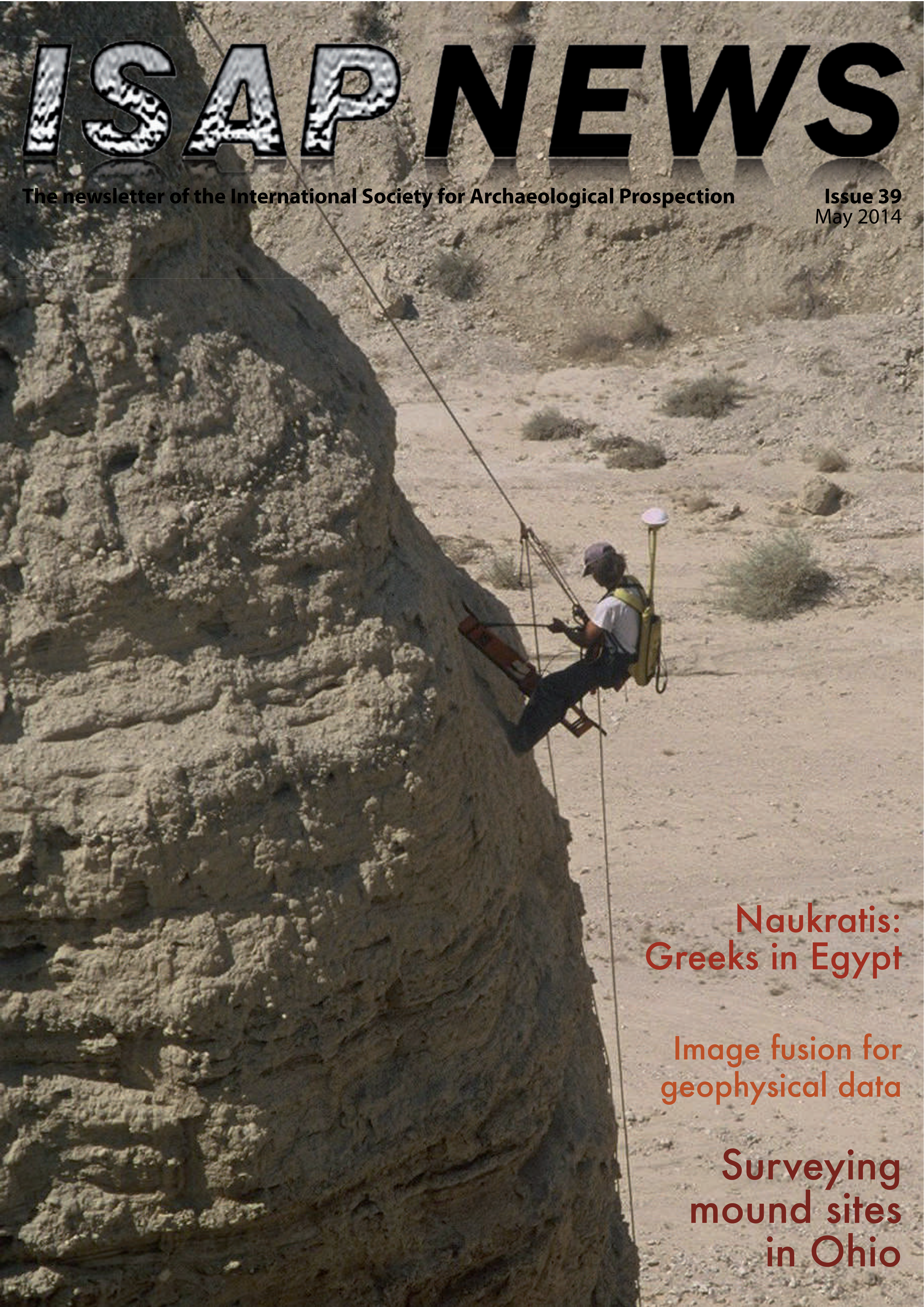
ISAP NEWS

The newsletter of the International Society for Archaeological Prospection

Issue 39
May 2014



Naukratis: Greeks in Egypt

Image fusion for geophysical data

Surveying mound sites in Ohio

Welcome to the 39th issue of ISAP News! Thank you to those who have found time to contribute to it - read on for some preliminary survey results from a British Museum project in Egypt, details of ventures into the fusion of geophysical images and large-scale magnetic surveys of Hopewell culture sites in the US. As well as the usual notifications, which include details of the 2014 NSGG meeting in London and a paper call for the journal of Near Surface Geophysics. We don't really have any house keeping notices for this issue, so we'll just get on with it and say we hope you enjoy reading it...

... although we will just mention that we'd really like to hear about your projects: 700-ish words and a couple of images would be great. Please send any contributions, notifications, cover images or queries for the next newsletter (ISAP News 40) to the email address below by the 31st August 2014. All entries are gratefully received!

Rob Fry & Hannah Brown

editor@archprospection.org

The Cover Photograph shows an EM38 being used to explore for Dead Sea Scroll caves along the marl bluffs above which the ancient settlement of Qumran sits. The Dead Sea Scrolls were discovered in 11 caves between 1947 and 1956: 6 of those were natural caves in the limestone cliffs, 5 were excavated in ancient times out of the marl terrace. "We (Worley Parsons, the University of Nebraska, and the University of Wisconsin) used the EM38, GPR and ERT to explore for other caves that may have been overlooked in previous investigations by archaeologists. 2 possible caves were identified, and one was excavated. While no scrolls were discovered, ancient remains of food debris and pottery were discovered. This is very significant in that it suggests that the population that put the scrolls in the Qumran Caves may have also lived in the caves, possibly to escape the extreme heat in the summer months, or possibly to hide from the advancing 10th Roman Legion that destroyed Qumran in the year 70. The second and much larger unexcavated cave will be explored when an excavation permit is secured" - Paul Bauman (Worley Parsons).

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Geophsyical survey at ancient Naukratis, Egypt

Kristian Strutt & Ross Iain Thomas

University of Southampton & the British Museum, UK. k.d.strutt@soton.ac.uk

In April and May 2014 the third season of geophysical survey, core survey and excavation was conducted by the British Museum at the ancient site of Naukratis, the modern village of Kom Ge'if, located near Damanhour in the Governorate of Beheira, between Cairo and Alexandria, Egypt. The fieldwork, directed by Ross Thomas of the British Museum, seeks to assess the surviving archaeology of this important ancient entrepôt using a range of complementary methods including topographic and geophysical survey, in addition to borehole survey and excavation. The work is part of a larger project, directed by Alexandra Villing of the British Museum's Department of Greece and Rome entitled 'Naukratis: the Greeks in Egypt' that aims to fundamentally reassess Greek-Egyptian relations at the site.

The latest season of work added to the existing dataset from the first two seasons in 2012 and 2013, mapping the extent of the ancient settlement and its association with the Canopic Branch of the River Nile. The 2014 team comprised staff from the British Museum, Bryn Mawr College and the University of Southampton, with inspectors from the Ministry of State for Antiquities (MSA) heavily involved in the day to day survey work. The 2014 fieldwork was largely funded by the Honor Frost Foundation and the Institute of Classical Studies.

The port of Naukratis was the earliest Greek port in Egypt, established in the late 7th century BC as a base for Greek (and Cypriot) traders and the port of the royal Pharaonic city of Sais. It was an important hub for trade and cross-cultural exchange long before the foundation of Alexandria and continued to be significant through the subsequent Ptolemaic, Roman and Byzantine periods. Previous fieldwork was conducted by Flinders Petrie amongst others, and concentrated on excavation of the central areas of the ancient town. Further research was required to fully understand this very important archaeological site. Techniques used in the three seasons to date have encompassed geophysical prospection, the creation of a topographic survey map using GPS technology, integrating and georeferencing archived survey plans and sketches, aerial photography and satellite images, surface pottery collection, excavation and geological work with a hand auger.

Survey Methods

For the magnetometer survey a Bartington Grad601-2 Dual Array Twin Fluxgate Gradiometer was used (**Fig. 1**). Readings were taken at 0.25m intervals along traverses every 0.5m within 30 x 30m grids, with all traverses walked in a zig-zag fashion. MSA inspectors were shown how to set up and use the equipment as part of a programme of training of Egyptian colleagues. They were also shown preliminary results and had the principles of the instrumentation explained to them.

Two ERT profiles were also undertaken using an Allied Associates Tigre ERT (**Fig. 2**). The first of the profiles ran from a point some 400m to the west of the site, over the kom or mound, to a point 400m to the east of the site, incorporating the line of the Canopic Branch of the Nile

Figure 1 *Magnetometer survey being conducted by MSA inspector Mohamed Roshdy Gomaa Soliman, with tuition from Kris Strutt, to the east of the kom.*

and Naukratis. This provided a section 15m deep running west-east across the southern part of the site. The main aim was to better understand the geological relationship between the river and the settlement, and to tie the profile in with the series of borehole surveys conducted along the same traverse. The results may also identify walls and other structures within the main area of the ancient settlement.

All magnetometry grids, ERT profiles, excavation trenches, structures, features, auger holes and spot finds were located in real-world coordinates using a Real Time Kinematic (RTK) Global Positioning System (GPS). This has ensured that survey data are fully geo-referenced, and facilitates the incorporation of the other survey methodologies into a real-world co-ordinate system.

Preliminary Survey Results

The survey work at Naukratis has produced significant new data on the layout of the ancient town, its local environment and hinterland, including the location of the Greek sanctuary complex, the Hellenion, and the Temenos or temple enclosure at the site. The magnetometer results located a large number of mud brick and stone structures in the fields around Kom Ge'if (**Fig. 4**: overleaf), particularly in the north and east of the site, with negative linear anomalies showing the potential location of substantial stone foundations of tower houses and other structures. We now know that the settlement exceeded 60 hectares at its peak, significantly larger than the 32 hectare settlement revealed by the previous excavations. The positive linear anomalies associated with the mud brick structures, and the internal units of construction of larger structures such as the Temenos enclosure wall, also show up clearly.

In addition to the plan of the ancient town, the magnetometer results also give us a much better idea of the extent of the ancient site in relation to the location and development of the Canopic branch of the Nile, which ran to the west of the ancient settlement. The magnetometry clearly shows the change from settlement to canal infilling, with structures positioned along the edge of the canal.

Figure 2 *MSA inspector Ashraf Salah El din Mohamed and workman Saad Mohamed Awad with the ERT set up to the west of Kom Ge'if, across the location of the Canopic Branch of the Nile.*

This data is reinforced by the results of the ERT survey (**Fig. 3**) which indicates coarse grained sediments giving high resistivity in the area of the Canopic Branch of the Nile, and smaller sediment grain size in the area of the kom.

The survey results highlight the need for, and the great potential of, further research in future fieldwork seasons. Many of the areas of the ancient settlement still require surveying using magnetometry, and a combined strategy of ERT survey with drilling of boreholes will provide useful comparative data for particular parts of the site and its hinterland.

Figure 3 *Preliminary image of the ERT profile, showing the contrast between the sediments of the Canopic Branch of the Nile (high resistivity, left) and the finer sediment of the kom (low resistivity, right).*

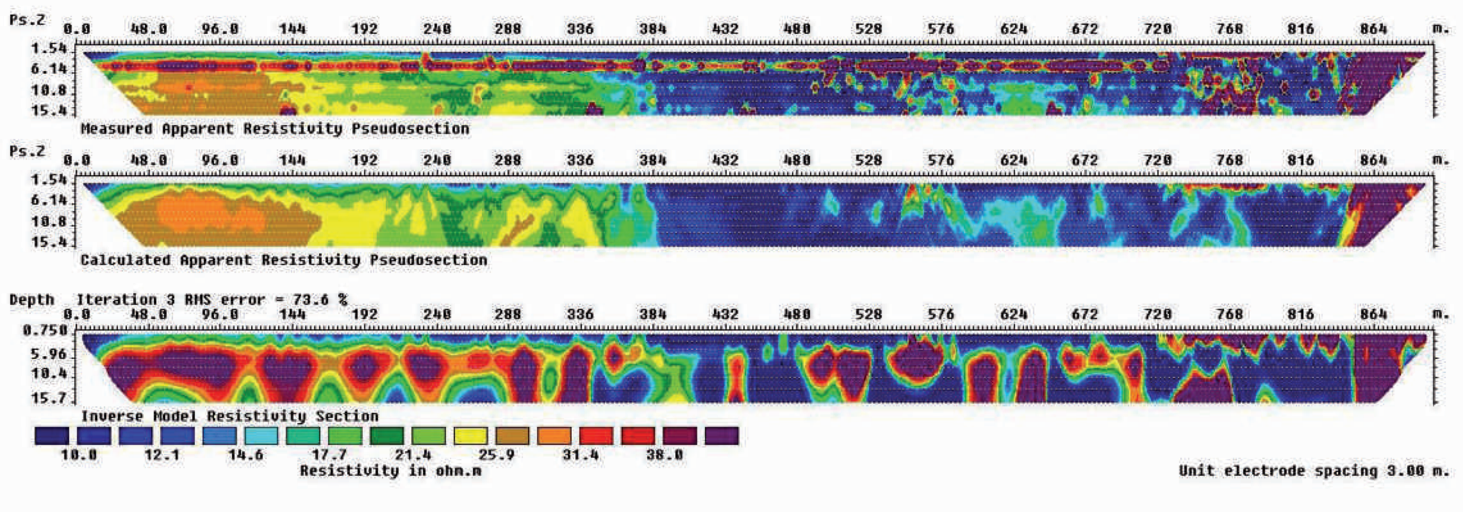

Figure 4 *Detail of the magnetometer survey results showing some of the anomalies representing structural remains.*

For more information on the fieldwork at Naukratis please visit the project website at:
www.britishmuseum.org/research/research_projects/all_current_projects/naukratis_the_greeks_in_egypt.aspx

To discover more about the artefacts recovered from Naukratis visit the Online Research Catalogue at:
www.britishmuseum.org/naukratis

Fusion between geophysical images to locate and map archaeological relics

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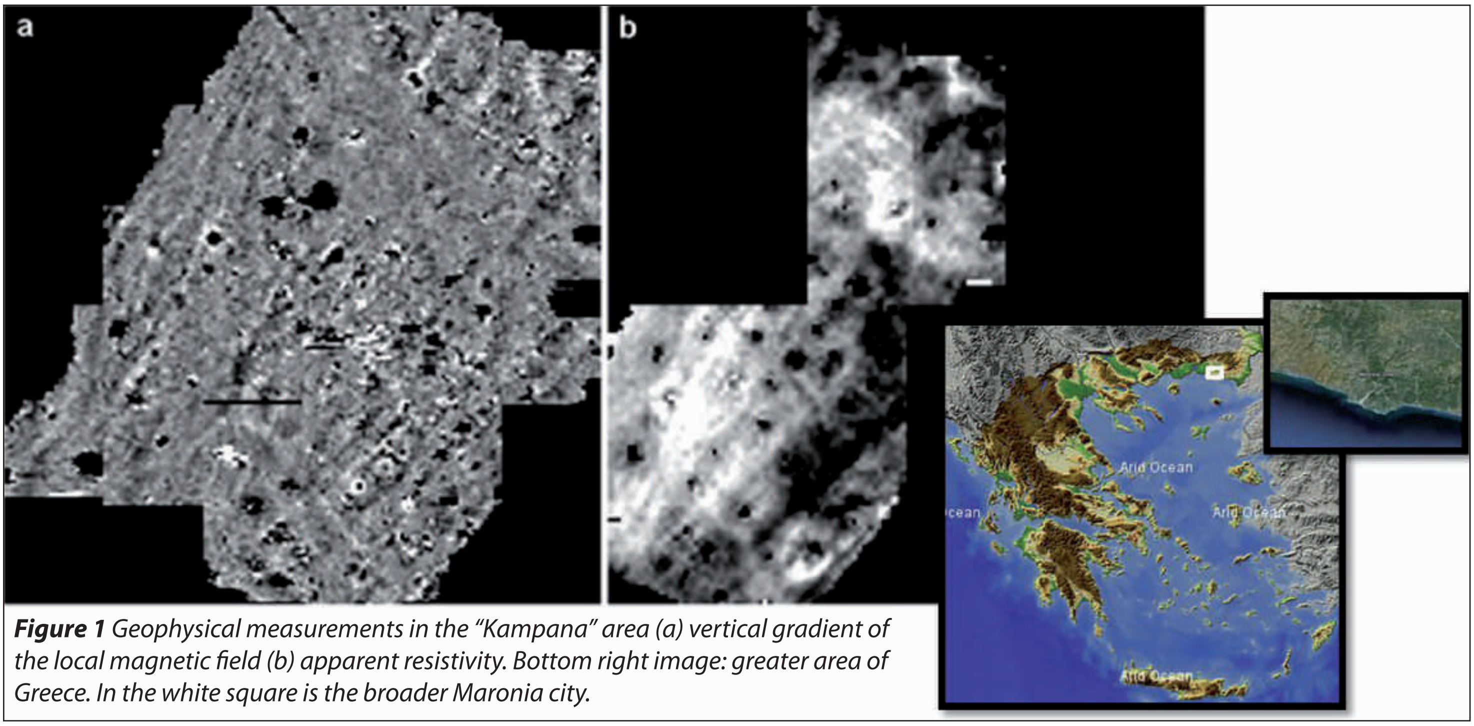

Figure 1 *Geophysical measurements in the "Kampana" area (a) vertical gradient of the local magnetic field (b) apparent resistivity. Bottom right image: greater area of Greece. In the white square is the broader Maronia city.*

Even though archaeology made significant discoveries in the past, the need to develop non-destructive methods for the location of valuable archaeological features prior to the excavation led to the use of different geophysical methods. Each method is sensitive to certain physical properties such as the magnetic susceptibility (e.g. Clark 1996; Kvamme *et al.* 2006), electrical resistivity (e.g. Mauriello 1998; Kvamme *et al.* 2006) and dielectric constant (e.g. Kvamme *et al.* 2006). The presence of an object with physical properties that contrast measurably from the background can be detected with the appropriate method. During the last decade new technologies made feasible the massive collection of high quality data within a small amount of time and with limited cost. This work deals with the problem of integrating data from various geophysical methods for the detection and the high-resolution mapping of buried archaeological remains. The aim is the reliable and efficient registration, and then fusion of the images obtained from different geophysical methods in combined images with higher information content.

Our target archaeological area is situated near the ancient theater of Maronia city in north-eastern Greece at a place called "Kampana". Excavations of the site, started at 1969, have brought to light important monuments such as the theatre of the city (323-146 B.C), a sanctuary (323-146 B.C), part of the fortification wall of the Classical city, the house of the mosaic (323-146 B.C) and some Byzantine monuments. Geophysical measurements of the vertical pseudo-gradient of the local magnetic field were performed in an area of 11200m2 and of the apparent resistivity in an area of 5500m2 (Tsokas *et al.* 2004), which was part of the magnetometer survey area (**Fig. 1**).

Typically, geophysical numeric data products are transformed into interpretable images. The usual practice includes the visual inspection and comparison of the different images and then the derivation of interpretations that take advantage of the information from all sources. However, geophysical images suffer from localized distortions since the data are collected usually from handheld devices and as such they are affected from topographic variations, vegetation and other obstacles. Although, in recent years various registration techniques have been developed for different fields, there are no such attempts known in the literature for the geophysical data and the registration is performed roughly based on the expected coordinates of some reference points and the geometry of the grids of the measurements (e.g. the corners of grids). The localized and random nature of the offsets in geophysical images makes typical registration algorithms applied in other fields not applicable in this case (e.g. Brown 1992; Zitova & Flusser 2003). We addressed the registration problem with a semi-stochastic, pixel-based algorithm that applies multiple local random affine transformations to improve the similarity between the geophysical images (**Fig. 2**; Karamitrou *et al.* 2011a; Karamitrou 2013). The similarity measure is chosen to be their mutual information (e.g. Papoulis 1991) due to its suitability in the case of images from multimodal sensors.

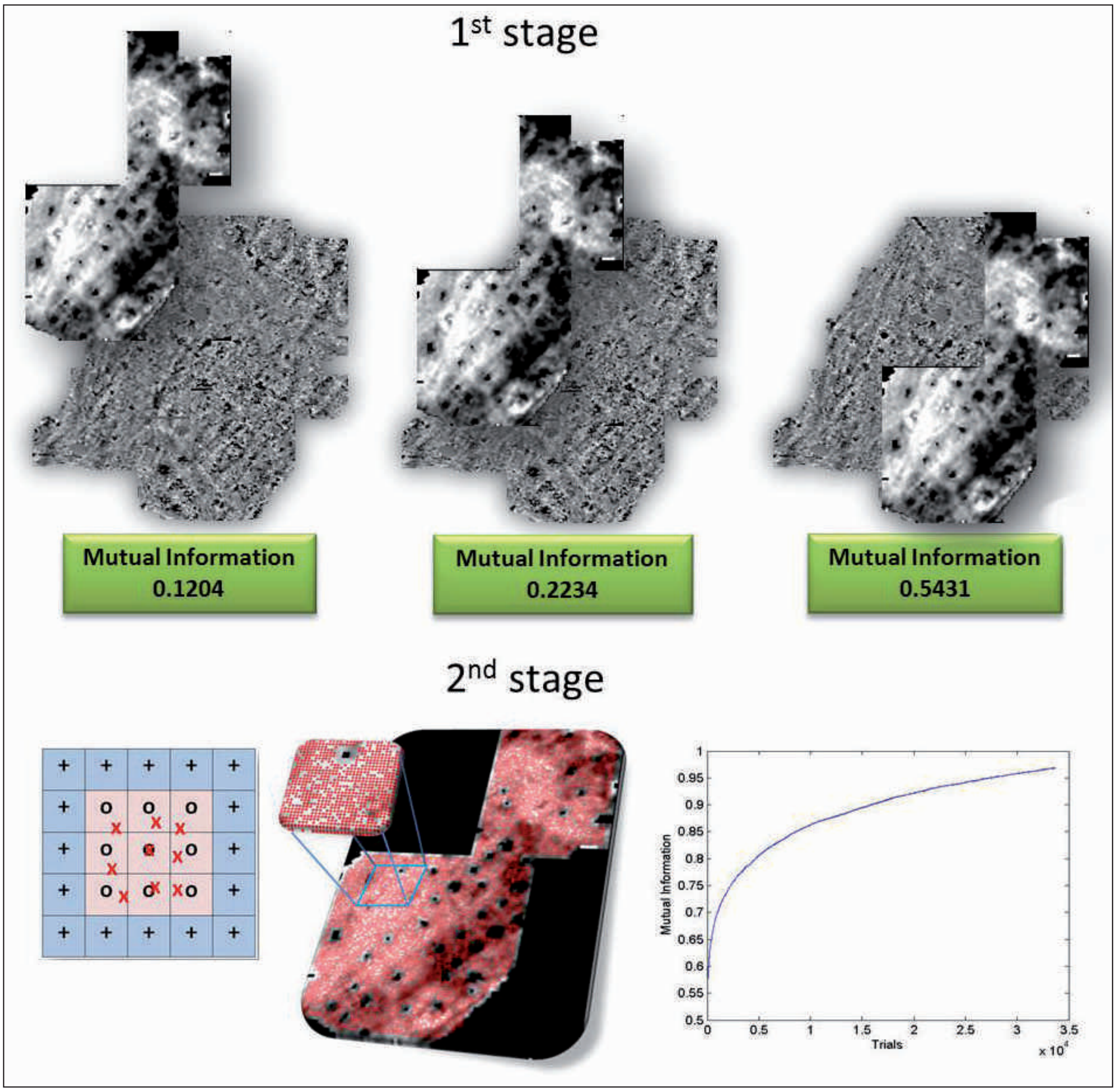

***Figure 2** During the 1st stage of the registration algorithm, an exhaustive search is used to find the parameters of the global translation that would maximize the mutual information between the pairs of images as well as their overlapping area. At the 2nd stage, random affine transforms are tested in multiple randomly selected patches of the image. Bottom centre figure shows the randomly selected central pixels, of the apparent resistivity image, while bottom left image is the 5x5 window around the central pixel. We apply the transformation only to the 3x3 window around the central pixel. Bottom right figure shows how the mutual information increases with the number of trials.*

After their successful co-registration we attempt to combine the two different images in one. In the last few years, the idea of combining images, called image fusion, appeared and it has become an important area of research (e.g. Stathaki 2008). We utilized a very recent methodology known as curvelet transform (Candes & Donoho 2000; Jianwei Ma & Plonka 2010), which unfolds an image and its features into space, wavenumber, and orientation domains. After transforming both images to curvelet domain we construct the fused image by selecting the optimum coefficients from the initial images. Our algorithm additionally allows the implementation of a-priori known information, such as the rough orientation of the relics, whenever it is available.

Our results suggest that the final fused images improve significantly the resolving capability and the robustness of the interpretation compared with separate examination of the initial images. In the final fused image (**Fig. 4C**: overleaf) features appear clearer, and the background noise is suppressed. Structures in the fused part of the image (fusion takes place only between the overlapping portions of the images) continue smoothly to the parts of the magnetic image in which there are no electrical measurements. A characteristic feature is the ellipsoid at the center of the image. Parts of this structure are faintly visible in the electrical image and some other portions are possibly distinguishable in the magnetic image. The fused image succeeds in showing clearly the complete ellipsoid.

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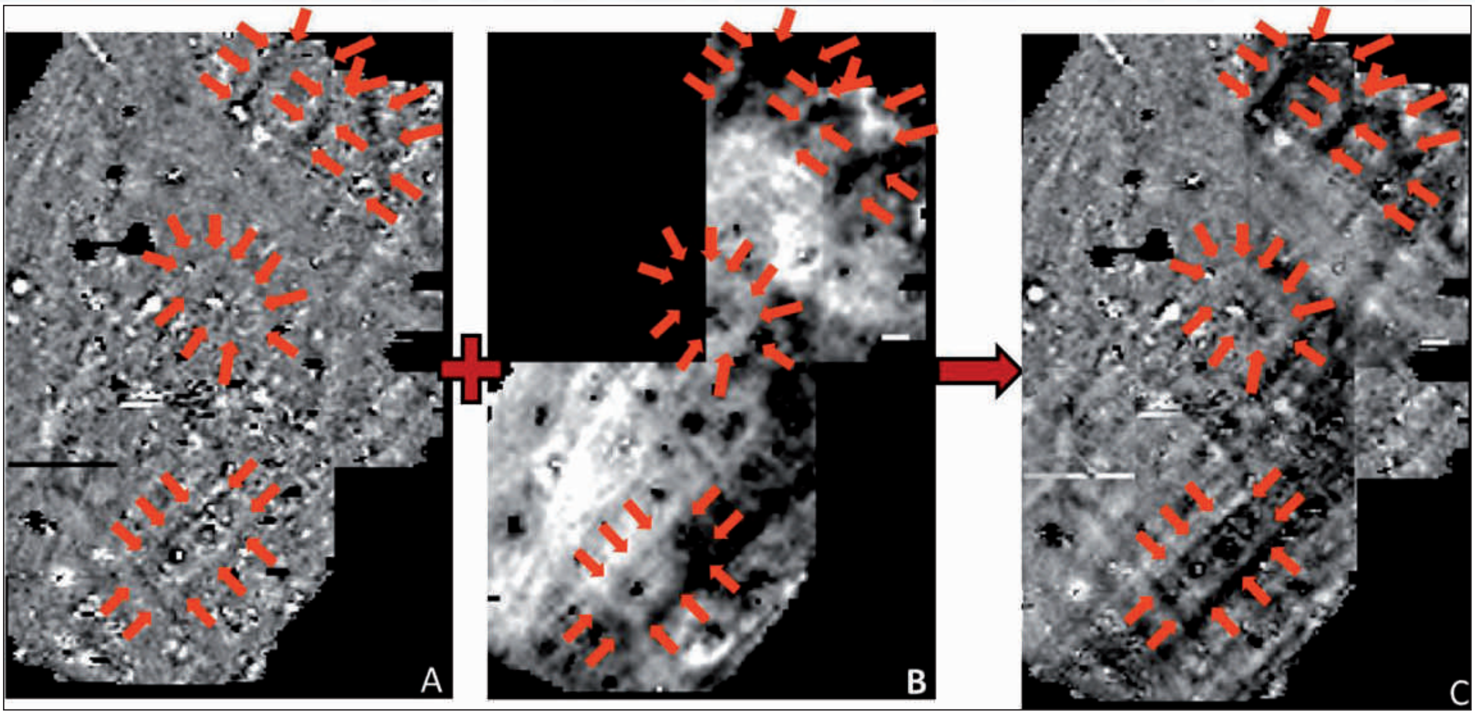

Figure 3 (A) *Magnetic image (vertical gradient of the local magnetic field),* ***(B)*** *apparent resistivity image and* ***(C)*** *fused image with the use of the curvelet transformation method. Red arrows indicate some possible archaeological features.*

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Recent large-area magnetic gradient surveys at Ohio Hopewell earthwork sites

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Ross County, Ohio is a wonderland for the study of ancient Native American earthwork sites, most of which date to the period AD 100-400. Some of the very largest earthwork complexes are found there and include small (0.1 ha) and very large (50 ha) ditch-and-embankment enclosures, enclosures with just embankments, and lots of other kinds of wood and earth architectural features. Most have been severely plough damaged, some to the point of being invisible at the surface. Over the last several years, I have had the opportunity to conduct magnetic gradient surveys at a good number of the Ross County sites and with much success.

Starting in late 2012, I have accumulated about 80 ha of magnetic data across three of the six sites in Hopewell Culture National Historical Park using Foerster's Ferex 4-probe magnetometer cart. While numerous geophysical surveys have been done in the park over the years (Steve DeVore, Nomi Greber, Mark Lynott, Jennifer Pederson Weinberger, John Weymouth, and several others), few (Lynott's work at the Hopeton Works being the prime exception) have had the benefit of producing the big picture—entire coverage on one of the big earthwork complexes.

For examples of some of these surveys, see the various issues of the Hopewell Archeology Newsletter: www.nps.gov/MWAC/hopewell/index.html

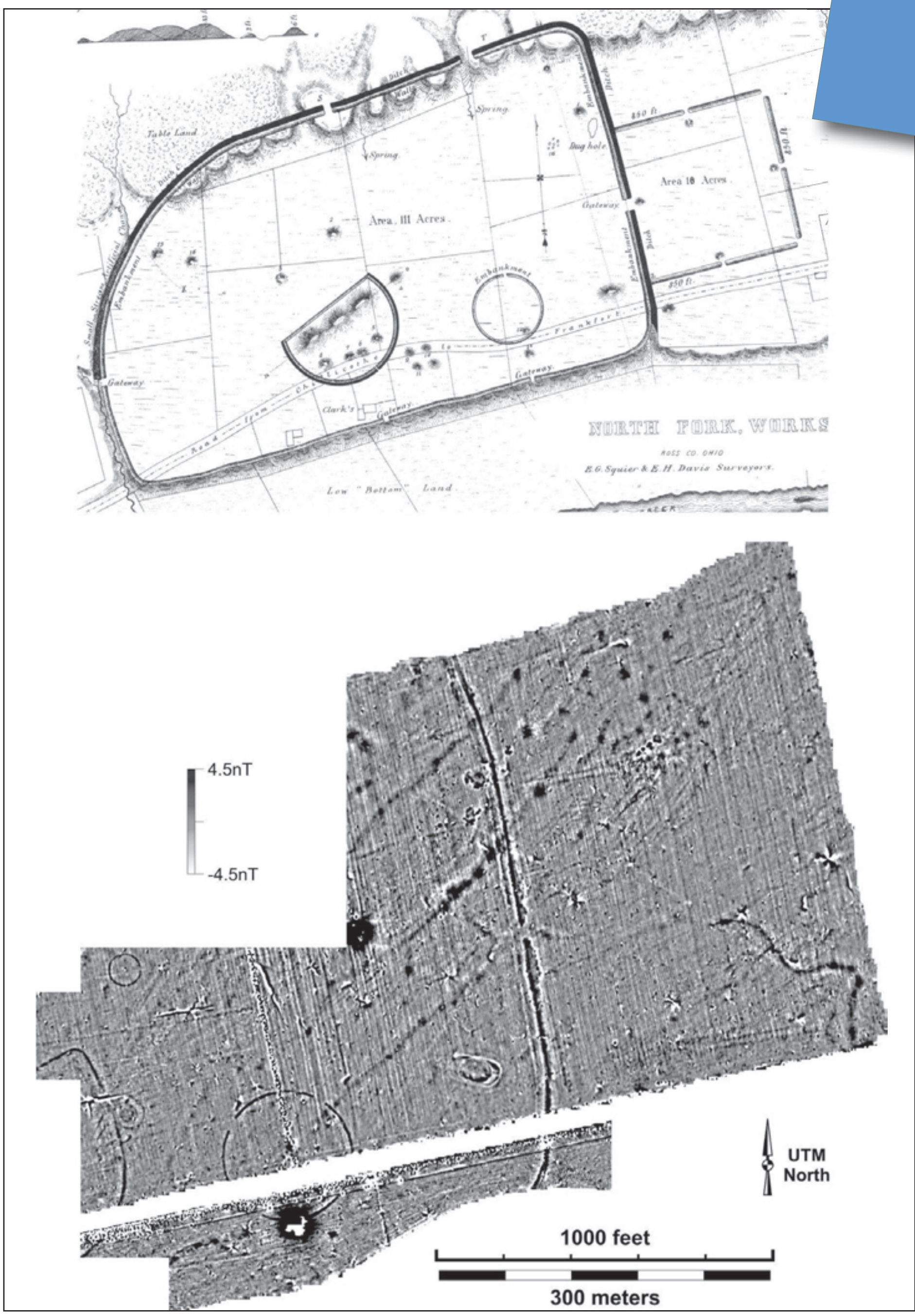

Fig. 1 includes about 29.5 ha of data from Hopewell Mound Group, the type site of the Hopewell culture. This work was funded by the Midwest Archeological Center, National Park Service. The survey focused on the area of the large square, a small circle found in 2001, and the site's large circle. Numerous types of magnetic anomalies were detected, including mounds, enclosure ditches and embankment walls, hundreds of possible pit features, several large burned features, and dozens of lightning-related anomalies and other unusual linear features. Perhaps the most intriguing results come from the site's large circle (**Fig. 2**: overleaf). This ditch-and-embankment enclosure is about 114 meters in diameter (measured from the outside edge of the ditch) and has at least two primary gateways, which were newly discovered during the magnetic survey. Also new to our understanding of this enclosure is a series of posts that line the inside edge of the ditch, perhaps preceding the construction of the embankment, and a cluster of four probable pit features at the center of the circle. The post circle measures 103

Figure 1 *About 29.5 ha of data from Hopewell Mound Group.*

meters in diameter, with the most obvious posts on the east side of the enclosure, and likely consists of about 108 utility-pole-sized posts. Bret Ruby, National Park Service, is investigating at least two of these posts in excavations this summer. The anomalies associated with the four pits at the center of the circle are each about 1.5-2 meters in diameter and are spaced 5-5.5 meters apart. A similar cluster of four pits was found to the northwest of the big circle and just outside the small circle's gateway. While it is not uncommon to find structures and/or mounds at the centers of large and small enclosures, clusters of pits have yet to be documented.

The magnetic gradient survey at the High Bank Works covered about 32 ha, or nearly all of the site's large circle and octagon complex (**Fig. 3**: overleaf). The work on the great circle was funded by the Midwest Archeological Center, National Park Service, while the octagon data were collected through collaboration between myself (running the instrument), Nomi Greber (Cleveland Museum of Natural History), Robert Cook (The Ohio State University), and Bret Ruby (National Park Service). Though no ditch is present at High Bank, the site's embankment walls show up nicely in the magnetic data. In addition to locating several hundred possible pit features within and outside the earthwork, the magnetic survey detected the subtle signature of a small circle located to the east of the circle-octagon neck and large feature complexes at the center of the great circle and at the center of the octagon. Some of these features appear to be located on significant astronomical observation lines, including the lunar maximum that crosses through the center of the octagon and perpendicular to the site's main circle-octagon axis.

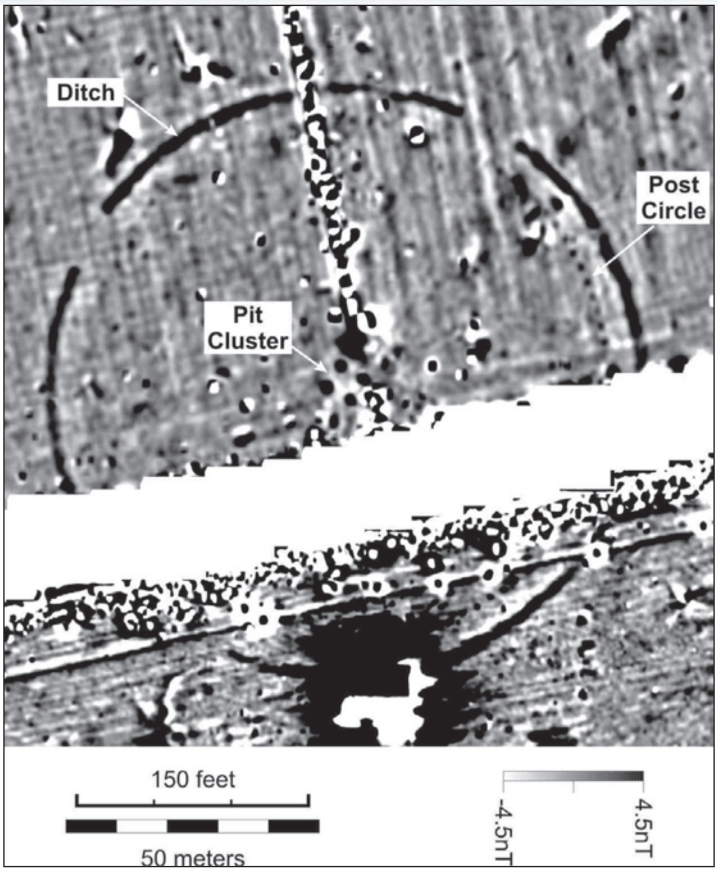

Figure 2 *Detail from the Hopewell Mound Group data.*

Though it has been a long time coming to Ohio, the geophysical work pioneered by the National Park Service, Nomi Greber, and others is finally culminating in large-area surveys that cover the entirety of these immense earthwork complexes. That said, we still have a long way to go to complete coverage of the earthworks in Hopewell Culture National Historical Park and even more work to cover all of the sites in Ross County. Stay tuned!

Figure 3 *Magnetic gradient survey at High Bank Works*

Two day meetings:
Archaeological Geophysics
Forensic Geoscience: Future Horizons

Geological Society of London, Burlington House, Piccadilly, London
2nd and 3rd December 2014

2nd December 2014: *Recent Work in Archaeological Geophysics*

The Near Surface Geophysics Group of the Geological Society of London (NSGG) is pleased to announce the eleventh in a succession of biennial day meetings devoted to archaeological geophysics. Near surface geophysical techniques have become increasingly established in archaeological research and evaluation over the past decade and are now routinely applied in archaeological investigations. This meeting offers a forum where contributors from the UK and further afield can present and debate the results of recent research and case studies. Suppliers of equipment and software also attend and the meeting therefore represents an invaluable opportunity for both archaeological and geophysical practitioners to exchange information about recent developments.

Convenor: Paul Linford, English Heritage, Fort Cumberland, Eastney, Portsmouth, PO4 9LD, UK; Tel: +44 (0)23 9285 6749; Fax: +44 (0)23 9285 6701
email: Paul.Linford@english-heritage.org.uk

3rd December 2014: *Forensic Geoscience: Future Horizons*

This multidisciplinary meeting will capture shared interests between the geological, environmental science, forensic science, geophysics, engineering, geotechnical, mining and archaeological communities in assessing the future of forensic geoscience. Sessions will include quality assurance in forensic geoscience; geoforensic applications in serious crime and terrorism investigations; techniques at crime scenes; environmental crime; and the issues of interpretation of geological forensic evidence.

Convenor: Dr Ruth Morgan, UCL Centre for the Forensic Sciences, 35 Tavistock Square, London WC1H 9EZ, UK. Tel: +44 (0)20 3108 3062 email: ruth.morgan@ucl.ac.uk

It is anticipated that each meeting will attract 100 or more participants. As well as oral presentations, there will be space for commercial and poster displays. Those interested in contributing to either meeting are warmly encouraged to contact the respective convenors, and to submit abstracts of up to 1000 words in length, accompanied by suitable illustrative material, no later than the 31st August 2014. These will be collated and made available to all those attending.

Paper Call for a Special Issue on Integrated Geophysical Investigations for Archaeology in the EAGE Journal of Near Surface Geophysics

The development and use of integrated geophysical prospection methods has over the past decade seen a considerable increase worldwide in terms of novel methodological approaches and number of applications. Near surface geophysics, alongside the latest airborne remote sensing methods, comprises a fully non-invasive approach to the investigation and documentation of buried archaeological heritage. This approach aims at efficient generation of detailed information on underground structures of archaeological or historical interest. According to the Valletta convention, the use of non-invasive methods wherever possible can provide not only important prior knowledge for the efficacy of archaeological excavation campaigns, permitting targeted investigations but as well offers the means for the investigation of entire archaeological landscapes at scales and resolutions that earlier have been inaccessible or unavailable. Magnetic, electrical resistivity tomography (ERT), ground-penetrating radar (GPR) and electromagnetic prospection methods are widely used in integrated applications for archaeological prospection because they can efficiently provide data that permit the imaging of buried archaeological structures in two and three dimensions. Besides the geophysical prospection methods referred to above, to a lesser degree the seismic methods, both conventional and tomographic, micro-gravity, self-potential, induced polarization and radiometric measurements are applied to specific archaeological problems. Likewise, the non-destructive testing and investigation of architecture and standing monuments using integrated geophysical prospection methods can help to map and document principal information of certain types of structural damage, such as cracks and fissures.

Considering the limitations posed from employing individual prospection methods alone, the term ‘integrated investigations’ refers to developments and applications that make use of more than a single method, resulting in complementary data sets for improved imaging and archaeological interpretation of the data describing buried archaeology. Focus should be placed on developments and applications that make use of joint analysis of different data sets and the added value gained through data integration.

We intend to collect presentations of state-of-the-art integrated geophysical approaches in archaeology in a *NSG* special issue. We hope that this special issue of *Near Surface Geophysics* will highlight the quality, if not excellence and international standards of the work conducted by our community.

We invite the submission of papers dealing with the following topics:

- Novel geophysical techniques for integrated archaeological investigations
- Airborne remote sensing (photo, LiDAR, satellite) applications associated with geophysical archaeological investigations
- Numerical modelling studies related to integrative geophysical archaeological prospection
- Technological developments in instruments for integrated prospection approaches
- Novel data acquisition and evaluation techniques for dealing with integrated investigations
- Innovative archaeological interpretation techniques for integrated prospection approaches
- Integrated applications for cultural heritage monument restoration and conservation
- Integrated archaeological prospection field surveys

Authors are invited to submit original manuscripts, prepared according to the ‘Guidance for Authors’ published on the NSG website www.nsg.eage.org. The online submission system for NSG is www.mc.manuscriptcentral.com/nsg. Please mention the name of the special issue in your cover letter. All manuscripts will be peer-reviewed in accordance with the journals established policies and procedures. The selection of final papers for publication will depend on both the results of the peer review process and reviews by guest editors as well as by the chief editor.

The deadline for manuscript submission to the NSG special issue is Sept 15th 2014

Publication: 2015

Inquiries concerning the special issue should be directed to the Guest Editors:
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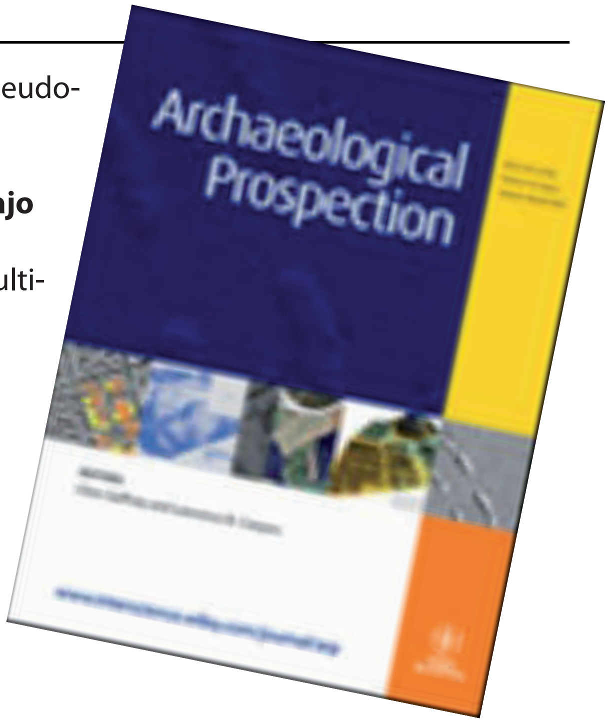
Publication coordinator Kasia Zuk (kzk@eage.org) is happy to assist you in managing your submissions.

Journal Notification

Archaeological Prospection 21(2) Current Issue



Using a 3d laser scanner for ultradense topographic correction in pseudo-3d GPR data. case of application: the constructive pattern of the monumental platform at the Segeda i site (Spain)
Teixidó, T., J. Peña, G. Fernández, F. Burillo, T. Mostaza & J. Zancajo

Comparing apparent magnetic susceptibility measurements of a multi-receiver EMI sensor to topsoil and profile magnetic susceptibility data over weak magnetic anomalies
Smedt, P., T. Saey, E. Meerschman, J. De Reu, W. De Clercq & M. Van Meirvenne

Geophysical observations at archaeological sites: estimating informatonal content
Eppelbaum, L.

Historic Shipwreck Study in Dongsha Atoll with Bathymetric Lidar
Shih, P., Y. Chen & J. Chen

Magnetic investigations of buried palaeo-hearths inside a palaeolithic cave (Lazaret, Nice, France)
Jrad, A., Y. Quesnel, P. Rochette, C. Jallouli, S. Khatib, H. Boukbida & F. Demory

Prospecting for Prehistoric Gardens: Results of a Pilot Study
Nolan, K.

UNIVERSITY OF BRADFORD
MAKING KNOWLEDGE WORK

MSc Archaeological Prospection Shallow Geophysics At The University of Bradford, UK

The course is a highly focused postgraduate degree programme which develops specialist skills in the theory and practice of archaeological prospection, in particular in near-surface geophysics.

It provides students with knowledge and experience of the principal geophysical and geochemical techniques currently available for the detection of buried archaeological features and other near-surface targets. The course provides appropriate background to materials and soil science, together with the relevant mathematical principles.

Other methods of detection such as remote sensing, topographical survey and field-walking are introduced as essential components of an integrated approach to landscape assessment. Sampling procedures and the computer treatment and display of field data from all methods are critically examined with the aid of case studies based on field experience. Skills and knowledge are developed through lectures, seminars, laboratory and fieldwork classes and a substantial individual research dissertation.

Course Syllabus:

- Electrical Methods of Survey
- Magnetic & Electromagnetic Methods of Survey
- Site Evaluation Strategies
- GIS for Practitioners
- The Nature of Matter
- Treatment, Display and Interpretation of Field Data
- Soils and Chemical Prospection
- Dissertation (MSc)

Special Features:

- In-depth specialist training, including hands-on experience in the Division's geophysics and computer laboratories and in the field
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