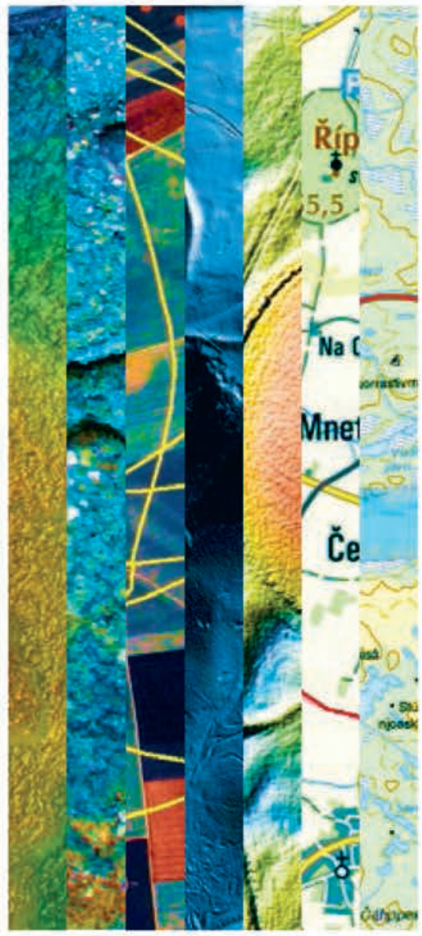
SEN-SING THE PAST



Contributions from the ArcLand Conference on REMOTE SENSING FOR ARCHAEOLOGY

Culture

ArcLand
HERITAGE · DATA · KNOWLEDGE

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Sensing the Past

Contributions from the ArcLand Conference on Remote Sensing for Archaeology

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Culture

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Foreword

Aerial and other remote-sensing techniques have yet to realize their full potential in many parts of Europe. In some countries of northern, eastern and southern Europe they have hardly been applied at all. The aim of the ArchaeoLandscapes Europe project (ArcLand; *http://www.arcland.eu/*) is to address this imbalance and to create conditions for the regular use of these strikingly successful techniques across the continent as a whole.

The ArcLand project is funded by the European Union within the framework of the Culture 2007-2013 framework (ArcLand 2010-1486 / 001-001; CU7-MULT7, Strand 1.1 Multi-Annual Cooperation Projects). Co-organising partners receive a total funding of 2.5 million Euros over the length of the project (September 2010 - September 2015), another 2.5 million Euros are be provided by the partners themselves.

Public awareness and dissemination of challenging skills in aerial and remote sensing techniques, at a very European scale, will be achieved by the ArchaeoLandscapes project through the eight following key Actions (WPs):

1. By creating an ultimately self-supporting ArchaeoLandscapes Network, with a small central secretariat, to provide leadership, coordination and advice on the use for heritage purposes of aerial photography, remote sensing and landscape studies.

2. By using traditional and innovative methods to publicize the value of aerial survey, remote sensing and landscape studies amongst the general public, students, teachers and all those who explore, enjoy or care for cultural landscapes and heritage sites across Europe.

3. By promoting the pan-European exchange of people, skills and understanding through meetings, workshops, exchange visits, placements and opportunities for specialist training and employment.

4. By enhancing the teaching of remote sensing and landscape studies through courses for students and teachers, and in the longer term, through a European Masters degree in remote sensing and heritage management.

5. By securing the better exploitation of existing air-photo archives across Europe by researching, assessing and publicizing their potential for heritage interpretation and landscape conservation.

6. By providing support for aerial survey, remote sensing and landscape exploration in countries relatively new to their use, especially in northern, eastern and southern Europe.

7. By further exploring the uses of laser, satellite and other forms of remote sensing and web-based geographical system in archaeological and landscape research, conservation and public education.

8. By providing technical guidance and advice on best practice in aerial survey, remote sensing and landscape studies, with a particular emphasis conservation and heritage management. One of ArcLand's main objectives was the organisation of different events to foster the knowledge about the use of modern remote sensing and surveying techniques for archaeology both within the archaeological and cultural heritage community as well as for the broader public. Within this scope the 77 project partners *(http://www.arcland.eu/about/partners)* organised six aerial archaeology training schools, 22 workshops (dealing with aerial image archives, geophysics, satellite imagery, LiDAR/Airborne Laser Scanning, GIS etc.), 15 conferences, symposia and public workshops as well as numerous sessions at various national and international conferences including a large number of public and conference presentations. 13 grants for internships at various project partner institutes provided support for students and young professionals to gain more insight into topics like Airphoto Archiving, Management & Interpretation, GIS Integration of Remote Sensing Data, Predictive Modelling and GIS & Aerial Archaeology.

This book represents the outcome of nearly five years of work of project partners from all over Europe and beyond which were presented by the project's final conference "Sensing the Past – New Approaches to European Landscapes", held at the Goethe University in Frankfurt from 24th - 26th February 2015 as part or the obligations of ArcLand's WP 2.

It compiles information about the remote sensing and surveying methods currently being used by archaeologists and cultural heritage professionals to explore, document and manage landscapes and the heritage within, based on the work of all project partners between 2010 and 2015 and presented as oral talk or poster at the Frankfurt conference.

The conference would not have been possible without the help of numerous people. My sincerest thanks go to all project partners for their contributions, to the Department of Archaeology of the Goethe University Frankfurt, namely to Ute Mangold-Scherer for her great support, and to Alexander Rick and his team from the Frankfurt University media lab for making it easily possible that the presentations were available online soon after the conference *(http://www.arcland.eu/news/1845)*. I would also like to thank Pete Horne (English Heritage) for editing the texts of this publication and Ian McCarthy (The Discovery Programme, Dublin) for his work on this book, for the layout of the ArcLand website as well as for the ArcLand travelling exhibition "Traces of the Past" *(http://www.arcland.eu/outreach/exhibitions/1641)*.

Many thanks also to my colleagues at the Roman-Germanic Commission in Frankfurt (Christoph Andreas Kracht, Dominic Mernberger, Eleonore Pape, Kai Radloff, Nadine Baumann, Nina Dworschak, Ruth Beusing) as well as to the student volunteers (Jonas Gregorio de Souza / Exeter University, Katherine McCormack / University College Dublin, Łukasz Banaszek / Poznan University, Mikolaj Kostyrko / Poznan University, Roman Brejcha / Pilsen University, Sarah Delaney / University College Dublin), all of them helped so efficiently and joyfully before and during the conference.

The conference not only marked an important milestone of the project's lifespan, it also was the official start of the ArcLand successor, ArchaeoLandscapes International *(http://www.arcland.eu/news/1846)*. Reflecting the interests of the International Society for Archaeological Prospection (ISAP) and Aerial Archaeology Research Group (AARG) memberships and those of the current ArchaeoLandscapes Europe network, the central aim of ArchaeoLandscapes International is the promotion of non-destructive prospecting methods for archaeological investigations. In particular it:

- considers all methods of remote sensing, aerial archaeology, ground-based geophysical and geochemical prospection and surface survey;
- is concerned with archaeological investigations on all scales, from monuments and sites to landscapes, along with their analysis and interpretation;
- has an international remit in archaeological research and membership;
- is a liaison partner for other organisations and institutions with regards to archaeological prospecting in landscape archaeology;
- promotes the use of archaeological prospecting as a method of archaeological enquiry;
- facilitates education in these methods;
- informs policymakers, government representatives and all parts of the general public about the potential and limitations of archaeological prospecting; and
- supports the development of new equipment, software and methods.

The website of the project *(http://www.arcland.eu)* will be maintained after the end of the EU funding period in September 2015, providing information about the previous work of ArchaeoLandscapes Europe as well as about the activities of the new ArchaeoLandscapes International network.

Frankfurt, July 2015

Axel G. Posluschny

ArcLand Project Leader

Contributions on:

AERIAL PHOTOGRAPHY AND AERIAL ARCHIVES

Contributions on:

LiDAR AND SATELLITE REMOTE SENSING

Contributions on:

GEOPHYSICAL SURVEY

Contributions on:

INTEGRATION AND OUTREACH ACTIVITIES

AERIAL ARCHAEOLOGY AT THE LEUVEN UNIVERSITY (BELGIUM) / AERIAL ARCHAEOLOGY IN DENMARK / AN IMAGE-BASED DIGITAL RETROSPECTION OF A DEMOLISHED VILLAGE BREGINJ AND ITS LANDSCAPE CHANGE ANALYSIS / ARCHAEOLOGICAL LANDSCAPE IN ROMANIA: 10 YEARS OF SURVEYS AND DOCUMENTATION / ARCHAEOLOGY FROM ABOVE: THE AERIAL ARCHAEOLOGY RESEARCH GROUP / DEFENCE IN THE RHYTHM OF RICHARD WAGNER'S MUSIC: THE LAST DAYS OF 'FORTRESS KÜSTRIN' / HISTORIC AERIAL PHOTOGRAPHIC ARCHIVES: REFLECTIONS AND LESSONS LEARNED / IN FLANDERS EARTH: WW1 AERIAL PHOTOGRAPHS IN A MUSEUM AND LANDSCAPE CONTEXT / ÍSLEIF: RECORDING ICELAND'S HERITAGE / MAPPING CRETAN HERITAGE FROM THE AIR: THE CHALLENGE OF MOUNTAINOUS LANDSCAPE / THE BLACKSTAIRS MOUNTAINS: SOUTH-EAST IRELAND: INVESTIGATING THE ARCHAEOLOGICAL POTENTIAL OF THE IRISH UPLANDS / THE CHANGING ROMANIAN LANDSCAPE: THE IMPORTANCE OF ARCHIVAL IMAGERY / UNIVERSITY OF FOGGIA INTEGRATED ARCHAEOLOGICAL RESEARCH IN NORTHERN APULIA

Contributions on:

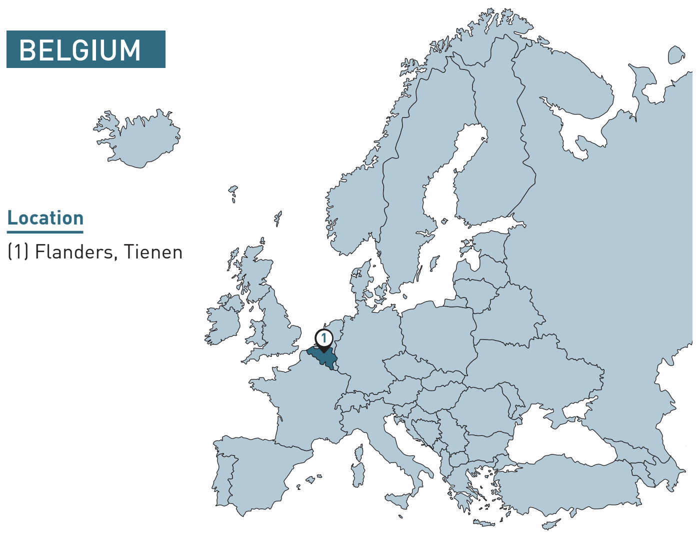
AERIAL PHOTOGRAPHY AND AERIAL ARCHIVES

Aerial archaeology at the Leuven University (Belgium)

René Pelegrin[1] / Marc Lodewijckx[1] / Tom Debruyne[2]
1. Leuven University, Department of Archaeology and Art History / 2. Inter-Municipal Archaeological Service PORTIVA

Introduction

For many years now, Leuven University (KU Leuven) has been carrying out traditional aerial archaeology. This has led to the discovery of many new archaeological sites, especially in the fertile loess belt in central Belgium.



In the last decade, a prevalent growth of interest in archaeological heritage management has prompted the discussion of how to improve insights into the processes that have formed the natural and cultural ecosystem of which these archaeological sites are a part. Aerial archaeology has also proved to be very effective for the updating of inventories of archaeological sites, for the appraisal of the archaeological potential of wide areas, for the search for specific marks on previously detected sites, for the identification of features on older aerial photographs and for the periodic assessment of sites, monuments and historic landscapes.

Although aerial archaeology in Belgium is still most commonly used as a survey instrument, its role is becoming increasingly more significant and its application more versatile, especially within the framework of heritage management. In mainly rural environments, aerial archaeology can be a highly effective tool, not only for making a synopsis of archaeological sites and off-site features along with their complex spatial and chronological associations, but also for identifying a number of problems raised in the framework of a good preservation and efficient management of sites. The archaeological remains survive in delicate environments which are under constant pressure because of the competing claims made by the many other actors requiring more land and space for various activities and new functions.

A large number of crop marks reveal a complex site, probably with elements from different periods.

Archaeology in rural areas

Although conditions for the proper management of the heritage in a rural environment need to be improved in future, we are happy to note that the management of archaeological sites is now being given priority and that a variety of new measures and tasks are being devised to prevent information from classified sites and as yet undiscovered sites from being lost.

A nice surprise at the end of the day: a series of ring ditches indicate a number of elite graves.

In the past, the main interest was focused on buildings' heritage but we are pleased to see that nowadays more attention is paid to the management of larger areas, not only for the benefit of the individual remains but to make a link between the various interests of economic activities, the enlargement of residential areas and the preservation of biologically important areas and historical landscapes.

Partnership with local services

With this poster, we want to illustrate a few of our more recent discoveries in the eastern parts of Flanders and especially the positive results of our cooperation with the Inter-Municipal Archaeological Service PORTIVA, which is active in a vast region in the heart of the Hesbaye loess area. Large scale agricultural activities in this highly fertile county cause vast erosion processes on the tops and slopes of the undulating landscape, and archaeological sites are in extreme danger of rapidly disappearing.

The enhanced exchange of information about archaeological sites between both our services has proved to be very fruitful and is an example of a more effective management of Belgium's archaeological heritage.

A marvellous composition of square features near Tienen. As there have been no obvious archaeological discoveries on the ground, the date of this site is not known.

Historical sites are often threated by the expansion of modern infrastructure.

Erosion processes are a serious threat to the preservation of archaeological remains in the subsoil, especially in the Hesbaye loess zone.

ArcLand HERITAGE · DATA · KNOWLEDGE Culture KU LEUVEN PORTIVA Intergemeentelijke Archeologische Dienst

Aerial archaeology in Denmark

Lis Helles Olesen[1]
1. Holstebro Museum, Denmark

Introduction

In 2008 Holstebro Museum secured funding for a research project aimed at examining the potential for aerial archaeology in Denmark: An aerial view of the past – Aerial archaeology in Denmark. The project ran until the middle of 2013, but further funding was secured, enabling it to continue until 2018. Total funding is around €1.33 million. The timing of the project proved fortunate in that, in 2009, it could become integrated into the ArchaeoLandscapes Europe project.

A brief presentation of the project: *An aerial view of the past – Aerial archaeology in Denmark*

The aim of the project is to draw attention to and to investigate the unique potential inherent in aerial archaeology with respect to research, communication and education and the planning process. It focuses on several different aspects:

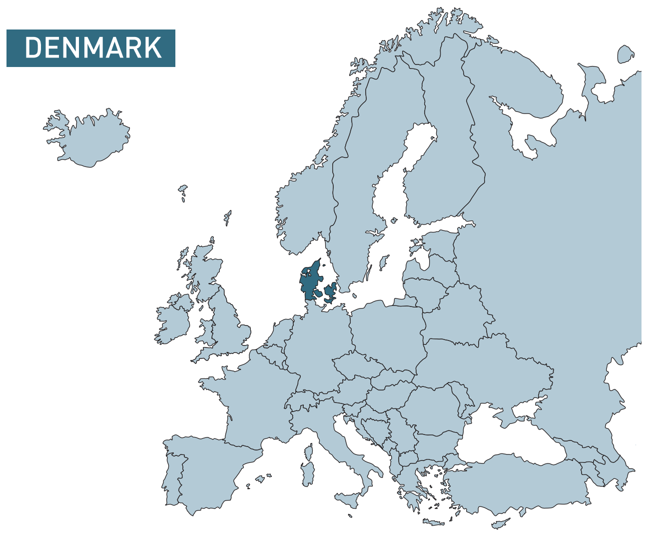
- Aerial surveys
- Studies of existing vertical photos
- Modern technology, e.g. Airborne Laser Scanning
- An overview of aerial photos covering Denmark
- National and international collaboration with institutions such as the International Aerial Archaeology Training School
- Monitoring of scheduled ancient monuments from the air
- Communication and education

The first five of these will be briefly outlined below.

Aerial survey

The aspects that have received greatest emphasis are aerial surveys and studies of vertical photos. A very brief account of the results of these is given here. Between 2008 and 2012, 745 sites showing marks of prehistoric and historic features were recorded **(Fig. 1)**. The localities span the period from the Mesolithic to recent times, with the majority being from the Iron Age/Viking Age. 84% of the recorded localities were previously unknown. On average, 3.5 localities were detected per hour of flying time, i.e. 2.9 previously unknown localities per hour of flying time. The total flying time was 220 hours. The traces recorded comprise 90% vegetation marks, 6% soil marks and 4% shadow marks. Of these, 91% are on sandy soil, only 6% on clay soils and the remainder in wetlands.

For example we found lots of settlements with traces of around 670 longhouses at 192 localities and 109 localities with pithouses **(Figs. 2 and 3)**. House sites are often a good way of dating the localities.



Studies of vertical photos

Nine areas, each of about 155 km^2, were selected with the aim of investigating and demonstrating the amount of cultural historical/heritage environment data that can be obtained through studies of aerial photos. All the areas were examined on four different aerial photo series and on the hillshade model from the Danish Elevation Model. Three of the series are in black and white and were photographed in spring, while the fourth is in colour and was photographed in summer.
A total of 2746 localities have been recorded of which 61% were previously unknown **(Fig. 4)**. As an example the ploughed-down burial mounds will be mentioned here. They comprise 86% of the localities and represent an increase of 34% relative to existing records. The increase is of approximately the same magnitude on clay and sandy soils, with an average of just less than one new burial mound per km^2. If these data are representative, this situation corresponds to the detection of around 33,600 new ploughed-down burial mounds in Denmark.

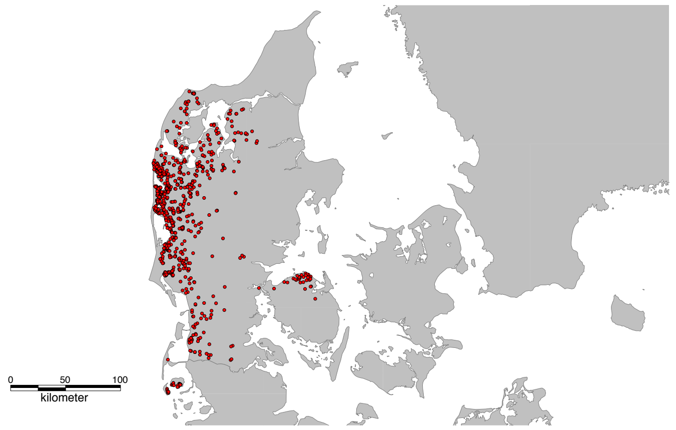


Fig. 1: All 745 sites located in our aerial surveys in the period 2008-2012 are marked with a red dot. Drawing Esben Schlosser Mauritsen.

Airborne Laser Scanning

The Danish Digital Elevation Model is freely available on the Internet. It has considerable research potential, but with only 0.45 points recorded per m^2, also has certain limitations, for example with respect to dense conifer plantations. We wanted to investigate whether better results could be achieved with a more detailed laser scan and in October 2010 an area of 65 km^2, which included both open land and forest, was surveyed. On open land, no better results were obtained with respect to ploughed-down features. In the woodland, on the other hand, a wealth of new cultural-historical traces was revealed, which were not visible on the Danish Digital Elevation Model. In particular, these included small burial mounds, details of larger burial mounds, sunken roads, Celtic fields and WWII structures. This excellent scan still has much unexploited potential and we are happy to make available to others who wish to continue work on it.

Overview of aerial photos in Denmark

The registration of aerial photos in the archives has a high priority in the ArchaeoLandscapes project. In our project we produced an overview of aerial photos covering Denmark. It was published in book form in 2011, together with a history of aerial archaeology and its applications.[1] A large body of material is available for Denmark: most of it is kept in the Royal Library in Copenhagen. In 2010, it contained around 5.5 million aerial photos; 2 million verticals and 3.5 million obliques. A remarkable number of series providing national coverage of Denmark is available on the Internet: Luftwaffe 1944, RAF 1945, US Air Force 1954, COWI 1995, 1999, 2002, 2004, 2006, 2008, 2010, 2012 and the Danish Digital Elevation Model.[2]

Aerial Archaeology Training School

We organised an Aerial Archaeology Training School, running from 2nd-8th July 2011, in partnership with ArchaeoLandscapes and LAND Aerial Archaeological Network Denmark. It brought together nine tutors and 16 students from 11 different countries across Europe in an intensive programme of ground-based instruction and in-air experience above the archaeologically-rich landscapes of western Jutland **(Fig. 5)**.

Over five days the students were introduced to the general principles of archaeological aerial survey, as well as the basic procedures of photo interpretation and mapping for communication with the general public, researchers and planners. All students also took part in supervised flights from Stauning Airport, seeking out and photographing some of Western Jutland's distinctive prehistoric, Viking and later archaeological sites. Throughout the training school emphasis was laid on the ways in which aerial evidence can broaden professional and academic understanding of past societies and capture the imagination of the general public, helping them appreciate the value of the often fragile traces of the past that lie half-hidden in the landscape around them.

Conclusions and future perspectives

All our results indicate that the use of aerial photography in archaeology has great potential in Denmark. The project will carry out further aerial surveys and studies of vertical photos, national and international collaboration, communication and education initiatives, geophysical investigations and the production of an exhibition.

Fig. 2. Pithouses with surrounding fence and entrance. Hyllerslev, southwest Jutland. Photo 5957, 22.07.13, Lis Helles Olesen.

Fig. 3: An Early Iron Age linear village which presumably was built on either side of a road. Ørre Gårde, western Jutland. Photo 0471, 01.07.10, Lis Helles Olesen.

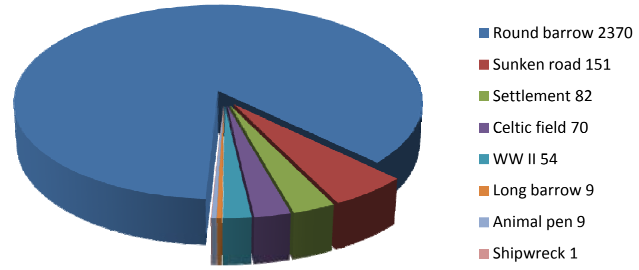


Fig. 4: Observed traces from studies of verticals organised by feature/structure type.

Fig. 5: All the students and tutors at the Aerial Archaeology Training School. Photo Velling Højskole.

Notes:

1. Olesen, L.H., H. Dupont & C. Dam. 2011. *Luftfotos over Danmark – luftfotoserier i private og offentlige arkiver.*

2. See for example: http://kort.arealinfo.dk; http://flyfotoarkivet.dk; http://www.i-gis.dk; http://www.grundkortfyn.dk; http://www.kortal.dk.

Literature:

3. Olesen, Lis Helles and Henrik Dupont and Claus Dam. 2011. *Luftfotos over Danmark – luftfotoserier i private og offentlige arkiver.* Holstebro: Holstebro Museum Publishers

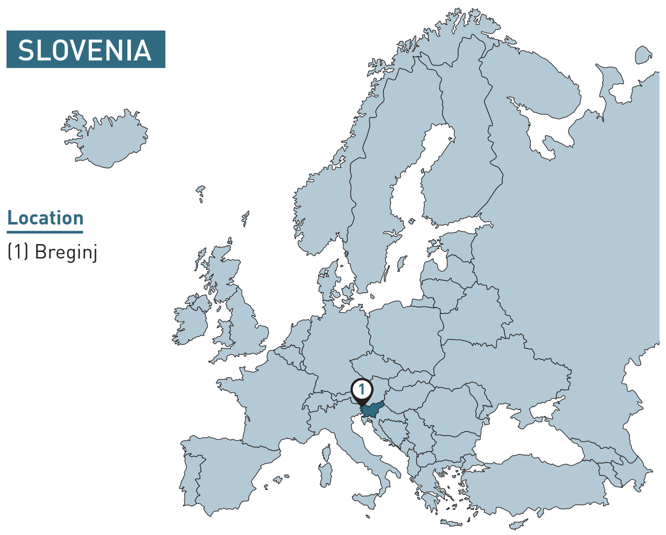
An image-based digital retrospection of a demolished village Breginj and its landscape change analysis

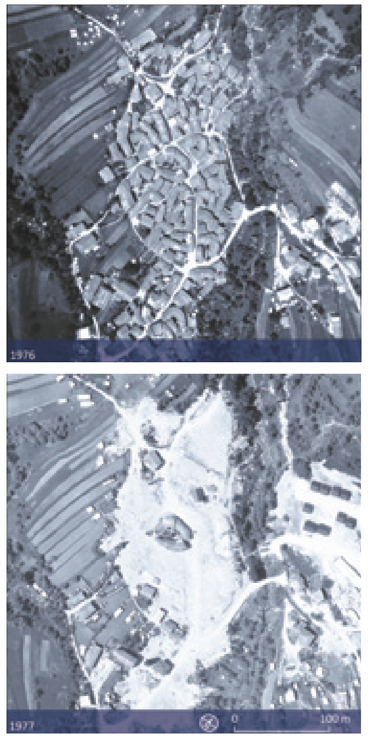
Tatjana Veljanovski[1] / Žiga Kokalj[1,2]
1. Research Centre of the Slovenian Academy of Sciences and Arts / 2. Centre of Excellence for Space Sciences and Technologies

Introduction

The mountain village of Breginj was for centuries the centre of a self-sufficient and highly organized local community. Its extraordinary folk architecture was protected as a first category cultural monument.

This lively area bordering Italy was subject to politically driven decisions after it was severely struck by two successive earthquakes. The way of life has changed and the situation has left striking evidence in the landscape evolution of the past decades.





The old Breginj **(Top)** was bulldozed almost overnight. Only a few houses were left to showcase the style and a new village with contemporary housing was built on a new location across the stream to the east **(Lower)**.

With this contribution we aim to raise awareness and show the potential of historical photography and a digital image-based retrospection of places that may no longer exist, but have left important traces in human and landscape history. Having in mind the retrospection of a lost village and its relevance through time we used historic aerial photographs and two different approaches to obtain:

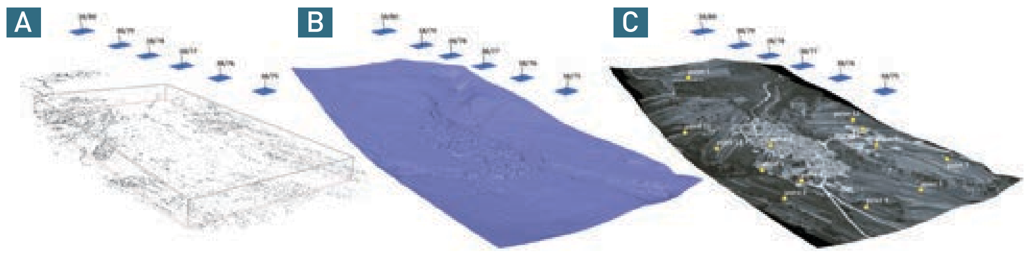
- a detailed 3D village reconstruction (with SfM modelling) and
- a landscape change study (with object-based image analysis).

Breginj and image-based digital retrospection

Cultural heritage is frequently photographed. It may be destroyed or altered, and photographs become the only evidence of its existence and modification. In the case of Breginj, the village completely changed its location and structure. This, together with the general depopulation of rural areas, gradually resulted in a change in the way of life and the use of the surrounding land.

Our question was how, where, and to what extent can the landscape change in a few decades? Modern image processing techniques support the production of a variety of digital approximations of historical objects. Digital reconstruction of demolished Breginj is important because it:

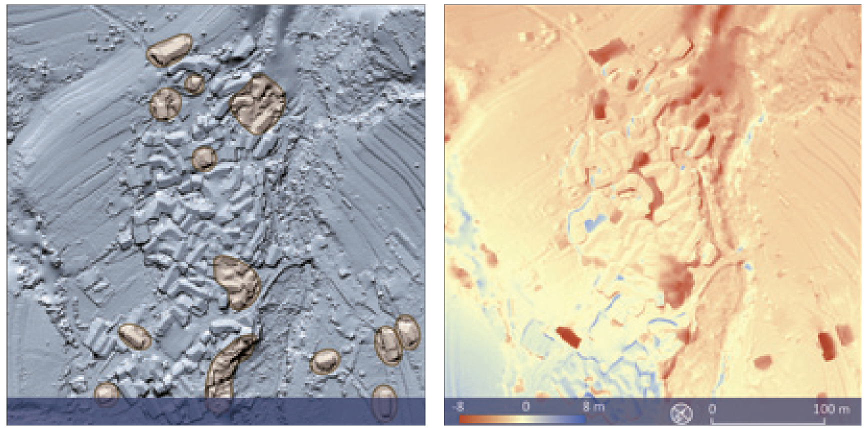
- enables a spatial and temporal retrospection of the historic processes, and the preservation and dissemination of the memory of this once remarkable village, and
- gives measurable evidence of the effects of post-earthquake reconstruction and political decisions on the structure and function of the landscape and people.



A digital reconstruction of the demolished village was created using Structure-from-Motion techniques on a series of six vertical aerial photographs. The computed model provides a good basis for a retrospection of a settlement that no longer exists and for detailed studies of landscape changes.

Structure-from-Motion derived digital model

A series of six vertical aerial photographs was taken after the first earthquake in May 1976 to observe the destruction. We used these images to create a digital reconstruction of the demolished village using the Structure-from-Motion technique. The photographs were taken in a single flight line and every point on the ground can only be seen on a maximum of three images, which is not the best arrangement for this type of reconstruction. Despite this two detailed elevation models were produced: the first from full resolution images and the second from reduced resolution images (by 55%). The latter model better defines the buildings despite the same processing settings. Because the reconstruction is only based on aerial photographs so far, the computed model is not of the best quality, but it still provides a good basis for a retrospection of the settlement.



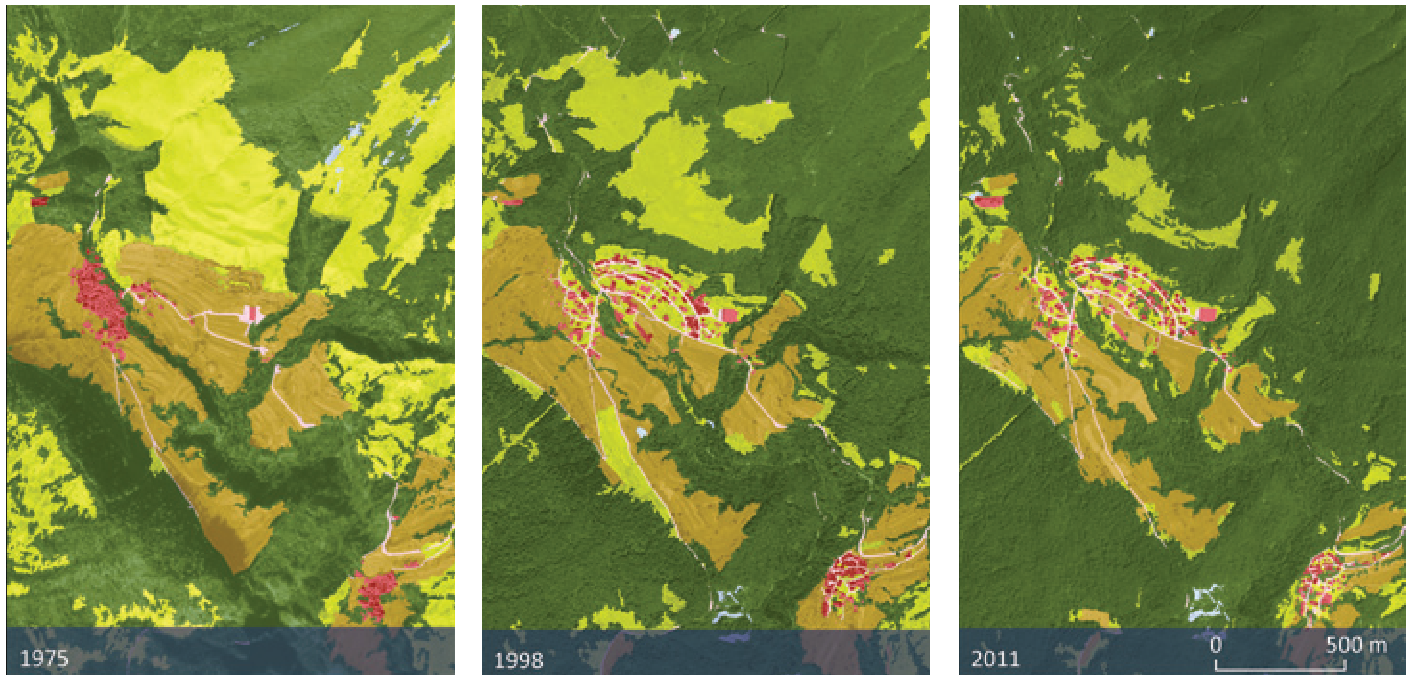
A model of Breginj was computed from full resolution (11 k2 px) and reduced resolution images (by 55 %) **(Left)**. The latter better defines the buildings. Note the differences in the computed terrain topography on the difference image **(Right)**.

OBIA land cover change

Object-based image analysis (OBIA) is an approach to semantically analyse imagery that was developed for the classification of very high resolution imagery. Image-objects represent ʼmeaningfulʼ entities or scene components that are distinguishable and form the geographical space evidenced in an image. OBIA consists of two distinct steps: segmentation (delineation of homogeneous zones) and classification (semantic grouping of segments). The result is a classified geographical space, according to its natural elements, land cover or land uses. OBIA of imagery from different periods enables quantitative and contextual tracing of changes in the landscape.

Conclusion

Photographs of the old village of Breginj can no longer be taken. But 3D reconstructions based on historic images might add to cultural resource management and services. A successful retrospection of landscape change and social processes demonstrates that aerial imagery can be a valuable resource for geographers, historians, and archaeologists.



Landscape changes around Breginj from 1975 to 2011. The village itself was relocated and the buildings (in red) are now much more dispersed. Pastures, meadows (both yellow), and fields (orange) are shrinking and giving way to forests (green).

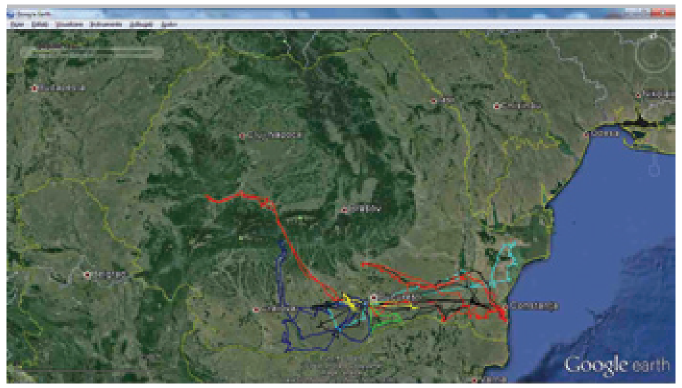
Archaeological landscape in Romania: 10 years of surveys and documentation

Irina Oberländer-Târnoveanu[1] / Bogdan Șandric[1] / Iuliana Damian[1] / Oana Borlean[1] / Adriana Vîlcu[1]
1. National Heritage Institute

Introduction

It is now 10 years since the former Institute for Cultural Memory-CIMEC *(www.cimec.ro)*, today part of the National Heritage Institute *(patrimoniu.gov.ro)*, started aerial and cartographical surveys in order to improve the National Archaeological Record *(ran.cimec.ro)*, mainly in Southern Romania along the Lower Danube Plain, Central Dobrudja, and up to Sub-Carpathian Hills but also in Northern Romania, Botoșani County. We have established the geographical location and context for known archaeological sites, identified unknown features and recorded changes in the landscape, combining aerial surveys with the study of historical maps and GIS techniques.

The main activities were: aerial photo investigation (25 flights & 7500 images), image interpretation and digital archive creation, using aerial imagery to map 3000 archaeological sites, updating the spatial distribution of settlements in Romania (13,756 places) and creating a cooperation network through the project "Archaeological landscapes. Outlook, history and evolution", developed between May and October 2014, in partnership with other Romanian public cultural institutions.



The paths of flights carried out between 2007 and 2012.

Argamum (Jurilovca, Tulcea county) Greek and Roman city on the shore of Razelm Lake.

ROMANIA

Locations

(1) Sprâncenata
(2) Alexandria
(3) Bucșani
(4) Stoenești
(5) Radovanu
(6) Frăsinet
(7) Buești
(8) Hârșova
(9) Valu lui Traian
(10) Pantelimon
(11) Tulcea
(12) Botoșani
(13) Călimănești
(14) Târgșoru Vechi
(15) Telega

Compile an aerial photo archive

After implementing the pilot project Mostiștea Valley (2005-2007) under the auspices of the "European Landscapes-Past, Present and Future" European project, we continued the aerial investigation of the Southern Romanian Plain (Neajlov, Argeș, Teleorman, Ialomița and Olt rivers), in Ilfov and Prahova Counties, along the motorways in construction (A2 Bucharest-Medgidia-Constanta, A3 București-Ploiești and Sibiu-Orăștie-Deva) and between the Danube and Black Sea in Central Dobrudja, in order to enrich the National Archaeological Map of Romania (map.cimec.ro). The main outcome is a database that contains almost 4000 processed photos from around 7500 photos taken from air. We assigned precise geographical coordinates and metadata such as: the nearest settlement, date of flight, county, mark type, general observation and landscape changes.

The operation will continue until the entire collection is completed. The photo archive is accessible on-line through a web site and a dedicated web GIS application entitled "Landscapes" (*www.peisaje-arheologice.ro*).

Eneolithic tell settlement at Magura in Teleorman county with 19th century Orthodox Cemetery above.

Using aerial orthophotoplans for sites inventory: The archaeological repertoire of Botoșani County

We contributed to the county sites inventory. Our main activity was to map archaeological sites using both topographical maps and orthophotoplans produced by the Topographic Military Directorate. All the 1809 sites were vectorised in a GIS project (using polygons as geometry) and were recorded in the National Archaeological Record. Additional resources and techniques were used: satellite imagery and field surveys. Information was provided about administrative location, state of conservation, levels of natural or human risks, type of inhabitation, time span and bibliography.

Medieval fortress (12th-15th century) at Enisala (Tulcea county).

The project was carried out in partnership with Ph.D. Octavian Liviu Șovan from Botoșani County Culture Directorate. The outcome was a volume accompanied by a DVD with topographic maps of each administrative entity, scale between 1:20,000 and 1:25,000, obtained both by vectorising settlements, roads, contour lines, rivers and lakes from orthophotoplans, and using different DEMs *(www.cimec.ro/arheologie/repertoriul-botosani/index.html)*. Copies of the volume were sent to local authorities and schools to be used in heritage conservation and education programs.

A successful project: Archaeological landscapes. Outlook, history and evolution (2014)

The project was developed by the National Heritage Institute (CIMEC Department) in partnership with the National History Museum of Romania, University of Bucharest (Geography Department), the Topography Military Directorate and UMR 7041 ArScAn-Équipe Archéologies Environementales (France). The project, funded by the Romanian Ministry of Culture, was placed under the auspices of ArcLand and supported its goals and activities by promoting the concept of archaeological landscape and its research methods within the Romanian scientific field, and by raising awareness of the intrinsic value of heritage among specialists (archaeologists, historians, cultural operators, students) and the wider public.

The final event was an international conference entitled "Approaches to Archaeological Landscapes. Tools, Methodology and Case Studies (22nd-23rd October 2014, Bucharest).
The event brought together 30 specialists, foreigners and Romanians, among them also ArcLand members, who tackled the topic of the archaeological landscape concept, displayed different methodologies and shared their experience in the field of landscape studies. An aerial photos exhibition hosted at the National History Museum of Romania accompanied the event.

Bogdan Șandric, Oana Borlean, Iuliana Damian, Adriana Vîlcu, Philippe Fajon and Irina Oberländer-Târnoveanu – project team, Bucharest, October 2014.

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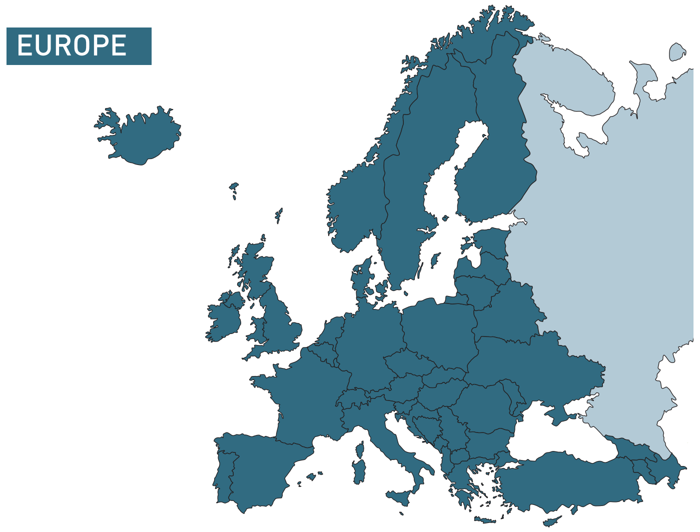
Archaeology from above: The Aerial Archaeology Research Group

Rachel Opitz[1]
1. Aerial Archaeology Research Group / CAST, University of Arkansas, USA

Introduction

What is it about the airborne perspective that fascinates us? Aerial photography was introduced into archaeology early in the 20th century as formal field methods were crystallizing, and continues to evolve alongside the wider discipline.

The view from above has become central to regional and landscape studies, monitoring and heritage management efforts, research on the rural world, and the integrated study of the remains of past human and natural activities, events and processes. Aerial archaeology plays an important role in today's and the future's archaeologies.



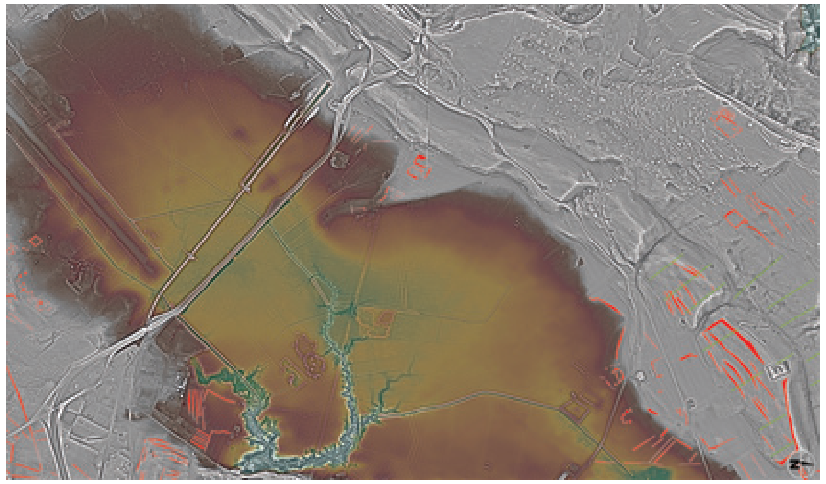
Belsar's Hill. Near-vertical hand-held shot taken by Chris Cox of the Iron Age ringwork at Belsar's Hill, Cambridgeshire, UK. The strips of ridge and furrow cultivation were superimposed in medieval times. In this pasture field they remain in upstanding form, in the surrounding arable fields they have been levelled by ploughing. Photo taken on 10 January 1992 when the grass field was still frost-covered and helped highlight the archaeological remains. Photo Chris Cox, 10 January 1992: 92.4/07.

Students at the ArcLand-funded training school at Kostolac, Serbia examining and discussing a set of aerial photographs in preparation for an interpretation and mapping exercise.

A brief (unofficial) history of AARG

AARG, the Aerial Archaeology Research Group, grew out of a group of working archaeologists interested in the problems of aerial information – description, depiction, interpretation and integration. Early years focused on meetings and discussions of the interpretation of air photos, drawing conventions for mapping and classifications of features, and integration of this information with the broader archaeological record. While debate on these ideas continues, the methodological remit of AARG has expanded from photos to any method of prospection carried out from an airborne perspective.

Structures seen underwater, from the air. Brijuni Islands, Croatia.



The Marais de Saone seen in a LiDAR visualization, with archaeological features on its margins interpreted and mapped in red and green. At least two patterns of fields are visible. Image/Data Credit: Nuninger – LIEPPEC.

Catherine Fruchart and colleagues taking aerial information (LiDAR) into the field on the AARG and ArcLand supported field trip in the Chailluz Forest at TRAIL 2014.

Topics at meetings range from the practical and technical, touching on questions of management, image processing, and data integration, to the theoretical, exploring the intersections of the airborne methods with landscape archaeology, environmental archaeology, and keeping people in the picture. AARG, has been going for over 30 years, expanding from a membership primarily from the UK to broad participation across Europe. As it has evolved, taking in new methods and developing a more reflexive bent, it remains focused on practice, occasionally irreverent and with its feet ever so slightly off the ground.

AARG and ArcLand

ArcLand and AARG share a core interest in past and present landscapes, and in expanding access to and understanding of the tools, methods, and frameworks for studying landscape through survey and remote sensing. As documenters and interpreters, AARG members are active participants in the ArcLand network and governance, promoting aerial methods and the associated large scale, integrationist approaches. AARG and ArcLand have co-sponsored several workshops and publications. AARG members are found across the ArcLand working parties, and contribute to best practices guidance, work with archives that are repositories for information on much of Europe's pre-industrial agriculture state, engage in outreach to raise public awareness of landscape heritage and aerial archives, and promote the exchange of ideas and expertise across national and regional divides.

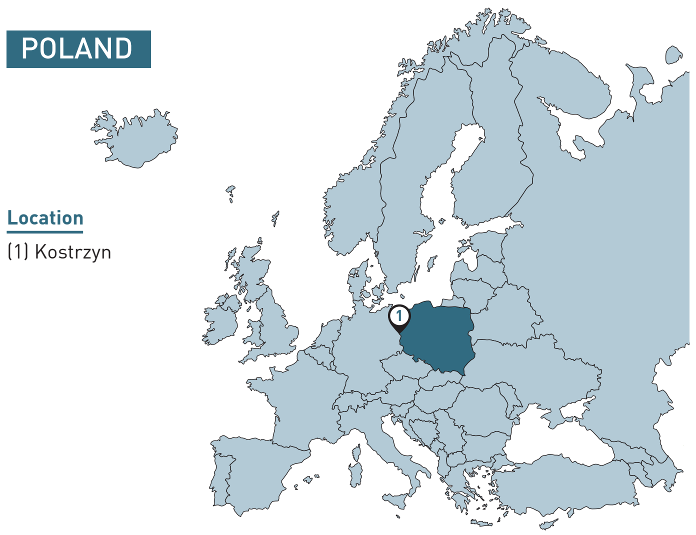
AARG activities

AARG's Annual Meeting is the group's main event, providing an opportunity to share ongoing projects and current practices, reflect on the direction of the field, and introduce new practi-tioners to the community. AARG engages in training and outreach activities, holding or contributing expertise to flying schools and workshops on topics including airborne laserscanning, image interpretation, and integration of aerial survey with ground based fieldwork and desktop mapping exercises. AARG supports the publication of monographs and articles relevant to the group's interests, as well as producing a newsletter, promoting new research and best practices in the field.

Defence in the rhythm of Richard Wagner's music: The last days of 'Fortress Küstrin'

Grzegorz Szalast[1] / Grzegorz Kiarszys[1]
1. Szczecin University, Department of Archaeology

Introduction



Kostrzyn (German Küstrin) is located at the confluence of the Warta and the Oder rivers. Since 1537 the town was gradually transformed into a mighty fortress. The stronghold of Küstrin gained its final shape in the second half of the 19th century. At that time the spatial plan of the town took on its characteristic shape of an irregular hexagon surrounded by six bastions.

At the turn of the 20th century the fortifications lost their military meaning and were gradually dismantled. That situation substantially changed on 28th of November 1944, when general Heinz Guderian ordered new fortification works. On 25th of January 1945 Küstrin was officially declared a stronghold of the Third Reich. It became the 'Gates to Berlin', an important strongpoint of the Nibelungs' Line (German Nibelungstellung). The Nibelungs' Line was a romantic metaphor inspired by Germanic mythology.

At the end of World War II in Europe Küstrin shared the fate of many other towns of strategic importance. After months of preparation the town was desperately defended from the Red Army advancing towards Berlin.

The fall of the fortress

Küstrin was located in a very convenient defensive position. The proximity of two major rivers and vast marshlands surrounding the town produced very difficult conditions for the approaching Red Army soldiers. During the winter time the frozen Oder river was an advantage to the assaulting Red Army soldiers. However, the ice was too thin to allow tanks and mobile rocket launchers to cross the river.

The strategic situation of Küstrin changed on the 31st of January 1945 when Soviet troops gained a bridgehead on the western bank of the Oder river, about 17 kilometres to the north of the town, in the region of Kienitz village. During the next few days another lodgement on the western bank of the Oder river was captured. It was situated about 10 kilometres to the south of the town, near Górzyca village. With the beginning of spring the ice melted and the level of the water table grew, covering the bridges built by the Red Army troops with a thin layer of water (25-30cm). For a while they became 'invisible' to the Luftwaffe pilots.

After over a month of fighting, in the first half of March 1945 the Red Army troops captured the New Town district of Küstrin. Josef Stalin was convinced that the siege was over. He congratulated the soldiers in the Order No. 300 and presented some of them with badges. Soviet propaganda started to celebrate the victory.

Fig. 1: The Fortress of Küstrin. German aerial intelligence photograph taken on 13th of March 1945 (© TARA).

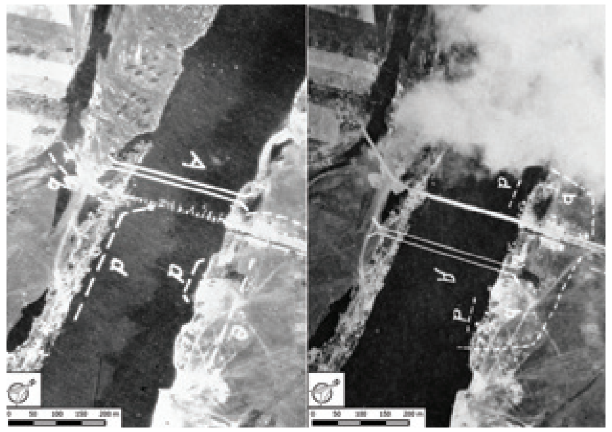


Fig. 2: The example of the wooden bridge built by the Red Army engineering troops within just several days (the photography on the left was taken on 11.04.1945, the photography on the right was taken on 14.04.1945) (© TARA).

However, the heavy fighting for the old part of the town continued. Finally, on the 30th of March 1945 the fortress of Küstrin was surrendered.

The aftermath

The siege of Küstrin lasted for almost 60 days. 637 German soldiers were killed and 5995 were considered to be missing. About 6000 Red Army soldiers died in this battle. The fall of Küstrin opened the way to Berlin. The Red Army troops were only 80km from their final destination - the capital of the Third Reich. The last, ruthless contest for the title and the glory of the conqueror of Berlin had begun between Marshal Zhukov and Marshal Konev.

Artillery barrages and heavy street fighting turned Küstrin into rubble. After the war the town was placed under Polish administration. The decision was made to not rebuild the old town. The bricks from demolished buildings were collected and transported for the rebuilding of Warsaw. For many years Kostrzyn was a restricted area because of a military base for rocket and engineering troops located within the New District of town.

Fig. 3: System of trenches built by the Red Army soldiers on the western bank of the Oder River (photography taken on 08.04.1945) (© TARA).

Fig. 4: On the left the German topographical map of Küstrin (Messtischblatt from 1936). On the right the soviet map of Küstrin from 1949.

Fig. 5: The ruins of the Fortress Kustrin in 1975. The only cleaned up area is the cemetery of the Red Army soldiers located within the Bastion König (© CODGiK).

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Historic aerial photographic archives: Reflections and lessons learned

Dave Cowley[1]
1. RCAHMS (from 1st October 2015 – Historic Environment Scotland)

Introduction

One of the eight collaborative actions of ArchaeoLandscapes (Action 5) is to secure the better exploitation of aerial photo archives across Europe, recognising that their potential for landscape and archaeological studies is largely un-assessed, and that their role in documentation and conservation is generally poorly developed. While it was recognized that the full exploitation of these archives is a long-term objective, this contribution presents a summary of what has been achieved for Action 5 so far, and what has been learnt to date that might inform future progress.

What have we achieved?

Action 5 activities have focussed on promoting awareness amongst a range of archaeological, landscape and heritage professionals, and on sharing experience and skills. Recognising that uneven knowledge of where aerial photographs might exist is a major limitation to their exploitation, an 'Archives Survey' was launched to identify such resources. The index achieved is a first step, reflecting those areas where the survey was actively promoted. Guidance for using particular archives has also been developed, including guidelines to accessing and using the more than 500 000 images in the known collections of World War I aerial photographs *(http://www.arcland.eu/archives/wwi-archives)*. Conferences and workshops have been held with the aim of sharing knowledge and experience, reaching out to new audiences and developing networks. These include 'Recovering Lost Landscapes' (Belgrade, November 2013), 'Patterns, Processes & Understanding' (Poznan, April 2014), and 'Conflict landscapes and archaeology from above' (Ypres, May 2014), selected papers from which are being published (below). Publications of work with historic aerial photographs will continue to promote awareness in the longer-term and include journal papers written within the ArcLand framework.

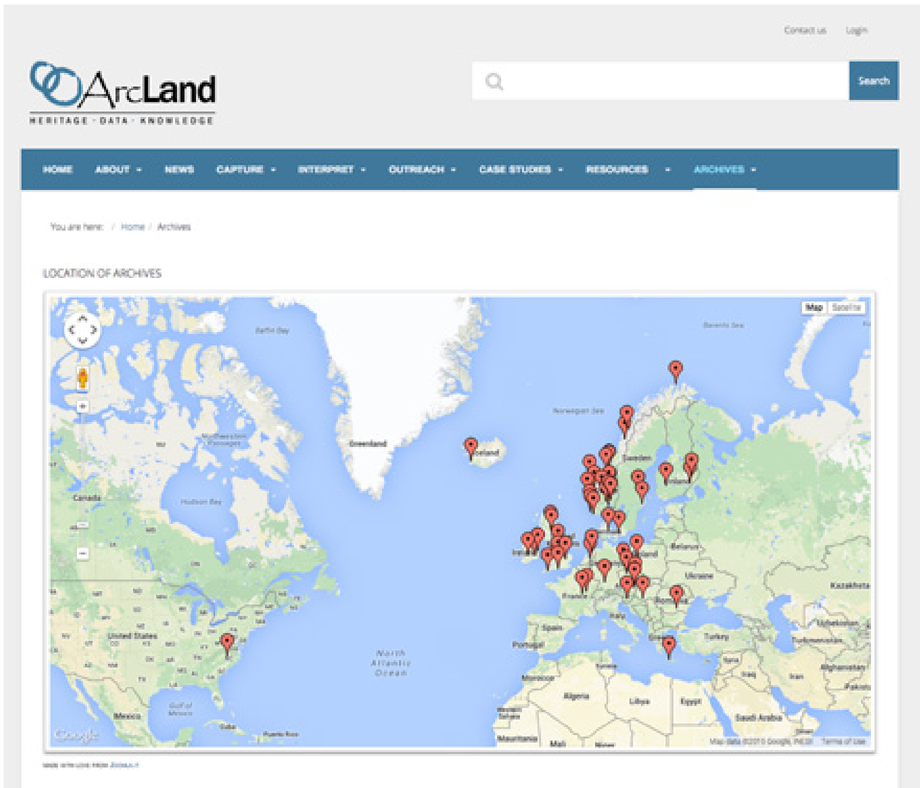
Books with this particular focus produced to date include Hanson & Oltean (eds), 2013, Archaeology from Historical Aerial and Satellite Archives and Stichelbaut & Chielens 2013, The Great War Seen from the Air: In Flanders Fields, 1914-1918, with two others in an advanced state of preparation at the time of writing (Stichelbaut & Cowley (eds), Conflict Landscapes and Archaeology from Above and Ivanišević et al. (eds), Recovering Lost Landscapes.

Lessons learnt

These activities have reinforced the value of historical aerial imagery for documentation/detection and landscape history, and increasingly, with developments in software, as sources of 3D data. However, there has also been a growing appreciation of the difficulties in developing use of archives. Access is not always easy for a variety of reasons, including military secrecy, costs and the commercial imperatives of some custodians. Finding aids and the metadata required to undertake a first-stage assessment of imagery for a particular purpose may not be available or even exist. This can make the exploration of an archive very time-consuming and expensive, and may result in disappointment. Furthermore, most aerial photographic archives were not created to serve the archaeological or heritage communities, and this means that generating a sense of common purpose or shared agendas with 'the archives' may be very difficult.

This has major implications for the strategies to promote the better exploitation of such archives, as these require recognition of the realities of dealing with archives on the one hand, and a consideration of the wider context of our own work, on the other. Amongst the issues for consideration is that archaeological projects often deal with relatively small areas, and that there is a real cost/benefit assessment to investing in cataloguing to create access. Investment by an archive in individual projects may have limited benefits, for example if that requires extensive work on uncatalogued material, and overall this compounds the fact that archaeology usually has little money and therefore limited leverage.

This general situation begs the question of whether archaeology can generate a better sense of common purpose with archives and other interested parties by considering the wider context of our work. Such an approach is partly about the potential role of large-scale, well-funded projects. To secure such projects demands greater archaeological engagement with broader-based agendas, almost certainly needs to be progressed at regional or trans-national scales and requires wider context for the archaeological imperatives, for example, in that provided by the European Landscape Convention and broad-brush landscape characterisation and management, neither of which has attracted much interest amongst archaeologists *(see http://hla.rcahms.gov.uk/ for an example of such an approach)*. However, as an approach that recognises landscapes as dynamic and creates broad-brush large area mapping, it is not only a tool for management and developing land use policy and spatial planning, but also provides an overview of landscape history, land use patterns and their impact on archaeological detection. Thus, it gives valuable context for much of what is done in the framework of landscape archaeology that could help generate greater leverage and funding through larger projects that may provide a cost-effective stimulus to mass-cataloguing or digitisation. For the specific objectives of ArcLand's Action 5, it is also an approach that promotes the importance of the earliest aerial photographs of Europe as an important 'baseline' from which to consider impacts of later landscape change. Finally, it is worth noting that investment is necessary to preserve and curate these collections as historic assets in their own right.



A map of the preliminary results of the Aerial Photographic 'Archives Survey' shows the marked variation in responses, which is none-the-less a good foundation to build on in creating a portal that advertises the existence of material.

The front page of one of the 'global' collections of aerial photographs does not list 'archaeology' or 'heritage' amongst selected applications, reflecting the origins of many of its users, amongst which archaeologists are relatively few in number. Where an archive has to sustain its activities through income generation it should be no surprise that its effort is concentrated on well-funded users.

In Flanders earth: WW1 aerial photographs in a museum and landscape context

Birger Stichelbaut[1] / Annick Vandenbilcke[1] / Piet Chielens[1]
1. In Flanders Fields Museum (IFFM), Ypres (Belgium)

Introduction

One of the focus points of the In Flanders Fields Museum is the conflict landscape of the First World War. Now that the last living witnesses who experienced the horrors of the First World have died, this war landscape is becoming the real 'last witness' of the conflict. During the First World War, millions of aerial photographs were taken by all combatant countries.

These provide an unparalleled record of both the progress of the war and the destruction of the landscape. In the framework of the ArchaeoLandscapes project the In Flanders Fields Museum has explored the potential of using these photographs in an interactive museum setup and a mobile application. The goal of both applications is to learn about this landscape and to present it visually for visitors to the region.

BELGIUM

Location
(1) In Flanders Fields Museum, Belgium.

In Flanders Earth

The first application is called In Flanders Earth (IFE) **(Fig. 2 & 3).** It is essentially an interactive application highlighing the bird's eye view of the conflict landscape of the First World War. It uses aerial photographs as a medium to provoke thoughts about the scale and intensity of this war in Belgium. The application consists of four large multi-touch screens that visitors can use to explore the war landscape in an interactive and dynamic manner. The content of IFE draws upon research carried out within the ArchaeoLandscapes project, where large numbers of historical aerial photographs were selected in archives, digitized, and georectified in a geographical information system.

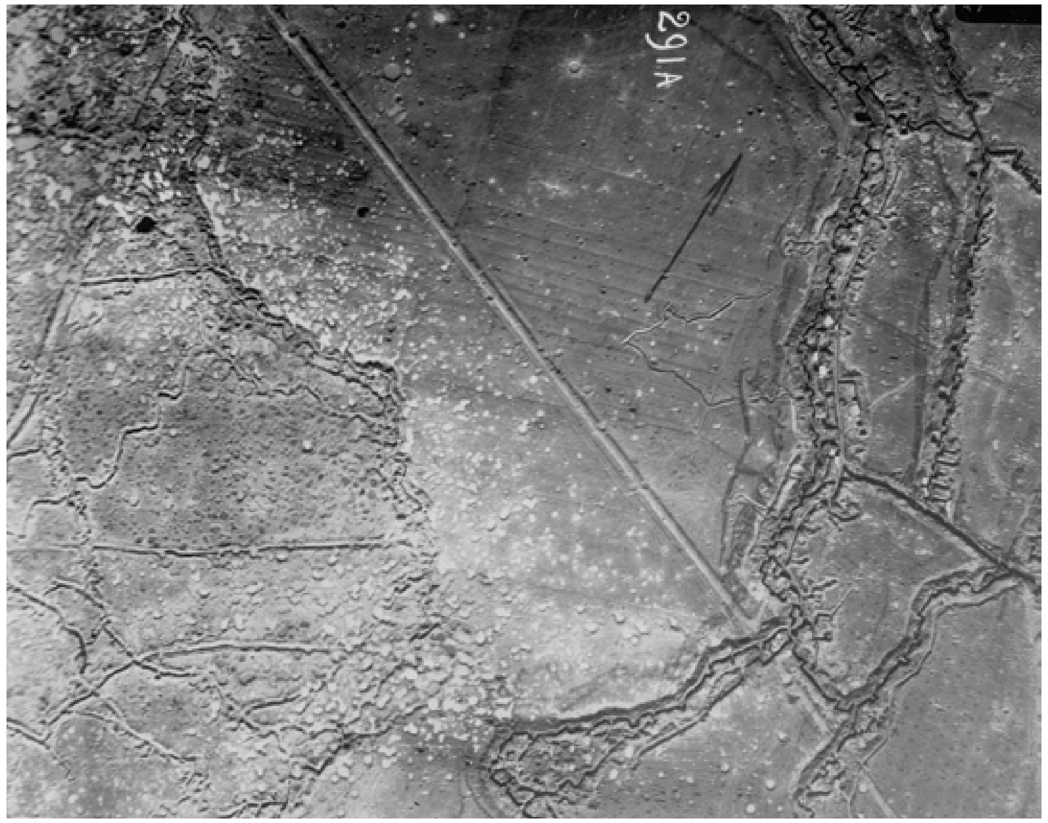


Fig. 1: Historical aerial photographs of the shell pocked battlefields of the First World War in the Ypres Salient (© In Flanders Fields Museum).

The interface is inspired by Google Earth™ and combines three layers of information **(Fig. 3).** An important layer is the present day aerial photo. A second layer of historical aerial photographs shows the war landscape on a regional scale. The third layer consists of hotspots, marked by large red icons, which are a selection of visually interesting case studies told by a sequence of aerial photographs and other historical documentation.

Visitors can navigate to the area they are interested in by clicking on the inset map, use the integrated address search engine or manually navigate on the present day aerial photo using multi-touch gestures. On the lower right hand side of the screen there are constantly updated thumbnails of aerial photographs that lie within the extent of the view. As soon as one clicks on a preview, the aerial photo is projected on the modern day aerial photo. One can zoom in and look at details of interest or can compare photographs of different dates. For a more in depth paper focusing on IFE see Stichelbaut & Chielens.

Fig. 2: Museum setup of the In Flanders Earth application (© In Flanders Fields Museum).

Mobile application

Within the framework of the ArchaeoLandscapes Europe project a mobile app is currently being developed. Visitors will explore the landscape in a number of walking routes guided by mobile devices featuring historical aerial photographs in combination with their position on the photograph. They will be able to walk on top of the trenches, see and experience how close the enemy frontlines were located to each other and be able to cross no man's land – all in a landscape where the vast majority of the visible surface expressions of the war have long-since been buried.

Fig. 3: Interface of In Flanders Earth (© In Flanders Fields Museum).

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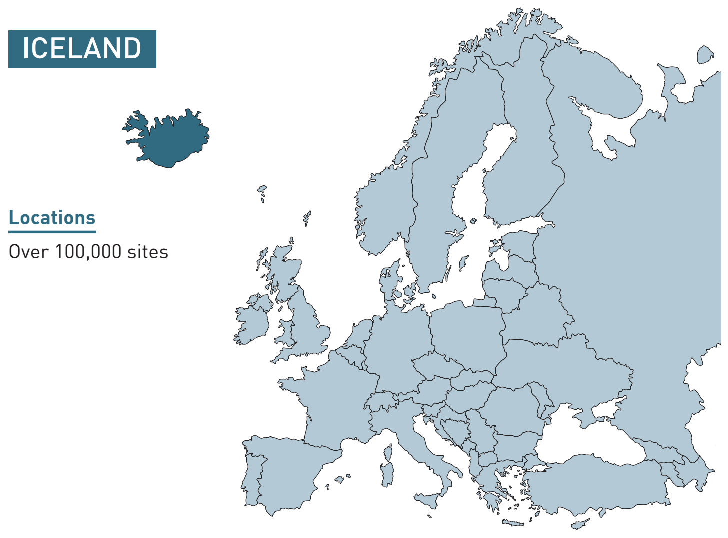
ÍSLEIF: Recording Iceland's heritage

Gísli Pálsson[1] / Adolf Friðriksson[1]
1. Institute of Archaeology, Iceland

Introduction

One of the main catalysts for the foundation of the Institute of Archaeology was a systematic discovery and survey of Iceland's heritage assets. At the time, in the mid-1990s, the number of heritage assets in the country was by no means clear. The state-compiled sites register (Friðlýstar fornminjar) included less than 500 sites, and continued instances of damage due to development and environmental change made clear the need for a comprehensive understanding of Iceland's historical landscape. Beginning in Eyjafjörður, in the north of Iceland, the Institute began a programme based on desk-based survey, aerial reconnaissance and finally detailed description of every location in the field.

The Institute has located ca. 100.000 sites so far, many of which were entirely unknown and undocumented beforehand.

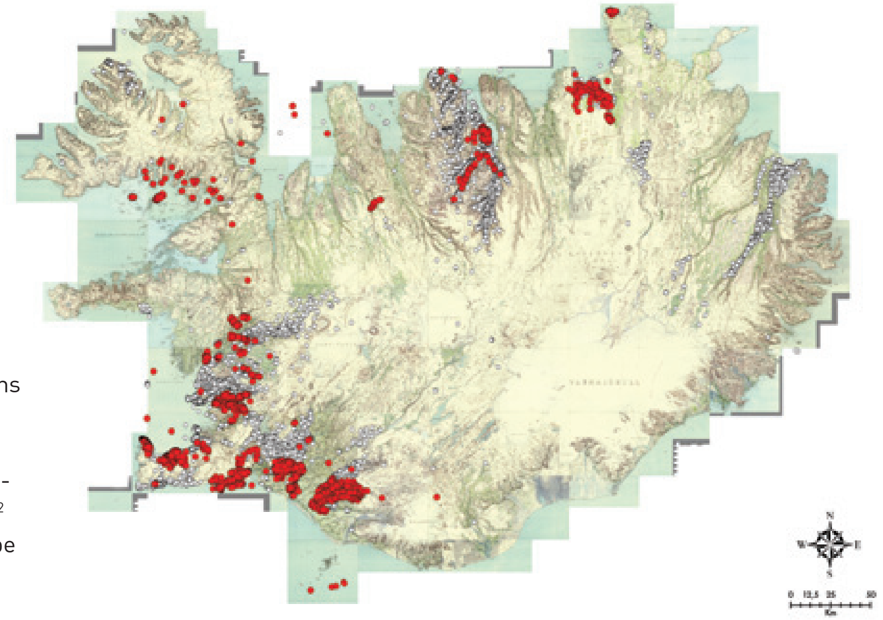


Orri Vésteinsson (Top) and Ágústa Edwald (Lower) record archaeological features for the Ísleif project.

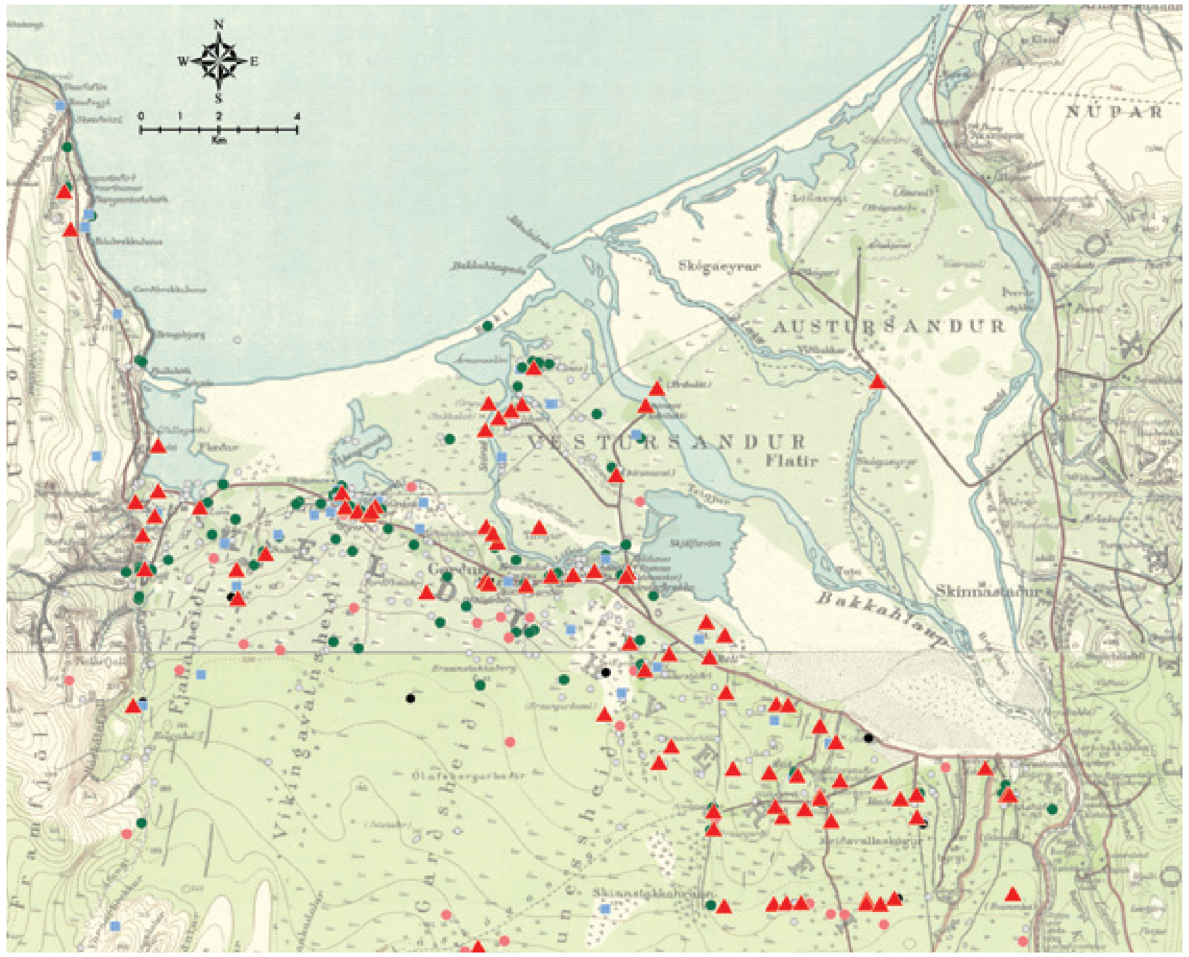
The ArcLand years

The number of known sites has increased substantially during the ArcLand project years. The database contained just over 86.000 sites in 2007 and has grown by 12.800 sites since. The increase has been influenced by the increased reliance on remote sensing methods, most notably in recent years by the use of UAV aerial photography.

The information collected has formed the foundations for a number of archaeological research and outreach projects. Of these the current major project is the on-going investigations of the long-term ecodynamic change in Mývatnssveitand Skaftártunga (Comparing Island Ecodynamics,[1] not to mention dozens of archaeological investigations conducted by the Institute.[2] The reports on the ISLEIF survey fieldwork can be downloaded at our website.[3] A pilot version of an online GIS where the survey and excavation data can be browsed and downloaded is underway and is available online.[4]



A map of Iceland showing recently discovered sites in red.



A detailed map of the recently surveyed Kelduhverfi with some major site types highlighted.

1: www.gheahome.org/cgi-bin/ghea_project.pl?project_id=6

2: www.instarch.is/verkefni.html

3: www.instarch.is/skyrslur.html

4: www.instarch.is/vefsja.html

Mapping Cretan heritage from the air: The challenge of mountainous landscape

Gianluca Cantoro[1]
1. GeoSat ReSeArch Lab - IMS-FORTH (Crete, Greece)

Introduction

Despite the long and consolidated tradition of studies and researches in aerial archaeology, the challenge of mountainous landscapes still seems to be under-explored. Special tools are often required together with, perhaps, a different way of capturing the area of interest. Targeted flights over Eastern Crete (Greece) showed the high potential of the bird-eye view, revealing at the same time the difficulties in accurate photo-location. This presentation shows some results of that particular campaign and the important contribution made by the free software AutoGR-Toolkit, developed at the GeoSat ReSeArch Lab, IMS-FORTH.

Challenging mountains

The island of Crete, the largest of the Greek islands and among the largest in the Mediterranean Sea, is a mountainous piece of land with an elongated shape. Also described as a "mountain emerging out of the sea" (Matton 1957, 13), its main mountain range (about 52% of the entire territory) crosses the island forming groups of peaks between 1500 and 2500 meters high. Despite the apparent inhospitality of this place (Buxton 1992, 10), it is still one of the most populated islands in the Mediterranean and in earlier times it was the centre of the Minoan civilization. This prosperous Bronze Age civilization constitutes an essential benchmark in Cretan (pre)history; until recently, one could say that "relatively little change has occurred in agricultural economy [...] since Minoan times" (Allbaugh 1953, 242).

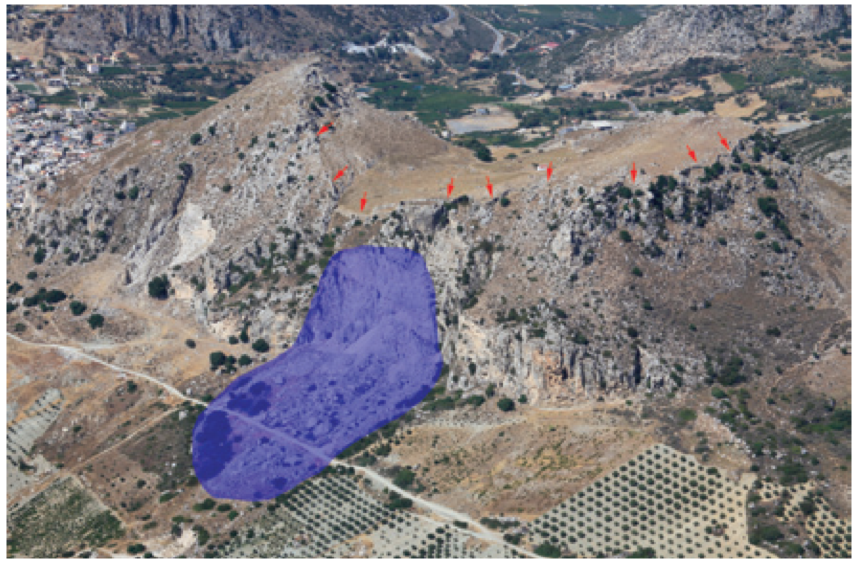


Fig. 1: Profitis Ilias, Temenos – Heraklion, Crete (Grece). Defensive walls of the Byzantine Castle built by Nikiforou Foka in 961 AD. In red the profile of the hardly accessible walls endangered by the collapse, highlighted in blue. (Ph. Gianluca Cantoro).

Although a good percentage of the remote uplands still maintain a traditional (perhaps ancestral) way of farming and habitation, some other regions have undergone major large-scale changes and landscape modifications. These are the locations where the mapping of traces of the past is not only a challenge, but also the last chance to document ancient human-landscape interactions (Chalikias and Cantoro 2014). When these interactions occur in inaccessible or hardly accessible areas **(Fig. 1)**, the mapping of cultural heritage with ground survey may be time consuming (Verhoeven et al. 2013, 34), and sometimes unsuccessful. Undeniably beneficial is the approach from the air, where professional digital cameras may be directed to specific difficult contexts during systematic or targeted survey flights.

In addition, historical imagery can provide unique and precious information for the understanding of past landscapes. In order for all this data to be exploited for the comprehension and mapping of the historical palimpsest, all the photographs (obliques and verticals) need to be orthographically projected (or converted into a map), with a consistent scale and nearly no distortion. It is often impossible to transform a still picture to fit a control map well, so that tall things (like buildings, trees or hills that are not directly under the camera) are not displaced or leaning.

And if this is a problem when dealing with almost flat fields, this becomes even more complex in mountainous rocky landscapes, since the more the field is corrugated, sloping or with tall features (far from being a rare case in aerial archaeology), the more ground control points are needed. And if the images to be georeferenced are in their hundreds or thousands, as is the case when using UAV platforms for photogrammetric documentation (Remondino et al. 2011), an automated system may provide undeniable benefits in terms of speed and accuracy (Cantoro and Sarris 2012). AutoGR-Toolkit **(Fig. 2)** *(http://www.ims.forth.gr/autogr)* (Cantoro 2012). Free software, developed at the GeoSat ReSeArch Lab - IMS-FORTH under the framework of ArchaeoLandscapes Europe, aims at helping amateurs and professionals dealing with large quantities of photographs or requiring high standards of accuracy in georeferencing, to reach their goal in no time.

A practical application of this software, using the thousands of photographs collected in the first extensive aerial archaeological survey in Crete- Greece *(http://photogrammetry.ims.forth.gr/AerialRemoteSensing.php?proj=Crete)*, allowed us to identify numerous new sites and photogrammetrically document known ones with great accuracy. The footprint of each photograph –enriched with archaeological photointerpretation– is being integrated and implemented in a WEB accessible geodatabase built at the hosting institution **(Fig. 3)**.

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Fig. 2: Screenshots of the main tools inside the free software AutoGR-Toolkit: Main menu **(Top left)**, GGrab **(Lower left)**, AutoGR-SIFT **(Top right)** and Photogrammetry-GetZ **(Lower right)**.

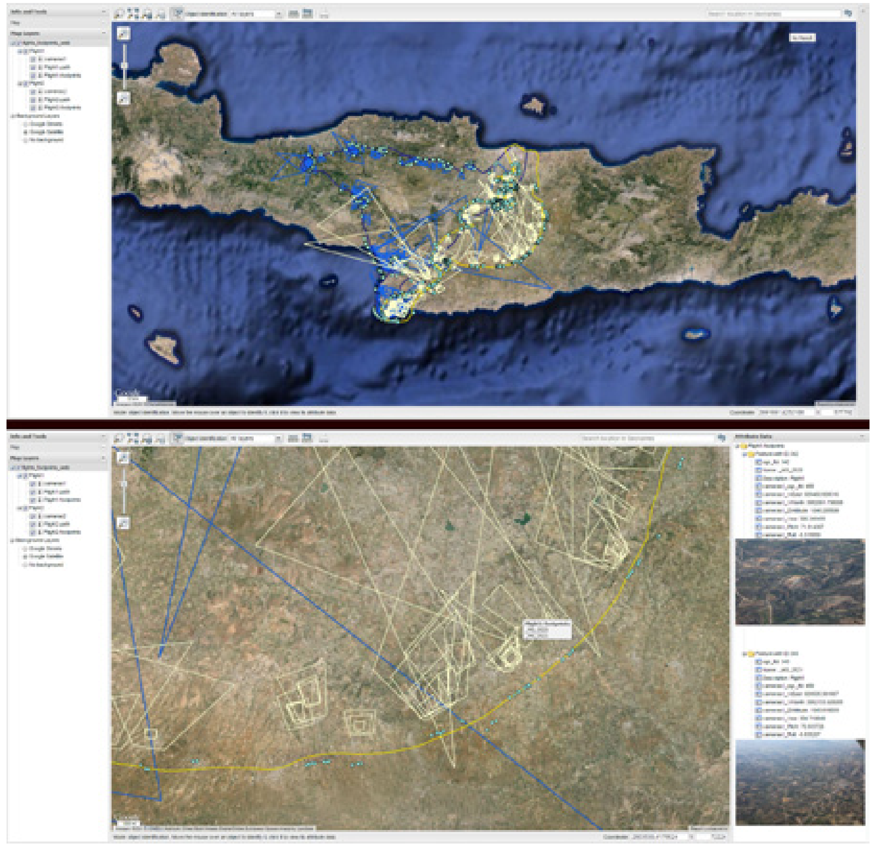

Fig. 3: Two previews of the working platform for the creation of the WebGIS. In the top screenshot, two flights –with their paths, photo stations and footprints– are presented on a Google Earth background. In the lower, image selection with photo-info-panel (including camera pitch) and preview.

The Blackstairs Mountains: South-East Ireland: Investigating the archaeological potential of the Irish uplands

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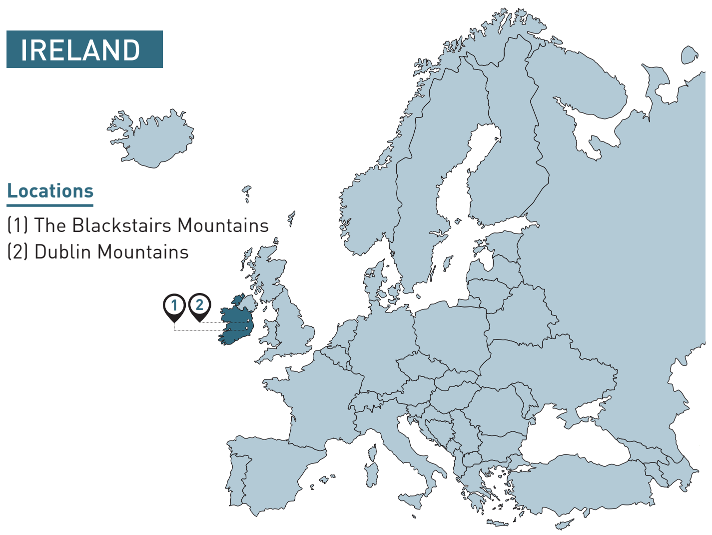
1. UCD School of Archaeology

Introduction

The Blackstairs form a chain of high ground in South East Ireland covering parts of counties Carlow, Wexford and Kilkenny. These uplands are not only visible at ground level because of their dramatic rise from the low-lying Barrow Valley, but also from above due to land management in recent decades which has been one of abandonment, rough grazing and forestry planting.



There had previously been no archaeological investigation into these uplands beyond basic recording. A history of burning episodes on the mountains, both controlled and accidental, has sometimes stripped the peat down to the bare bedrock. Such an event occurred in 2010 when burning over 2km^2 revealed many previously unidentified features including hut sites, cairns and pre-bog field walls. 70 new sites were recorded here through fieldwalking where only 16 had been recorded previously **(Fig. 1)**. Was this an isolated occurrence or could it be replicated across the entire mountain range?

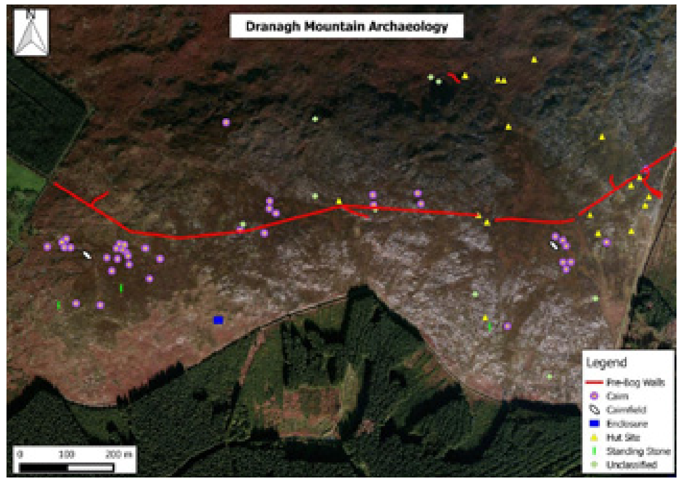


Fig. 1: The results of a fieldwalking survey on Dranagh Mtn. following a fire incident.

Methodology

To investigate the entire mountain range, a more rapid survey approach was needed. Historic aerial photographs and modern remote sensing techniques were unavailable and focus switched to open source imagery such as Bing and Google Earth. Bing imagery, in particular, proved to be an invaluable source revealing most of the newly identified sites. Desk-based analysis was followed up by 100% ground truthing, kite aerial photography and fieldwalking in targeted areas **(Fig. 2)**. Ground truthing highlighted the importance of follow up confirmation, especially in upland landscapes. Some of the mapped features were revealed to be modern or natural, which most often occurred at rock outcrops or in extremely dense heather. The imagery was not detailed enough to pick up smaller features, especially cairns, which were later recorded through fieldwalking. The work was supported by local engagement and a citizen science programme both of which enhanced the understanding of what has been found.

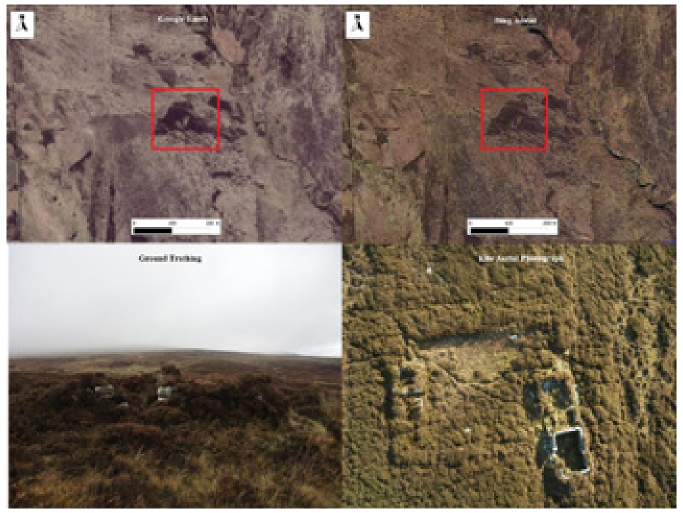


Fig. 2: The sources used to investigate the landscape centred on the remains of a cottiers house (c. early 19th C) on Knockroe Mtn. Co. Carlow.

Summary of results

The Blackstairs work has revealed 172 new sites (112 Bing, 10 Google Earth, 50 Fieldwalking) in the upland zone (200mOD+) where only 38 had been previously recorded **(Fig. 3)**. These included hut sites, enclosures, sheepfolds, trackways, field systems, cultivation ridges, cairns, house structures and turf cutting remains **(Fig. 4)**.

Local groups further assisted in the interpretation and modern understanding of many features. Uplands can be considered as unspoiled by humans and are designated as a Special Area of Conservation despite a poor understanding of the archaeological remains. Intensive survey has shown that this landscape was settled, moved through, farmed and exploited from prehistory to the modern period. Most significantly desk-based research, local engagement and fieldwork combined has demonstrated how the Great Irish Famine (1845-60), which is traditionally seen to have had little effect in the south-east, had a major negative impact on the population, settlement pattern and land-use of this region.

Fig. 4: Examples of some of the archaeological features in the Blackstairs Mtns.

Future research

This project adds to the slowly increasing number of projects targeting Irish uplands and recognising their research potential. A case study using LiDAR and multispectral satellite imagery on known features in a similar landscape, the Dublin Mountains, revealed little more than was visible in open source imagery or fieldwalking due to the dense vegetation cover **(Fig. 5)**. Future research would include targeted environmental analysis to gain a better understanding of the timing of its onset and the historical vegetation cover. Excavations may provide a tighter chronology especially for features which could date to any period (e.g. hut sites). Periodical burning episodes will be monitored into the future and exploited in order to capture as much information as possible before regrowth. In the meantime, fieldwalking and open source imagery offer a valuable and cost-effective survey method in order to gain a rapid assessment of the archaeological character of these landscapes.

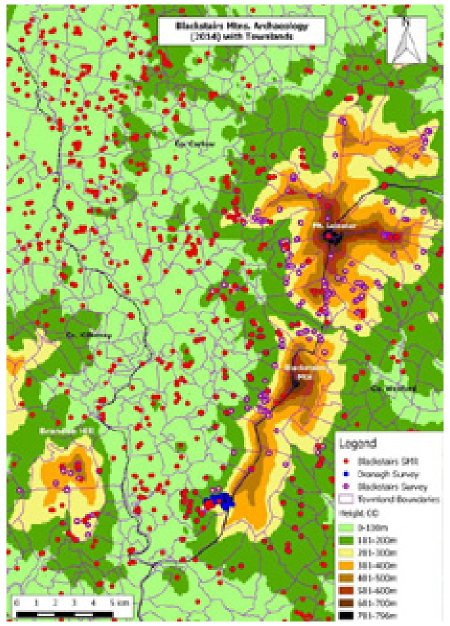


Fig. 3: Distribution of archaeological features in the Blackstairs following intensive investigation. The large gaps still present in the uplands are due to forestry plantations.

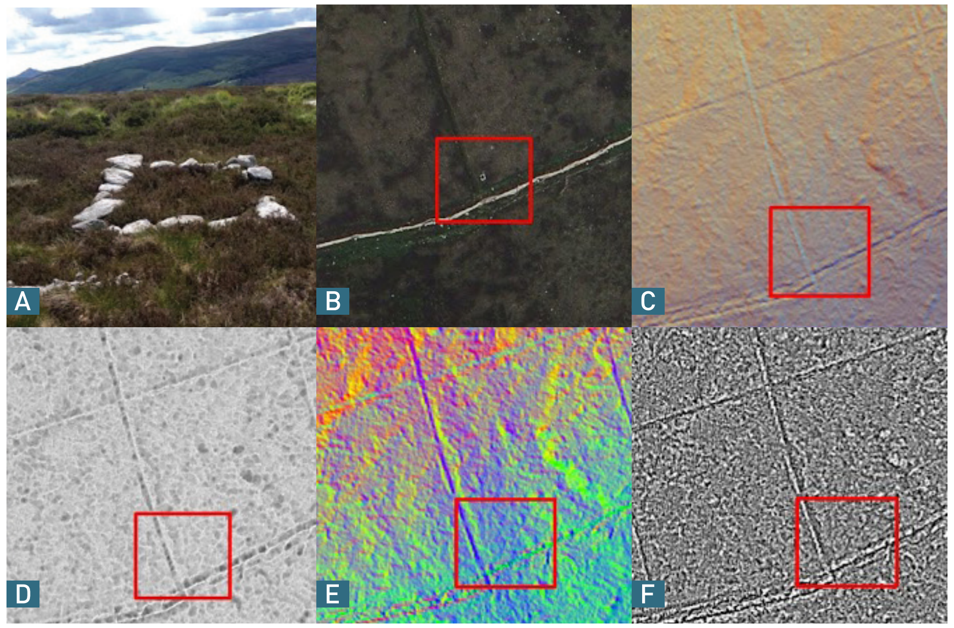


Fig. 5: Some Comparative LiDAR Visualisations: A. Hut Site, Kilmashogue Mtn., Dublin; B. Bing Aerial Image; C. Multi-Directional Hillshade; D. Openness (Negative); E. Principal Components Analysis (RGB); F. Simple Local Relief Model. LiDAR provided by DLRCC. Produced using Relief Visualisation Toolbox (RVT) (Zakšek, K., Oštir, K., Kokalj, Ž. 2011 "Sky-View Factor as a Relief Visualization Technique". Remote Sensing 3, 398-415; Kokalj, Ž., Zakšek, K., Oštir, K. 2011 "Application of Sky-View Factor for the Visualization of Historic Landscape Features in LiDAR-Derived Relief Models". Antiquity 85, 327, 263-273).

The changing Romanian landscape: The importance of archival imagery

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1. University of Glasgow / 2. University of Exeter

Introduction

Archives of historical vertical aerial and satellite photography exist around the world. The images they contain were taken for a variety of purposes, but often originate in military reconnaissance. Such archives offer huge, but largely untapped, potential to advance our understanding of past archaeological landscapes.

The photographs have a number of particular advantages over more recent aerial and satellite imagery. First and foremost, they provide a unique insight into the character of the landscape across large parts of Europe as it was some seventy or more years ago before the destructive impact of later twentieth century development, whether from the increasing mechanisation of agriculture, intensive industrialisation or urban expansion. Thus, they facilitate the recognition of archaeological features that have since been erased or severely damaged. Secondly, the character of the photographs, usually consisting of overlapping runs of vertical images, provides more systematic block coverage than traditional archaeological, observer-directed aerial reconnaissance. This encourages a more landscape-focused approach, which better enables the identification of more ephemeral remains, such as roads, trackways, field systems and cultivation traces. In addition, because of the stereographic nature of much of the coverage, the photographs can be more than a two dimensional medium.

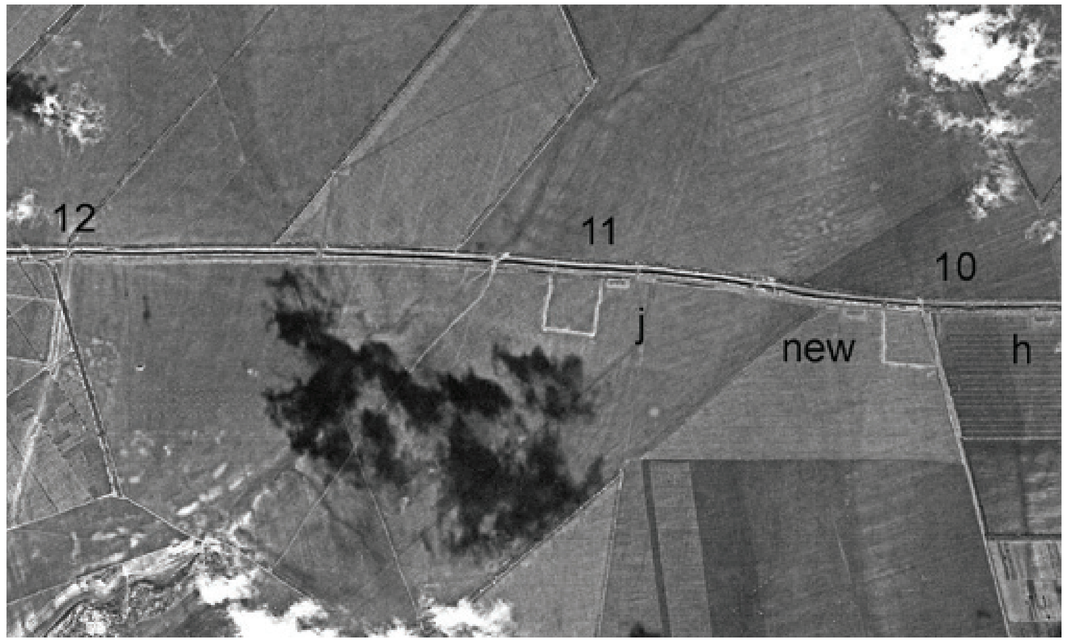

Fig. 1: Corona image from 1966 showing forts and fortlets at the eastern end of the Large Earthen Wall (US Geological Survey).

Though most countries possess their own national archives, the largest and most well-known international archives are the National Collection of Aerial Photography (NCAP) in Edinburgh, the Imperial War Museum in London, the National Archives and Records Administration (NARA) in Maryland, and the declassified intelligence satellite photographs held by the United States Geological Survey. Between them these archives hold tens of millions of vertical photographs of Europe from the First World War onwards. One of the main problems in utilising this archival photography, however, is its accessibility, which varies considerably, not just between but even within archives. Thus the US declassified satellite photography is readily accessible and can be searched online. By way of contrast, however, of the four main Second World War collections held by NCAP, only the Allied Central Interpretation Unit material covering western Europe currently has an on-line catalogue, while there are currently no readily accessible geographical finding aids for the other three collections.

Fortunately, a high proportion of the historical aerial photographs held by NARA is geographically indexed, but the finding aids are not available on-line. Two case studies from Dobrogea in eastern Romania highlight the potential of this photography. The Valu lui Traian is a multi-phase linear rampart and ditch system, with associated fortifications, whose character and date are poorly understood. Archival aerial photography (from both World Wars) and CORONA satellite imagery, in conjunction with modern observer-directed oblique reconnaissance and Romanian mapping ortho-photographs, has facilitated a re-assessment and re-mapping of the fortifications. This has clarified their distinctive characteristics, demonstrated their complex history of development and supported their interpretation as predominantly Roman in construction, analogous with frontier barriers in Britain and Germany.

The same photographic sources, with the exception of imagery from World War I, have also enabled the mapping of some 8700 burial tumuli. This has in turn facilitated the analysis of patterns of clustering of the barrows, hinting at the presence of a number of previously unsuspected settlement foci of Hellenistic and Roman date.

Fig. 2: Corona image from 1966 showing cemeteries of tumuli around the ancient town of Callatis (Mangalia) (US Geological Survey).

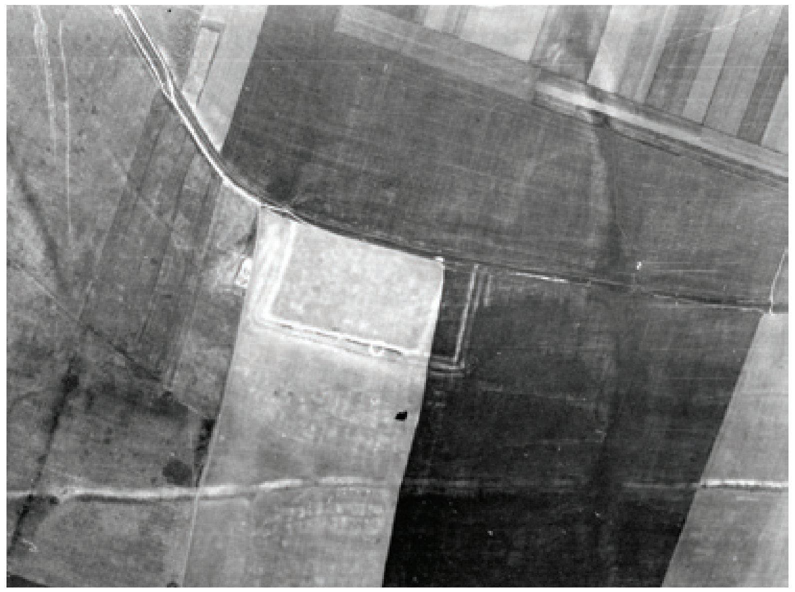

Fig. 3: MAPRW photograph from 1944 showing a large fort on the Stone Wall at Cumpana (Licensor NCAP/aerial.rcahms.gov.uk).

Fig. 4: Luftwaffe photograph from 1940 showing cluster of tumuli at Fantana Mare (Licensor NCAP/aerial.rcahms.gov.uk).

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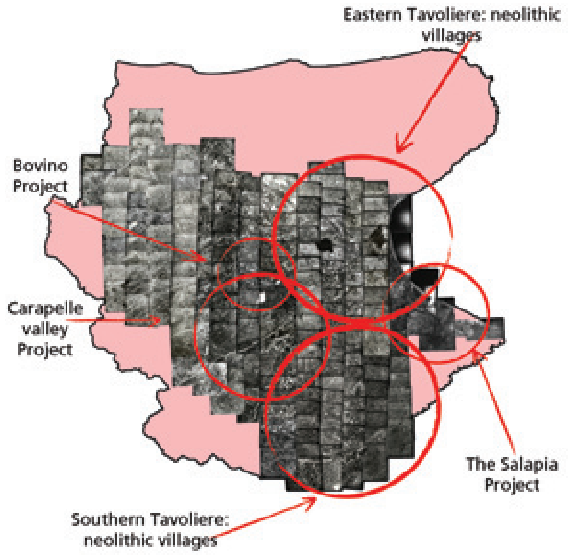
University of Foggia integrated archaeological research in Northern Apulia

Volpe Giuliano[1] / Goffredo Roberto[1] / Romano Angelo Valentino[1] / Galano Marianna[1] / Maulucci Paolo[1] / Volpe Valeria[1]
1. University of Foggia

Introduction

The University of Foggia équipe has carried out an integrated programme of archaeological research in northern Apulia concerning not only the flat area of the so called 'Tavoliere delle Puglie', but also the coastal Adriatic area and the inland mountains.



Map showing the main research areas in northern Apulia.

A wide programme of aerial archaeological research has been carried out over the last twelve years for the whole province of Foggia. Other field activities run in these years have contributed to the aim of a total approach to the archaeological heritage. Intensive field survey, geophysical prospections, archaeological excavation, archaeo-zoological and archaeo-botanic researches have been conducted in various focus areas and sites (Carapelle and Cervaro valleys, the Roman town of Salapia). Other intense activities have been carried forward on the huge archive of oblique aerial photos of the Department of Humanistic Studies and on the various coverage of vertical air photos (both historical and recent).

Salapia project: geophysical prospections and the first excavation campaign.

Locations

(1) Province of Foggia, northern Apulia
(2) Carapelle Valley (Ascoli Satriano, Foggia)
(3) Roman city of Salapia (Cerignola, Foggia)
(4) Bovino (Foggia)

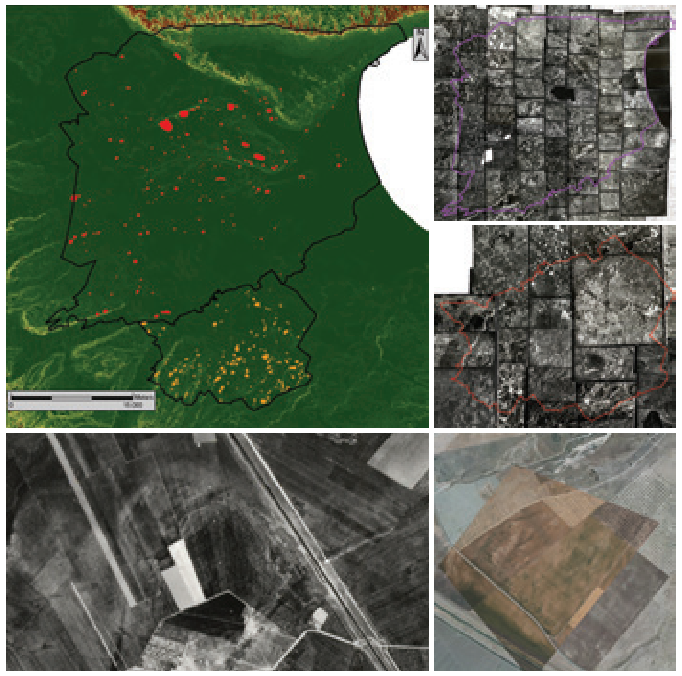
Research in the Roman town of Salapia

The Archaeological Team of the University of Foggia (directed by Dr. Roberto Goffredo), in collaboration with the Davidson College – N. C. – USA (directed by dr. Darian M. Totten), has launched a research project in the area of the ancient Lake of Salpi, which corresponds to the Saline basin of Margherita di Savoia along the Adriatic coast. The project aims to locate and study the Roman town of Salapia, partially covered by the medieval settlement of Salpi, and its port.

Two campaigns of systematic, intensive excavation and geophysical prospections have so far been conducted, in 2013 and 2014, covering 16 continuous hectares up to the edge of the lake itself. Structures of an imperial and late antique domus and evidence of a craft area, maybe a tannery, have been found during the intensive field survey and geophysical prospections on the hilltop and the coastal plain surrounding it.

Aerial archaeology in the Tavoliere delle Puglie

An intensive programme of aerial survey and analysis of aerial photos has been conducted in recent years in northern Apulia by the University of Foggia, involving many degree, MA and PhD students. The work on the huge AP archive, set up in the last twelve years, involved not only making a catalogue, but also the analysis, orthorectification and mapping of thousands of APs both oblique and vertical.

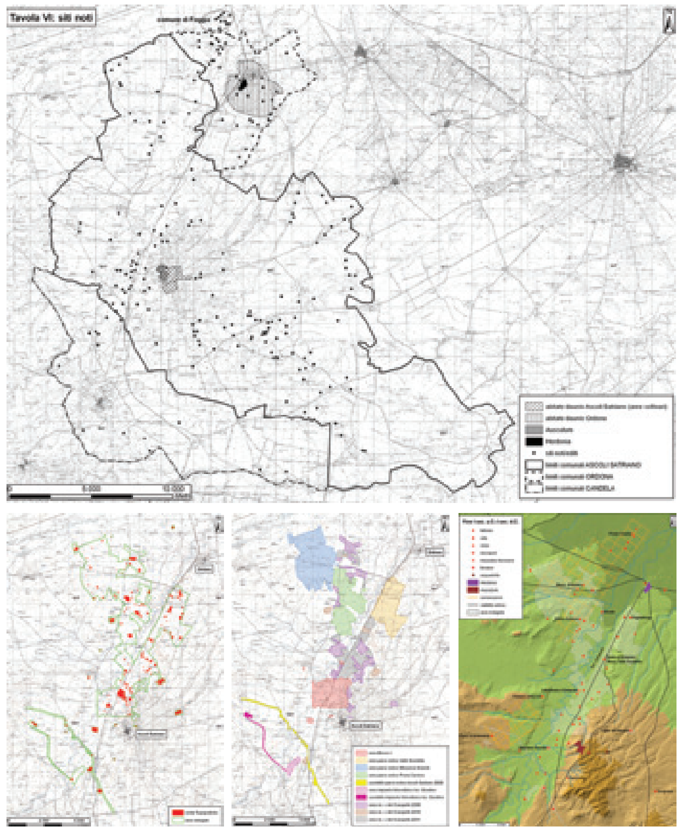


Aerial photo analysis in Central and Eastern Tavoliere: newly discovered Neolithic settlements.

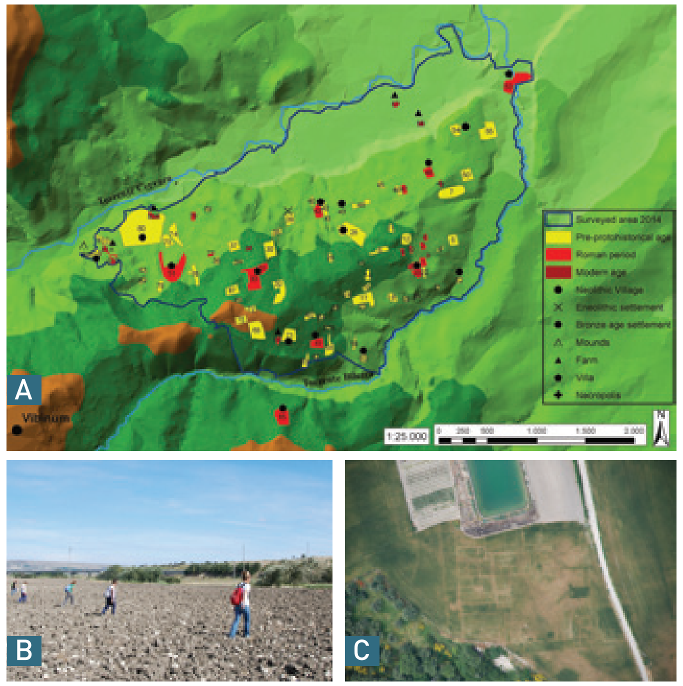
Areas of focus have been the Central and Eastern Tavoliere: hundreds of anomalies, expecially related to Neolithic villages, have been interpreted and mapped. The analysis focused on different kinds of aerial photographs: historical vertical photographs (by the Italian Military Geographic Institute between 1954 and 1955), recent oblique photographs from the archive of the Laboratory of Landscape Archaeology and ortho-photos taken in different years. More than 300 previously unknown Neolithic sites have been discovered in this area which was already very well known thanks to the research of Bradford, Jones, Schmiedt, and Brown.

Field activities in the Carapelle and Cervaro valleys

Two Landscape Archaeology projects have been carried out in two different zones, the Carapelle valley and the Cervaro valley, in order to enrich the historical knowledge of the Tavoliere and the Subappennino areas. Both represent extraordinary stratified, palimpsestic and multiphase fossil landscape systems. The Carapelle Valley project was led under the direction of dr. R. Goffredo between 2006 and 2011, linked to the excavation of the villa of Faragola, and supported by the ArcLand project during the 2010-2011 campaigns. The Cervaro valley project started in the autumn of 2014, under the direction of dr. A. V. Romano, with the first intensive field survey. This will be followed by the enlargement of the sample survey area and by the excavation of the villa of Casalene. In both cases the field surveys are part of wider projects that also involve the analysis and interpretation of aerial photographs, geophysical prospection and the study of historical, epigraphical and archaeological sources.



The Carapelle Valley - study of the published sites and field surveys.



(A) 8,5 km^2 area that has been surveyed during the 30-days field survey, with its 85 archaeological areas and the main sites.
(B) The archaeological *équipe* during the field-walking.
(C) The oblique aero-photograph of the Roman - late Roman *villa* of Casale (Bovino) (picture taken by A.V. Romano).

AIRBORNE LASER SCANNING AND VISIBILITY ANALYSES: SOME REMARKS ON THE USE OF ALS IN ARCHAEOLOGICAL INTERPRETATION / ALS FOR ARCHAEOLOGY: PARALLEL AND CONVERGING DEVELOPMENTS IN EUROPE AND THE AMERICAS / AN IRON AGE LANDSCAPE IN SOUTH-HUNGARY: NEW METHODS WITH NEW RESULTS / CHANGING PAST LANDSCAPES: NEW DATA, NEW DILEMMA, MORE DOUBTS DOCUMENTING PAST CULTURAL LANDSCAPES: A 3D APPROACH / EXPLORING THE PAST ROMANIAN LANDSCAPE: THE APPLICATION OF SATELLITE AND LIDAR IMAGERY / FROM POINT CLOUDS TO ARCHAEOLOGICAL EVIDENCE: IMPROVING VISUALIZATION AND SPATIAL ANALYSIS OF 3D DATA / FROM RESEARCH TO EDUCATION: UTILIZATION OF ARCLAND EXPERTISE IN HUNGARY/ HISTORICAL LANDSCAPE THROUGH THE LENSES OF LIDAR AND PHOTOGRAMMETRY: LATE ANTIQUE SITES IN SERBIA / INTEGRATING A TRADITIONAL METHOD AND A MODERN TECHNIQUE OF ARCHAEOLOGICAL REMOTE SENSING: THE VALUE OF COMPLEMENTARITY / LARGE AREA ARCHAEOLOGICAL MAPPING AND PROSPECTION USING MULTIPLE LIDAR VISUALISATION TECHNIQUES: CHALLENGES, RESULTS AND IMPLICATIONS FOR ARCHAEOLOGICAL RESEARCH AND HERITAGE MANAGEMENT / LIDAR AND GEOPHYSICAL SURVEY AT THE TLACHTGA, CO. MEATH, IRELAND: A LATE IRON AGE RITUAL ENCLOSURE / PAST LANDSCAPES AND CONTEMPORARY CULTURAL IDENTITIES. SOCIAL ROLE OF NON-INVASIVE ARCHAEOLOGICAL METHODS / REMOTELY SENSED PAST: A STUDY OF MULTI-TEMPORAL HISTORIC AERIAL PHOTOS AND ALS-GENERATED DEMS IN RETROSPECTIVE MONITORING / REMOTE SENSING ARCHAEOLOGY ON THE OUTSKIRTS OF EUROPE / SCOURING THE SURFACE AND PEERING BENEATH IT AT THE ANCIENT CITY OF HYETTOS, BOEOTIA, GREECE / SENSING THE MATERIAL REMAINS OF THE FORGOTTEN GREAT WAR IN POLAND. SENSIBLY OR SENSATIONALLY - THE DILEMMA IN FRONT OF PRESENTING RESULTS OF THE AIRBORNE LASER SCANNING VISUALISATIONS / THE POTENTIAL OF LIDAR VISUALISATIONS FOR THE IDENTIFICATION OF ARCHAEOLOGICAL FEATURES IN THE PRIGNITZ / VISUALIZATION OF LIDAR RASTER DEMS: GUIDELINES AND TOOLS

Contributions on:

LiDAR AND SATELLITE REMOTE SENSING

Airborne Laser Scanning and visibility analyses: Some remarks on the use of ALS in archaeological interpretation

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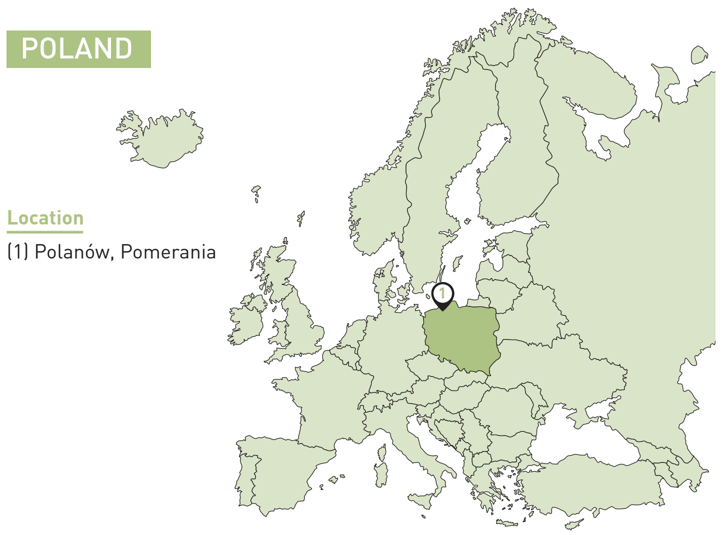
Introduction

Viewshed analysis is one of many beneficiaries of the application of Airborne Laser Scanning in archaeology. High quality data allows calculation of the visibility of a single object (Fig 1). At the same time, interpretation of ALS derivatives shows some limitations of such an analysis. The aim of this poster is to present a significant aspect of landscape dynamics, which alters the results of viewshed calculations. It was identified during the research conducted in the vicinities of Polanów.



Amongst many others, one criticism concerning visibility analysis in archaeology relates to palaeoenvironmental issues[1]. In Pomerania the land surface was shaped mainly due to the presence of an ice sheet. However, after the last glaciation further geomorphological changes occurred (e.g. the valley network was formed, peat bogs came into being and a fluctuation of lake water levels took place). Moreover, with the arrival of the first groups of hunter-gatherers, a lasting human impact on the land had begun. The process can be divided into three main groups: (a) progressive deforestation that increased the erosive action of flowing waters, leading to the filling of valleys with transported material; (b) exploitation of natural sources that left deep scars on the surface; (c) the introduction into the landscape of human made features – e.g. megaliths, strongholds, levees, railway embankments etc[2]. Although it has to be acknowledged that the contemporary topography differs from the past one, the identification of these differences can be difficult, especially at a local scale[3].

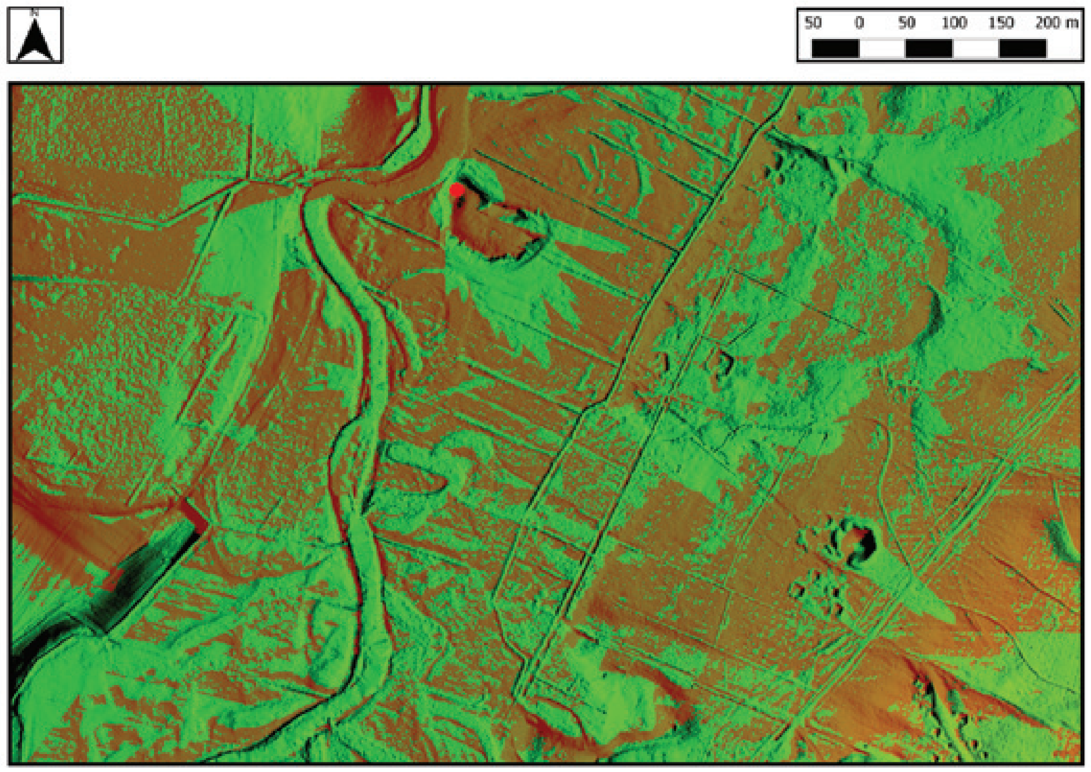


Fig. 1: High quality data allows the calculation of the visibility of a single object.

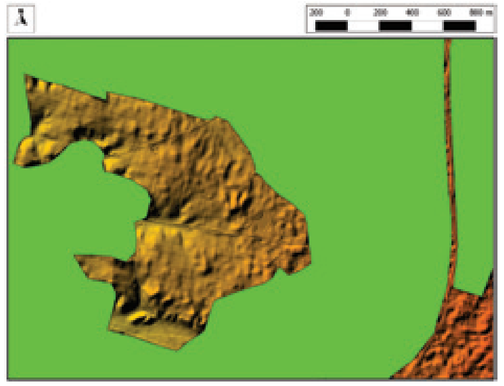


Fig. 2: Extent of forest cover (green) agaist a background of DEM.

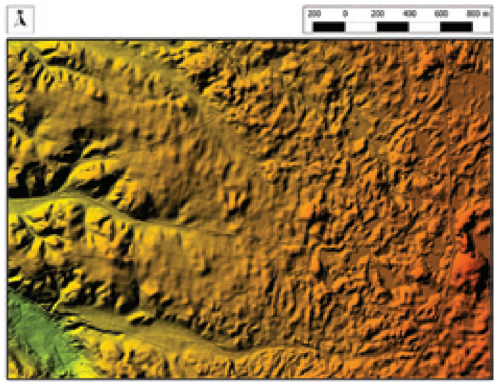


Fig. 3: Texture differences due to variability in land use.

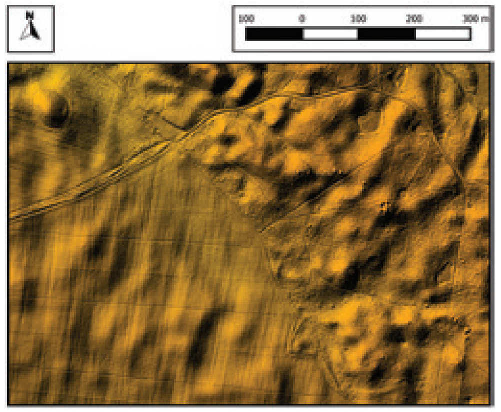


Fig. 4: At the top of preserved, and forested hills one can easily identify barrows.

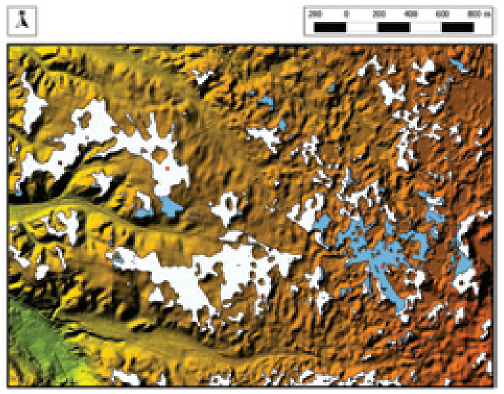


Fig. 5: Results of two viewshed analyses. More open vista in cultivated areas is a consequence of destruction of hillocks (due to continuous ploughing).

Texture

Whilst interpreting ALS data archaeologists deal with different textures[4]. This aspect of a landscape results from various reasons (cultural, procedural and natural). Although differences between textures at a large scale can be easily recognised (due to regional diversification), some differences can even be identified locally. This is clearly visible in the case of Polanów, where the surface of a deforested area **(Fig. 2)** is smoother than the rest of the moraine **(Fig. 3)**.

Landscape change and visibility in a young postglacial area

In this case agricultural works have led to the probable erasure of the relatively small archaeological features (mainly barrows) which are still preserved and often clearly visible at the top of nearby forested hills **(Fig. 4)**. Continuous ploughing has also caused the removal of the hills themselves. As a result, one of the most characteristic glacial landforms (hillocks on the top of a moraine), that has accompanied humans dwelling in this region through the ages, has been levelled. A map showing the permanence of land-use[5] shows that this part of the area has not been used for agricultural purposes since at least the 16th century. Thus long-term ploughing leads not only to the destruction of archaeological heritage, but also to a modification of an extensive aspect of landscape.

Since levelled parts of the moraine are currently more 'open', the results of a visibility analysis are significantly altered **(Fig. 5)**. In contrast to a limited, detached view of isolated upper parts of the hillocks (separated by invisible hollows between them), which is characteristic of the forested areas, the vista in arable areas is broader. Thus constant cultivation has a crucial impact on the landscape, not only in the sense of an increase in the erosive action of flowing waters, but also through the effect on the interpretative potential of visibility analysis.

The acquired results are not limited to the presented case study, but can be applied to a larger, postglacial context. In a sense, the presence of vegetation, which usually constitutes a problem for viewshed analysis, turned out to be advantageous, as the landforms located in 'permanent' forest are better preserved. Moreover, the application of ALS is not limited to the prospection of 'essential' archaeological features. It may also be used for the identification of significant aspects of landscape which affect the interpretation.

Funding

The research project Ancestors' forests. Non-invasive prospection of past landscapes in the vicinities of Polanów is financed by the National Science Centre (decision no DEC-2012/07/N/HS3/00825). The acquisition of ALS data was financed by ArchaeoLandscapes Europe.

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ALS for archaeology: Parallel and converging developments in Europe and the Americas

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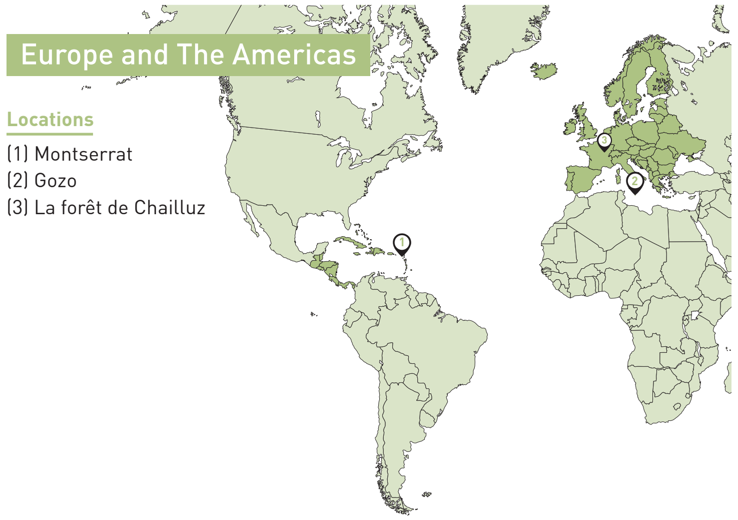
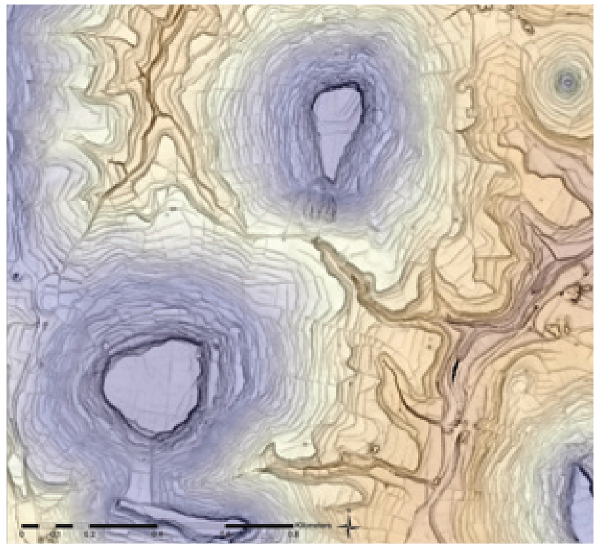
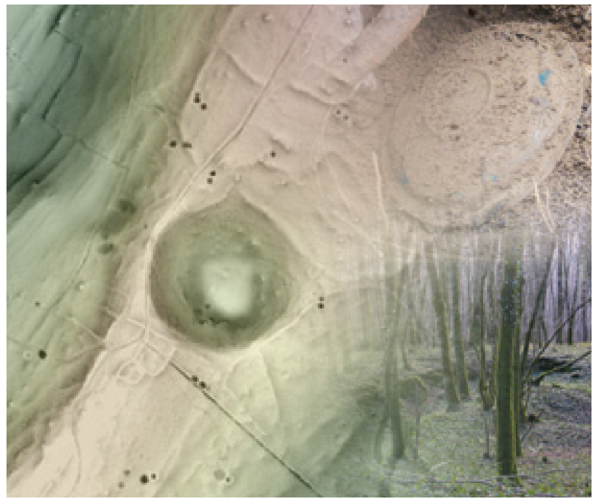
Introduction

What is so revolutionary and wonderful about recording the shape and place of things? The ability to record these fundamental archaeological data has been around since the beginning of the discipline. Gordon Willey stated that the objectives of archaeology are "approached by the study and manipulation of three basic factors: form, space and time" (Willey 1953).





Agricultural terraces on Gozo, visualized using an ALS terrain model. (Image/Data Credit: Malone – FRAGSUS ERC, RDF LiDAR data, 2012, ERDF156 Developing National Environmental Monitoring Infrastructure and Capacity, Malta Environment and Planning Authority).



Fields, enclosures, habitats, limekilns, and charcoal burning platforms in the Chailluz Forest. A bronze Roman plate was found during prospection in this area. (Image/Data Credit: Opitz and Nuninger - LIEPPEC).

Topographic survey has long been an essential tool for recording shape and place, and the adoption of Airborne Laser Scanning Survey (ALS), a method to collect high precision and high density topographic data rapidly over large areas, into archaeology represents not merely an improvement on our former methods but a fundamental shift in how we create and engage with the archaeological record.

The application of ALS in archaeology is developing in both the European and American context, and the regionally-distinct and shared challenges prompt us to revisit basic issues of archaeological ALS and topographic survey.

ALS in the European context

In the European context, ALS has seen broad application in both research and management over the past 10+ years, with its greatest impact in forested areas, where other forms of archaeological prospection are generally not successful. Projects include those in SouthWest Germany (Hesse 2013), Eastern France (Fruchart 2014), Lorraine, France (Georges-Leroy et al. 2012), NorthWest Spain (Fernández-Lozano 2014) and Italy (Coluzzi et al. 2010). The opening of these wooded and scrub landscapes to archaeological study provides important research opportunities, exposing a set of activities previously not readily or well-studied (archaeology of the woodlands) and creating opportunities for fine grained studies of impacts of past anthropogenic activities on woodland vegetation communities. Persistent effects of human alterations of soils and terrain morphology are emerging, with implications for contemporary landscape management and soils.

In parallel, ALS has become an increasingly standard part of desktop assessment in the UK, the Netherlands, and elsewhere in heritage management. This integration into the standard management toolkit is essential for its widespread adoption.

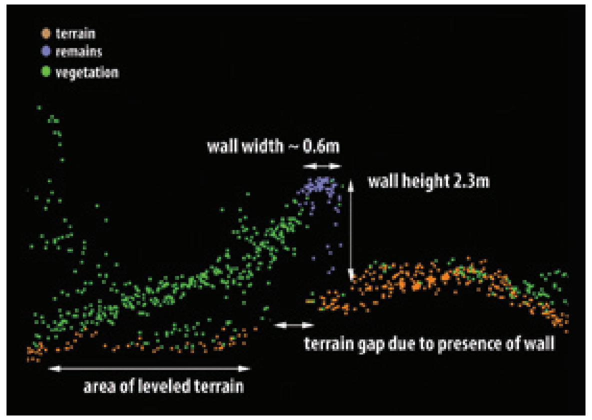
Fieldwork in Montserrat **(left)** and Chailluz **(right)**. (Image Credits: Cherry & Ryzewski –SLAM Project and Daval – LIEPPEC).

ALS in an Americas context

While ALS data applications in Europe primarily have impacted rural studies and heritage management, in the Americas they are altering and promoting research on diffuse urbanism, notably in tropical and sub-tropical regions, with dramatic effect (e.g. Chase et al. 2012). Landmark studies, including those in the Mosquitia region of Honduras (Fernandez-Diaz et al. 2014) and Caracol (Chase and Chase 2011), are illuminating a form of urbanism that is a far cry from the compact form often imagined when we think 'city'.

In the Americas, ALS is also driving projects toward a holistic landscape approach, notably for colonial and post-colonial archaeologies in places like Montserrat (Opitz et al., in press) and New England (Johnson and Ouimet 2014).

In a heritage management context, practice in the Americas varies widely, with most uptake seen in the USA and Canada. Methodological advances and best practices developed in Europe are being adapted, providing an opportunity for trans-Atlantic exchange.

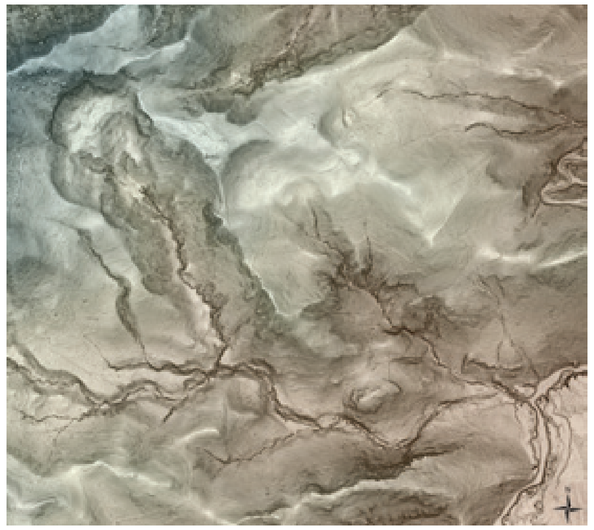


Standing remains at a colonial villa on Montserrat, seen in the ALS point cloud. (Image/Data Credits: Opitz, Cherry, Malone & Ryzewski - SPARC/SLAM Collaboration).

Convergences

ALS is reviving topography as a key data source in the form of contextual topography, combining micro-relief representing diffuse archaeological features embedded in landforms and proxies for recent land use. Taking a global perspective, regions with well-developed traditions will continue to benefit from diverse and well established bodies of comparanda and archaeologists habituated to thinking through a topographic palimpsest. The convergence of practices and cross-regional conversations will spread the benefits of methodological advances.

In all contexts, the challenge now lies in going beyond the identification of features and patterns of features. ALS has been used almost exclusively as a prospection tool. Creative analyses and uses for this data beyond identifying new sites and features (in itself a substantial contribution) have not yet emerged. What is really meant by 'understanding a site in its landscape context'? ALS data has a role to play in responding to this question in a way that transcends generalities.



Pyroclastic flows, an active volcano, and dense jungle make ALS essential to prospection on Montserrat. A Colonial era windmill and associated plantation structures can be seen here. (Image/Data Credits: Opitz, Cherry, Malone & Ryzewski –SPARC/SLAM Collaboration).

An Iron Age landscape in South-Hungary: New methods with new results

Csilla Gáti[1] / Gábor Bertók[1]
1. Janus Pannonius Museum, Pécs

Introduction

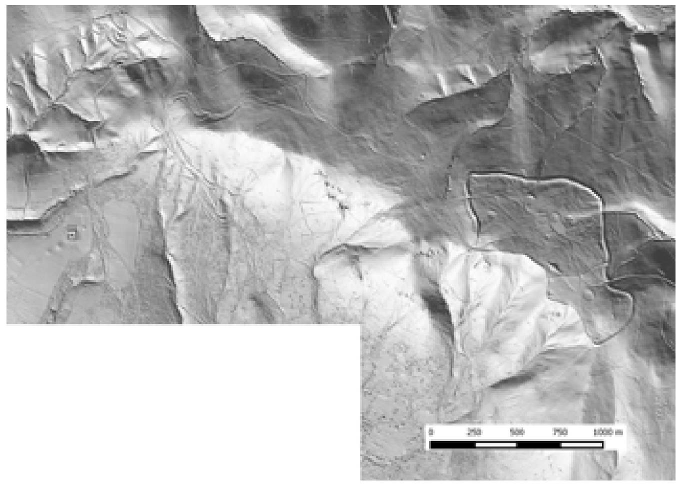
The Jakab-hegy in South-Hungary is one of the biggest (ca.50 ha) known Iron Age hillforts in the Carpathian Basin. The place is nowadays a woodland covered with dense vegetation. The ramparts of the hillfort, in some places 10m high, are clearly visible on aerial photographs, as well as on satellite pictures.

HUNGARY

Location

(1) Pécs-Jakabhegy

Aerial image of the hillfort.



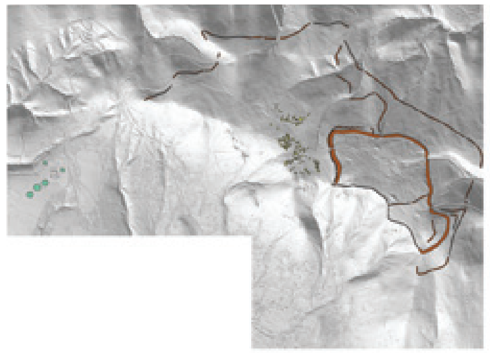
LiDAR survey of the hillfort and the neighbouring area.

Previous research on the hillfort

The Iron Age hillfort Jakab-hegy near Pécs has been known for a century now. The first archaeological investigations took place in the 1950s, when some of the nearby lying barrows were excavated. During the 1980s planned excavations were undertaken by the local Janus Pannonius Museum. This campaign produced evidence about the age of the tumuli and also partly of the ramparts. The archaeological material of the tumuli could be dated into the 8th–6th centuries BC. However, because of the dense woods and undergrowth the exact size of the tumulus cemetery could only be estimated.

Research within the ArcLand project

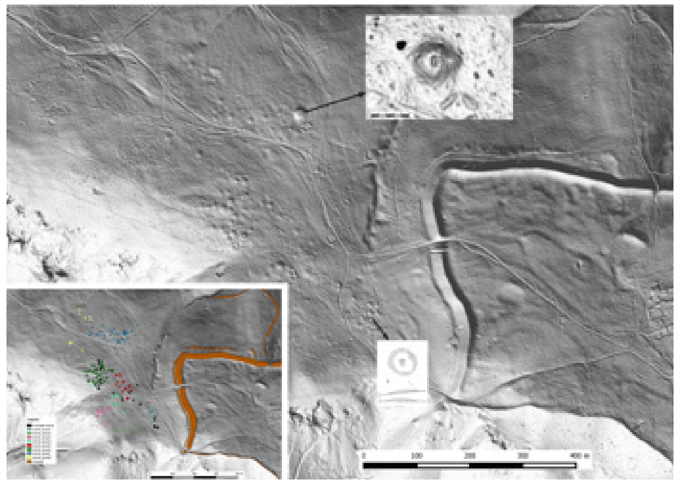
In 2011 we reinitiated the archaeological research of the hillfort and its surroundings within the framework of the ArchaeoLandscapes Europe project. We have fieldwalked selected areas within the ramparts using metal detectors uncovering a formerly unknown chronological horizon (Early Roman Period) in the history of the hillfort. Also supported by ArcLand, a LiDAR survey was undertaken in 2012. The results have shown a detailed plan of the barrow cemetery and the complete structure of the earthwork: new elements of the ramparts could be recognized on the outer parts that indicate multi-period developments to the fortifications. Also it has been proven that over the centuries the hillfort had several entrances which are still visible today. In the interior of the hillfort small terraces were observed. The number of the tumuli could roughly be counted: there are ca. 150 individual barrows, scattered in 8 groups. The former excavated tumuli are also easily recognizable. It is a future task to confirm all the possible barrows in the field.



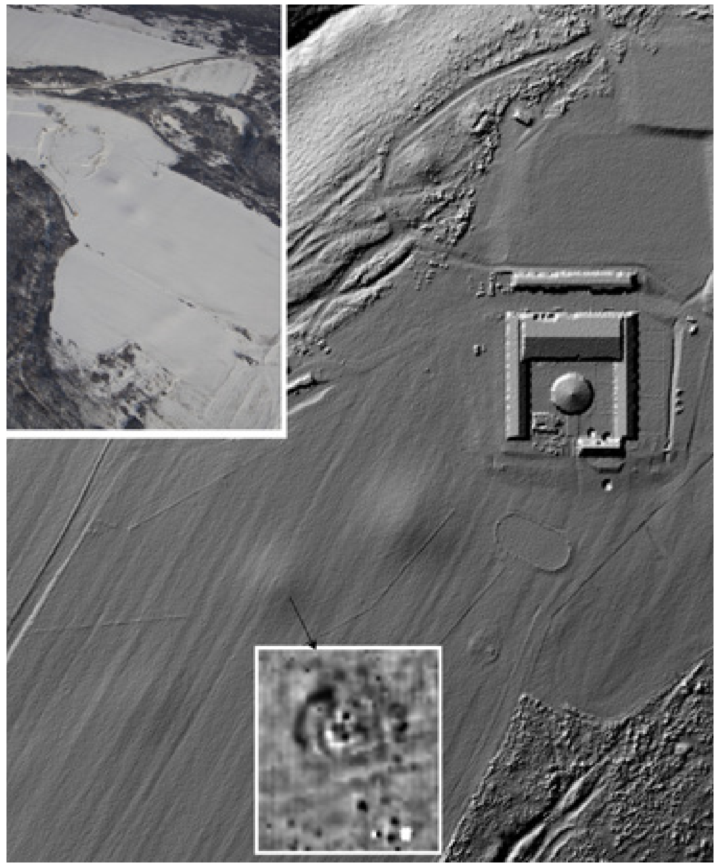
Interpreted map of the LiDAR data.

Surrounding area

Under the hill of the Jakabhegy there was an archive record of 3 stand-alone tumuli lying next to each other, most certainly connected to the hillfort. One of them was partially excavated, and had material from the 7th century BC, which is contemporary with the tumuli by the hillfort. On the LiDAR map we could recognize 4 barrows with certainty, and possibly one or two more. The magnetometer survey of one barrow showed signs of a possible chamber inside, and a ditch around the outside.



The tumulus field by the ramparts. In the 1980s some of the barrows were excavated, revealing their inner structure. On the basis of the LiDAR map it is possible to identify groups in the tumuli field.
The biggest tumulus lies at the northern edge of the area encircled by smaller barrows. On the eastern side there is a possible corridor inside, according to the LiDAR survey.



Four (or 5-6?) possible burial mounds under the hill, 2 kilometers west from the hillfort. The magnetogram of one barrows shows traces of possible inner structures.

Changing past landscapes: New data, new dilemma, more doubts

Włodek Rączkowski[1]
1. Adam Mickiewicz University Poznan, Poland

Introduction

The aim of the ArchaeoLandscapes Europe project (2010-2015) was to promote and disseminate the use of advanced technological prospection techniques such as aerial photographs, satellite imagery, geophysical methods, Airborne Laser Scanning, and hyper- and multi-spectral imagery in scientific investigations into Europe's past landscapes. The results of these studies are to extend our knowledge of the past, raise social awareness of the value of Europe's cultural heritage (mostly archaeological), create local identities and so on. The multi-directional exchange of ideas, information on research underway, educational and promotional projects within universities, research institutes and the conservation services all play a part in encouraging the application of the latest technologies in the study of past landscapes and to raise existing standards in current research practice.

ArcLand is just one of a number of recent initiatives connected to non-invasive archaeological prospection on a large scale. This trend, reinforced by the Valletta Convention, can be seen in the activities of numerous organisations (AARG[1], ISAP[2], EARSeL[3], EAC[4]), working parties, conference initiatives (e.g. From Space to Place[5]), etc. The ArcLand project has provided the framework within which many of its partners have been able to carry out case studies.

Likewise in Poland, several small and large scale projects taking the application of non-invasive methods into account have been completed (Łukasz Banaszek, Magdalena Felis, Mikołaj Kostyrko, Lidia Żuk, Grzegorz Kiarszys, Grzegorz Szalast, Wiesław Małkowski, Lidia Wróblewska). Does such a wealth of initiatives, activity, and research projects realised, signify progress in the study of past landscapes, local archaeology and history?

Past landscapes and technology

A consensus within archaeology exists today that it is the researchers who construct various understandings of space and past landscape. This is dependent on research traditions and accepted theoretical concepts[6]. A fundamental difference is the belief that it is possible to learn about past landscapes, in which physical objects play a significant role (culture-historical archaeology, processual archaeology, Marxist archaeology etc.). In contrast to this view, opinions are submitted that it is not possible to study the past world and to begin discourse on the construction of past landscapes and attempts to access the significance of past, dynamic landscapes (postprocessual archaeologies).

So how do modern remote sensing methods relate to the research methods archaeologists apply? Do they introduce anything new? Open up new research fields?

In short, the relationships between remote sensing methods and past landscapes in the context of various theoretical currents can be put as follows:

1. culture-historical archaeology has exploited these methods, and continues to do so in order to discover new facts;

2. processual archaeology focuses mainly on the possibility of performing detailed and objective measurements of cultural phenomena which has a spatial dimension;

3. postprocessual archaeologies highlight the role of remote sensing methods in perceiving meanings within the past landscape, understanding it and attempts at empathy.

Therefore, it is not the case that each person will look for the same, and will see the same, in remote sensing data. On the other hand, I have no doubt that remote sensing methods can deliver new research perspectives, research fields as a subject of interest. It does, however, require a critical approach to data and the methods used in gathering data, and theoretical self-reflection.

This in turn reveals new, past landscapes, which up till now could not have been studied. A particularly important feature of remote sensing methods is that they allow the landscape to be studied as a palimpsest and make it possible to access erased layers, currently invisible. Thus metaphorically speaking, remote sensing methods "bring past landscapes back to life" (in the researchers' interpretations of course).

Technological progress as a step backwards?

The dynamics of the development of technology in archaeology regarding data acquisition and processing have reached an unprecedented level. This should signal a leap forward in the study of the past, though analysis of the avalanche of publications presenting applications of airborne remote sensing methods paradoxically leads me to a different conclusion. I have a feeling that remote sensing methods are in vogue at the moment (mainly ALS in Poland, but geophysical methods and aerial photographs too). A complete lack of criticism or theoretical awareness means that in the hands of archaeologists these "new research methods" are simply "new toys". The following elements can be identified in current research practice:

1. the domination of empiricism and, consequently, the conviction that the objective study of the past thanks to these tools which are "independent of the archaeologist" means a return to reflection on a cultural-historical archaeology level;

2. a trend for employing various remote sensing methods regardless of whether this makes sense or not;

3. the lack of a critical approach to data and understanding of their cultural character;

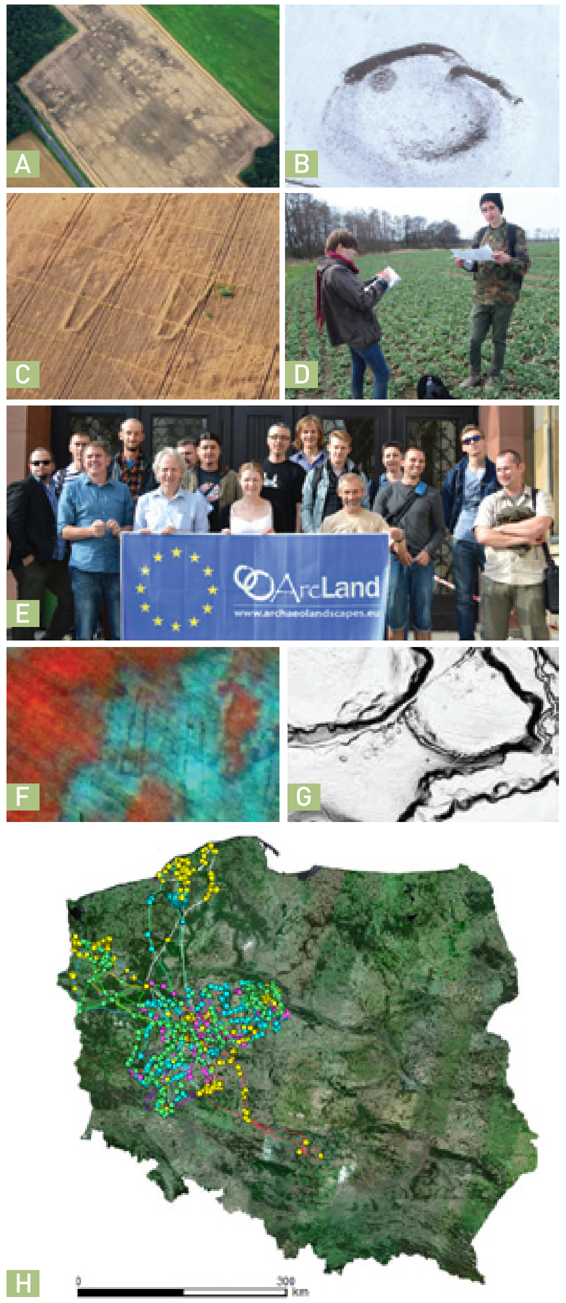
4. a fetish for data integration, which in practice leads to data sets (or their presentation in a visual form) as separate GIS layers;

5. a fascination with the image as the end product and form of data presentation and the accompanying manipulation through such visualisations.

Aerial archaeology became aware of these problems at the close of the 20th century and discussed this issue in depth, as can be seen in numerous publications as well as in the education process[7]. This same group of people has a critical approach to ALS data[8], though as the data are now openly accessible their thoughts do not reach the majority of the users. Discussion of this type is practically absent amongst those using geophysical methods or satellite images.

Conclusion

Our image of the past landscape is constantly changing. The question is, are we focusing too much on technology and not enough on thinking about what we are doing and how? ArcLand has provided a unique opportunity to disseminate new technologies. We cannot however forget about the Heideggerian "being-in", as we create the impression that we are "above".



Above (A-H): Visual report.

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Documenting past cultural landscapes: A 3D approach

Sorin Hermon[1]
1. The Cyprus Institute

Introduction

3D technologies for documenting cultural landscapes have a long history of applications, most common being the use of LiDAR for the identification of cultural landmarks, isolation of archaeological features or registration of places for further excavations. This poster summarises five years of research by the Digital Heritage group of STARC, The Cyprus Institute, carried out within the framework of the ArchaeoLandscapes Europe project, aimed at defining a research approach built around 3D as a documentation and investigation method to help better understand past cultural landscapes. The case studies chosen are of various natures, they are distributed over three countries, and address different research questions, in order to exemplify the wide range of applicability of 3D.

Italy / Israel / Cyprus

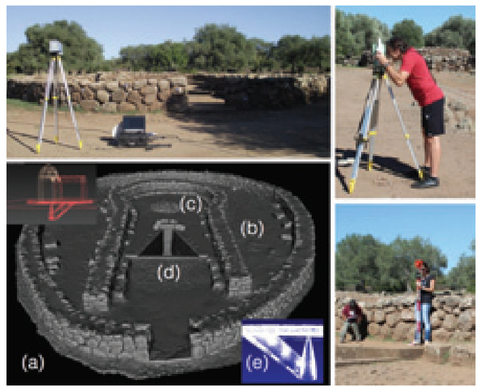
Locations
(1) Santa Cristina, Sardinia, Italy
(2) Cenacle Room, Jerusalem, Israel
(3) Tombs of the Kings, Pafos, Cyprus
(4) Hala Sultan Tekke, Larnaca, Cyprus

STARLab mobile unit operating in the field.

Fieldwork and laboratory data processing

Our research group utilises a mobile laboratory (STARLab, Image 1), which consists of a 4x4 truck with a customised cabin, capable of hosting 4 researchers and their equipment. It is a fully autonomous unit, with its own electricity generator and water supply. The 3D data acquisition equipment consists of a Surphaser laser scanner (0,4 – 20 meters acquisition range and margin of registration error of 5mm), and a Menci ZScan system, consisting of a calibrated (fixed lens) digital reflex camera controlled by software installed on a tablet.

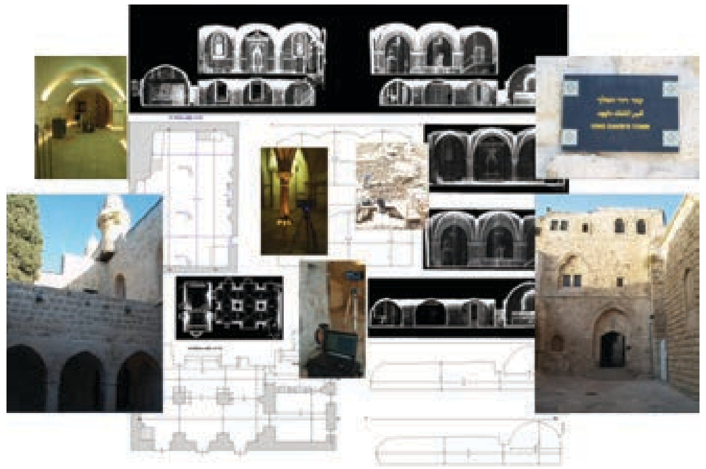
The field documentation instrumentation is complemented by a Leica total station and GPS system.The laboratory software includes Meshlab for creating 3d meshes, JRC Reconstructor for 3D analysis of data, and AutoCad for measurements and virtual reconstructions.



Santa Cristina well sanctuary, Sardinia, Italy – 3D analysis of the architectural remains.

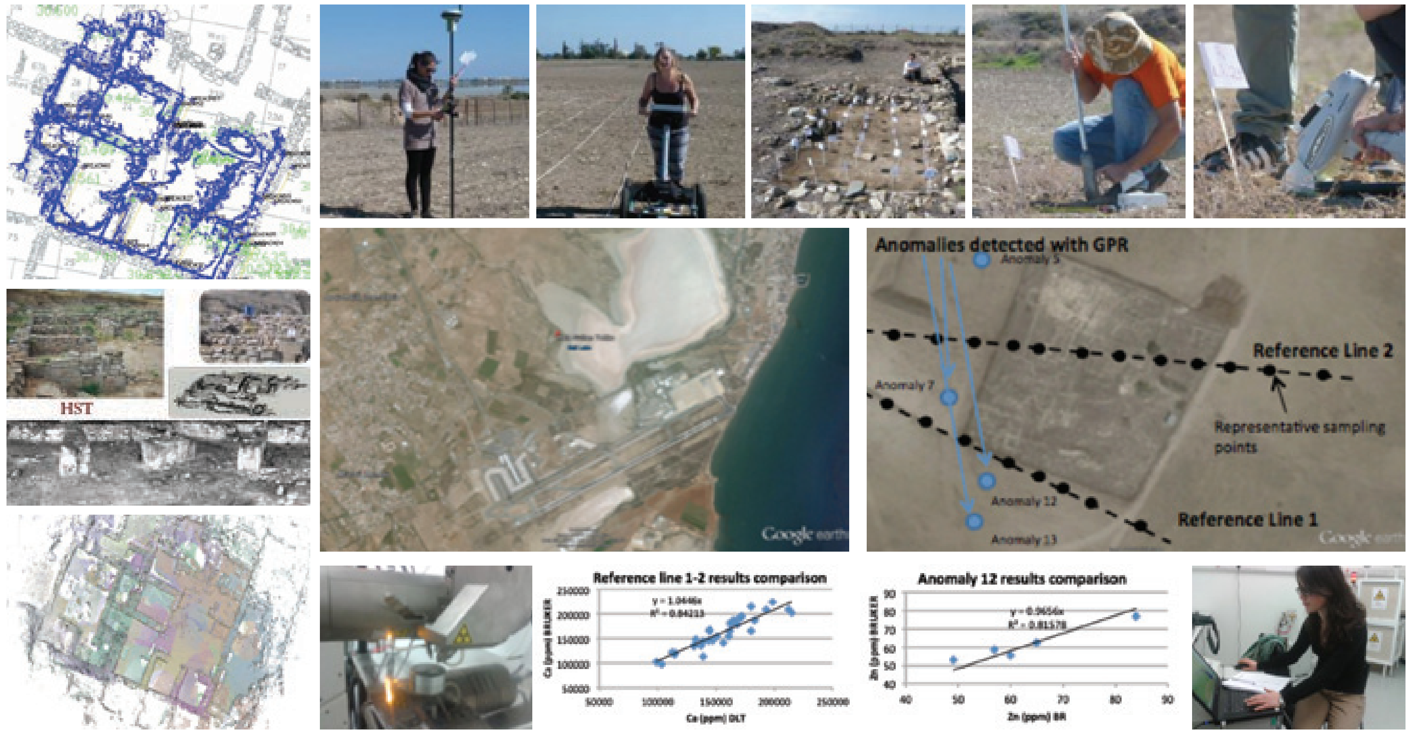
Archiving and retrieving data

All data created by our group are described through a comprehensive metadata schema and stored in a repository. This allows access to the full record detail and visualisation, through X3D, of 3D models, along with more traditional digital assets, such as text, video and images. Our repository already contains hundreds of 3D models that can be visualised directly through the browser, without the need for any plug-ins.



Analysis of the architectural history of the Cenacle complex (The Room of the Last Supper and King David's Tomb) in Jerusalem, Israel.

Characterization of cracks and other natural damages at the UNESCO World Heritage site of Tombs of the Kings, Pafos, Cyprus.



Integrating 3D documentation with geophysical and geochemical survey at Hala Sultan Tekke (Late Bronze Age) site, Larnaca, Cyprus.

Exploring the past Romanian landscape: The application of satellite and LiDAR imagery

Ioana A. Oltean[1] / William S. Hanson[2]
1. University of Exeter / 2. University of Glasgow

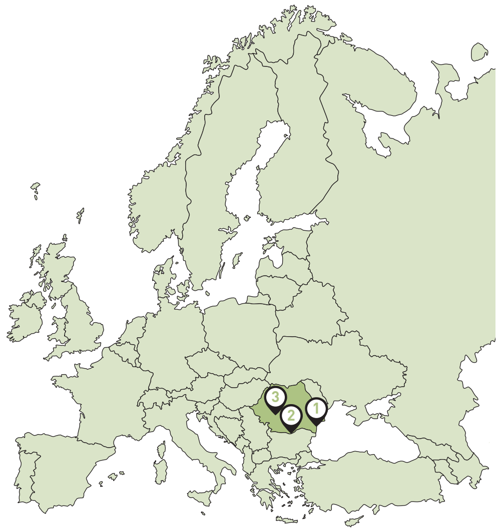
Introduction

The areas of Romania in which we have sought to promote and develop the application of aerial survey for archaeology offer different challenges, and in all three the recovery of data by traditional archaeological observer-directed aerial reconnaissance has been variable.

Both southern Dobrogea and southern Muntenia, with their extensive farmed landscapes, have excellent potential for the discovery of new archaeological sites. Therefore we sought to test the value of more systematic block coverage and examine the possibility of improving the recovery of sites, particularly as cropmarks by extending their perception beyond that of visible light, through the application of modern, multi-spectral, high-resolution satellite imagery.

ROMANIA

Locations
(1) Southern Dobrogea
(2) Southern Muntenia
(3) Western Transylvania



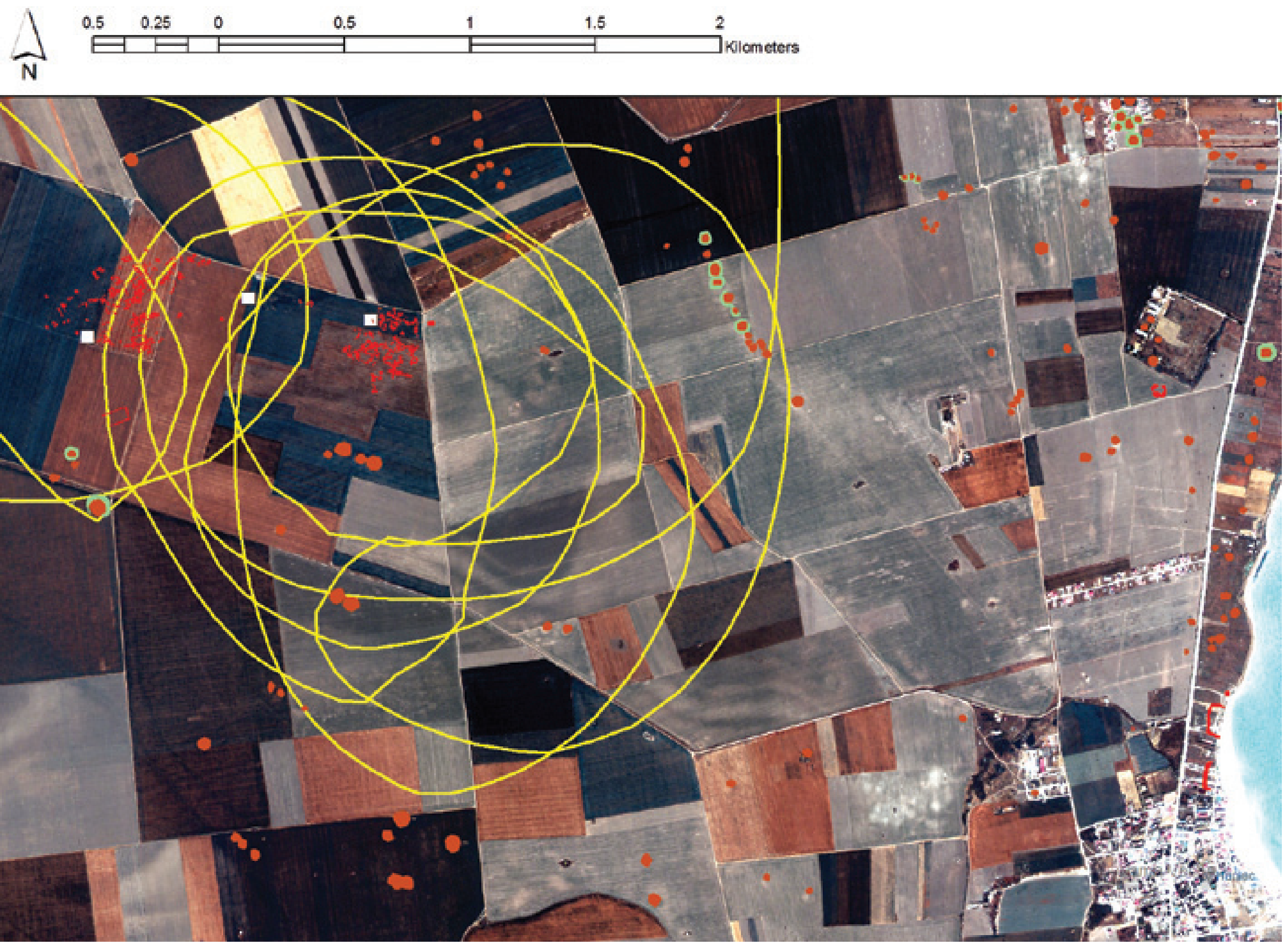


Fig. 1: Enhanced barrow visibility in near-infrared at Limanu-Vama Veche adding new sites in the area outside the reconnaissance flight path.

Fig. 2: Satellite image from July 2012 of the Roman fortlet on the Transalutanus frontier at Rosiorii de Vede.

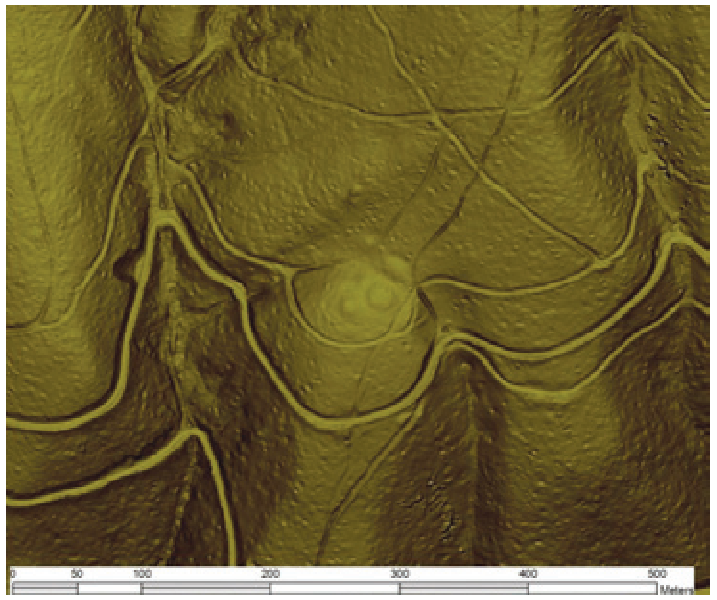


Fig. 3: ALS image using slope analysis visualisation of terraces with Dacian house platforms typical of the area around Sarmizegetusa Regia.

In western Transylvania, with its more constrained areas of arable cultivation and heavily forested mountain ranges, the application of Airborne Laser Scanning (ALS)/LiDAR seemed an ideal method to apply in the upland areas to help penetrate the forest canopy. Though increasingly employed in archaeological surveys across Europe, ALS has to date seen very little application in Romania, while there have been no previous attempts to explore the multi-spectral properties of modern satellite imagery for archaeology.

Multi-spectral satellite imagery can help to identify new archaeological information even in areas already extensively mapped, as for example in relation to the recording of clusters of tumuli in the Vama Veche - Limanu area of southern Dobrogea. However, it is useful only for larger objects because of its relatively poor spatial resolution in comparison to photography or pan-sharpened imagery. It can also be difficult to acquire imagery acquired at the best time for cropmark visibility, even when paying a premium for a specified acquisition period, since the time window offered can be quite wide. Nonetheless, it can help to extend the time window of site visibility into the period immediately after the harvest or provide good responses from soilmarks, as for example at Rosiorii de Vede on the line of the Roman Transalutanus frontier.

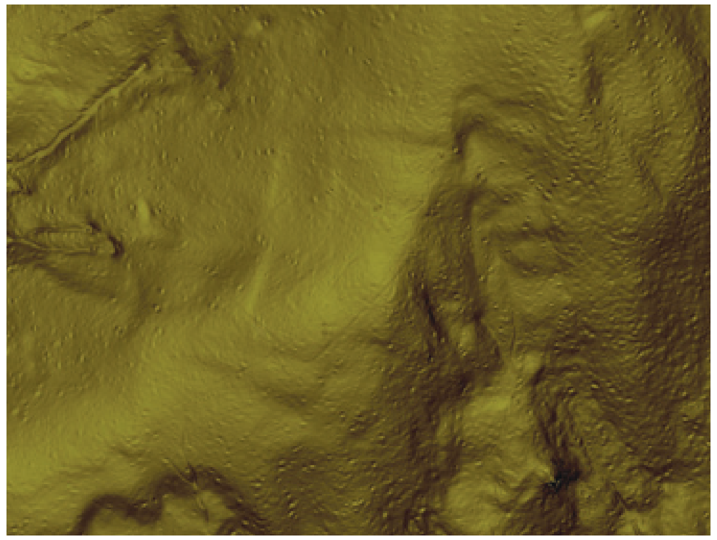


Fig. 4: ALS image using slope analysis visualisation of Sesului Hill Roman temporary camp.

An ALS survey of 100 km^2 in heavily forested mountainous terrain centred on the Dacian capital at Sarmizegetusa Regia demonstrated the massive potential of such imagery. A range of different data visualisations were applied, not just standard hillshade, but also slope analysis and SkyView factor. As a result, large numbers of archaeological sites were revealed, including over 1600 man-made terraces, a number of which could be seen to support circular structures, highlighting a previously unsuspected density of Iron Age occupation in the area. Two new Roman temporary camps were also discovered and a previously recorded camp re-identified as a more permanent auxiliary fort, enhancing our understanding of the Roman conquest and exploitation of the area. In addition, new light was shone on the history and development of the much-investigated Dacian capital, revealing a previously unrecognised phase of Roman military occupation.

Bibliography:
A monograph and papers for Antiquity and Journal of Roman Archaeology are in preparation.

From point clouds to archaeological evidence: Improving visualization and spatial analysis of 3D data

Hugo Pires[1] / Luis Gonçalves-Seco[2] / Joao Fonte[2] / Patricia Mañana[2] / César Parcero-Oubiña[2] / Pastor Fábrega-Álvarez[2] / Jose Señorán[2]
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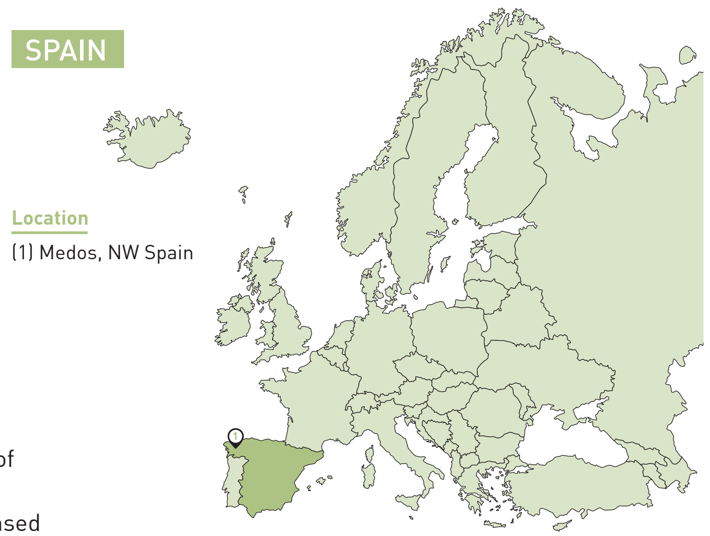
Introduction

Point clouds are becoming a common source of data for the documentation of archaeological elements, at different scales (Devereux 2008, Crutchley 2010, Cowley ed. 2011, De Reu et al 2012, Verhoeven et al 2012, Opitz and Cowley 2013,...). Either from aerial LiDAR sensors, close-range laser scanners or photogrammetry, point clouds allow the documentation of features from the scale of the landscape and sites, to the scale of objects or details of them (Gilboa et al 2013, Cassen et al 2014).



The visualization and enhancement of significant archaeological elements in those point clouds has been the subject of a number of proposals so far. Regarding topographic data, existing techniques range from hillshading to more complex calculations like those based on Principal Components Analysis, Sky View Factor (Zakšek et al 2011) or Local Relief Models (Hesse 2010). These visualization techniques have been investigated and analysed (Bennett et al 2012, Štular et al 2012) and the results confirm that no single visualization method outperforms the rest in all types of terrain.

Among the more effective for archaeology are the trend removal procedures (Hesse 2010) based on the theoretical assumption that when a smoothed surface is compared to its original, fully detailed shape, local small-scale topographic features are distinguished from large-scale landscape forms. The key factor for the quality of this visualization technique is the calculation of the trend surface.

Decimation for visualization

While the trend removal methods proposed so far (Štular et al 2012) have been mainly focused on the use of smoothing filters, we propose a new procedure called Morphological Residuals Model (MRM) (Pires et al forthcoming) that introduces a decimation factor to decrease the sampling rate of point cloud data prior to smoothing filtering.

At the scale of landscapes and sites, it has improved the contrast and visibility of topographic alterations such as Megalithic burial mounds, historical fortresses **(Fig. 1)** or the remains of Roman mining **(Fig. 2)**. The examples shown here have used open access data from the Spanish national LiDAR coverage[1], and are intended as a contribution to assess the applicability of such datasets for archaeological purposes.

This technique has been also applied to 3D models of objects or small surfaces, helping in the interpretation of faint carvings **(Fig. 3)** or engravings **(Fig. 4)**, as well as providing improved graphical depictions of them. The 3D data for these two examples was calculated with image-based 3D reconstruction techniques (Agisoft Photoscan).

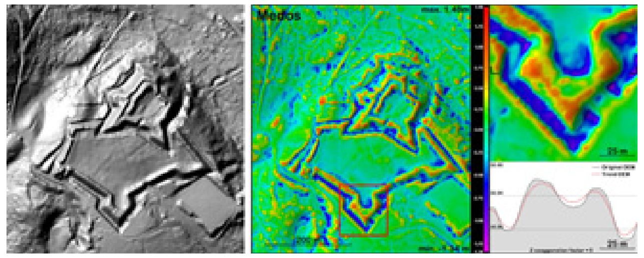


Fig. 1: 'Hillshade vs. MRM of the XVIIIth century fortress of Medos NW Spain, near the Portuguese border).

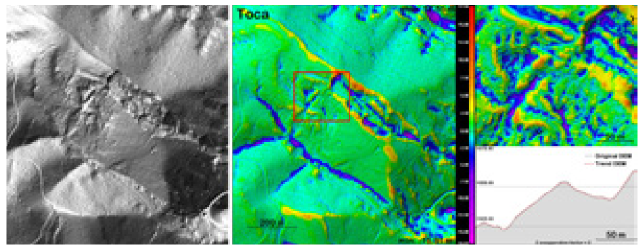


Fig. 2: 'Hillshade vs. MRM of the Roman mine of Toca (NW Spain).

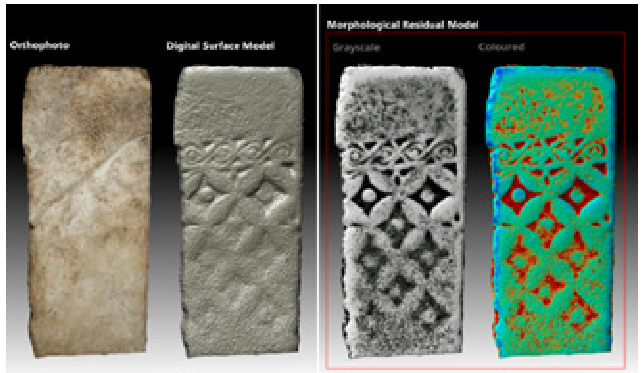


Fig. 3: 'Application of the MRM technique to highlight the details and improve the visualization of an VIIth century decorated slab (Museu de Évora, Portugal; in collaboration with Mélanie Wolfram).

Decimation for spatial analysis

For other archaeological purposes, like when we want to analyse spatial relations between archaeological sites and the surrounding topography, the density of point cloud data can contain too much detail. In these cases, decimation can be an effective way of decreasing the sampling rate while preserving the main topographic features. The main advantages of this procedure are a reduction of the effect of modern topographic features like roads, quarries or buildings, and a substantial improvement in the processing time needed to accomplish the calculations. A graphical example of the proposed procedure using the PNOA dataset (average GSD of 0.5 m) is presented in **Fig. 5:** the decimated mesh blurs most major topographic alterations, such as the modern road to the East, allowing **(Top)** a much more reliable calculation of least cost paths (highly coincident with wild animal tracks). However, the simplification doesn't imply a lower accuracy **(Lower):** the detailed viewshed for the burial mound in the centre is remarkably similar for both DEMs (original and decimated), and coincident with the actual visibility as tested in the field.

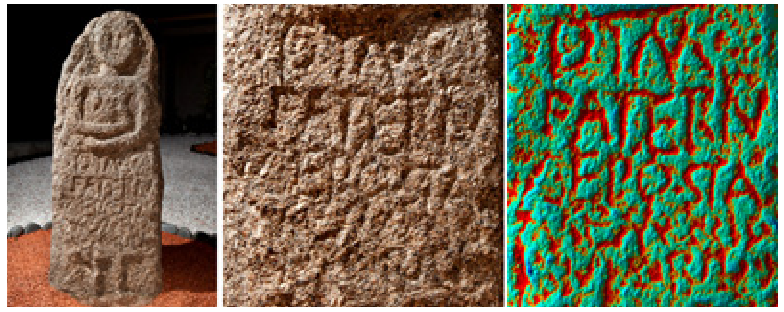


Fig. 4: 'Application of the MRM technique (right image) to improve the legibility of the Roman funerary stela of Capela (Penafiel, Portugal), as compared with the traditional raking light approach (left and central image) (Soeiro 2013, Correia Santos et al 2014).

Acknowledgements

The field experiments in Barbanza were developed in collaboration with Marcos Llobera, University of Washington (USA).

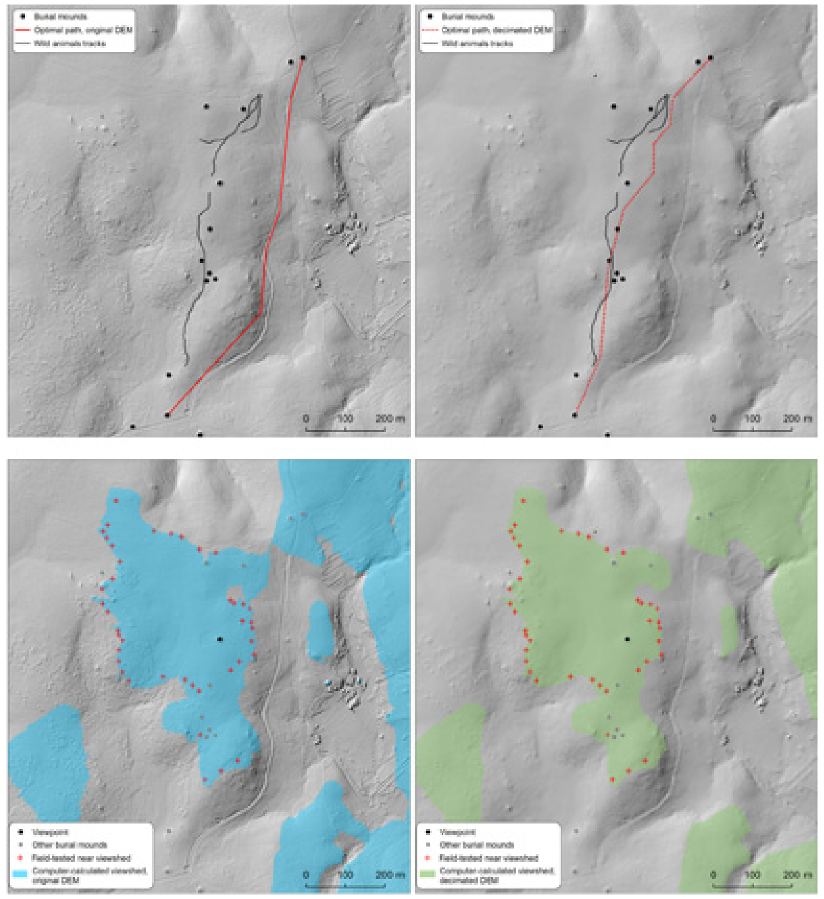


Fig. 5: Original **(Top left)** vs. decimated DEM **(Top right).** Decimation reduces the effect of major topographic alterations, as seen in the calculation of least cost paths between two burial mounds, top. However, accuracy remains high, as seen in the similarity between viewsheds **(Lower).**

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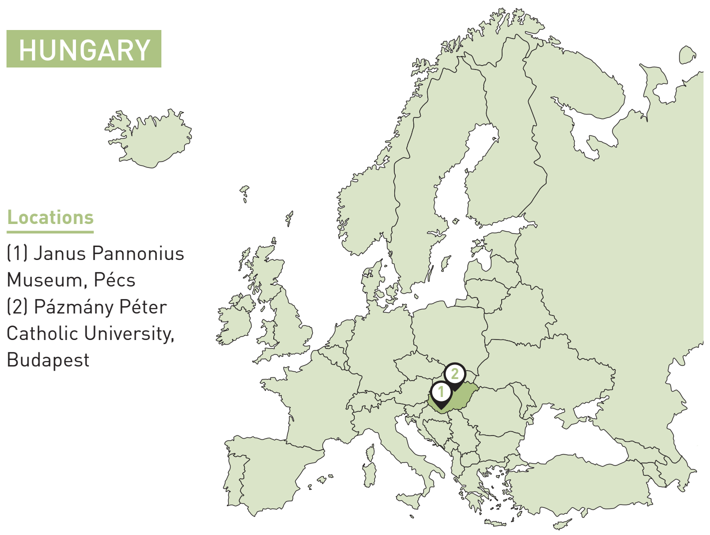
From research to education: Utilization of ArcLand expertise in Hungary

Gábor Bertók[1,2] / Csilla Gáti[1]
1. Janus Pannonius Museum (Hungary) / 2. Pázmány Péter Catholic University, Hungary

Introduction



The Archaeological Department of the Janus Pannonius Museum (JPM), Pécs, Hungary, has participated in international projects co-financed by the European Union since 2004. Our involvement started with the European Landscapes – Past, Present and Future project within the framework of the EU-Culture 2000 programme (2005–2007). Our participation in international cooperation continued with our application as co-organizer in the ArchaeoLandscapes Europe project (ArcLand). in 2010. With the help of the prospection methods and techniques promoted by ArcLand, such as remote sensing (aerial photography, LiDAR) and geophysics (GPR, magnetometry), we have achieved some spectacular results for the archaeological heritage of Baranya County, Southwest Hungary.

Our achievements range from the survey of Late Neolithic and Early Bronze Age landscapes to the non-invasive research of the Iron Age hillfort near Pécs, and the Late Medieval battlefield of Mohács. Before our surveys started, most of the Prehistoric sites in Baranya were known either as individual finds brought to the Museum from villages, or as sites identified from surface find-scatters by archaeologists; only a few of these sites had been excavated or researched in detail, and few had any information on the layout and topography. Our aerial photographs significantly changed the picture in many cases. For the Neolithic period, we have identified and mapped 18 sites with enclosures of various types that had been unknown before.

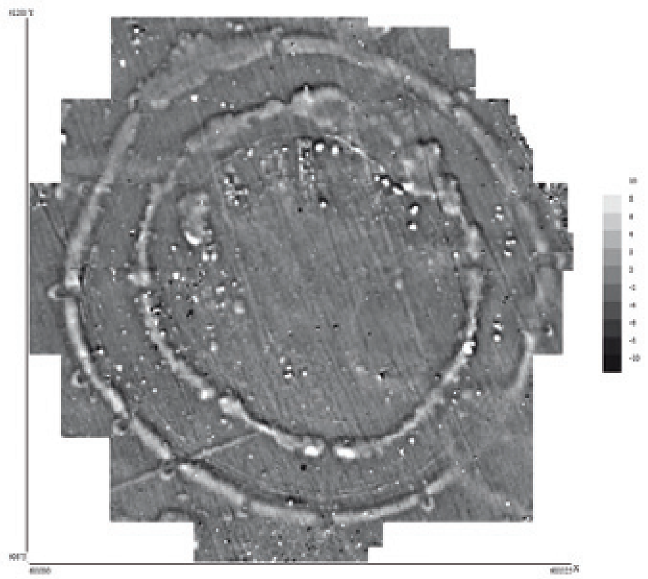


Fig. 1: Magnetometer survey of the Villánykövesd Late Neolithic enclosure complex.

We have identified 11 early Bronze Age fortified settlements that seem to form a network in addition to the two previously known sites. The 140 km² LiDAR survey, financed by ArcLand, greatly enhanced our understanding of several already known sites, like the Iron Age Hillfort and barrow cemetery near Pécs-Jakab-hegy. At the Olasz-Olaszi-hegy EBA fortified settlement, the analysis of LiDAR data revealed forest-covered ramparts additional to the hilltop ditches known from aerial imagery.

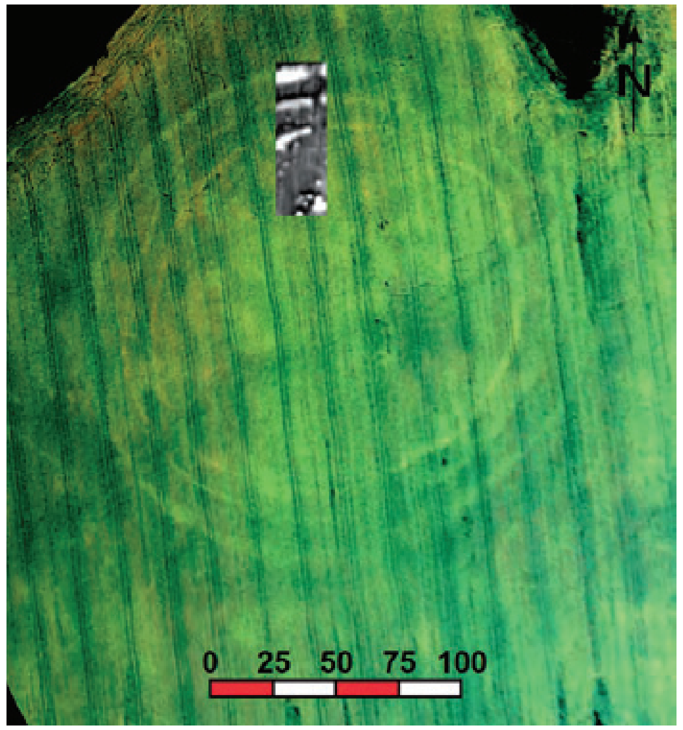


Fig. 2: Rectified aerial photograph of the Kökény enclosure with the magnetic gradiometer map based on the data surveyed and processed during the NATS 2013 field school.

LiDAR also revealed several previously unknown archaeological phenomena, such as a possibly Medieval 'rig-and-furrow' field system near the village of Vokány.

Our aerial images and LiDAR data have already been used several times by JPM for site assessment, and by external partners of the Museum, e.g. the Technical University of Budapest, where LiDAR data were provided for M.Sci. theses. To fulfil the 'outreach' goal of ArcLand, we organized an international fieldschool (Non-invasive Archaeology Training School, NATS 2013) in Pécs, and a travelling exhibition first on display in Pécs in 2012, then in the Hungarian National Museum in Budapest, and later at the Pázmány Péter Catholic University in 2013.

As part of our efforts to publish our results, we have written several research papers, and published the book 'Old Times – New Methods' in 2014. 150 sites in Baranya County have been mapped from our aerial photography so far and have been added to a GIS database available online for research purposes (www.jpm.hu/Arcland). Combining research with education, Janus Pannonius Museum was instrumental in the expansion of the ArcLand network with another Hungarian institution, the Department of Archaeology of Pázmány Péter Catholic University (PPCU), now an associated partner of ArcLand.

Fig. 3: Non-Invasive Archaeology Training School (NATS), 2013, Pécs.

Fig. 4: Cropmarks of a large cemetery discovered by NATS 2013 students during one of the training flights.

Fig. 5: Aerial photograph taken in 2014 of the recently discovered Roman urban settlement Iovia.

Fig. 6: LiDAR-based hillshade image of the forest-covered Iron Age hillfort Pécs - Jakab-hegy.

Our common activities started with 4 PPCU students participating in NATS 2013. Since then, the teaching of GIS, and non-invasive prospection methods have been an important part of the curriculum for students of archaeology at PPCU.

To enhance the level of training, a common research project started at Iovia, a hitherto undiscovered Roman town, with 25 PPCU students carrying out fieldwork, and JPM providing technical assistance, aerial, and LiDAR data. Expertise and software, gained through ArcLand by the JPM, also contributed to the success of the research mission led by the Department of Archaeology of PPCU in Iraqi Kurdistan in November 2014.

ArcLand HERITAGE · DATA · KNOWLEDGE
Culture
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Historical landscape through the lenses of LiDAR and photogrammetry: Late antique sites in Serbia

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Introduction

Within the scope of the ArcheoLandscapes Europe project the Institute of Archaeology, Belgrade, started a programme of LiDAR and photogrammetric surveys of the area of some of the most important sites in Serbia. Technologies for both airborne 3D scanning and modeling of the terrain were introduced to Serbian archaeology for the first time. The majority of the surveyed sites are multilayered, with important traces from Late Antiquity.

In one case, we have succeeded in measuring what is left of the town of Margum, situated at the heavily flooded confluence of two major rivers, the Morava and the Danube **(Fig. 1)**. The obtained DTM showed that the area of the Roman town and later Mediaeval settlement have been drastically reduced by frequent riverbed displacements and soil erosion. The preserved area of the two settlements measures 7–8 hectares. The eastern part of the city with the cemetery could not be studied due to the construction of massive flood-defence earthworks and the levelling of the terrain, which has severely damaged the landscape.

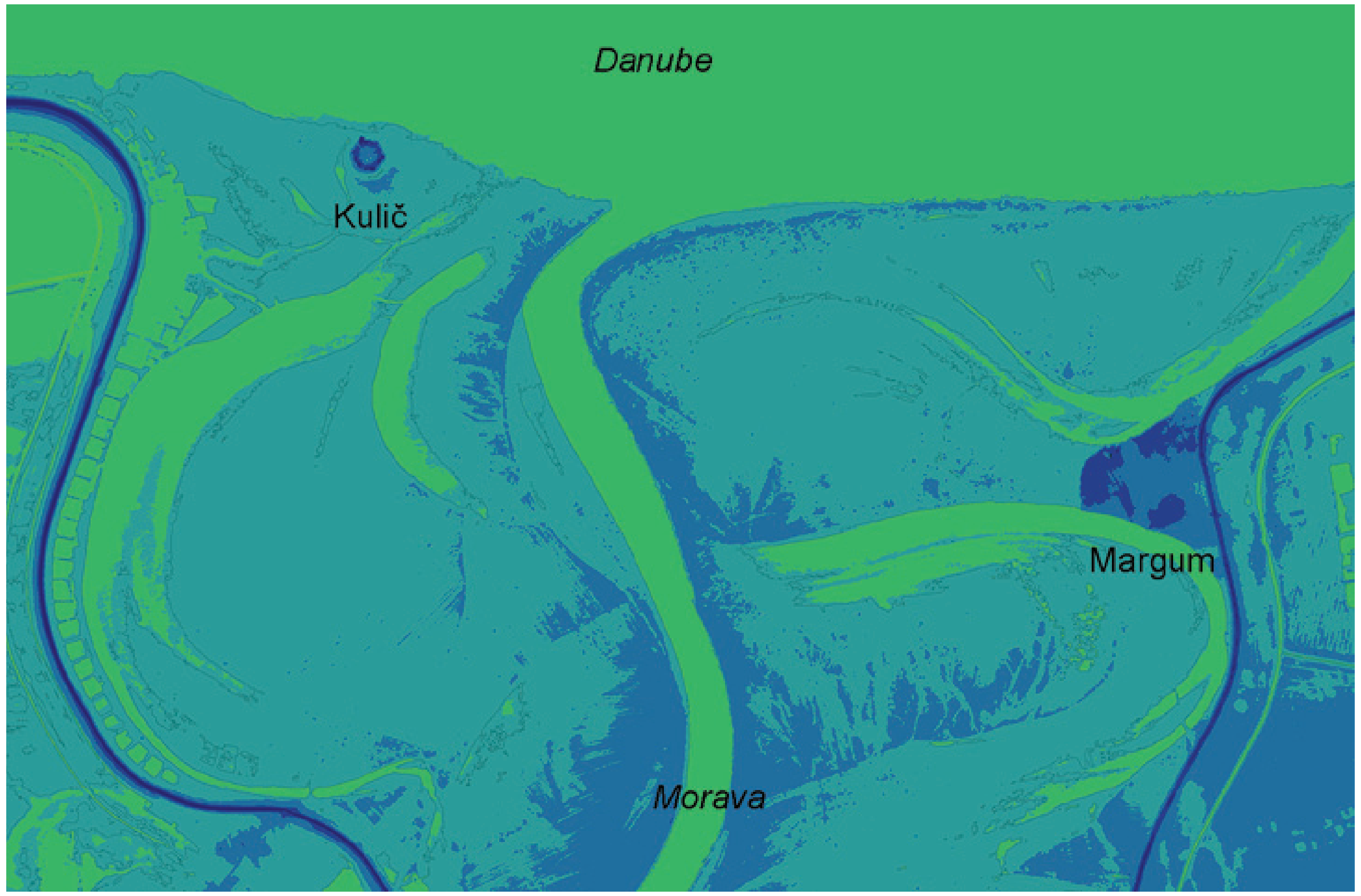

Fig. 1: DTM of the confluence of the Morava and Danube Rivers and the position of Roman Margum and Turkish Kulič.

On the other hand, the topography of the nearby fort Kulič has been studied. It has often been thought that this fortification was originally built in Roman times, but analysis of the DTM has shown that the fort was constructed on a round embankment in the confluence area where most of the Roman and Mediaeval architecture had already been destroyed, and therefore in Turkish times.

Secondly, after 100 years of archaeological excavations at Caričin Grad (Justiniana Prima), thanks to this technology we have spotted another rampart in the configuration of the terrain **(Fig. 2)**. After the excavations which followed, we concluded that this was a fourth line of fortifications built in opus mixtum, enclosing a 4.5 ha large suburb. The same LiDAR survey led us to resolve the question of the town's water supply system, as we were able to reconstruct the 22 km long aqueduct route. The ground plans of three fortlets from the sixth century were also obtained, as well as the location of an Iron Age hillfort **(Fig. 3)**. On the other hand, as a result of a photogrammetric survey conducted separately from the LiDAR scanning, ground plans of unearthed buildings were revealed and a precise documentation of excavated structures was obtained.

While waiting for new LiDAR data sets, we have undertaken a series of photogrammetric surveys, the most important of which was the one focused on Felix Romuliana, where both the Galerius' palace with its surroundings, and the consecration complex on the nearby Magura hill were photographed and modelled in 3D. This allows us to compare the drone-derived DEM with the results of a recent geomagnetic survey of this area. In the obtained DEM the terrain profiles, terraces and swamp areas are clearly demarcated **(Fig. 4)**.

However, in the case of the fortress of Ras, best known for its Mediaeval stratum, we could not detect the Late Antique phase by means of photogrammetric modeling of the wooded terrain, but we were able to demarcate the populated areas of the rocky hill **(Fig. 5)**.

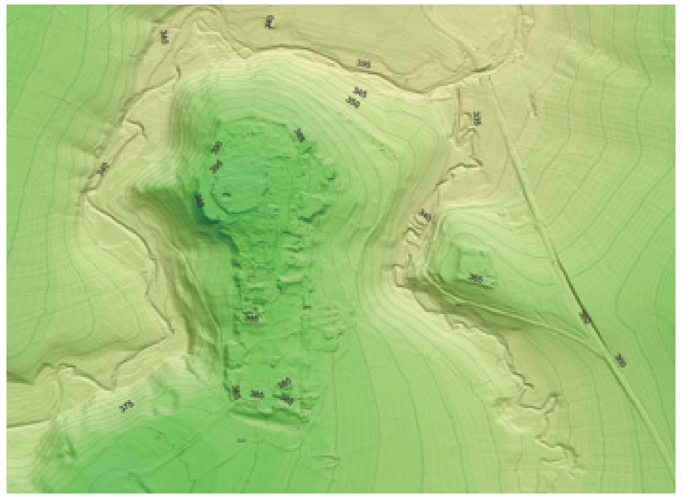

Fig. 2: DTM of Caričin Grad (Justiniana Prima).

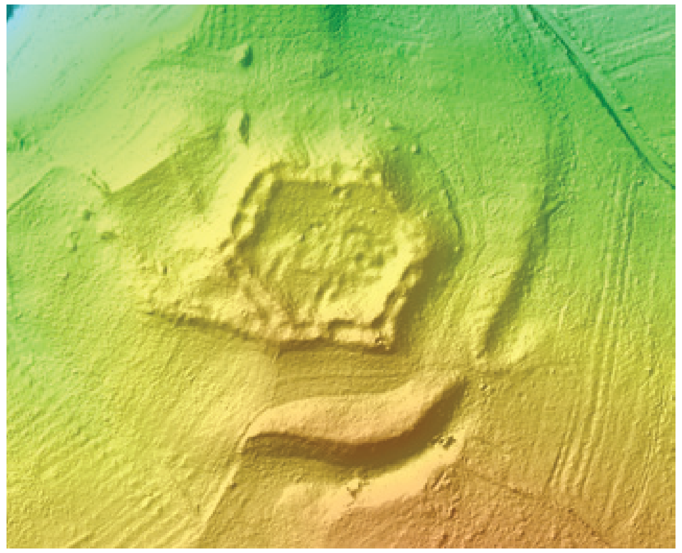

Fig. 3: DTM and ground plan of the Svinjarica - Gradište fortification.

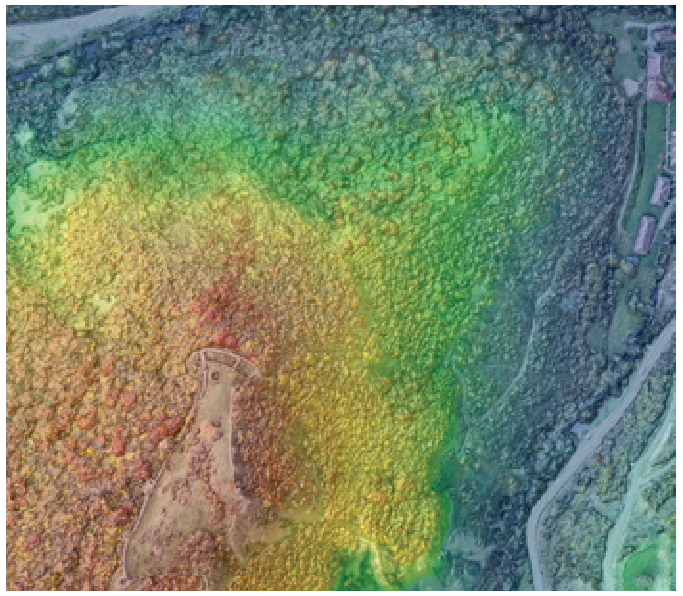

Fig. 4: DTM and orthophoto of the Ras fortress.

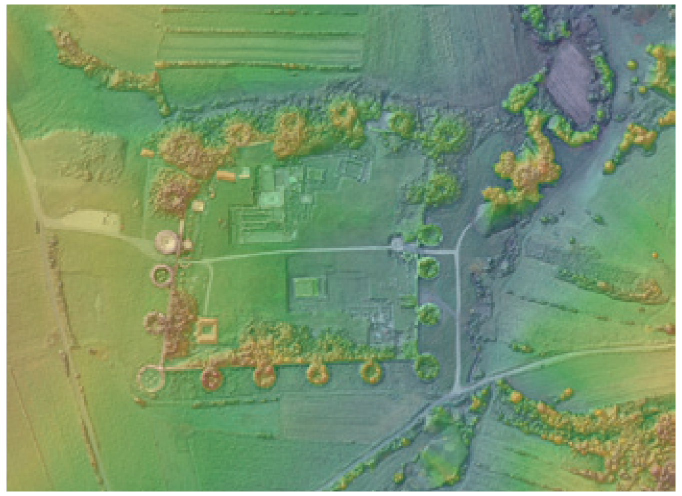

Fig. 5: DTM and orthophoto of Romuliana.

Integrating a traditional method and a modern technique of archaeological remote sensing: The value of complementarity

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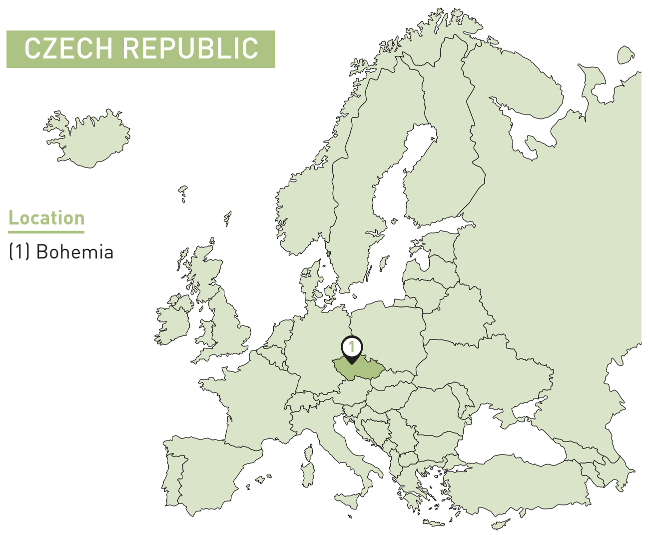
Introduction

In contrast to the twenty years which have elapsed since a systematic long-term aerial archaeological survey programme was launched in Bohemia, it is just a half decade since data from airborne LiDAR was first included in the package of air/space-borne methods of archaeological prospection, documentation and mapping used in the Czech Republic. This early stage in the integration of data from both sources occurred during the course of the ArcLand project, so it is worth summarizing our experience with this combination and to offer a general evaluation.

The information potential of data resulting from both *cropmark aerial survey - CAS* and *Airborne Laser Scanning - ALS* is similar when one considers the range of quality (types of features) and quantity of newly identified, recorded and mapped components of the archaeological heritage. (CAS mainly consists of oblique air photographs intentionally taken by aerial archaeologists to document a discovery made during a prospection flight. ALS has been used as a digital elevation model in the form of either DTM or DSM respectively; LiDAR intensity data has not been used in a comparable way yet.)

Undoubtedly, these two methods are by far the most profitable of all prospection methods based on observation of the landscape from above. It is also important that, due to their different principals, each of these two heuristic methods collect data on two different groups of archaeological sources: those completely buried under the current Earth's surface (physical traces of them are not preserved at the surface and so they are invisible to a ground observer) on one hand, and those preserved in a ruined form (termed earthworks)



on the other. Consequently, CAS and ALS are highly complementary prospection methods in terms of the acquisition of data of both categories of past man-made structures.

This is certainly true on a national level. Once a centrally administrated sites and monuments record (SMR), archiving data from a large territorial unit (such as state/country), is taken into account, due to the variability of a typical European country's landscape in terms of geomorphology, landuse, cultivation practices, urbanisation process, etc., archaeological features are preserved and visualised principally in the two forms mentioned above.

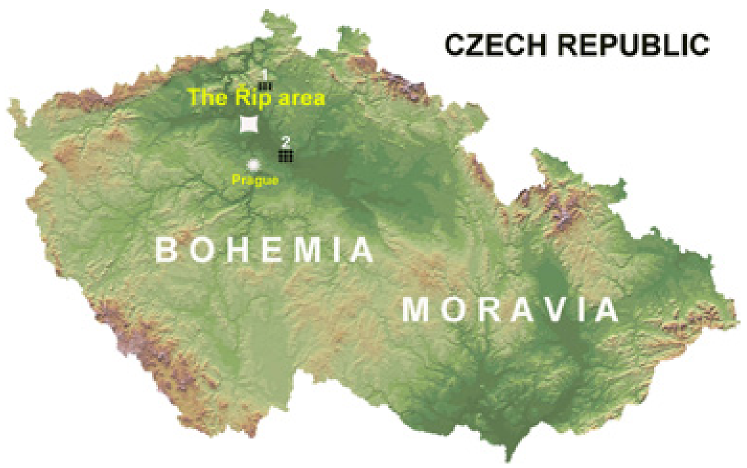


Fig. 1: Physical map of Bohemia with indicated targets: the Říp area, the Litoměřice – Třeboutice defensive system (1) and the Přerov nad Labem hillfort (2). All maps and DTMs used in this work as illustrations are oriented to the North apart from **Fig. 5.**

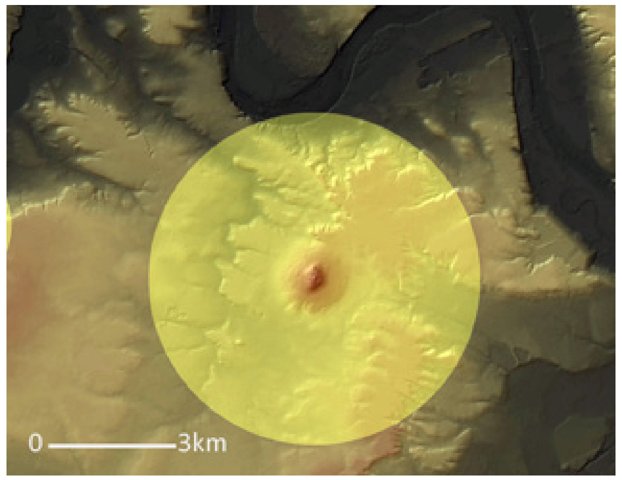


Fig. 2: Detailed DTM of the Říp project area (in light yellow circle). The plateau around the Říp, raised above the Labe/Elbe basin, is clearly discernible.

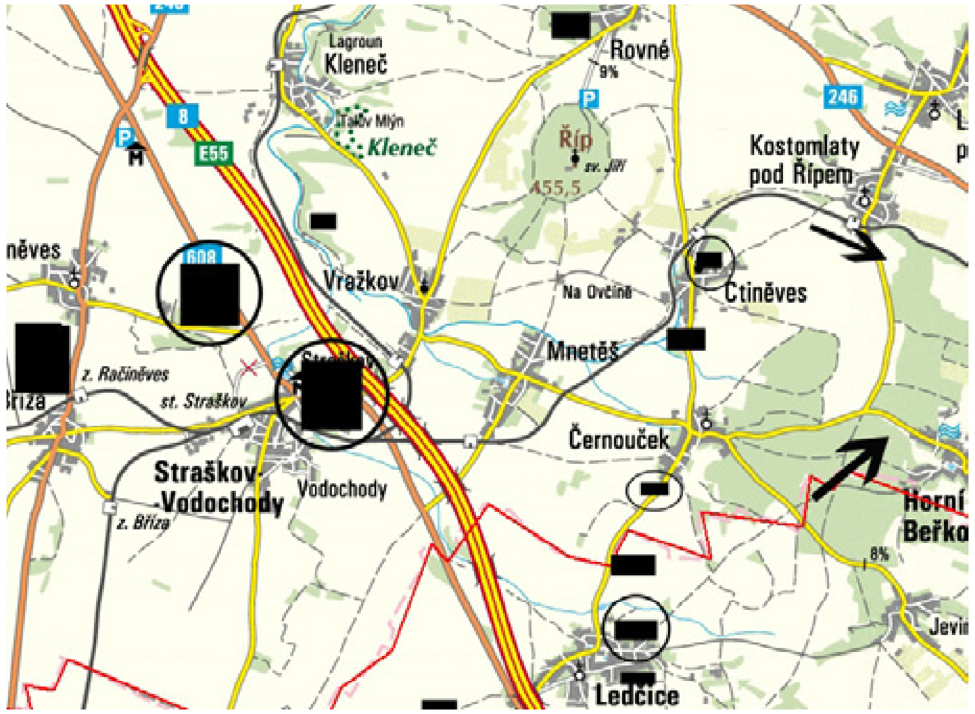


Fig. 3. Right: Distribution of areas with traces of prehistoric settlement identified during aerial reconnaissance in the landscape around the Hill Říp. The size of rectangles corresponds to the size of individual areas (in terms of quantity of features or number of sites). Circles around black rectangles mark areas in which ring ditches, some of them probably leveled barrows, have been identified.

In this sense, no alternative complementarity of remote sensing methods applied for archaeological prospection is as high as in the case of CAS and ALS. The aerial reconnaissance programme in Bohemia, carried out since the early 1990s by the Institute of Archaeology, Czech Academy of Sciences, has influenced (and in many respects also changed) ideas on prehistoric settlement forms and dynamics in the studied areas(Gojda ed. 2004). A thousand prehistoric to post-medieval sites, evidenced by CAS in the traditional, most intensively and continuously occupied Bohemian lowland settlement zone (situated in the valleys of the river Labe/Elbe and its tributaries), complement extensively the archaeological source/data base for that core territory of prehistoric Bohemia.

The existence of continuous settlement areas documented by large accumulations of cropmark features (datable to the post-Mesolithic era) has been confirmed by analytical field walking and surface artefacts collection campaigns. After the launch in 2010 of the first Czech ALS project by the University of West Bohemia, detection of earthworks in forested landscapes has started to reveal a highly valuable resource hidden in this kind of environment, including small forests located in the lowland zone (Gojda – John eds. 2013). Since then the complementary character of CAS and ALS in terms of site detection has begun to be tested.

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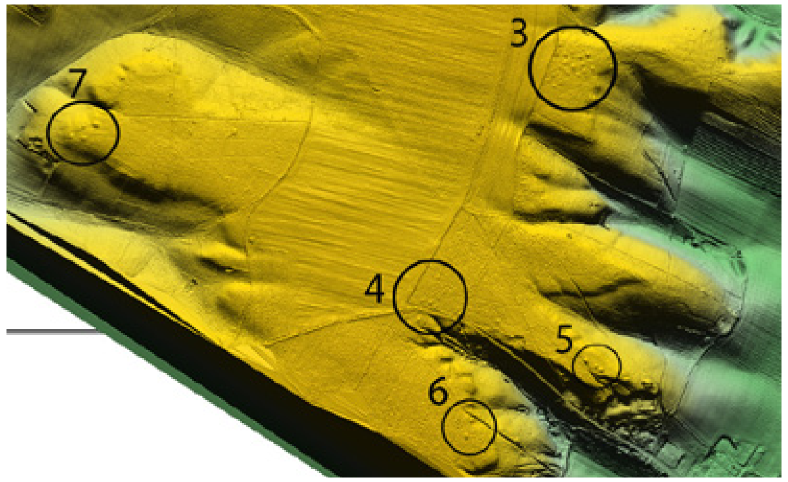


Fig. 4: 3D Surface DTM of the northern part of the Beřkovice Woodland with barrow groups 3 – 7.

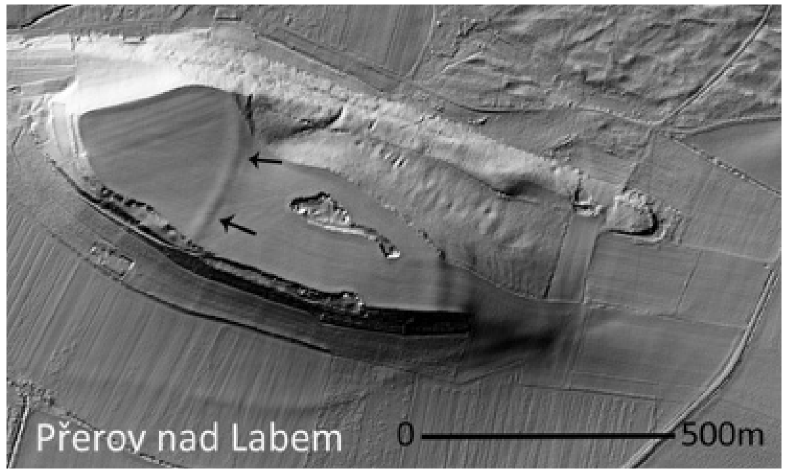


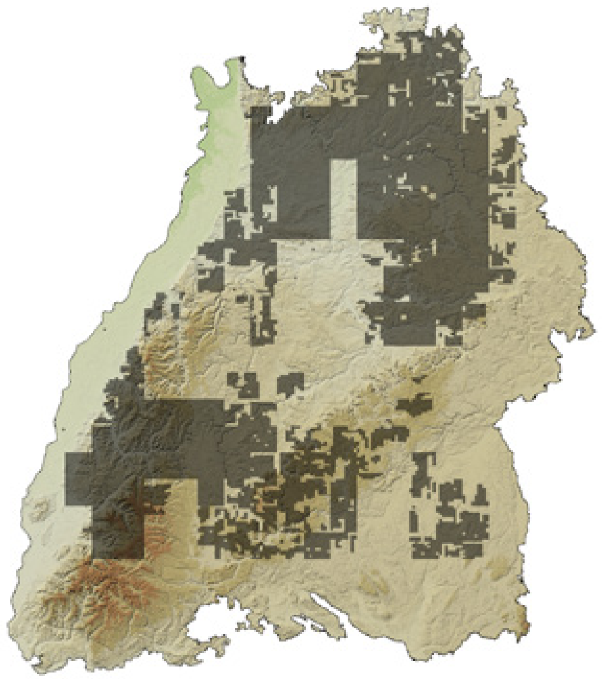
Fig. 5: Table plateau of the hillfort at Přerov nad Labem with the line of its former rampart.

Large area archaeological mapping and prospection using multiple LiDAR visualisation techniques: Challenges, results and implications for archaeological research and heritage management

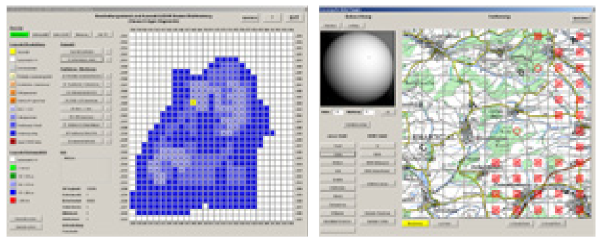
Ralf Hesse[1] / Jörg Bofinger[1]
1. State Office for Cultural Heritage Baden-Württemberg

Introduction

Since 2009, an ambitious project aims at the spatially complete archaeological mapping and prospection of the south-west German state of Baden-Württemberg (35,751 km²), using high-resolution digital elevation models based on airborne LiDAR (Bofinger and Hesse, 2011). LiDAR data offer the first opportunity for a systematic, full area coverage archaeological prospection largely irrespective of present-day vegetation cover. Tackling such a large project with very limited resources entailed challenges with respect to data management and processing and time-efficient workflows. The development of dedicated software for automated data processing and graphical user interfaces for data handling and mapping has made it possible to work with the large data volumes.



Overview map of Baden-Württemberg showing the progress of the project (dark areas still to be mapped as of January 2015).



Graphical user interfaces developed for handling large data volumes and for rapid mapping.

Visualisation techniques

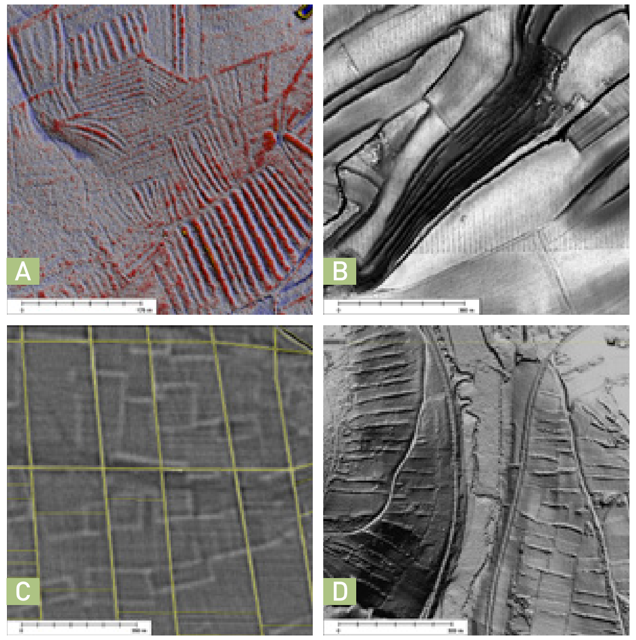
A key role in reaching high performance (in terms of both mapping speed and archaeological feature detection) has been played by the development and adoption for archaeological questions of multiple DEM visualisation techniques. At the start, only two visualisation techniques were used: Shaded Relief (Imhof, 2007) and Local Relief Model (Hesse, 2010). By 2015 the number of techniques used on a regular basis has risen to seven, now including Sky-View Factor (Zakšek et al., 2011), Local Dominance (Hesse, forthcoming), Laplacian of Gaussian (Mlsna & Rodríguez, 2005), Openness (Doneus, 2013) and Multi-Scale Integral Invariants (Mara et al., 2010).

Results

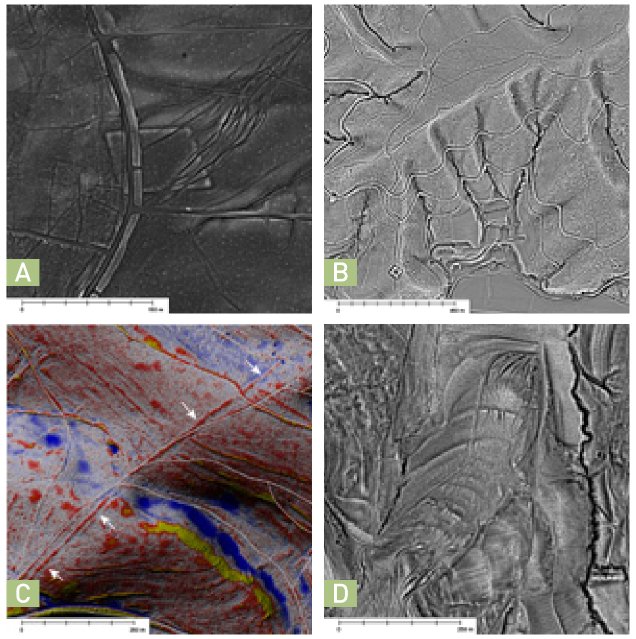
The application of multiple visualisation techniques has several benefits. As each technique has particular advantages and disadvantages depending on the type of archaeological relief feature and the topographic situation, their combination reduces the risk of overlooking features and facilitates correct interpretation. Furthermore, even very subtle relief features can be detected. As a result, on average approximately thirty archaeological features have been detected per square kilometre, including former field boundaries, hollow ways, mining traces, charcoal burning platforms, dams and mounds, but also Iron Age rectangular enclosures, Roman roads or medieval castle sites. The most numerous relief features relate to resource exploitation, mainly agriculture, mining and charcoal production.

Implications for archaeological research

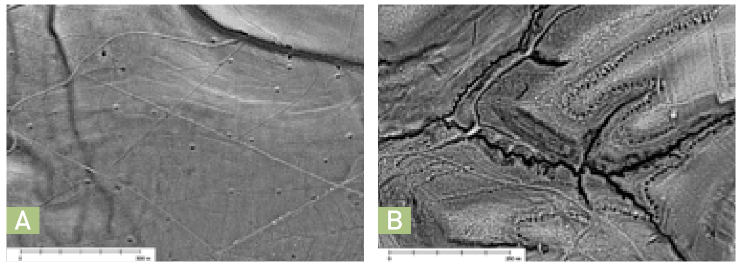
The results in general and the very high number of archaeological features in particular, have far-reaching implications for both archaeological research on one hand and heritage management and protection on the other. Verification and follow-up research of such large numbers of archaeological sites and features will pose considerable challenges.



Examples for field systems encountered in Baden-Württemberg: **(A)** ridge and furrow (colour-coded Local Relief Model overlaid over Shaded Relief); **(B)** terraced slopes (Sky-View Factor); **(C)** plough headlands (Local Dominance, current field parcel boundaries shown as yellow lines); **(D)** clearing cairns/ridges (Shaded Relief). ALS data © LGL Baden-Württemberg.



Examples for settlement/fortification and roads encountered in Baden-Württemberg: **(A)** Iron Age rectangular enclosure (Multi-Scale Integral Invariants); **(B)** early modern fortifications (Laplacian-of-Gaussian); **(C)** Roman road (colour-coded Local Relief Model overlaid over Shaded Relief); **(D)** hollow ways dissecting older agricultural terraces (Laplacian-of-Gaussian overlaid over Sky-View Factor). ALS data © LGL Baden-Württemberg.



Examples for traces of resource exploitation encountered in Baden-Württemberg: **(A)** charcoal burning platforms (Laplacian-of-Gaussian overlaid over Local Dominance); **(B)** medieval iron ore mining traces (Laplacian-of-Gaussian overlaid over Sky-View Factor). ALS data © LGL Baden-Württemberg.

As a complete verification of all mapped features (the estimated total number will be approximately one million) will not be possible, representative sampling strategies and well-targeted follow-up work will be necessary to assess the mapping results. In the field of archaeological research, the newly discovered sites and features may in some cases require the reassessment of previous notions of settlement patterns, resource exploitation and land use.

Implications for heritage management

In particular the very extensive traces of former field systems and hollow ways recognisable in LiDAR-DEM visualisations now afford landscape-scale studies. Such landscape perspectives will also require a rethinking of heritage management and protection practices: how can heritage protection and economic development coexist if the focus shifts from individual sites to entire landscapes? And in terms of the sheer numbers of archaeological sites and features detectable in large-area LiDAR data sets, how can heritage management and protection authorities develop (and justify on scientific and economic grounds as well as with regards to the significance to the local population) priorities for protection?

In other words: If archaeological features are ubiquitous and their destruction is an unavoidable part of economic development, how do we decide which sites to protect? Does the sheer number of sites devaluate the individual one? Is it better to focus the limited resources for protection on "iconic" rather than on "average" sites? How can the many newly discovered archaeological landscapes that have often remained almost unchanged under forest be protected in the face of increasingly mechanised forestry?

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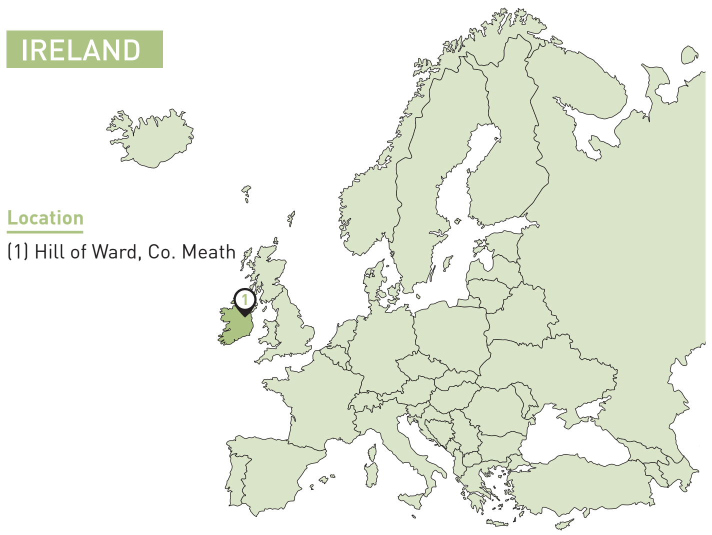
LiDAR and geophysical survey at the *Tlachtga*, Co. Meath, Ireland: A late Iron Age ritual enclosure

Stephen Davis[1] / Chris Carey[2] / Elizabeth Richley[3] / Cathy Moore[1] / Rena Maguire[4] / Susan Curran[1]
1. University College Dublin / 2. University of Brighton / 3. University of Southampton / 4. Queen's University Belfast

Introduction



Tlachtga is a quadrivallate hilltop enclosure located c. 2 km east of the town of Athboy, Co. Meath, Ireland **(Fig. 1)**. It is one of very few sites in Ireland with four defensive circuits of banks and ditches and is today occupied by the remains of a large earthwork, c. 150m in diameter.

It has been hypothesised to have late Iron Age affinities through comparison with sites such as the Rath of the Synods on the Hill of Tara. The site is closely associated in mythology with the druidic festival of Samhain, equivalent to modern-day Halloween: according to early Irish sources *Tlachtga* was a major religious centre where druids and priests would meet at this time to make sacrificial offerings and light fires.

On this evening all fires except the fire of *Tlachtga* were to be extinguished and rekindled from this place. Other monuments of similar status in Ireland are usually found within major ceremonial complexes; however, *Tlachtga* has until recently appeared to stand in isolation. Since 2010 multiple remote sensing methods have been applied to the site and its hinterland with an initial aim of determining whether this apparent isolation was an artefact of preservation or a genuine phenomenon. LiDAR survey now covers an area of c. 100km^2 centred on the Hill **(Fig. 3)**, with geomagnetic survey covering in excess of 30 ha **(Fig. 2)**. Selected areas of the central complex have also been surveyed using GPR and earth resistance. An area of raised mire at Bohermeen, 1km east of the site has been subject to pollen analysis to provide environmental context to the site **(Fig. 4)** and in summer 2014 a first season of excavation was undertaken, specifically to provid information on the chronology of the complex sequence of development evident in the geophysical surveys.

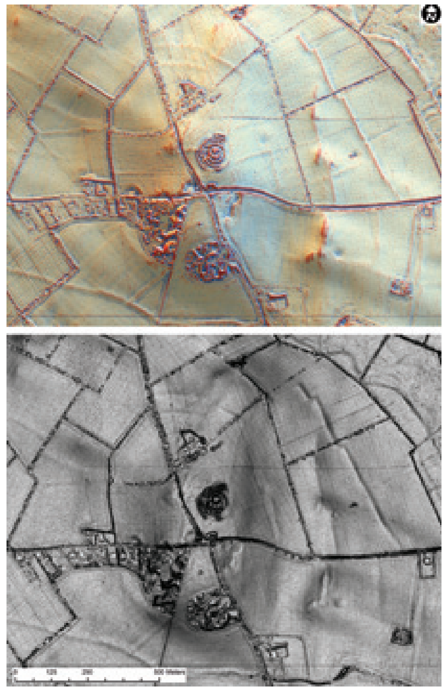


Fig. 1: **Top:** *Tlachtga* Local Relief Model overlain on multi-direction hillshade; **Lower:** Sky-View Factor image.

Fig. 2. **Top:** *Tlachtga* under excavation, summer 2014 (Image courtesy Korec Ltd.); **Lower:** Geomagnetic survey in the immediate area of Tlachtga.

Remote sensing at *Tlachtga*

Both LiDAR and geophysical surveys **(Fig. 2; 3)** have focused placing the monument within a landscape context. *Tlachtga* has been shown to partially overlie a much larger (195m) enclosure with at least three closely-spaced ditch circuits, a combined circumference of c. 2500m. A smaller enclosure (c. 40m in diameter) is apparently respected by the current monument and enclosed by the earlier, larger phase. Such closely-spaced multivallation is considered to be a late Iron Age innovation in Ireland, implying that the two large enclosures may have been constructed in relatively quick succession. To the east of the hill at least two approaches to the summit have been identified, one of which is clearly associated with a later medieval farm complex which itself appears to overlie early medieval field systems. To the north of the hill at least three ring-ditches have been identified, associated with a possible coaxial field system.

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Palaeoenvironments and excavation

Excavation in summer 2014 explored some features identified through geophysical survey, revealing a series of rock-cut enclosures. Initial 14C dating suggests that the southern enclosure was infilled contemporary with the construction of the outer portion of *Tlachtga*, c. 450 cal. AD. The larger enclosure was decommissioned c. 400 cal. BC, suggesting the earliest phases of *Tlachtga* might have been constructed shortly after this. Pollen analysis shows that this is an exceptionally active period within the *Tlachtga* hinterland, with significant charcoal peaks and overall reduction in woodland cover. This is apparently followed by a period of heightened human activity within the catchment, then a period of reduced activity in the centuries either side of the year zero, reflecting the so-called Late Iron Age Lull evident in many Irish pollen diagrams. Further excavation and geomagnetic survey are planned in 2015 in an effort to further constrain the chronology of features identified through remote sensing.

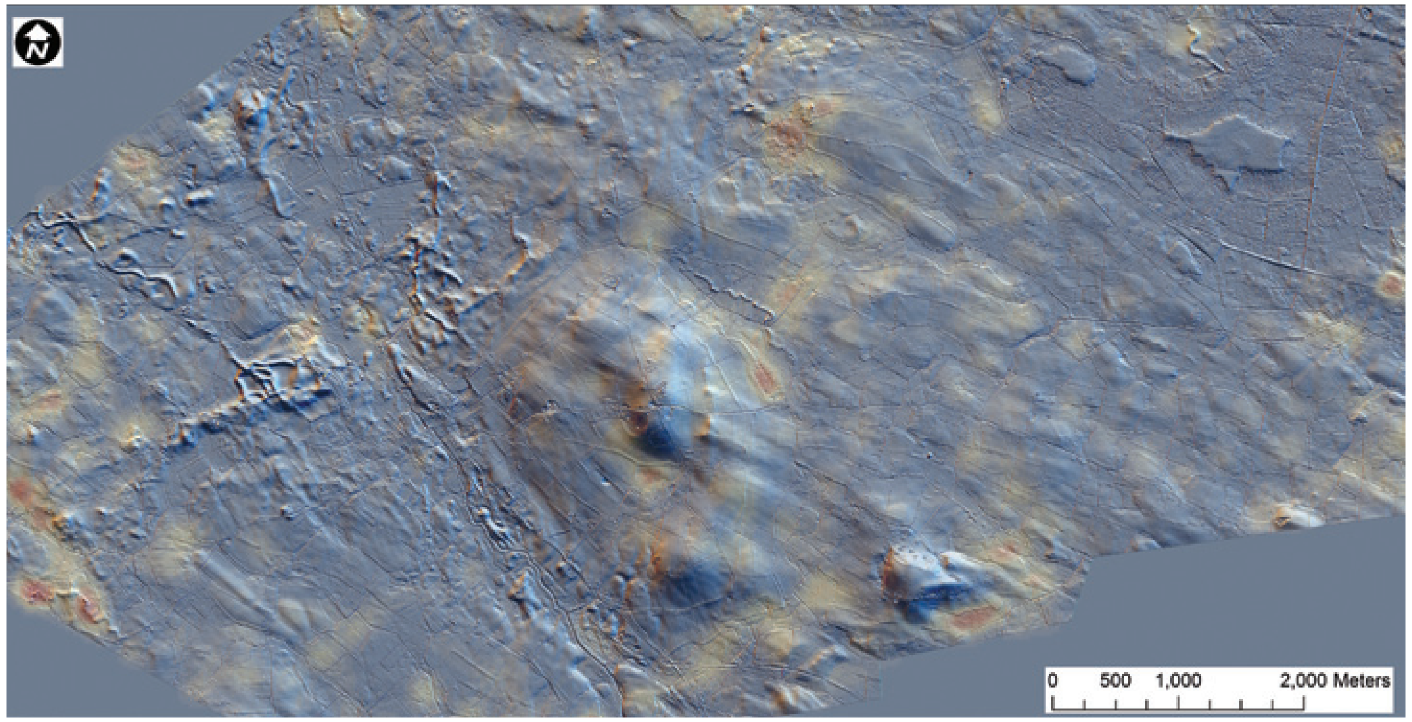

Fig. 3: Full LiDAR extent centred on the Hill of Ward. Overlain with line-density kernel function, highlighting areas of high archaeological potential.

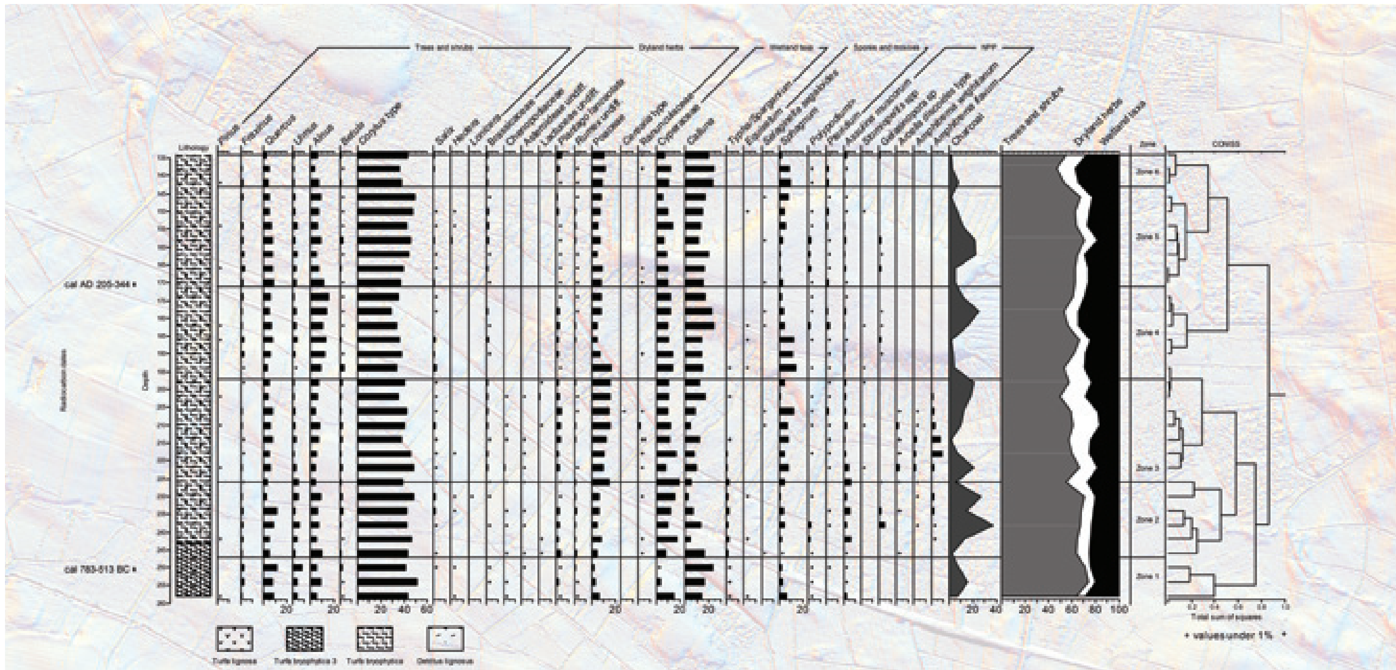

Fig. 4: Selected taxa percentage pollen diagram, Jamestown Bog, Co. Meath (Analyst: Rena Maguire).

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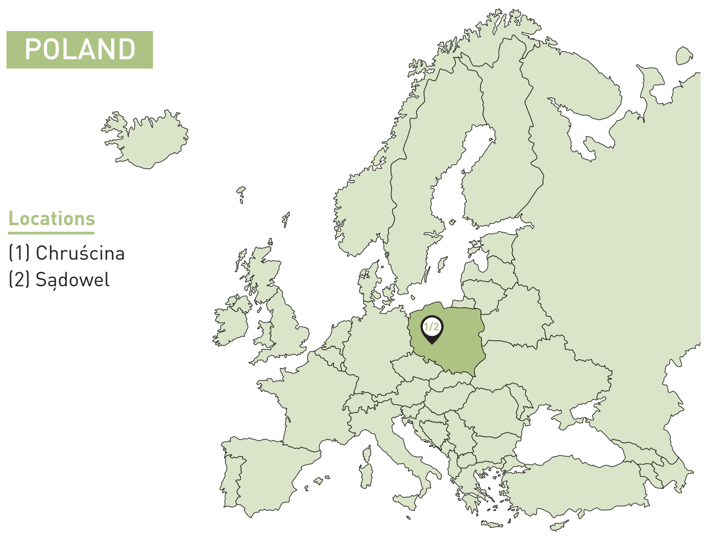
Past landscapes and contemporary cultural identities. Social role of non-invasive archaeological methods

Grzegorz Kiarszys[1]
1. Szczecin University, Department of Archaeology, Poland

Introduction

The results of modern non-invasive archaeological methods can be visualized in a very persuasive way. Yet they are rarely used in Poland in the wider social context, remaining an object of interest restricted to professional and academic use. In my paper I argue, that non-invasive methods can also be useful for popularizing archaeology, and widening the awareness of historical places in local societies.

The research project 'The remains of medieval strongholds in the cultural landscape of the Góra district (Lower Silesia Region)' (financed by the Polish Ministry of Culture, coordinated by the National Heritage Board of Poland and supervised by G. Kiarszys, with the aid from ArcLand) aims to restore the social memory of cultural heritage sites.



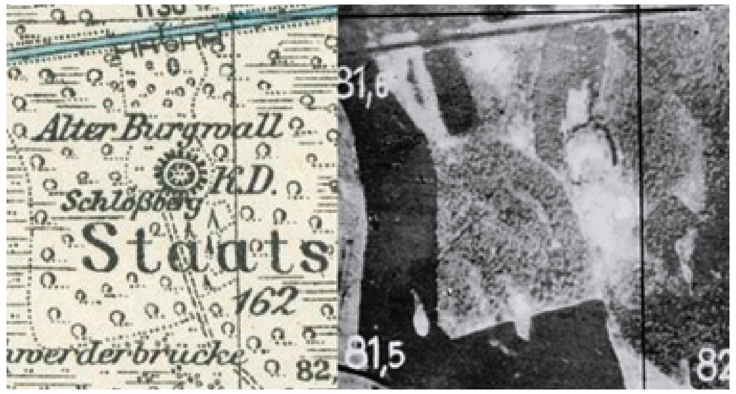


Fig. 1: Early medieval stronghold from Chruścina (district Góra, Lower Silesia Region). Comparison of a fragment of the Messtischblatt map and a fotomap from 1930s © TARA.

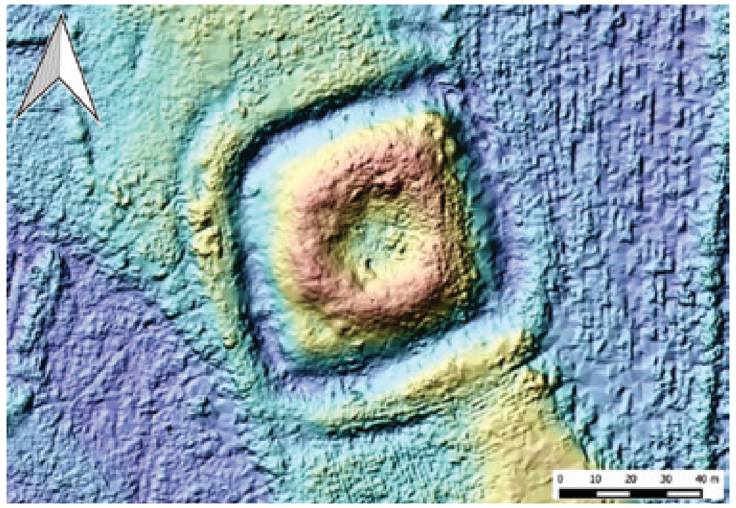


Fig. 2: The early medieval earthwork from Chruścina. A combination of colour-coded *Digital Terrain Model* and *Hill Shaded Relief model*, processed from Airborne Laser Scanning, shows clearly the well preserved archaeological monument (Author G. Kiarszys, © Szczecin University).

The studies focus on the relics of early medieval strongholds and late medieval motte castles located in the region. These features are often considered as mysterious objects of anthropogenic origin. However, their original purpose and cultural value is seldom recognized by the local community.

This research is an attempt to suggest a way of communicating the archaeological record to a wider public. Application of such methods as aerial photography (both archival and contemporary), Airborne Laser Scanning, magnetometry and historical cartography can be valuable, not only for professional archaeological landscape studies, but also in the process of construction of a narrative about the biography of specific archaeological features.

Relatively low historical awareness in western Poland results from the historical context of those territories. After the end of World War II, due to decisions made at the conferences in Yalta and Potsdam, the eastern part of the Third Reich was put under Polish administration. The local German population was replaced by Polish settlers from the eastern and central territories.

Post-war reality in western Poland caused the meaning of archaeological and historical monuments to be devalued. Polish citizens, resettled to the western territories, perceived the landscape as 'alien' or 'German'. After the horror of war they were unable to recognize the heritage sites or imagine their abstract value and identify with it. In their eyes the landscape of 'Regained Territories' didn't have any past or tradition worth acknowledging and commemorating.

Historical and archaeological monuments were not seen as their property. On the other hand, the communist ideology was about creating the new social order; it exploited the past for political reasons, developing interest only in specific archaeological sites, for example those related to the early Polish Piast monarchy. Such archaeological sites could later be used in the discourse of propaganda and to justify border shifts after WW II.

Along with the disappearance of archaeological earthworks from the Polish topographical maps, they also vanished from the awareness of the local population, losing their cultural value. The consequence of that process had a great impact on the contemporary perception of cultural heritage in western Poland.

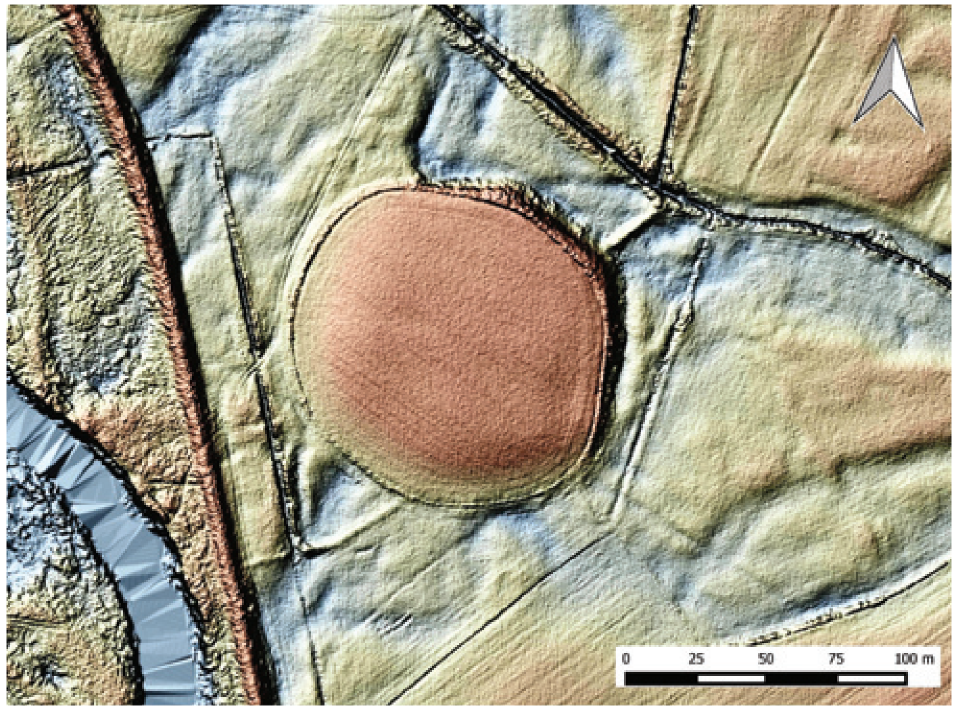


Fig. 3: The remains of an early medieval stronghold from Sądowel (district Góra, Lower Silesia Region). A combination of colour coded *Digital Terrain Model* and *Hill Shaded Relief*, processed from Airborne Laser Scanning (Author G. Kiarszys, © Szczecin University).

Archaeological sites can be valued due to their physical form and state of preservation, as well as their chronology or relationship with historic events that are considered to be important. As soon as such a place is identified as significant, it starts to play a part in contemporary social discourse, receiving a new cultural context. This can be created in relation to different roles such as education, or becoming an active part of the construction of social identity etc.

Non-invasive methods can produce a persuasive and aesthetic background for such discourse. Restoring the memory of archaeological heritage sites in the region, with the aid of a properly constructed narrative and images of specific monuments, can revive the imagination of local society and fill in the empty places with stories being told once again.

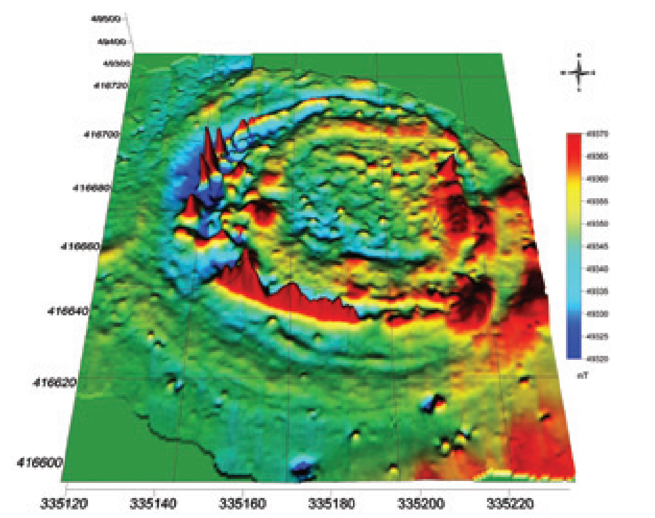


Fig. 4: Early medieval stronghold from Sądowel. The results of magnetometry. The image indicates that after the early medieval stronghold (circular anomaly) was burnt down its earthworks were used to establish a motte castle (rectangular structure located within the relics of early medieval feature (Author W. Matkowski, © Szczecin University).

Fig. 5: The artistic reconstruction of the early medieval settlement in Sądowel. The meeting of Dukes Henry IV Probus, Henryk V the Fat, Premislaus II of Greater Poland, and Henry III of Głogów on 9th of February 1281 (Author Dariusz Bufnal, © Szczecin University).

Remotely sensed past: A study of multi-temporal historic aerial photos and ALS-generated DEMs in retrospective monitoring

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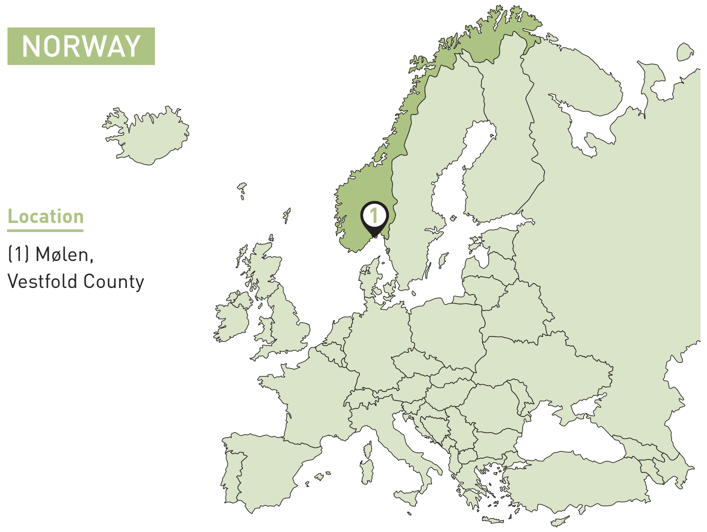
Introduction

In this study we have looked at the usefulness of multi-temporal historic aerial photos and Airborne Laser Scanning (ALS)-generated Digital Elevation Models (DEMs) for retrospective monitoring in a cultural heritage landscape. Our objectives were:

- Is it possible to document previous alterations?
- What are the strengths and weaknesses of different approaches?
- What would be the most fruitful approach to monitor future changes?

A vulnerable grave field site, including several hundred pebblestone cairns from the iron-age, was chosen as a case study area. It is a highly valued and popular site with many visitors. Thus changes are expected to occur rapidly.



Aerial photographs

A visual, manual approach in an ArcGis software was used to compare the photographs. Changes down to the decimetre level were marked, and the character of change described in a table (if something was added, removed or the features reshaped). Pro: This approach provides detailed information about the location and distribution of changes, and the nature of change e.g. stones moved or vegetation growth was usually easy to see, due to the colour information in the photograph. Con: it is time-consuming, and there is a likelihood of human error.

DEMs produced from ALS

Digital Surface Models (DSMs) from 2008 and 2010 were chosen for comparison. A standard automated change detection tool in the Quick Terrain Modeler software were set to detect changes ≥ 10cm. Pro: change of volume is quantified, it is time-efficient, provides detailed height information and exact positioning. Con: changes detected depend on parameter settings. Changes in vegetation cover could easily be mistaken for being changes to the cultural heritage. Some of the detections could arise from differences in data quality between the two datasets, not real changes. Compared to aerial photography, which shows colour variation, change was harder to assess on the models as they only provide surface shading.

Archive studies

Museum archives, papers and books were studied, searching for descriptions of changes to the site and in the landscape surrounding the cairns. Finds were listed in a table. Pro: many changes were described which were not detected on photographs or models. The cause of alterations was usually described. Written texts provided information about periods when remote sensing was not available. Con: Studying written sources is time-consuming, and detailed information about the location and extent of changes was often not available.

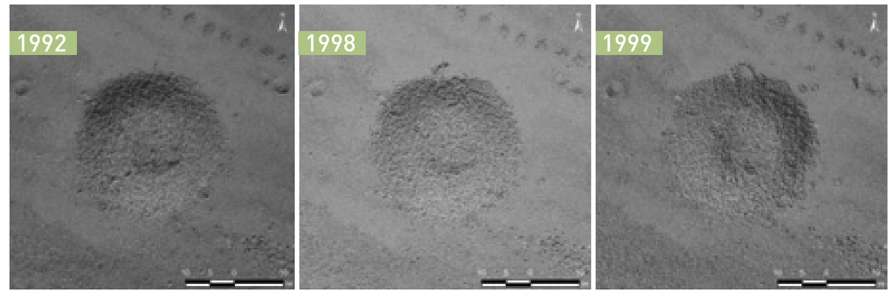
DEMs generated from historic aerial photography

A series of aerial photos from 1968, 1979 and 1999 was used. DEMs were produced from the photos by the following process: approximate georeferencing using manually measured control points in the Match-AT photogrammetric software. A dense point cloud was generated using Match-T DSM, for final georeferencing Least Square Matching was utilised. The final digital surface models (0.25m grid) were interpolated by the method moving planes. These models were compared to ALS datasets from 2008 and 2010. Seven difference models were created using the OPALS software. Pro: detailed information about the location, extent and volume of changes through 45 years. The possibility to provide the same information from historic aerial photographs as from LiDAR- generated DSMs. Con: this is a time- consuming, technically advanced approach including several procedures done in different software. A limiting aspect is that only DSMs can be generated, not Digital Terrain models (DTMs).

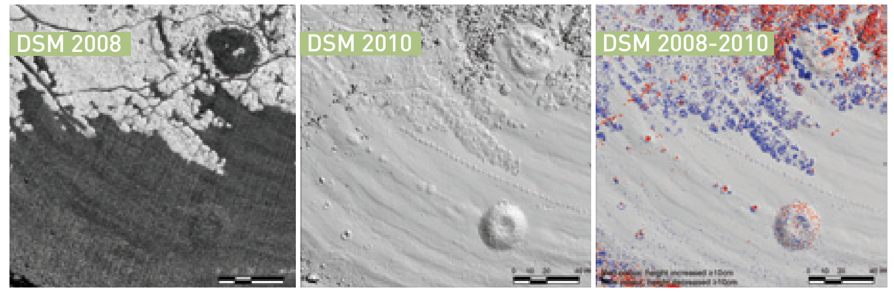

LARVIK MORGENAVIS
Lørdag 3. september 1949
Hærverk på Mølen i Brunlanes
De fredede røysene utsatt for ødeleggelse


Ødeleggelsene på Mølen av stort omfang
De militære har „pløyet opp" området med tunge lastebiler
En vet hvem som har fjernet steinen - vedkommende har brukt den til et nytt fjøs og en låvebru

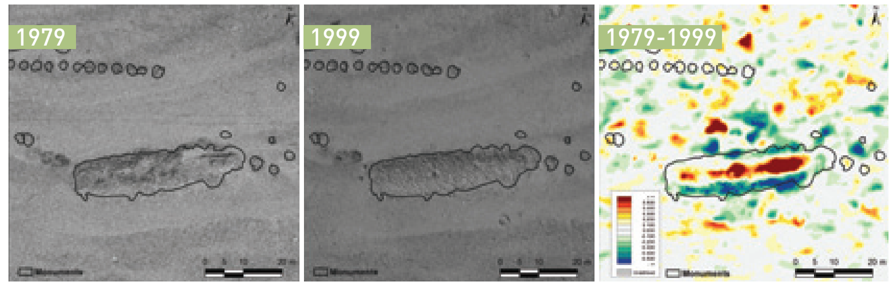
Museum archives, papers and books were studied, searching for causes of changes.



Aerial photos were studied manually and compared in order to detect changes.



DSMs were produced based on ALS. The models were compared using an automated "detect changes" tool.



DSMs were built from a series of historic aerial photo. By comparing these DSMs to DSMs generated from ALS, several difference models were created.

Conclusions

These studies have demonstrated how retrospective monitoring can benefit from the use of historic remote sensing data, by comparing either conventional aerial photos, aerial photos transformed into digital elevation models or ALS-generated DEMs. Aerial photographs, elevation models derived from laser scanning/aerial photographs and written sources provide different kind of information and the choice of method(s) in monitoring projects should be guided by the aim of the monitoring program, and the sources available.

Mølen is a vulnerable cultural heritage site with several hundred pebblestone cairns from the iron-age.

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Remote sensing archaeology on the outskirts of Europe

Ole Risbøl[1] / Alma Elizabeth Thuestad[1] / Stine Barlindhaug[1] / Elin Rose Myrvoll[1]
1. NIKU – Norwegian Institute for Cultural Heritage Research

Introduction

Remote sensing offers great opportunities to identify and map archaeology in various landscapes (Doneus and Briese 2011). This possibility is met with ever growing interest amongst archaeologists as methods and techniques are improved especially concerning data resolution. It is a huge challenge for both archaeological research and cultural heritage management that only a small proportion of archaeological remains and sites are mapped and listed in national cultural heritage databases (Risbøl 2013). This is in many cases most conspicuous in peripheral areas with sparse population and limited development activities like the Cap of the North. In a study located to the very far north of Europe we have examined how satellite images and Airborne Laser Scanning (LiDAR) can contribute to a better overview of the archaeology in this region.

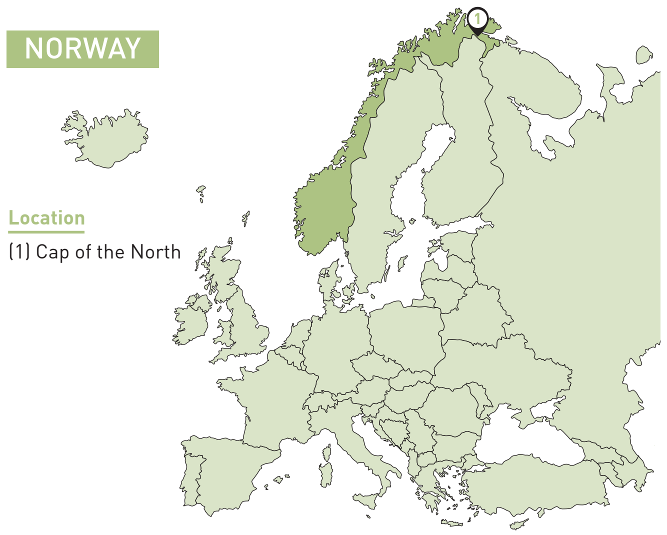

Fig. 1: A map showing the geographical location of the case study area.

Fig. 2: A photo showing the morainal landscape with extensive wetland areas and sparse vegetation.

The Cap of the North is the region situated north of the Arctic Circle in Norway, Sweden, Finland and Northwest Russia (the Kola Peninsula). Like the rest of Northern Europe, this area was gradually settled by humans as land emerged following the retreat of the ice cover at the end of the last ice age about 11-12,000 years BP. The region's archaeological material dating from the final millennium BC onwards shows clear evidence of Sámi cultural elements. The Sámi people and their way of life have consequently left their mark on the landscape for more than 2,000 years. The Cap of the North is a vast area equivalent to one third of the Nordic countries' landmass, but it has always been very sparsely populated; even today it contains only 5% of the Nordic population.

Numerous traces of past settlements, human burials and a diverse range of resource exploitation are found in this region. Resource exploitation is most prominently apparent in the form of activities connected with reindeer catching and hunting – and for the last five hundred years – reindeer husbandry. Sites with turf huts, hearths, stone-built graves, hunting hides and pitfalls for catching reindeer are found in large numbers in this region. Due to environmental (vast outfield areas) and demographic (sparsely populated) circumstances many of these archaeological remains and sites are still visible and appear to be comparatively well preserved.

Utilizing a case study area of 30 square kilometres in the very north of Norway, we have studied how satellite images and LiDAR can contribute to the identification of archaeological features, both independently and in combination **(Fig 1).**

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Risbøl, Ole. 2013. "Cultivating the 'wilderness' - how LiDAR can improve archaeological landscape understanding". In Interpreting archaeological topography. 3D data, visualisation and observation, edited by Rachel S. Opitz and Dave C. Cowley, 51-62. Oxford: Oxbow Books.

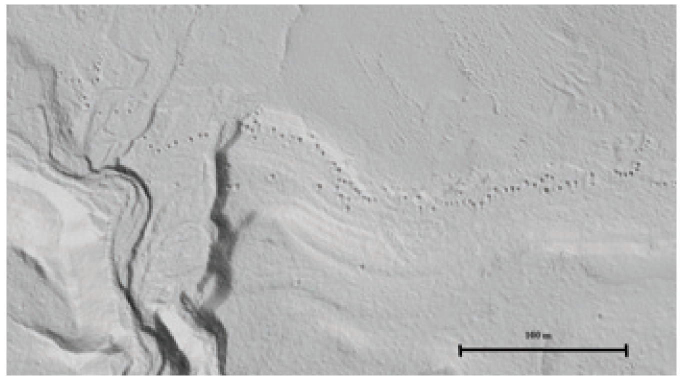


Fig. 3: A LiDAR generated digital terrain model showing a section of pit falls in the case study area.

The study area comprises a 15 kilometre-long transect through the landscape, from an inland river to a coastal fjord, and captures a range of different cultural remains and sites. This landscape is characterized by extensive marshy tracts combined with moraines and forest-covered plains. The trees are mainly small birch trees and the vegetation mainly grass and reindeer lichen **(Fig. 2)**. By far the most dominant archaeological features are pitfalls used for catching reindeer. These are found in clusters across the landscape and can be counted in the hundreds. In addition quite a lot of house sites are found in the area as well as a few other remains like stone circles and mounds.

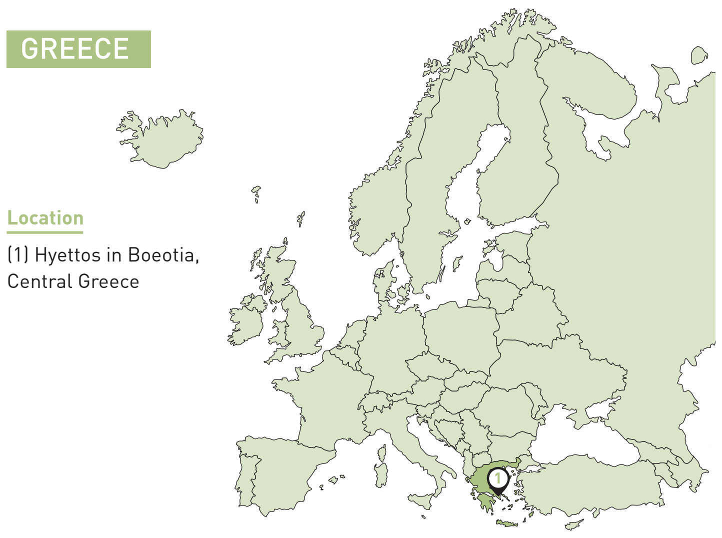
How these appear in the landscape – and thus to what degree they are identifiable by remote sensing – relates to a series of different circumstances, like their morphological characteristics as well as their environmental context. In addition the character of vegetation at the sites affects the visibility of cultural features. The present study has contributed new knowledge about the pro and cons of using satellite images and LiDAR-generated 3D models with the purpose of identifying and mapping cultural heritage in this specific region **(Fig. 3).**

Scouring the surface and peering beneath it at the ancient city of Hyettos, Boeotia, Greece

Apostolos Sarris[1] / John Bintliff[2]
1. Laboratory of Geophysical - Satellite Remote Sensing and Archaeoenvironment (GeoSat ReSeArch Lab), Institute for Mediterranean Studies, Foundation for Research and Technology, Hellas (F.O.R.T.H.), Rethymno, Crete, Greece / 2. Department of Archaeology, Edinburgh University, United Kingdom

Introduction

Traditional intensive surface survey techniques were coupled with extensive geophysical techniques with the aim of reconstructing the infrastructure of the 26-ha Greco-Roman city of Hyettos in Boeotia, Central Greece. The geophysical methods focused on the areas of the archaeological site where the highest density of ceramics has been recorded, considered to mark the maximum built-up area of the ancient town.



Satellite remote sensing **(Fig. 1)** and aerial photography were employed to image any anthropogenic features in the wider landscape of the archaeological site, whereas more detailed information was acquired via the employment of ground based geophysical techniques, such as ground penetrating radar (GPR), electrical resistivity tomography (ERT), electrical resistance mapping and magnetic techniques.

The synthesis of the geophysical results clearly demonstrated the importance of the manifold geophysical strategy to survey the area of Hyettos, especially due to high levels of noise that influenced the magnetic and GPR measurements. Magnetic measurements were able to pinpoint 2 extensive (6-8m x 65m) prominent magnetic anomalies **(Fig. 2)**, right below the acropolis of the site, that most probably have been caused by magnetic ores, known to exist in the region since a reference by the Elder Pliny, and which drove years of ferrous mining activities in the area during the past century. Dipole-Dipole and Induced polarization ERT measurements above these anomalies indicated that they are caused by highly magnetized bodies, buried at depths of 0.9-2m below the ground surface.

A number of rectangular buildings were revealed by the GPR survey mainly in the central area of the settlement. The buildings have a similar orientation to the rest of the grid of the city and their strong signal indicates a good degree of preservation. Large architectural complexes appear also on the plateau to the south of the acropolis. These are in good correlation to linear anomalies (possibly ancient streets) found in the same area, extending in E-W or S-N directions and suggesting that the planning of the city reaches the foot of the acropolis.

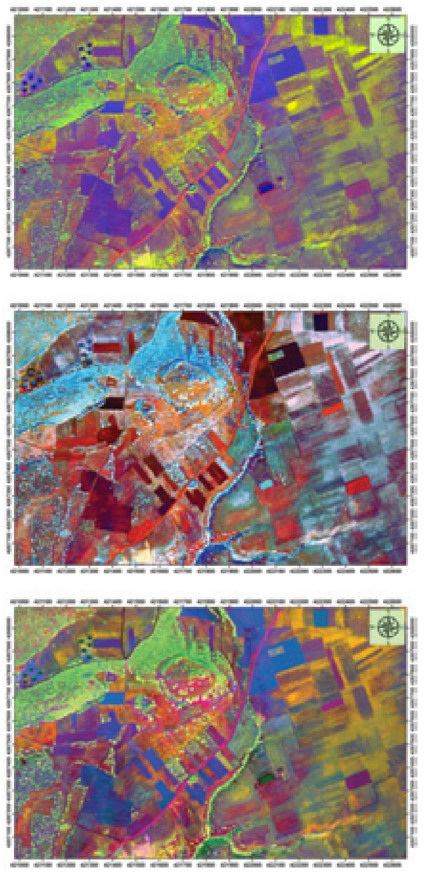


Fig. 1: Results from satellite remote sensing image processing. **Top:** Tasselled Cap filtering, **Middle:** Intensity – Hue – Saturation (HIS) filtering, **Lower:** PCA Analysis.

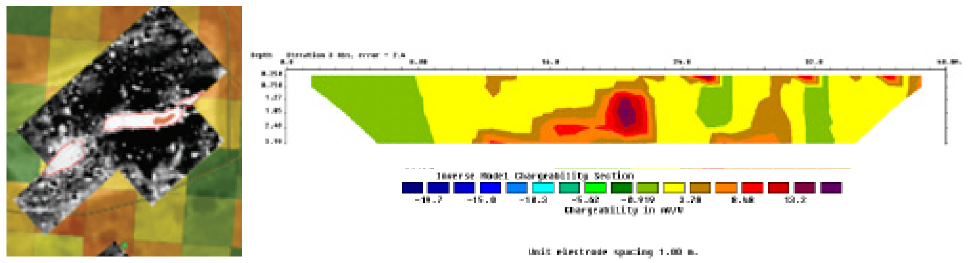


Fig. 2. Left: The two magnetic anomalies that were attributed to the magnetic ores. **Right:** the results of the ERT measurements pinpointing a number of high resistivity anomalies related to the eastern magnetic anomaly.

A few more GPR reflectors were identified above the asphalt road and the area of the churchyard in the south of the urban site. A total area of more than 40,000 square meters was covered by electrical resistance techniques **(Fig. 3)**, which proved to be the most suitable for reconstructing the urban network of Hyettos.

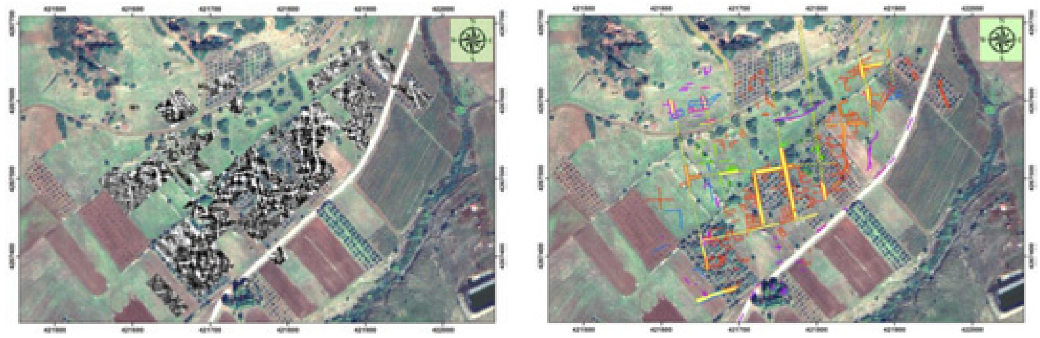


Fig. 3. Left: Combined results of the soil resistance mapping and ERT surveying at Hyettos. **Right:** Integrated diagrammatic interpretation of the geophysical anomalies that were registered by all the geophysical anomalies at Hyettos and a representation of the suggested road/grid plan of the ancient city.

Building complexes either consisting of simple rectangular walls or more complicated divisions, almost all of which are aligned in a S-N/E-W direction, were clearly identified. Long linear anomalies aligned in a S-N and E-W directions were also identified as streets. To the south, the S-N streets are about 38m apart, but they start deviating as they are extended to the north, towards the slopes of the acropolis. Some of the long linear street sections are traced for more than 93m and correspond to the main pathways leading to the entrances of the acropolis. A total of about 8 S-N roads and 6 E-W streets were revealed through the combination of all the geophysical techniques, making it possible to reconstruct the city's grid and the street plan **(Fig. 3)**.

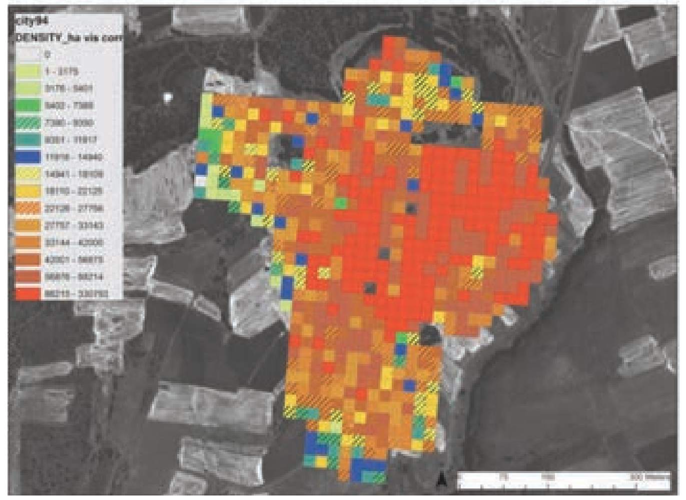


Fig. 4: Surface ceramic densities corrected for visibility at Hyettos (E. Farinetti).

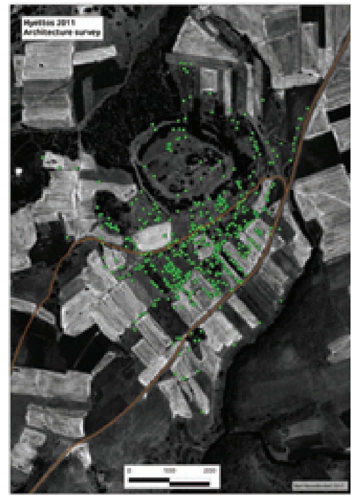


Fig. 5: Mapped surface architecture at Hyettos (B. Noordervliet and J. van Zwienen).

It becomes evident that the city plan reaches the foot of the acropolis and expands within an area of at least 300x300m, whereas the magnetic susceptibility measurements indicate a further expansion of the habitation to the east and south. The geophysical surveys that were carried out in various seasons were accompanied by a hands-on training module for students and theoretical seminars. The workshops were oriented towards Geophysics, Remote Sensing Techniques and Ground-Based Digital Recording Methods for Archaeological Sites and Cultural Landscapes and were able to provide a thorough and in-depth training to graduate, PhD and Postdoc students.

It is important to add that the practical training course for postgraduates during which this research was achieved included students with and totally without prior scientific training, although all had a background in archaeology or ancient history. Nonetheless, a combination of practical experience in operating all the geophysical and related devices in the field, and laboratory training in statistical and computer analysis of the resultant data, allowed all the student participants to achieve a very successful and enjoyable degree of skill in non-destructive scientific approaches.

This was noted not only by the training staff but also confirmed by the extremely positive student feedback on the courses themselves. In archaeological terms, the combination of high-resolution ceramic survey in a grid of 670 units, usually 20x20sqm, gave a clear density focus (marked in red) to mark the built-up area in the maximum extension of the town in Classical to Hellenistic times (from dated surface ceramics) **(Fig. 4)**, and this allowed the geophysics team to focus on the urban infrastructure. The site also has remarkable amounts of surface architecture, which can now be related to the street and insula plan revealed by the geophysics with the intention of separating public and private domestic buildings **(Fig. 5)**.

Sensing the material remains of the forgotten Great War in Poland. Sensibly or sensationally - The dilemma in front of presenting results of the Airborne Laser Scanning visualisations

Anna Zalewska – Principal Investigator of the Project[1] / Grzegorz Kiarszys – Member of the Project's Team[2]
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2. Szczecin University, Department of Archaeology

Introduction

The research project "Archaeological revival of memory of the Great War. Material remains of the life and death in trenches of the Eastern Front and the condition of the ever changing battlescape in the region of the Rawka and Bzura (1914-2014)" (implemented by The Institute of Archaeology and Ethnology, Polish Academy of Sciences, financed by The National Science Centre Poland and supervised by Anna Zalewska) aims to restore the social memory of World War I through archaeological studies of the material remains of the front established between December 1914 and July 1915.

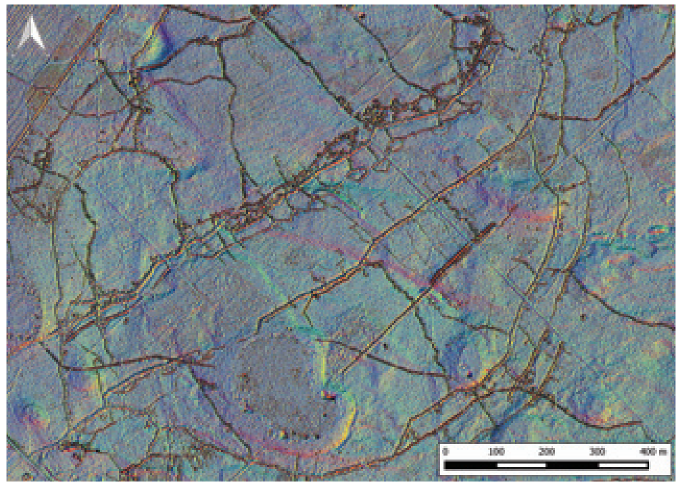
Currently the memory of the Eastern Front of World War I is being marginalised in Poland. This refers to the research, education and mass media. The social awareness of the bloody conflict that emerged a century ago was gradually replaced, over time, by that of the wars that followed.

POLAND

Location

(1) Bolimow, No Man's Land

The archaeological excavations on No Man's Land, close to Joachimów Mogity, where significant numbers of human remains were found (2014).



No Man's Land of the Eastern Front in Bolimow Municipality. LiDAR Visualization SVF+PCA+DTM (colour coded).

Poles on the fronts of World War I

We estimate that about 80.000 soldiers died during the Battle of Rawka and Bzura. Among them were many Poles. Also the local inhabitants were adversely affected. In total about 3,5 million Poles fought in World War One, more than 400,000 Poles were killed and 800,000 were injured fighting for the three empires. How many of them lost their lives near Bolimow remains unknown. We think it fitting to revive the memory of all those who suffered, and lost life and normality, during 1914 and 1915 in the Eastern Front.

The Battle of Rawka 1914-1915

The Battle of Rawka fought in 1914 and 1915 was among the bloodiest engagements of World War I on the Eastern Front. The tragic uniqueness of this encounter is partially due to the fact that it was the place where the Germans resorted to chemical weapons as they found themselves unable to breach the Russian defences in any other way. For the first time, on 31 January 1915 close to the Rawka River, the Germans deployed on a massive scale chemical agents (irritant and tear gases).

The attempt was seen as unsuccessful by the perpetrators. Soon, lethal chlorine was released in the form of a poisonous cloud from thousands of cylinders: on 31 May, on 12 June and on 6/7 July 1915. Each use of the poisonous gases in the area of Bolimów was the climax of that drama, which caused harm to the thousands of soldiers from both sides, as well as to the local civilians and natural environment.

The landscapes of conflict

The Great War left its bitter marks in the valleys of Rawka and Bzura Rivers along with various material traces of the past events. Application of Airborne Laser Scanning allowed us to identify many kilometres of trenches, numerous dugouts, shell and mine craters, graves of unnamed soldiers etc. All those objects are scattered throughout the countryside along the former front lines.

The field verifications and test excavations exposed a great number of finds, also human remains that had not been formally buried. Results of the first stage also raised questions about the contemporary value of the former battlefield and its social and scientific status and significance. Should it be just another forgotten battlefield or a socially active warning (!) – a material testament to the atrocity of war, including chemical warfare?

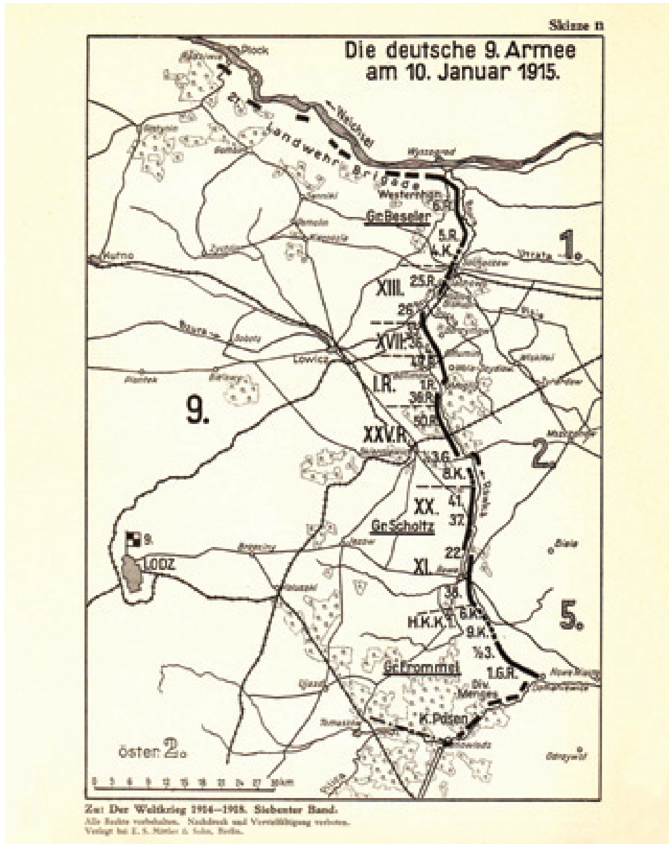
Presenting the research results to the wider public. Sensibly or sensationally?

Archaeological studies of the material remains of everyday life, fights and survival in the front lines from 1914 and 1915 can shed a light on the stories of individual people. The outcomes of our survey can be valuable and persuasive to the general public. However, in the shadow of the research remains a specific threat.

The former battlefield attracts not only tourists interested in the unique cultural and natural landscape of Rawka region, but unfortunately also destructive 'militaria collectors' driven by the desire of finding personal belongings of the fallen soldiers. Thus, the results of the research must be presented in the most reasonable and sensible way, to preserve the uniqueness of these material witnesses of WWI in the Eastern Front.

German soldiers marching through a village in the Polish Kingdom (1915). From the private collection of Anna Zalewska and Jacek Czarnecki.

German soldier in gas mask in the trench (model 1915). From private collection of Anna Zalewska and Jacek Czarnecki.



German map with the course of the front line in January 1915.

The potential of LiDAR visualisations for the identification of archaeological features in the Prignitz

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Introduction

The Prignitz is a 3000 km² region in the state of Brandenburg in north-eastern Germany (Fig. 1). The region is rich in archaeological sites. Archaeological relief features date from Bronze Age to modern. The most prominent of them are the large Seddin burial mound and several clusters of smaller mounds. To complete the record of archaeological relief features and to improve the understanding of the landscape in which they are embedded, high-resolution DEMs based on airborne LiDAR provided by LGB Brandenburg are analysed. The available data set has a resolution of one metre.

GERMANY

Location
(1) Prignitz region, Brandenburg

Visualisation techniques and archaeological features

Multiple visualisation techniques are used, including Shaded Relief (Imhof, 2007), Sky-View Factor (Zakšek et al., 2011), Local Relief Model (Hesse, 2010), Openness (Doneus, 2013), Local Dominance (Hesse, forthcoming) and Laplacian of Gaussian (Mlsna and Rodriguez, 2005; Hesse, forthcoming). Depending on the archaeological relief features to be detected and the surrounding natural topography, each visualisation technique has particular advantages and disadvantages. For example, Sky-View Factor was found to work particularly well to visualise topographic depressions and features on slopes while Local Dominance was found to work well to visualise very low relief features on plains. Thus, the complementary use of multiple visualisation techniques results in a more complete record and a more reliable interpretation of archaeological relief features.

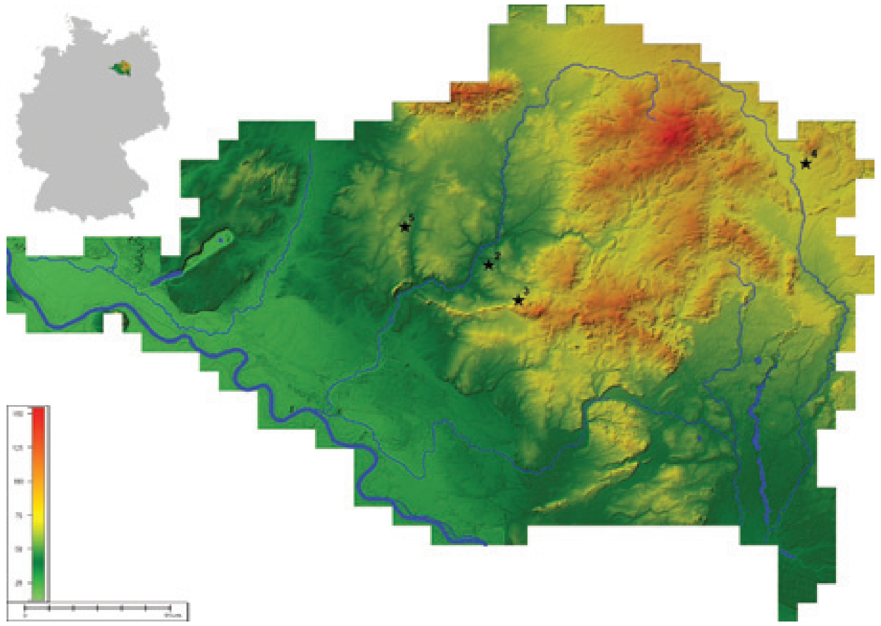

Fig. 1: Overview map of the Prignitz region with location of the examples. ALS data ©GeoBasis-DE/LGB /2013/.

Archaeological relief features that have been identified include burial mounds, fortifications, settlements, ridge and furrow, but also material extraction pits as well as traces of WW II and the Cold War. **Fig. 2** shows the site of a previously unknown settlement visible due to the surrounding radial field structures typical for the medieval German colonisation of the region. The low relief radial field structures are clearly visible in the Local Dominance visualisation. Some of them can also be seen in the Shaded Relief image; however, their visibility strongly depends on the chosen illumination azimuth. Interrelations of anthropogenic and environmental processes during the past centuries are clearly seen in the aeolian erosion of and incipient dune building on ridge and furrow **(Fig. 3)**.

It is, however, not possible to decide whether the abandonment of fields was due to aeolian erosion or vice versa. Edges are highlighted in the Laplacian of Gaussian image while relative topographic highs and lows are clearly shown in the colour-coded Local Relief Model (blue for negative, red and yellow for positive relief features). The combination with a Shaded Relief image greatly improves readability of the landscape and archaeological features.

In many cases, we are looking at a truly multi-temporal, "messy" landscape (cf. Mlekuz, 2013). **Fig. 4** shows a cluster of probably Bronze Age burial mounds that is still visible despite multiple phases of anthropogenic overprinting: Traces of an early field system with slightly raised field boundaries are in turn overprinted by two phases of ridge and furrow, the earlier of which ran roughly north-south while the later ran southwest-northeast. The most recent anthropogenic relief features in this example are modern quarries, ditches and forestry roads. While the combination of colour-coded Local Relief Model with Shaded Relief also proved efficient in this case, an even better visibility and understanding of the multiple land use phases is afforded by the Local Dominance image.

Small topographic depressions (cf. Hesse et al., submitted) are very common features in the Prignitz region (likely several thousand; **Fig. 5**). In most cases, their function was probably material extraction for field improvement, although some are kettle holes. These features are clearly visible in several visualisations, including Shaded Relief, Sky-View Factor and Local Dominance. Analysis of the Prignitz LiDAR data set is ongoing. The application of multiple visualisation techniques will be an integral part of this work.

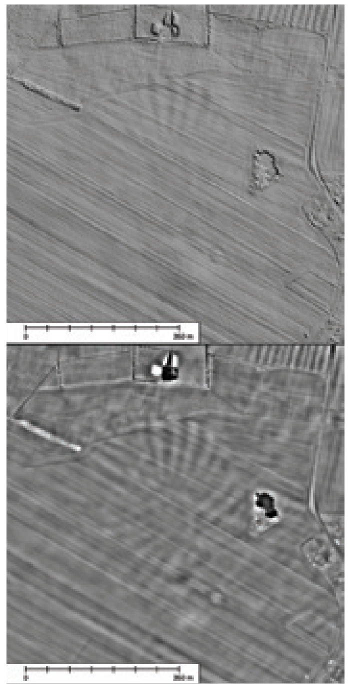

Fig. 2: Medieval settlement. **Top:** Shaded Relief, **Lower:** Local Dominance. ALS data ©GeoBasis-DE/LGB /2013/.

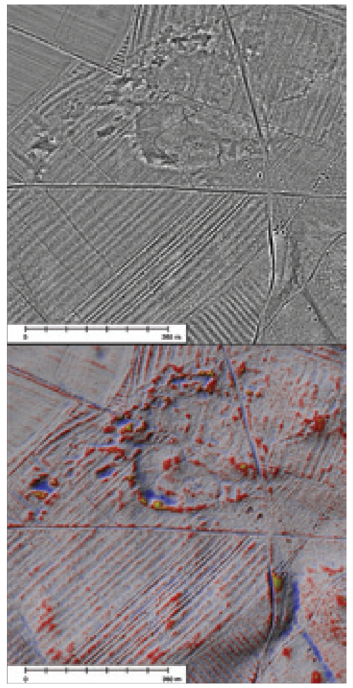

Fig. 3: Ridge and furrow with traces of aeolian erosion and deposition. **Top:** Laplacian of Gaussian, **Lower:** colour-coded Local Relief Model overlaid over Shaded Relief. ALS data ©GeoBasis-DE/LGB /2013/.

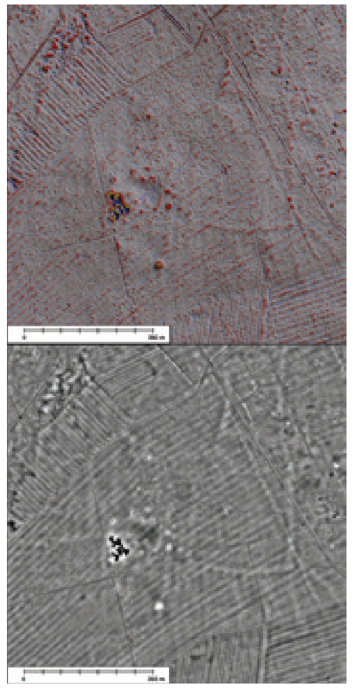

Fig. 4: A multi-temporal archaeological landscape with Bronze Age burial mounds, at least three phases of field systems and modern quarries, ditches and forestry roads. **Top:** colour-coded Local Relief Model overlaid over Shaded Relief, **Lower:** Local Dominance. ALS data ©GeoBasis-DE/LGB /2013/.

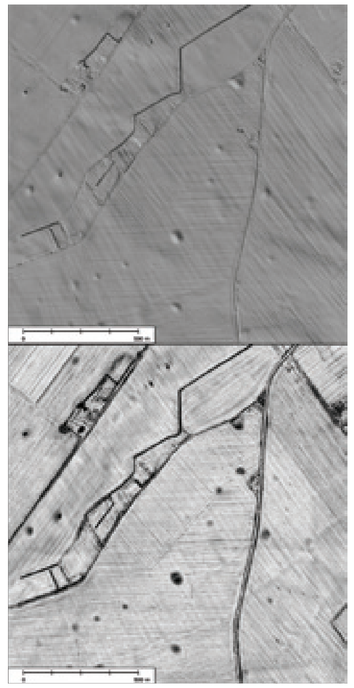

Fig. 5: Extraction pits. **Top:** Shaded Relief, **Lower:** Sky-View Factor. ALS data ©GeoBasis-DE/LGB /2013/.

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Visualization of LiDAR raster DEMs: Guidelines and tools

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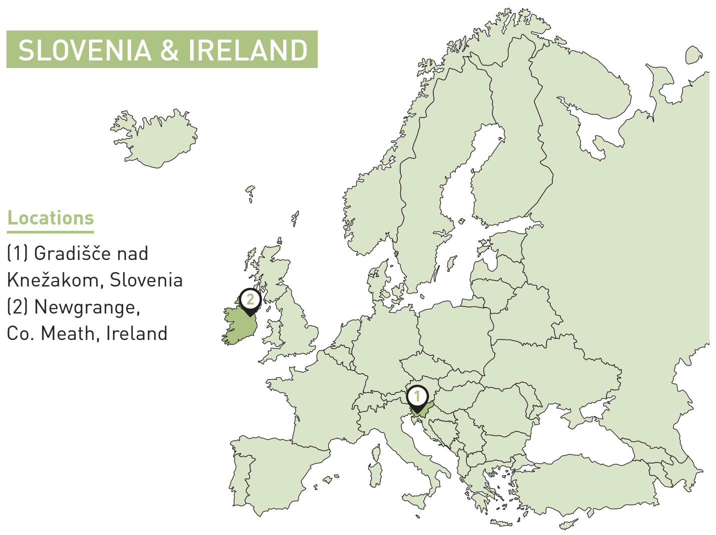
3. State Office for Cultural Heritage Management Baden-Wuerttemberg

Introduction

Various terrain visualizations help scientists determine the characteristics of terrain morphology. A range of techniques is implemented in the free LiVT and RVT software toolboxes.



Visualization guidelines

Recognition of natural and anthropogenic microrelief features on detailed terrain models is of paramount importance for the observation of numerous processes and events. We have therefore prepared a guide to good practice in visualization of Airborne Laser Scanning raster data and have supplied the community with tools that support the fast production of different visualization types for scientific exploration. The aim of the guide is to help both specialists and the interested public to produce or to ask for such LiDAR products that will facilitate 'reading and exploring' the landscape for meaningful information.

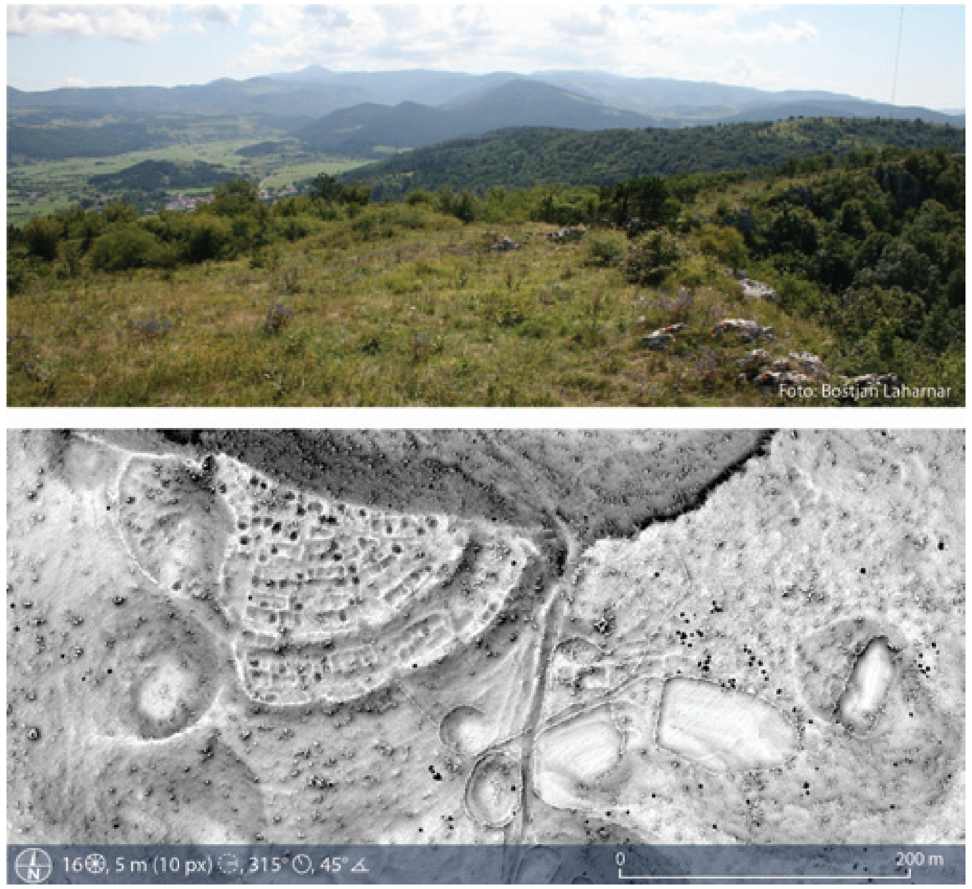


Fig. 1: Gradišče nad Knežakom hillfort from the first millennia BC was once a central settlement in the Pivka area (Slovenia). It sits on top of a ridge **(in the centre of the top image)** and is today totally covered by impenetrable forest. An anisotropic Sky View Factor visualization of LiDAR derived terrain model reveals the ramparts and inner structure of the settlement **(Lower image)**.

The guide provides insights into several visualization techniques, their specifics, advantages and weaknesses in the context of investigation and interpretation of various types of historical and modern, cultural and natural, small-scale landscape structures. It also explains why a knowledge of the processing techniques and visualization methods used for archaeological interpretation is important, sometimes critical, if we want to produce identification maps and interpretations with quantifiable reliability.

Some visualization techniques produce results that can be related to physical quantities (e.g. sky-view factor – SVF, and local relief model – LRM) while others only have a presentational value (e.g. principal components of hillshading from multiple directions). Some work better on an almost flat terrain (elevation differentiation), or topography with gentle slopes (LRM), while others are better for rugged or mixed terrain (SVF).

The value of the techniques for exploration varies significantly with respect to the characteristics of the structures observed; their size, shape, orientation, concavity or convexity, degree of prominence, and edge type. Not all methods can be recommended for interpretation when relative or absolute comparisons need to be judged. This is because most can change the observable properties of structures, depending on the settings used in the calculation. The guide presents a series of strategies to assist selection of the preferred visualization technique for structures of various shapes and sizes, set in varied landscapes. Often the answer is not definite and commonly a combination of techniques has to be used to map a very diverse landscape.

Fig. 2: Visualization techniques are applicable to raster elevation data from different sources (e.g. produced with airborne or terrestrial LiDAR scanning, Structure-from-Motion photogrammetry, or structured light scanning), various scales (continental, regional, local), and for observation of a range of entities (landscape, site, object). The images show a photograph **(Top image)** and Sky View Factor visualization **(Lower image)** of one of the richly decorated kerbstones from Newgrange World Heritage site in Ireland.

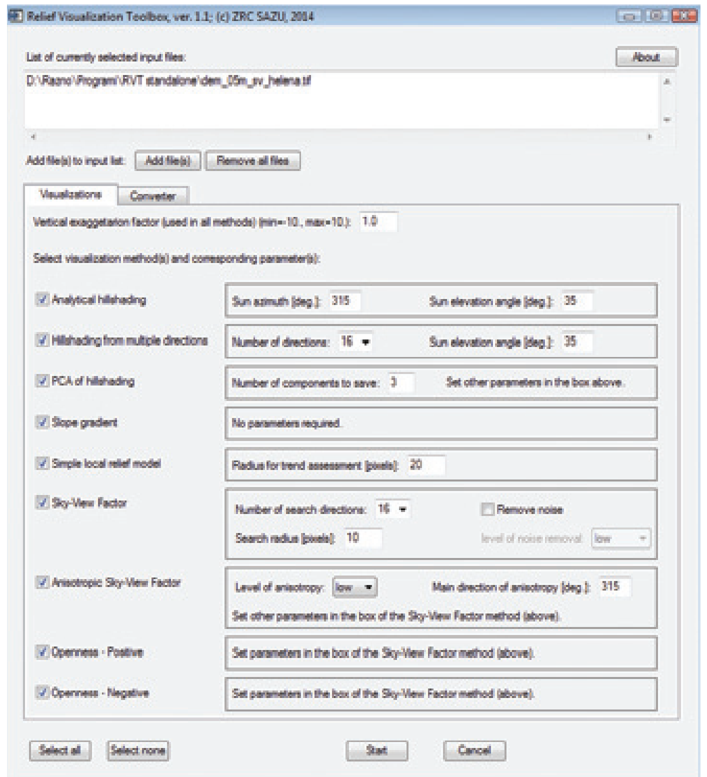


Fig. 3: RVT offers a range of only the best techniques with just the essential options. It is extremely easy to use and can process multiple files and all techniques in one go.

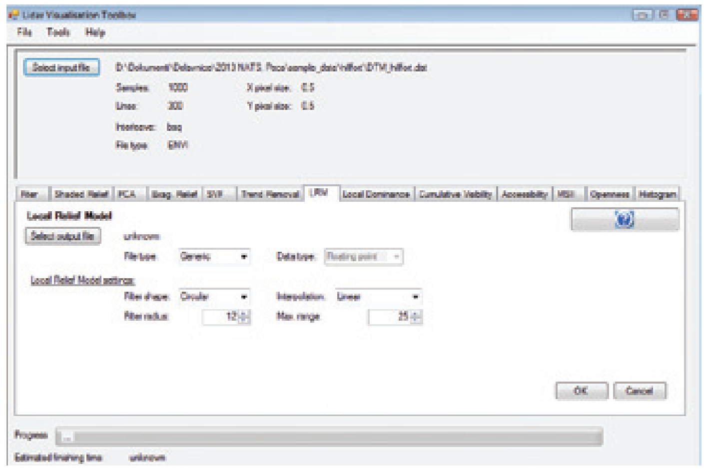


Fig. 4: LiVT supports calculation of more techniques with intricate options to manipulate the settings.

Tools

Researchers have only very recently been able to benefit from free software for the calculation of advanced visualization techniques. The LiDAR Visualization Toolbox (LiVT) and Relief Visualization Toolbox (RVT) are both free, easy-to-use applications to create visualisations from high-resolution digital elevation data derived either from aerial laser scanning (LiDAR) or structure-from-motion photogrammetry. The first is aimed towards more advanced users with some knowledge in data processing and geographic information systems, while the second is tailored also for those new to relief interpretation. LiVT offers a range of techniques, from simple hillshading and its derivatives, to local relief modelling, sky-view factor, openness, and local dominance, with settings for intricate manipulation. RVT has a narrower range of methods and includes only those proven effective for the detection of small scale features, with limited settings and default values set to do this task. Simplified results of RVT can be viewed in non-GIS software and the tool also supports elevation raster file data conversion. It is possible to convert all frequently used single band raster formats into GeoTIFF, ASCII gridded XYZ, Erdas Imagine file and ENVI file formats.

3D MODELLING OF AN HISTORICAL BUILDING USING GEODETIC AND GEOPHYSICAL METHODS: ST. GEORGE'S CHURCH, SVÄTÝ JUR, SLOVAKIA / ARCHIVING GEOPHYSICAL SURVEY DATA FROM THE BRÚ NA BÓINNE WHS, CO. MEATH, IRELAND / DISCOVERIES THROUGH REMOTE SENSING: INVESTIGATING LATE PREHISTORIC SITES IN EASTERN IRELAND / EXPLORING AERIAL ARCHIVES AND NON INVASIVE PREHISTORIC SETTLEMENT PROSPECTION IN LITHUANIA / NEW REMOTE SENSING AT THE DOWTH ESTATE, BRÚ NA BÓINNE WHS, IRELAND / OWIECZKI: CONSTRUCTING THE ARCHAEOLOGICAL LANDSCAPE / PROSPECTING METHODS IMPLEMENTED WITHIN THE ARCLAND PROJECT IN THE YEARS 2010-2014 – SLOVAKIA

Contributions on:

GEOPHYSICAL SURVEY

3D modelling of an historical building using Geodetic and Geophysical methods: St. George's Church, Svätý Jur, Slovakia

Jaroslava Pánisová[1] / Igor Murín[2] / Jana Haličková[3] / Peter Brunčák[3] / Roman Pašteka[2]
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Introduction

The Gothic Church of St. George, located in Svätý Jur (Fig.1a), is an important example of Slovak cultural heritage. In the framework of the OPIS project this historical monument was recorded using laser scanning (Riegl VZ-400 terrestrial laser scanner) combined with precise geodetic surveying (Fig. 3). The aim of the geophysical survey was to identify potential subsurface anthropogenic features inside the church.

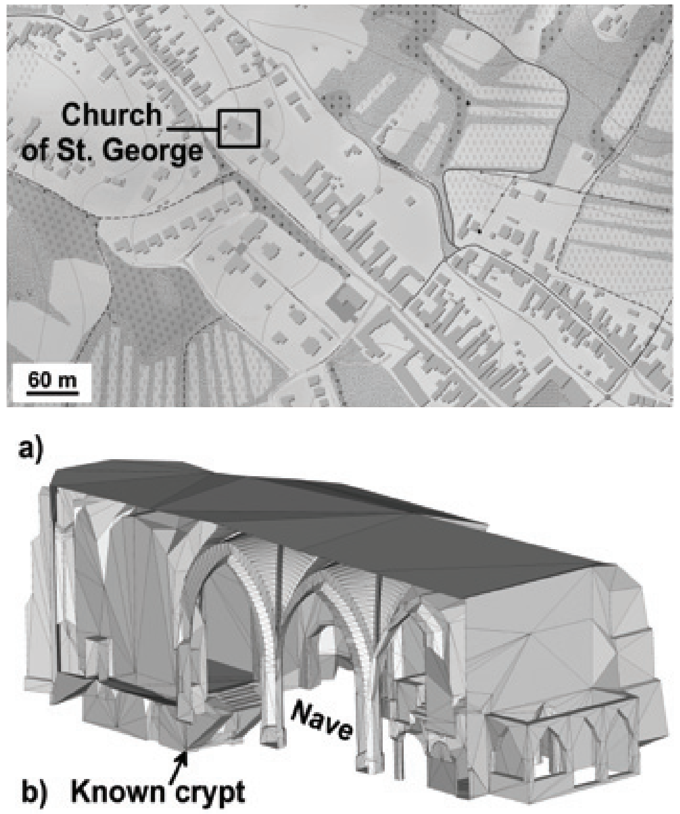

Fig. 1 (a) Location map of the St. George's Church in Svätý Jur. **(b)** Simplified model.

Microgravity and GPR methods were applied. The interior of the church was surveyed on a closely spaced grid of 351 stations **(Fig. 2)** using Scintrex CG-3M and CG-5 gravimeters. GPR survey was carried out along 34 parallel lines 0.2m spaced in zigzag mode over an area of 6.5×14m. A MALÅ system with a 500 MHz antenna was used, allowing a good penetration depth of up to 3m. To correct the gravity data for the gravitational effect of the massive edifice (average density of 2.2g/cm³) a simplified polyhedral model was created, neglecting architectural details and the roof **(Fig. 1b)**.

Results from the geophysical measurements shed light on the architectural history of the church. Three crypts, predicted from historical archives, together with the west wall foundations of the Romanesque construction were detected. Combined GPR and density modelling helped to construct a spatial model of these cultural features, which is now integrated into the visualization of the visible parts of the church **(Fig. 3, left)**. Comparing its similarities and differences can help to achieve a more accurate image of the subsurface features **(Fig. 3, left down)**.

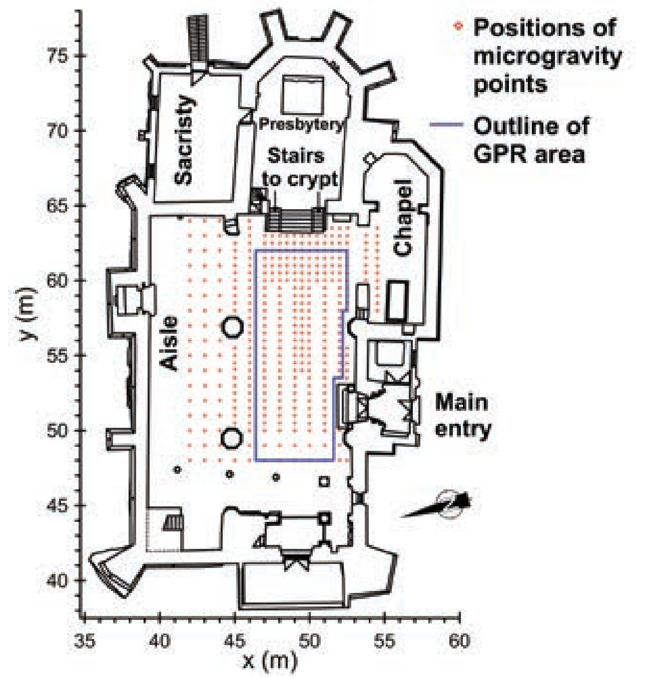

Fig. 2: Positions of microgravity and GPR profiles in the church interior.

Due to the ambiguity in gravity field interpretation the geometry of the modelled crypts has to be verified by drilling or archaeological excavation. This case study highlights the benefits of a multidisciplinary approach to sense the present and past of our historical monuments and thus contribute to their documentation for future generations.

Geophysical results

Microgravity results are displayed in **(Fig. 4)**. In the residual Bouguer anomaly map calculated for a correction density of 2.4g/cm³ the main anomalies of interest are two distinctive gravity lows **(A–D)** in the upper part of the nave **(Fig. 4a)**. To estimate the depth and size of anomalous sources **(Fig. 4b-d)** the following methods are used: density modelling, Euler deconvolution (structural index one) and harmonic inversion. The harmonic inversion provides a volume density model calculated for preselected densities. The cavities **(A–C)** were modelled as three polygonal prisms of an arched cross-section with a density contrast of −2.4g/cm³. The depth to the volume of these cavities is interpreted in the range of 0.5–2.3m. **Fig. 4b** shows a reasonable fit between the calculated and observed gravity.

The collected GPR data were processed by applying a standard steps sequence to improve its quality. From the diffraction hyperbola analyses EM-wave velocity was estimated to 0.1m/ns. Then time slices were generated **(Fig. 5a)**. Subsequently the data were processed and visualized into isosurface volume **(Fig. 5d)**. Finally a three-dimensional vector model was created **(Fig. 5e)**. **Fig. 5** shows the GPR horizontal depths slice sequence where several features **(A–E)** are clearly identifiable **(Fig. 5a)**. The GPR vertical depth sections in **Fig. 5b-c (Profiles A and B)** show reflection patterns indicating the top part of crypts **(A, B and C)** at a depth of around 0.6m (10–12ns).

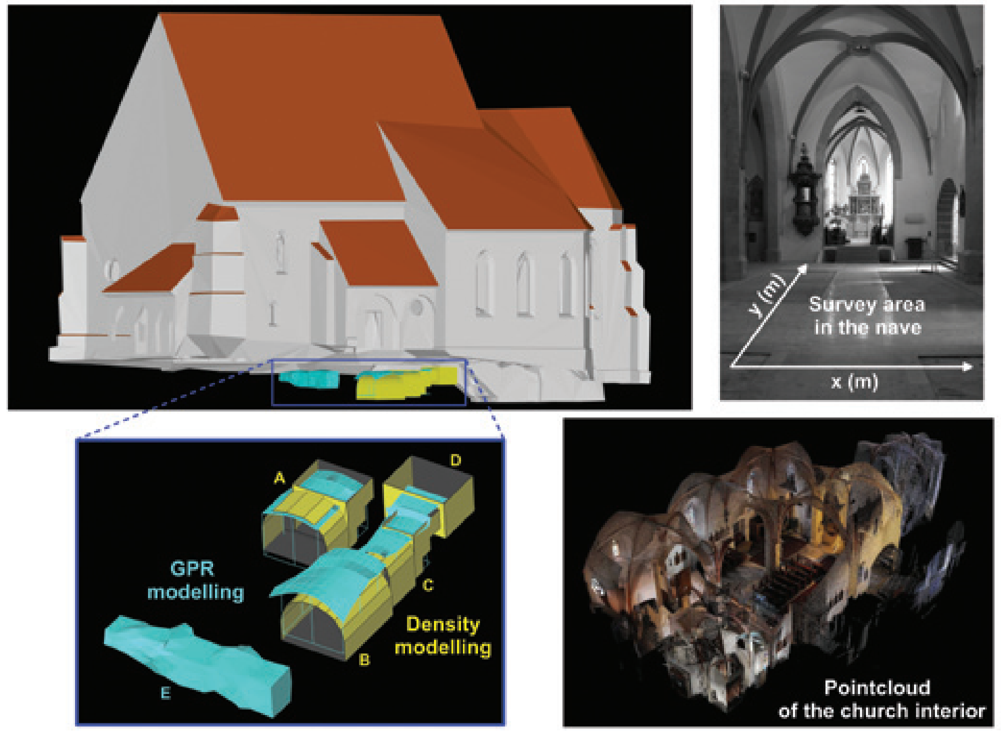

Fig. 3: Three-dimensional models of the religious building with a detailed view of subsurface structures and the interior.

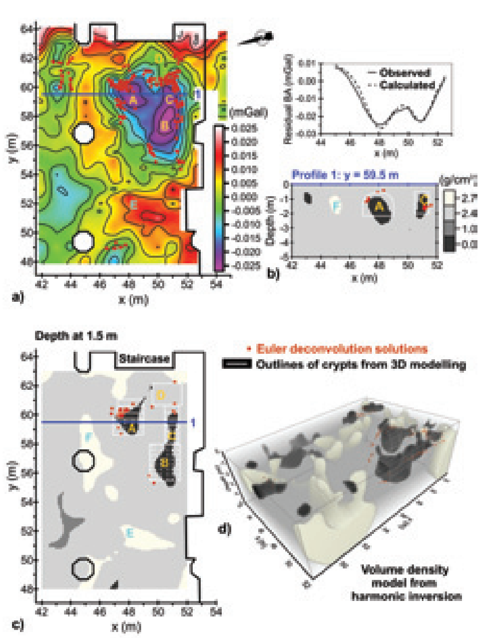

Fig. 4: Microgravity results: **(a)** Residual Bouguer anomalies. **(b-d)** Quantitative interpretation by three different methods.

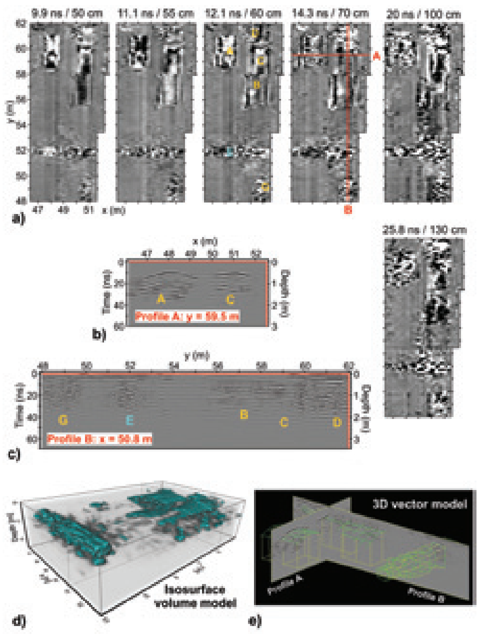

Fig. 5: GPR results: **(a)** Horizontal time slices sequence. **(b-c)** Selected radargrams with labelled GPR anomalies. **(d-e)** 3D images.

Archiving geophysical survey data from the Brú na Bóinne WHS, Co. Meath, Ireland

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Introduction

The Brú na Bóinne World Heritage Site is known for its Neolithic passage tomb cemetery although much recent evidence indicates that many other low-visibility and subsurface monuments and sites also survive in this landscape. Numerous archaeological excavations have taken place and various remote sensing datasets exist for the area.

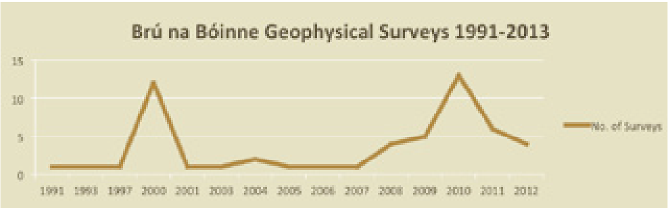
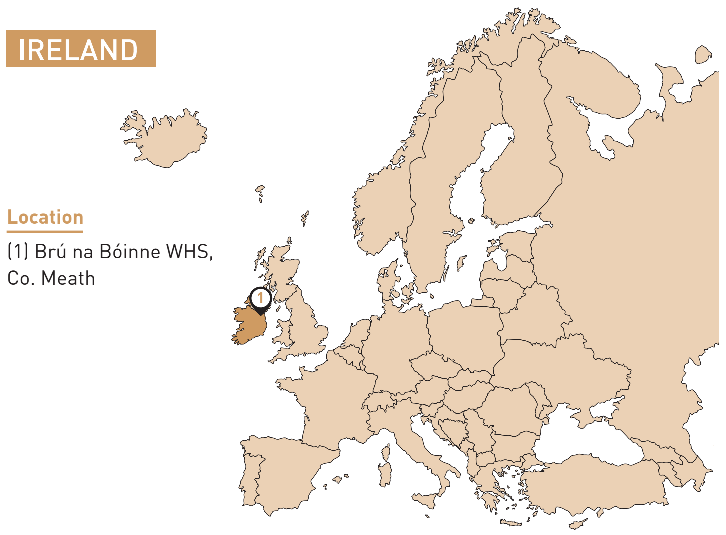


Fig. 1: Graph showing numbers of geophysical surveys carried out in the Brú na Bóinne area 1985-2013 (preliminary).

Year	Townland/Location	Survey for	Survey by	Methods	Report/Publication
1991	Newgrange Site A	Research	Stout, Geraldine	ER, MS & phosp.	PRIA 1991C
1993	Newgrange	ADS for OPW	Noel and Hale	MG,	unpublished
1997	Knowth Site N	Knowth excavation projec	MacCarthy	MG	unpublished
2000	Oldbridge	Battle of the Boyne devel.	Brady et al	MG	J Conflict Arch.
2000	Newgrange	Nat Monu Service/researc	Barton & MacCarthy	MG, ER, MS	unpublished
2000	Littlegrange	CRSS	MacCarthy	MG	unpublished
2000	Cullen, Field 3	Lithic Scatters project	Brady & Fenwick	MS	unpublished
2000	Gilltown Field 5	Lithic Scatters project	Brady & Fenwick	MS	unpublished
2000	Newtown, Field 7	Lithic Scatters project	Brady & Fenwick	MS	unpublished
2000	Newtown Field 8	Lithic Scatters project	Brady & Fenwick	MS	unpublished
2000	Newtown Field 19	Lithic Scatters project	Brady & Fenwick	MS	unpublished
2000	Rossnaree Field 22	Lithic Scatters project	Brady & Fenwick	MS	unpublished
2000	Rossnaree Field 88	Lithic Scatters project	Brady & Fenwick	MS	unpublished
2000	Newtown Field 19	Lithic Scatters project	Brady	ER, phosp	unpublished
2000	Oldbridge	Battle of the Boyne dev.	Brady and Byrnes	MG & phosp	J Conflict Arch.
2001	Newgrange/Dowth	Adrian Phillips	Phillips et al	ERT	unpublished
2003	Knowth	Knowth Excavation	Alex Gibson	?	unpublished
2004	Knowth Site M	Stout, G and Stout, M.	Earthsound	MG, ER, MS	Site M Report
2004	Newgrange enclosure	Brugh na Bóinne AP	Fenwick, J. NUIG	MG	Riocht na Midhe
2005	multiple	Meath CoCo/NRA	GSB	MG	published online
2005	Rathmullan	IAC	?	scanning/ MG?	unpublished
2006	multiple	Meath CoCo/NRA	GSB	MG	published online
2007	Oldbridge	ADS	?	?	unpublished
2008	multiple	Meath CoCo/NRA	GSB	MG	published online
2008	Gilltown Field 5	Lithic Scatters project	Brady & Barton	MG, ER	unpublished
2008	Rossnaree Field 22	Lithic Scatters project	Brady & Barton	MG, ER	unpublished
2008	Newtown Field 19	Lithic Scatters project	Brady & Barton	MG, ER	unpublished
2009	Newtown Field 8	Lithic Scatters project	Brady & Barton	MG	unpublished
2009	Cullen, Field 3	Lithic Scatters project	Brady & Barton	MG, ER	unpublished
2009	Cullen, Field 20	Lithic Scatters project	Brady & Barton	MG, MS	unpublished
2009	Rossnaree Field 88	Lithic Scatters project	Brady & Barton	MG	unpublished
2009	Rossnaree Field 22	Lithic Scatters project	Brady & Barton	MG, ER	unpublished
2010	Rossnaree Field 22	Rossnaree Excavation	Brady & Barton	MG, ER	unpublished
2010	Crewbane	Private landowner	Fenwick, J. NUIG	MG	Riocht na Midhe
2010	Dowth LP1	INSTAR Boyne	Barton et al.	MG, ER, ERT	INSTAR report
2010	Newgrange LP2	INSTAR Boyne	Barton et al.	MG, ER, ERT	INSTAR report
2010	Newgrange Site B vicinity	INSTAR Boyne	Barton et al.	MG, ER, ERT	?
2010	Monknewtown Site W	INSTAR Boyne	Barton et al.	MG, ERT	INSTAR report
2010	Monknewtown Sites V &	INSTAR Boyne	Barton et al.	MG, ER, ERT	?
2010	Knowth Site M vicinity	INSTAR Boyne	Barton et al.	MG, ERT	INSTAR report
2010	Newtown Field 19	Lithic Scatters project	Brady & Barton	ER, ERT, GPR	unpublished
2010	Rossnaree Field 22	Lithic Scatters project	Brady & Barton	ERT, MS, MG, ER	unpublished
2010	Cullen, Field 3	Lithic Scatters project	Brady & Barton	ER, MG	unpublished
2010	Gilltown, Field 4	Lithic Scatters project	Brady & Barton	MS	unpublished
2010	Drybridge	ADS for Bord Gais	?	MG?	unpublished
2011	multiple	Meath CoCo/NRA	J.M.Leigh	MG?	unpublished
2011	Knowth Area 11	Knowth Excavation	Fenwick, J. NUIG	MG, ER, MS, topo	Knowth vol. 5
2011	Newgrange mound	research	Barton et al.	Microgravity, EM, ERT	Arch. Irel.
2011	Staleen	Private developer	Barton	MG?	unpublished
2011	Newgrange mound	OPW	Barton	MG?	unpublished
2011	Dowth great mound	Brugh na Bóinne AP	Fenwick, J. NUIG	MG, ER	unpublished
2012	Dowth & Newgrange	Research	Barton et al.	CsMG, EM, MG, ER, ERT	unpublished
2012	Dowth great mound	Davis UCD	?	ERT	unpublished
2012	Dowth Promontory	Davis UCD	?	MG	unpublished
2012	Dowth Henge	Davis UCD	?	MG	unpublished

Fig. 2: Table showing geophysical surveys carried out in the Brú na Bóinne area 1985-2013 (preliminary).



Although a number of geophysical surveys have been conducted, many were piecemeal and site- or monument based and are not integrated with other forms of landscape data. The Brú na Bóinne WHS Research Framework[1] advocates the construction of a Spatial Data Interface to store, connect and display current and future information relating to the WHS and make this accessible as a web-based database/interface. Legacy geophysical datasets must be properly archived and mapped to safeguard the resource and maximise their utility in planning future research campaigns.

A history of geophysical survey in the Brú na Bóinne WHS

The first geophysical survey in the area took place in the late 1980's and the results were published promptly. Between then and 2013, upwards of 55 separate surveys have taken place using a variety of techniques **(Fig. 1)**. The majority of surveys relate to research activity although some relate to development activity. Construction of the database is ongoing. Further work needs to be done on exact survey locations and extents, equipment used, methodologies, data processing etc.

Less than 30% of the surveys are either published or are available online and already it is clear that for some of the earlier surveys data compatibility and archiving issues mean that they will probably not be available for any assessment exercise **(Fig. 2)**. This makes the current archiving project all the more important to salvage data from some of these older datasets.

The preliminary database

The Table and map show known geophysical surveys conducted to the end of 2013 **(Fig. 1&2)**. It is based on published references, mentions in the *www.archaeology.ie* and the *www.excavations.ie* databases. Excavations.ie gives summary accounts of excavation activity on a year-by-year basis and also on conference presentations and personal communication. Extensive linear surveys were carried out to the west of the WHS for Meath County Council and the National Roads Authority along the route of the proposed N2 Slane Bypass and in 2006 there was another linear survey carried out along a line parallel to the M1 motorway at the eastern edge of the WHS.

The line of the M1 motorway was not geophysically investigated prior to excavations along the route in 2000/2001 **(Fig. 3)**. A significant number of surveys were carried out as part of larger more recent studies; particularly the Lithic Scatters and Geophysics project and the Boyne Valley Landscapes project.

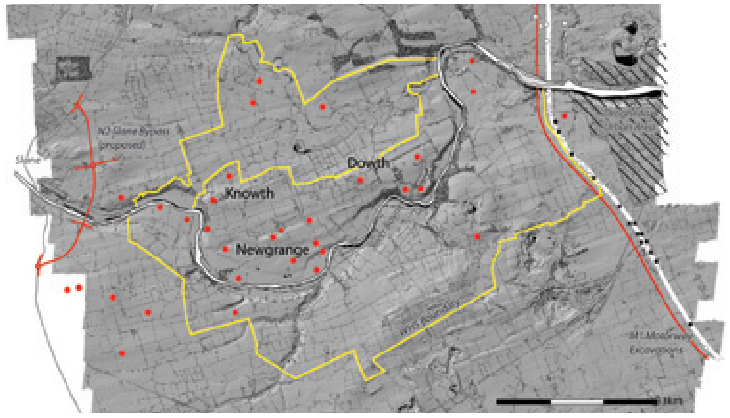


Fig. 3: Map indicating approximate locations of surveys listed in the Table. (LiDAR map courtesy of Meath County Council/The Discovery Programme).

Selection of surveys

Open source Quantum Geographical Information System (QGIS) is being used to map the catalogued ground geophysical surveys carried out in the WHS. The data are displayed on a raster image of airborne LiDAR data combined with a vector image of the digitised field boundaries **(Fig. 4)**. Initial survey data input to the GIS include electromagnetics, total field and vertical gradient magnetics, magnetic susceptibility and earth resistance. Individual surveys on a field-by-field basis have been carried out using hand-carried instruments and simultaneous multi-method surveys have been carried out using a towed Geophysical Equipment Exploration Platform (GEEP) **(Fig. 5)**. The final stage will be to input the linear ground surveys carried out as part of planning and construction of road developments. Future work will include the input of satellite multi-spectral and orthophoto images to the GIS as it is further developed to include all geophysical surveys carried out within the WHS.

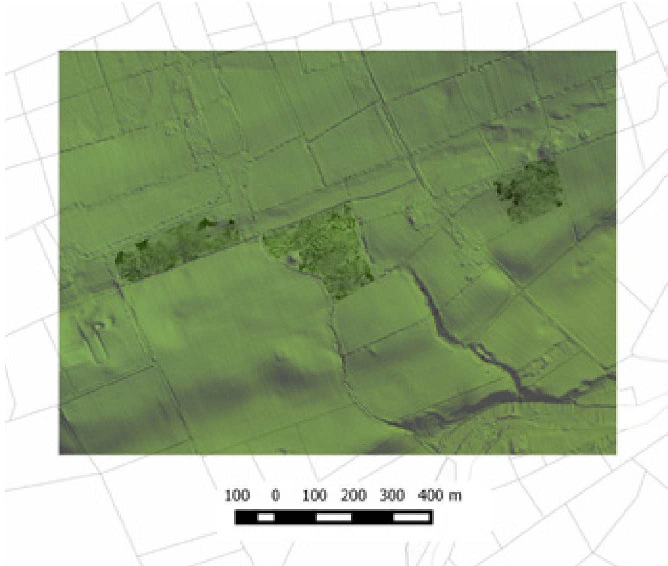


Fig. 4: Part of the Brú na Bóinne WHS showing selected layers from the GIS. GEEP Total magnetic field data (white = positive, range -4 nT to +5 nT), 1m x 1m gridded LiDAR data with global shading and digitised field boundaries. (LiDAR data courtesy of Meath County Council and the Discovery Programme; digitised field boundaries courtesy of Will Megarry).

Fig. 5: Geophysical Exploration Equipment Platform (GEEP) system in operation at Newgrange, Brú na Bóinne WHS. The sled is configured with 4x caesium vapour sensors spaced 1m apart and a centrally mounted DualEM 421S 6-receiver coil EM system.

Reference:
1. Smyth, J. 2009. Brú na Bóinne World Heritage Site Research Framework. Kilkenny: The Heritage Council.)

Discoveries through remote sensing: Investigating late prehistoric sites in Eastern Ireland

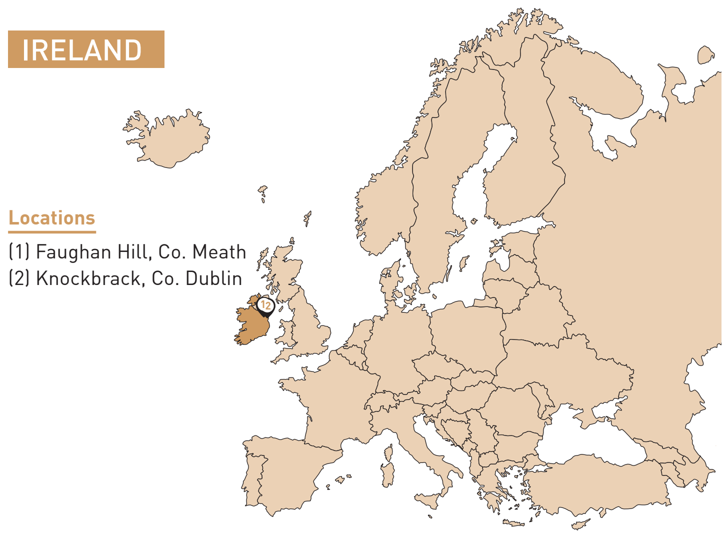
Ger Dowling[1] / Rob Shaw[1]
1. The Discovery Programme

Introduction

The Discovery Programme has recently completed a dedicated campaign of geophysical investigations as part of the 'Late Iron Age and 'Roman' Ireland' (LIARI) Project. The project sought, among other things, to shed light on settlement and society in Ireland during the first five centuries AD.

The four study areas chosen are shown on the map, which also highlights their close proximity to archaeological sites of known late prehistoric significance, as well as important natural features.

Archaeology students and graduate researchers from the National University of Ireland, Galway, and University College Dublin participated in the investigations. The student volunteers were trained in the fundamental stages of geophysical survey – from survey planning, data gathering through to data processing and interpretation, with the intention that on completion they would have gained the basic skill set to undertake such surveys on their own.



Locations

Building on a substantial body of research undertaken by the Discovery Programme in the Meath–north Dublin region since the early 1990s, the present investigations marked the beginning of a new phase of field work that targeted a selection of prominent hilltop sites suspected on the basis of archaeological, topographical and early documentary evidence to have been important focal centres in later prehistory. Despite the obvious archaeological potential of these sites, however, none had been subject to detailed investigation prior to the present study. The selection process utilised a range of remote sensing resources, online geospatial data, LiDAR derived terrain models and orthoimagery.

Results

The surveys have revealed a spectacular array of features, ranging from large-scale enclosures to numerous smaller features and structures (see below), with two of the target sites, namely Faughan Hill (Co. Meath) and Knockbrack (Co. Dublin), emerging as places of exceptional, if previously ill-understood, archaeological significance.

Faughan Hill

Faughan Hill (109m above sea-level) is identified in early documentary sources as the burial place of Niall of the Nine Hostages, eponymous ancestor of the Uí Néill federation of dynasties that came to dominate the kingship of Tara from the seventh to early eleventh centuries AD. Although nothing of archaeological potential is visible on the hill today, the array of features revealed by survey is astonishing and includes at least two massive hilltop enclosures, as well as a range of smaller, circular, features (ring-ditches and enclosures) on the summit.

The most striking enclosure (about 400m in overall diameter) is defined by two widely-spaced boundaries, the outer example of which consists of two closely-spaced ditches, with traces of a possible palisade trench located inside the inner ditch. About 50m inside and concentric with the outer enclosure, the inner enclosure (c. 270m in diameter) is defined by a single ditch. The concentricity and similarly-aligned entrances (on the north-east) of the inner and outer enclosures suggest them to be contemporary, perhaps dating from the Late Bronze Age or Iron Age. Another, potentially earlier, hilltop enclosure was also identified inside the inner enclosure and is defined by a pair of closely-spaced lineations, possibly representing narrow ditches and/or slot-trenches, that extend in a broad, angular arc around the summit of the hill.

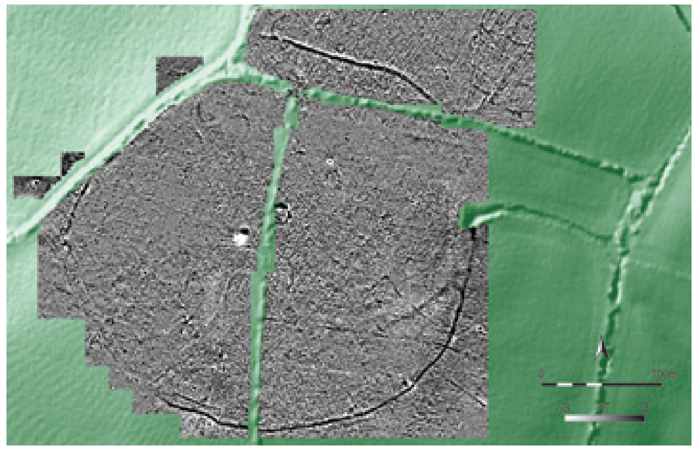
Knockbrack

The summit of Knockbrack (176m above sea-level) is the location of a significant concentration of archaeological remains, including at least six prehistoric burial mounds and the remains of a massive, possibly internally-ditched, enclosure. One of the burial mounds lies at the approximate centre of the hilltop enclosure, the significance of which was corroborated by geophysical survey. Although the outer bank of the enclosure is largely levelled today, the circuit of the enclosure ditch (2m to 5m in width) was mapped by survey, revealing it to have maximum dimensions of 350m east–west by 330m north–south. The monumental scale of the enclosure, together with its internally-ditched morphology, hilltop siting and central burial mound, suggests that it may represent an Iron Age ceremonial site, comparable to the first-century BC internally-ditched enclosure of Ráith na Ríg at Tara. Indeed, like the latter, the enclosure at Knockbrack is also distinguished by a significant concentration of internal features, including many small circular enclosures and ring-ditches, which collectively point to multi-period, ceremonial and funerary, activity, potentially spanning many centuries.

Orthoimagery from the Ordnance Survey Ireland was used to help define the potential survey area at Faughan Hill where no LiDAR resources were available.

Faughan Hill: results of magnetic gradiometer survey.

Digital Terrain Model (DTM) of Knockbrack generated from LiDAR data (1m resolution). A number of burial mounds are visible, but little evidence of the enclosure and other features subsequently identified by geophysical prospection.



Knockbrack: results of magnetic gradiometer survey.

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Culture
The Discovery Programme Centre for Archaeology and Innovation Ireland

Exploring aerial archives and non invasive prehistoric settlement prospection in Lithuania

Romas Jarockis[1]
1. Klaipėda University

Introduction

Within the "ArchaeoLandscapes Europe" project Klaipėda university chose three main objectives:

First objective – create a digital database of black-and-white archival aerial images, which are used for research and educational purposes. Thousands of archival aerial images dated from 1949 to 1980´s were scanned, mainly covering parts of the western region of Lithuania.

Second objective – the non invasive prospection of Iron Age hill forts and settlement complexes using geophysical techniques. In collaboration with the Roman Germanic Commission (Dr. Sebastian Messal) several archaeological sites were surveyed in both western and eastern parts of Lithuania. A certain number of building, fortification and burial sites were identified within archaeological complexes which were previously unknown (for results of the survey of Opstainis-Vilkyškiai Iron Age hill-fort/settlement complex see below).

Third objective – the organization of specialist workshops for students. The first workshop, mainly on the interpretation of archival black and white aerial photos, was held at Klaipėda University 27th - 31st August 2012. Another workshop, on geophysical field survey methods and interpretation of data, is planned for early April 2015.

Results of the geophysical survey of Opstainis-Vilkyškiai hill-fort/ settlement-complex in 2010-2012

This hill-fort/settlement-complex is situated in western Lithuania. The fortification is built on the tongue of a hill on the left-hand bank of the Apsta rivulet. The outer settlement of the hill-fort is – according to surface finds, small-scale excavations and geomagnetic data – situated in two places. The so-called eastern settlement is situated east and northeast of the hillfort and covers an area of ca. 2.5 hectares. The other settlement, called northern, is situated north and northwest of the hillfort, covering an area of approximately 3 hectares.

Geomagnetic surveys have been conducted in Opstainis-Vilkyškiai since 2010. The hill-fort plateau and the outer settlement, east and northeast of the hill-fort, were surveyed in 2010 (5-channel-magnetometer) and 2011 (16-channel-magnetometer). The area covered was 320m and long and 110 m wide in a field which is slightly rising from south towards north, with the hilltop located in the northwest of the field. In 2012 further larger areas of the upper settlement north of the hill-fort were surveyed; currently a total area of 3.9 ha has been investigated by geomagnetic surveys **(Fig. 1)**.

Eastern settlement

It can be suggested that accumulations of anomalies may indicate suspected areas of anthropogenic impact, primarily settlement traces. This is especially true for the close-spaced anomalies in the southern part of the measured area which are located within, or close to, the known "black earth" area of the settlement. They can be interpreted as archaeological features of various types that have already been confirmed by excavations of selected anomalies (semi-pit houses, storage pits; wells) **(Fig. 2)**.

In the northernmost part of the survey a rectangular structure consisting of at least 20 small rounded and oval anomalies could be detected. The structure is about 19m long and 7–9m wide; the average distance between the single anomalies is about 1.8 and 2m. The interpretation of this structure remains open but the rectangular plot as well as the size of the structure may indicate the location of a post building **(Fig. 3)**.

Northern settlement

The geomagnetic survey revealed a rectangular structure with dimensions of 6 x 4 m which may be interpreted – according to numerous analogies – as remains of a burnt building. Other larger accumulations of anomalies south and east of this structure may therefore indicate similar structures. A linear structure was detected in the north-eastern part of the plot and extends from north to south; the recorded length is 22.5m. This structure is also visible in the field and marks the current field boundary to the adjacent field track **(Fig. 4)**.

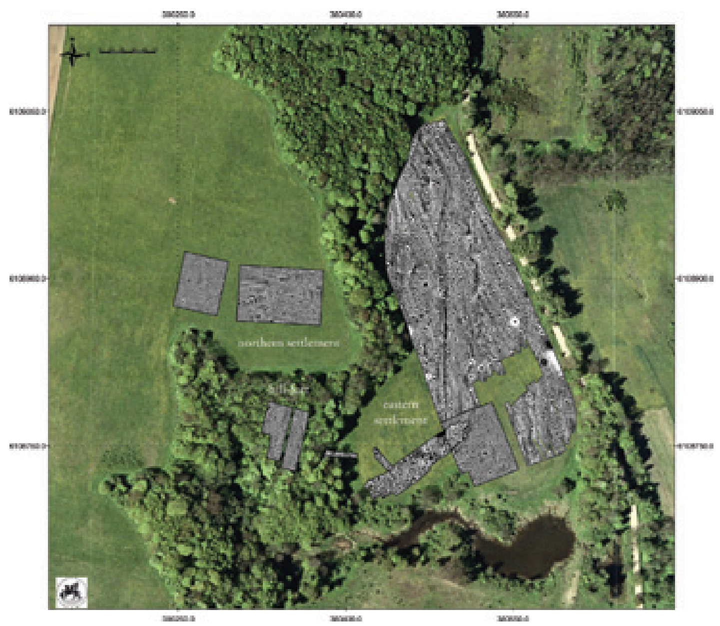


Fig. 1: Opstainis-Vilkyškiai. Geomagnetic surveys 2010-2012 (5-/16-channel-magnetometer; -6/+6 nT). Graphics: S. Messal.

Fig. 2: Opstainis-Vilkyškiai. Geomagnetic survey; details of eastern settlement with probable semi-pit houses, storage pits; wells (5-/16-channel-magnetometer; -6/+6 nT). Graphics: S. Messal.

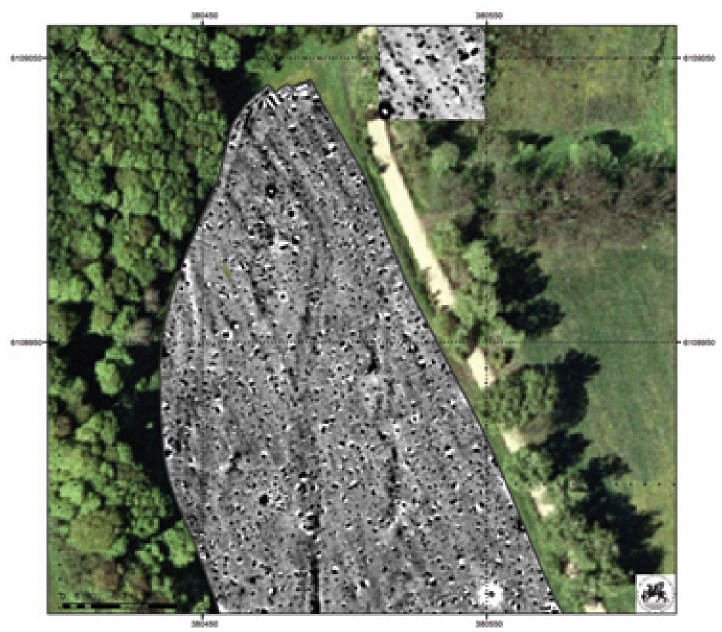


Fig. 3: Opstainis-Vilkyškiai. Geomagnetic survey; details of eastern settlement with probable location of a post building (5-/16-channel-magnetometer; -6/+6 nT). Graphics: S. Messal.

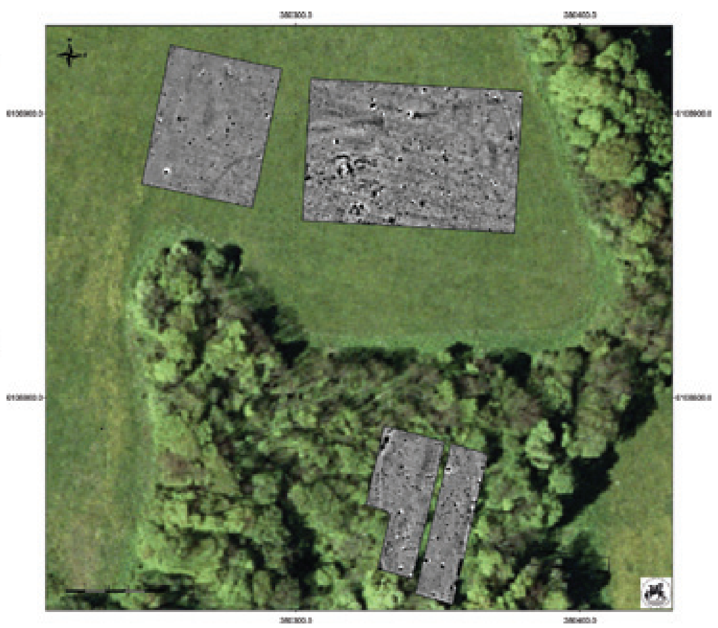


Fig. 4: Opstainis-Vilkyškiai. Geomagnetic survey; details hill-fort plateau and northern settlement with probable ditch and burnt houses (5-/16-channel-magnetometer; -6/+6 nT). Graphics: S. Messal.

New remote sensing at the Dowth Estate, Brú na Bóinne WHS, Ireland

Stephen Davis[1] / Knut Rassman[2] / Hans-Ulrich Voss[2] / Chris Carey[3] / Christine Markussen[4] / Lizzie Richley[5]
1. University College Dublin / 2. RGK, Frankfurt / 3. University of Brighton / 4. LBI, Vienna / 5. University of Southampton

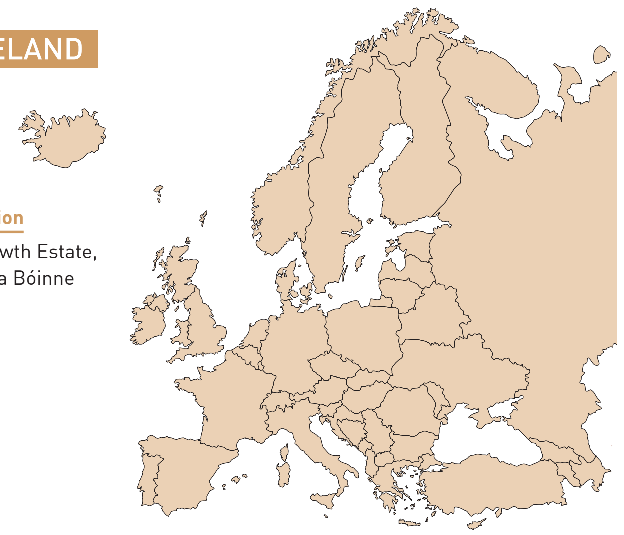
Introduction

The Dowth Estate represents one of the largest land holdings within the Brú na Bóinne World Heritage Site, one of only two UNESCO WHS within Ireland (Fig. 1). It comprises over 20% of the core area of the WHS and is best known for its large henge monument known as Site Q or Dowth Henge. The estate is dominated by 18th Century plantation features, representing an exceptionally well-preserved planned landscape, with multiple 'tree ring' features, a deer park and an old race course. A range of other monuments, both prehistoric and medieval are recorded, including two passage tombs, a concentric enclosure and the site of a now destroyed stone circle.

Surveys using a variety of remote sensing methods have been ongoing at Dowth since 2010. Initially these used LiDAR data at 1 point per metre, and aerial images. Initial geomagnetic survey in 2012 concentrated on key monuments (e.g. Site Q) and on features previously identified through LiDAR data, resulting in the identification of the concentric enclosure previously mentioned. In 2013 the estate was acquired by Devenish Nutrition who commissioned a new FliMap LiDAR survey at 40 points per metre with the joint aims of better defining the archaeology of the estate and estimating above ground carbon. This was also accompanied by new, large-scale geomagnetic prospection in collaboration with the RGK, Frankfurt, using both 16-sensor and 5-sensor geophysical rigs. Additional survey using a dual-sensor rig was undertaken in collaboration with Dr Chris Carey, University of Brighton resulting in a total coverage of c. 60 ha by the end of August 2014 **(Fig. 3)**. Selected areas have also been surveyed using a combination of ERT and GPR. The scale and resolution of the data gathered has begun to revolutionise our understanding of this landscape and represents the largest, most detailed remote sensing survey to date within the WHS.

Remote sensing at *Tlachtga*

The new LiDAR survey represents a significant advance from the 1 point per metre data of 2007 **(Fig. 2)**. It clarifies a number of demesne features which were impossible to see in the earlier data, such as the walled garden and pond features, as well as highlighting at least three very small or very low profile enclosure features. New agricultural landscapes are also revealed, in particular cultivation traces on the steep terrace slopes. Digitisation of features has been undertaken in a semi-automated fashion using contouring of the geomagnetic data **(Fig 4)**. This has resulted in large numbers of polygons giving a detailed picture of magnetic anomalies throughout the estate. Several areas have revealed exceptional previously unidentified archaeological features, in particular the area between the henge and the demesne house (Dowth Hall) and the area of the concentric enclosure.



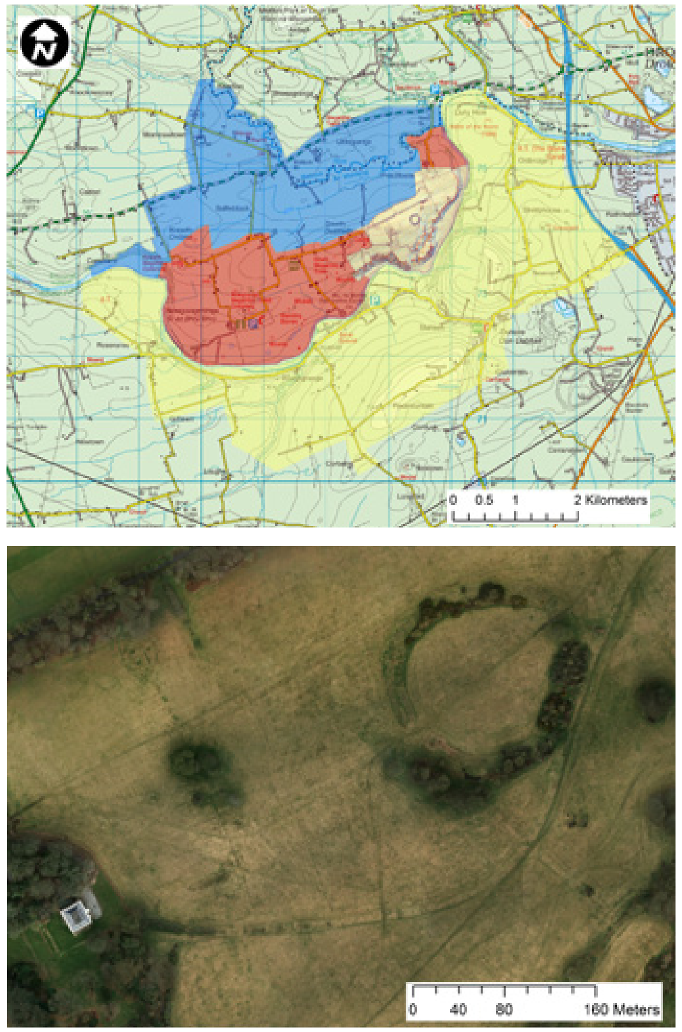


Fig. 1. Top: Brú na Bóinne World Heritage Site, showing position and extend of Dowth Estate (LiDAR Local Relief Model overlay); **Lower:** Orthophotograph of Dowth Henge (Site Q) and its position in relation to Dowth Hall.

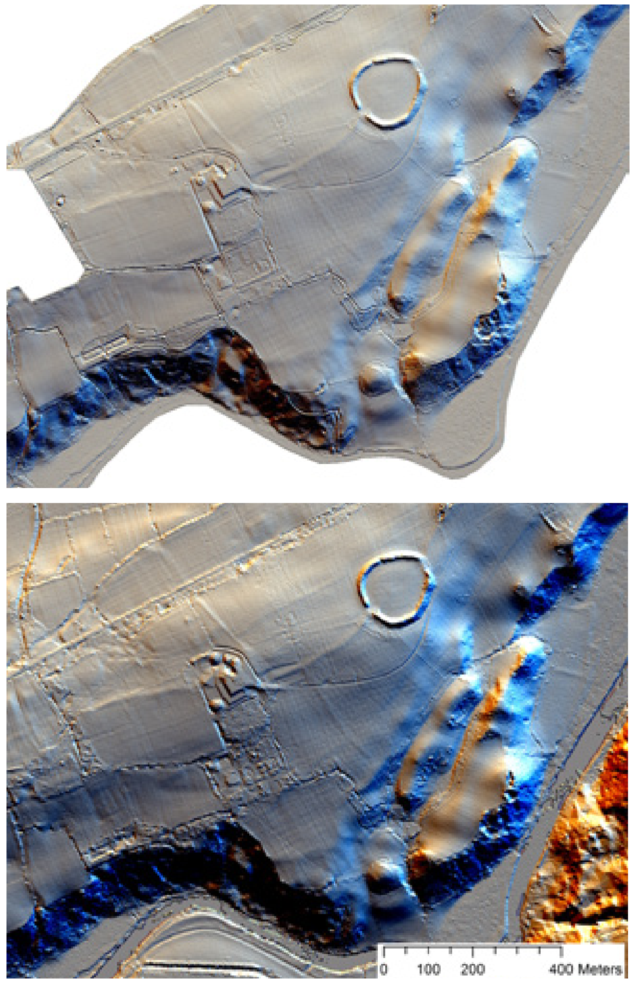


Fig. 2: Comparison of 2007 UK Environment Agency LiDAR (1 point per metre; Courtesy Meath Co. Council) and 2014 FliMap survey (40 point per metre). 16-direction hillshades.

Palaeoenvironments and excavation

The area between Site Q and Dowth Hall represents what appears to be a previously unidentified complex of prehistoric features. These are dominated by a broadly-ditched circular enclosure, 45m in diameter which may represent a second henge monument. Further south of these is a complex collection of enclosures and pit-alignments, akin to other important ritual centres towards the end of the Neolithic in Ireland (e.g. Newgrange Pit Circle; Ballynahatty). This is associated with a 'box-like' entrance feature, also bearing closest similarity to Ballynahatty, Co. Down.

The area of the concentric enclosure includes at least three likely house structures, including one very large (c. 8m x 9m) rectangular structure in addition to at least one probable souterrain. A second enclosure, probably also early medieval in date was also discovered less than 100m NE of the known feature. Additionally elements of both co-axial field systems (Racecourse Field) and later medieval settlement (Glebe Field) were discovered. Additional survey is planned to further enhance our understanding of this important ritual landscape, with plans for limited excavation in summer 2015.

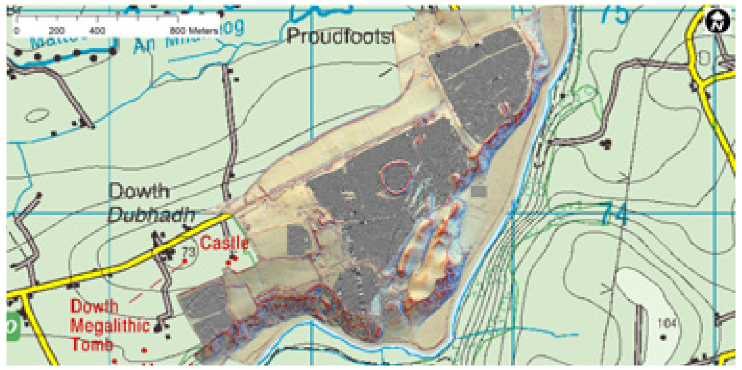


Fig. 3: Dowth Estate extent of geomagnetic survey, summer 2014. Overlain on LiDAR local relief model.

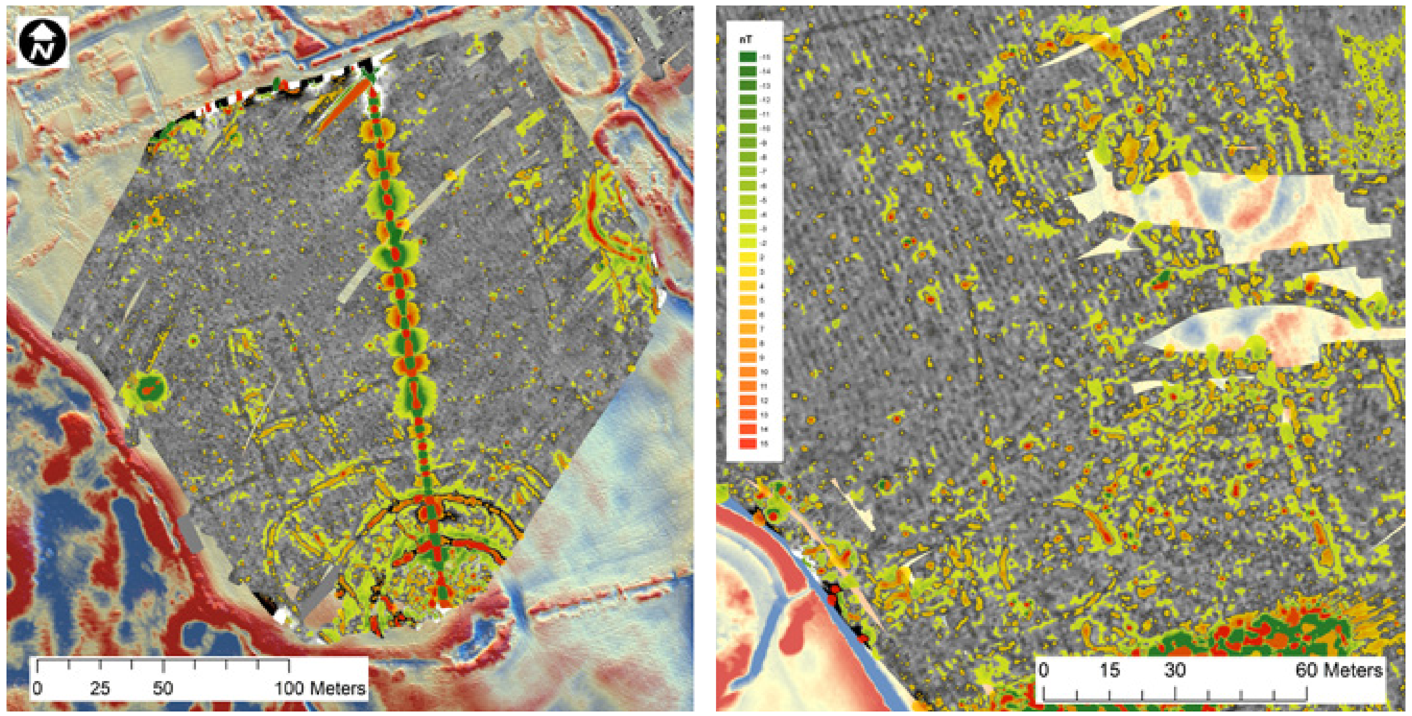


Fig. 4: Semi-automated digitising of features in GIS. **Left:** Concentric enclosure and promontory area; **Right:** Prehistoric complex between the Hall and the Henge.

Owieczki: Constructing the archaeological landscape

Magdalena Felis[1]
1. Adam Mickiewicz University in Poznań, Istitute of Prehistory; Poznań Archaeological Museum

Introduction

The aim of this poster is to show how both archeologists and the local community construct the archaeological landscape and to discuss whether non-invasive methods can help in the interpretation of the past in this context. The problem will be presented based on the site in Owieczki, situated by the lake Owieczki in Wielkopolska Region, Poland **(Fig. 3).** The village was first mentioned in historical sources in 1397.

POLAND

Location
(1) Owieczki

History of the research of the site

The site was first recorded in 1912 when two questionnaires were filled in. Both described a mound – the first one was filled in by the landowner who described the site as a burial mound, the second one was done by the village administrator who did not define it.

Fig. 1: Mound in 1964 (G. Mikołajczyk – contemporary reproduction of the original photo).

Fig. 2: Mound in 2011 (M. Felis).

Archaeologists 'discovered' the site for their study in the 1930s. W. Kowalenko published it in 1938 as an early medieval stronghold, based on information from a local teacher. The Regional Conservator of Monuments in Poznań described the site as a motte of great value for an early stage of Polish statehood.

In 1964 G. Mikołajczyk, archaeologist from Gniezno returned to the concept of the site as a burial mound associated with the open settlement **(Fig. 1).** This view was repeated in 1971. In contrast, two eminent archaeologists (W. Hensel and Z. Hilczer-Kurnatowska) published the site as a motte, and consequently the interpretation of the site as a burial mound disappeared from archaeological discourse. Their opinion was repeated in the recording of the site during a field-walking project in 1984. Surprisingly the value of the site was described as 'medium'. In each publication the mound was described as 3-3,5 meters in height and 13-13,5 meters in diameter. In each description an old pear tree on the top of the mound was mentioned. Also the negative impact of ploughing was mentioned in each document and publication.

Local society discourse versus new research methods

Whilst scientists finally concluded that the site is a motte, the inhabitants of the village at the beginning of 20th century interpreted it as a burial mound. It was supposed to be a grave of officers, or soldiers, or Russians or Russian officers. An interpretation like that mentioned in both first questionnaires.

Due to migrations and changes of the local community and the discontinuity of the local traditional narrative, nobody remembered the meaning of that place. Currently local people do not have much interest in the site.

Actually, we still do not know what the site was in the past. Consequently, the area was a subject of several aerial surveys but no traces of past human activities were identified (neither traces of the mentioned settlement nor structures or a ditch related to the motte) **(Fig. 2).** Geophysical prospection took place on November 19th, 2013. A Geometrics G858 Magmapper cesium magnetometer and RTK GPS were used for precise measurement of the site and vicinity.

Unfortunately, the mound itself could not be surveyed using the magnetometer due to the large inclination of the mound's slopes and very thick shrubs. Based on ground survey, the size of the mound was about 15m in diameter and 3,5m height **(Fig. 4).** On the surveyed area some changes in the intensity of the magnetic field were observed but no data suggested the presence of stone or wooden structures surrounding the mound **(Fig. 5).** So far even geophysical methods could not give an answer about the function of this site.

Fig. 3: Fragment of the 19th century map - Urmesstischblatt 1861.

The site in Owieczki shows that everyone participates in constructing past landscapes, especially when it comes to the remains of them. It is not necessarily the archaeologists who are right in their interpretation, as even now there is no final conclusion to what the site was in the past. Let's leave it to the people.

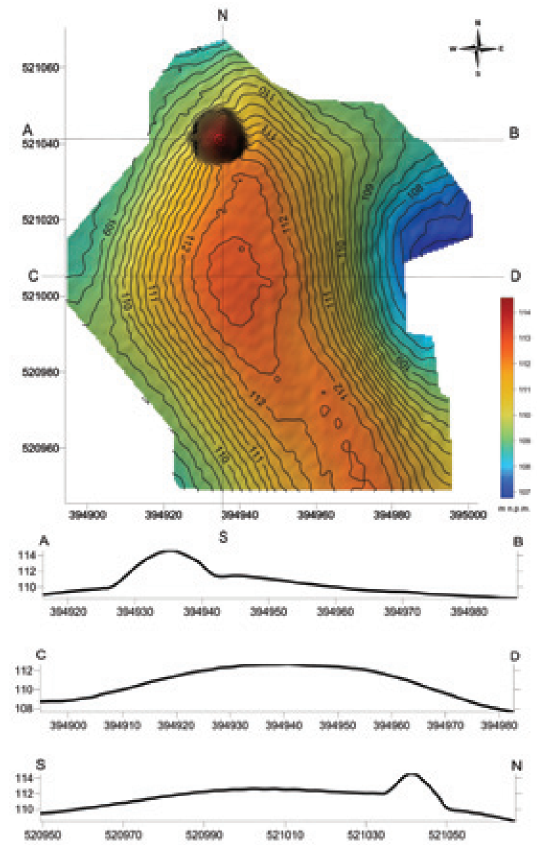


Fig. 4: Height model of the mound and its surroundings (W. Małkowski).

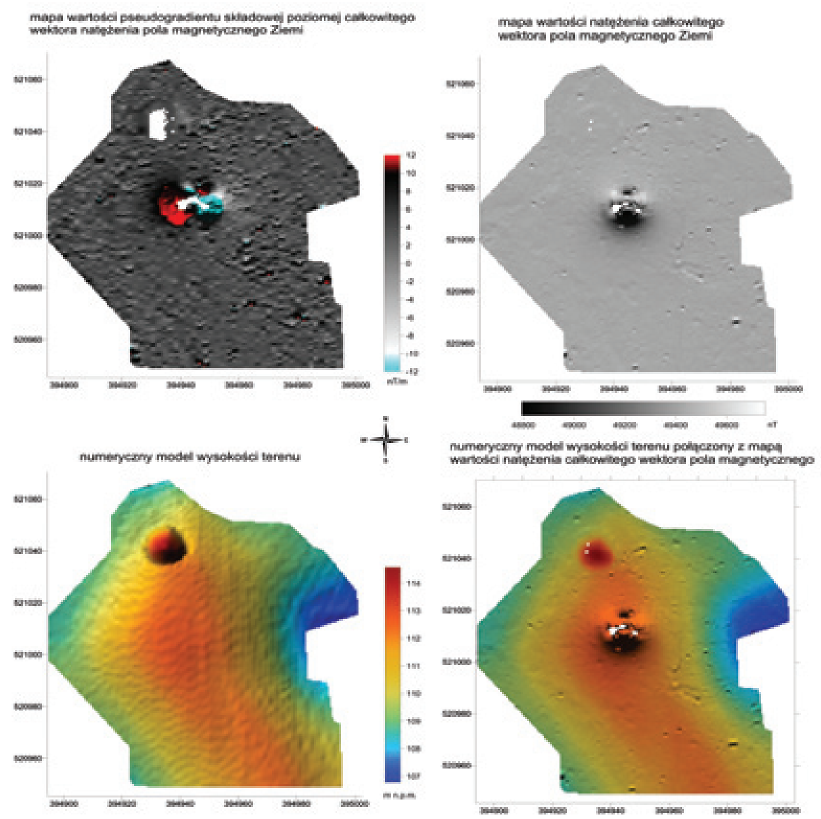


Fig. 5: Comparison of the geophysical prospection results (W. Małkowski).

Prospecting methods implemented within the ArcLand project in the years 2010-2014 – Slovakia

Martin Bartík[1] / Mário Bielich[1] / Elena Blažová[1] / Ivan Kuzma[1] / Klaudia Daňová[1] / Monika Gabulová[1] / Ivan Cheben[1] / Michal Cheben[1] / Peter Gabor[1] / Branislav Kovár[1] / Róbert Ölvecky[1]
1. Institute of Archaeology of the SAS in Nitra

Introduction

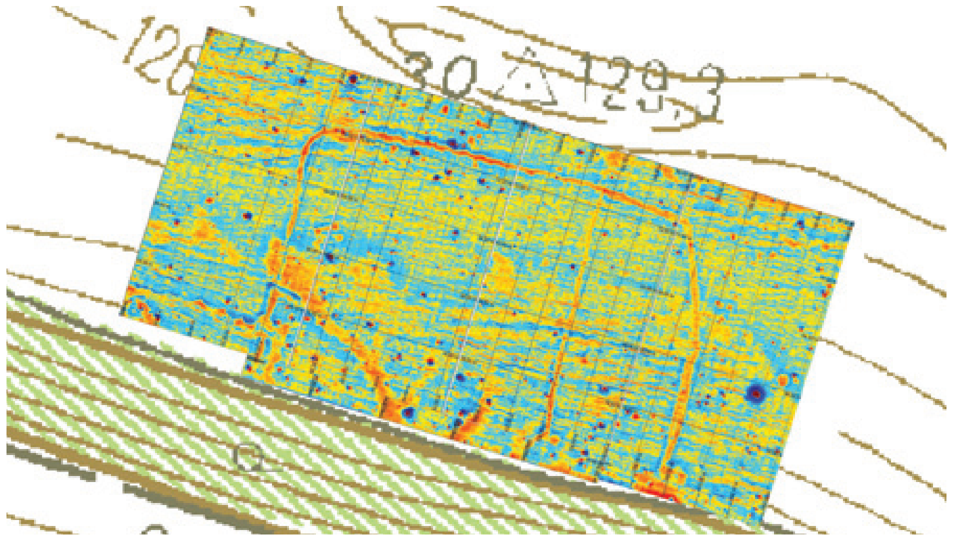
The Institute of Archaeology of the SAS in Nitra participates in the project through prospection of Žitný ostrov, the largest river island in Central Europe. Any changes made in the subsoil that are not filled with the original soil can be identified by aerial archaeology through vegetation and soil symptoms.

The reconstruction of the archaeolandscape of the studied territory can be divided into two separate subgroups - artificial and natural interventions. The artificial intervention means creation of an "ancient country" with an original river network and possibly also an "ancient" road network. This method of reconstruction is mainly done from perpendicular ortho images. The second method is the collection and analysis of relevant archaeological facts. For this option a set of activities such as aerial prospection, digital data processing, geophysical measurements with geodetic analysis and data collection are carried out at several sites in the studied territory.

Prospection

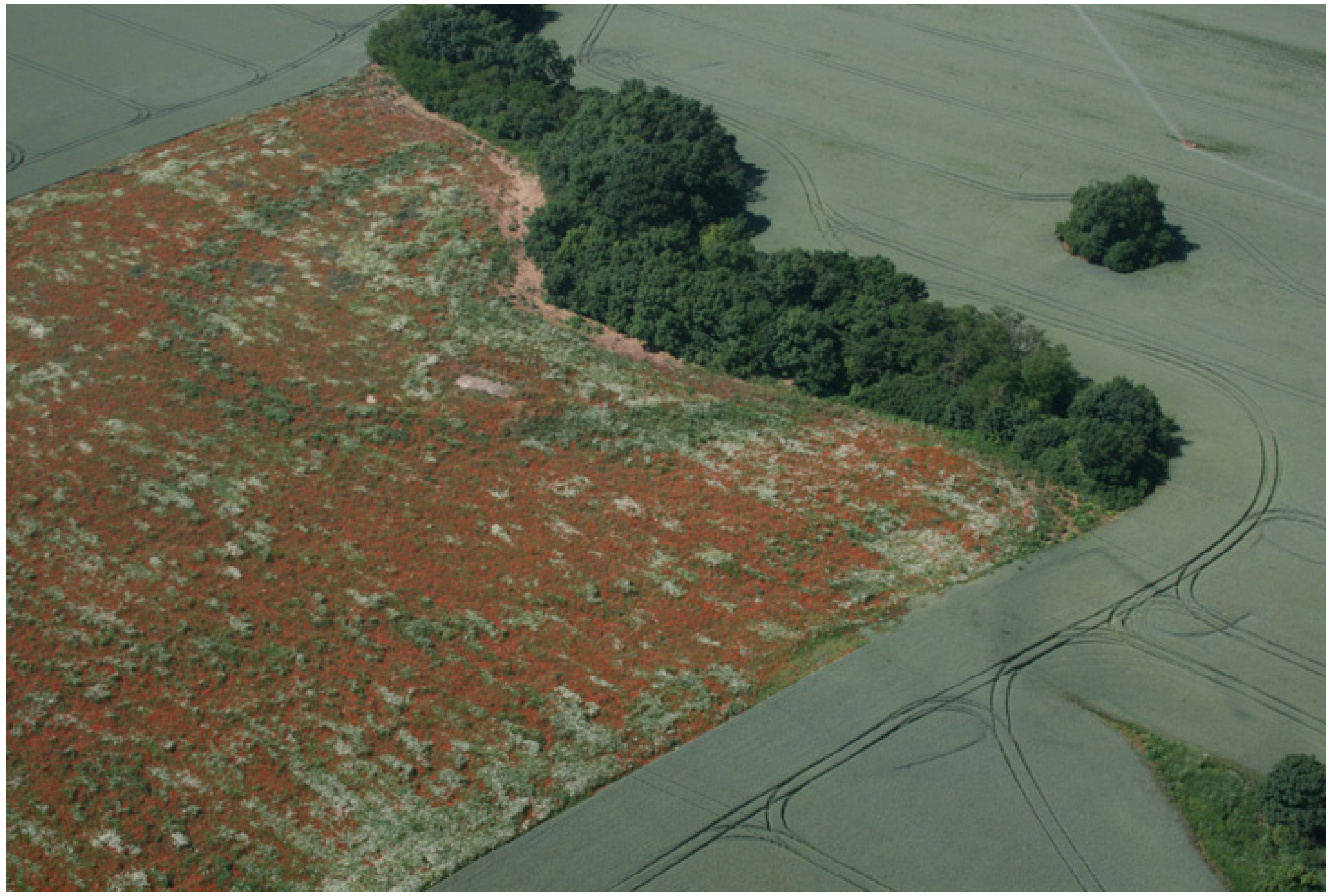
In the years 2010-2014, 14 flights were conducted. Over this period about 200 sites with vegetation and soil symptoms were recorded in the studied area. The following types of feature occurred most frequently: linear features, ditches, Roman marching camps, linear remains of extinct fortification systems, closed round features, closed rectangular features with rounded corners of different dimensions and settlement features. A significant part of the project is processing previous records and loading data through the program ArcGis into the geographic information system, in which the aerial prospection data create an independent information layer. The aerial archive built in 1987 contains about 7000 analog images in the form of monochrome negatives and diapositives and about 9500 images in digital form.

The aerial survey in Pusté Uľany/linear features.



The geophysics prospection in Mužla /linear features.

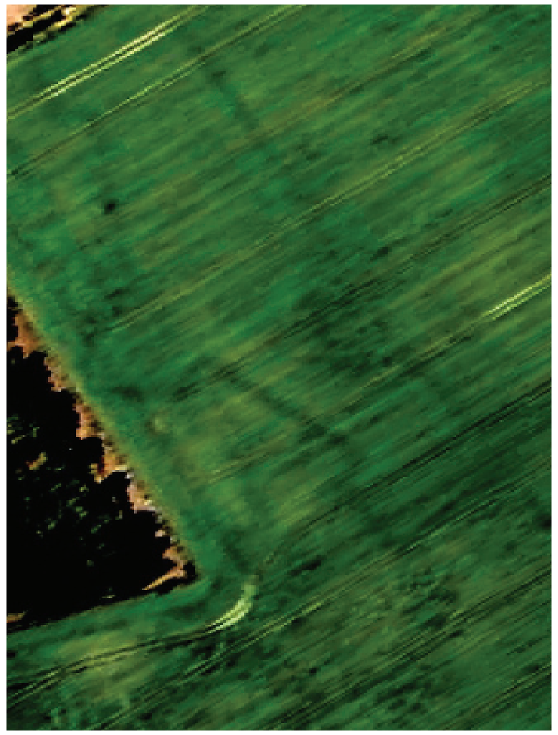
ArcLand HERITAGE · DATA · KNOWLEDGE
Culture



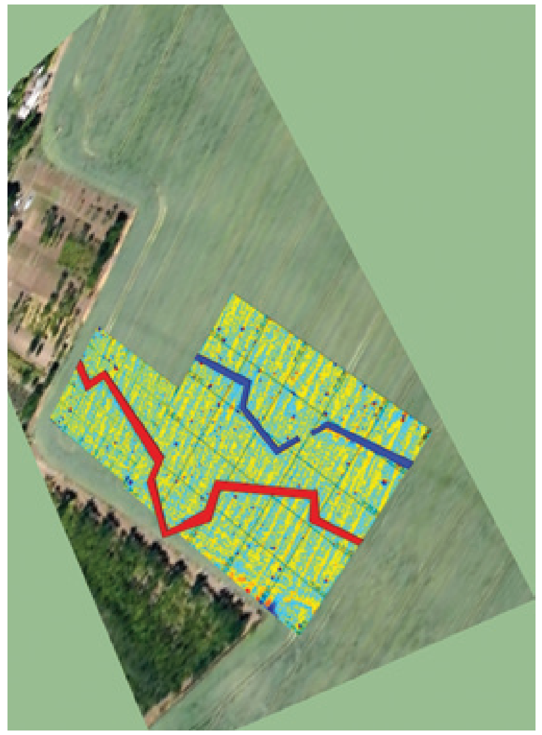
The aerial survey in Vráble-Fidvár /fortification from the Bronze Age.

Geophysical measurements

Geophysical measurements were carried out with a SENSYS five channel magnetometer using parallel transects with a 25 centimetre spacing. The obtained data were processed in the program MAGNETOARCH. Twenty eight locations were measured and in several cases the geophysical measurements confirmed the data from the aerial prospection.



Aerial survey in Štúrovo/fortification, post-medieval age.



Application of geophysics prospection and geodetic measurements in Štúrovo/fortification, post-medieval age.

ABOVE AND BELOW: COMMUNITY ENGAGEMENT IN REMOTE SENSING IN IRELAND / ARCHAEOLOGY INVOLVED. PROMOTING REMOTE SENSING ARCHAEOLOGY THROUGH COOPERATION WITH LOCAL COMMUNITIES / CARS: COMMUNITY ARCHAEOLOGY REMOTE SENSING / COUNCIL FOR INDEPENDENT ARCHAEOLOGY: COMMUNITY ARCHAEOLOGY AND REMOTE SENSING / EXPLORING EUROPE'S PAST LANDSCAPES: CURRENT TECHNIQUES AND FUTURE DEVELOPMENTS / FROM ARCLAND TO EMPTYSCAPES: FILLING 'EMPTY' LANDSCAPES, MAPPING THE ARCHAEOLOGICAL CONTINUUM / FROM INTEGRATION TO INTERPRETATION: UNDERSTANDING THE ARCHAEOLOGICAL RECORD FROM A MULTI-METHOD PERSPECTIVE / GEOPHYSICAL SURVEY OF THE VIKING AGE BURIAL MOUND OF HERLAUGSHAUGEN IN NORWAY / KILMOKEA AND KILBERRY: COMMUNITY-BASED ARCHAEOLOGICAL REMOTE SENSING IN IRELAND / MAKING ANCIENT MEDITERRANEAN LANDSCAPES ACCESSIBLE / MAPPING ARCHAEOLOGICAL LANDSCAPES IN CENTRAL AND SOUTHERN ITALY: THE URBAN CONTEXT OF AQUINUM AND THE ANCIENT ROUTE OF VIA TRAIANA / OLD LANDSCAPES, NEW EYES: A SUMMARY REPORT OF ENGLISH HERITAGE PARTICIPATION IN THE ARCHAEOLANDSCAPES EUROPE PROJECT / RATHCROGHAN & THE ROLE OF REMOTE SENSING IN INTERPRETING A UNIQUE ARCHAEOLOGICAL LANDSCAPE / THE ERASMUS IP SUMMER SCHOOL "PREVENTIVE ARCHAEOLOGY. EVALUATING SITES AND LANDSCAPES" (2013-2014) / THE ODIT-CHEF PROGRAM: OBSERVATORY OF INDUSTRIAL AND TERRITORIAL DYNAMICS – CREATION OF HISTORIC FORESTED LANDSCAPES

Contributions on:

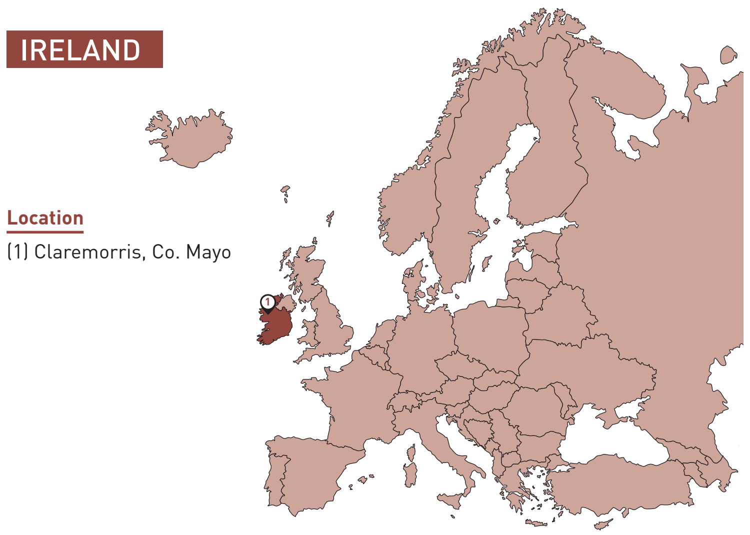
INTEGRATION AND OUTREACH ACTIVITIES

Above and below: Community engagement in remote sensing in Ireland

Kevin Barton[1]
1. Landscape & Geophysical Services, Claremorris, Co. Mayo

Introduction

Within a local community there are a number of motivations that can create an interest in initiating an archaeological remote sensing project. There are also a number of factors that may affect the ability of a community to carry out a project.



Motivations include:

- A sense of and pride in their local environment.
- A desire to learn more about known monuments, local landscape and history.
- A possibility of discovering or confirming a new monument.
- A desire to carry out original work.

Factors include:

- Development of a core team with energy, enthusiasm and commitment.
- Funding.
- Land access.
- In the Republic of Ireland ground-based archaeological remote sensing requires a licence.
- Aerial remote sensing methods do not require a licence.
- Availability of training and experience in acquisition, processing and interpretation of remote sensing data.
- Availability of low cost equipment and software.

Work within a community has to be sensitive to the above motivations and factors. Most projects have not involved formal classroom-style tuition; the delivery mode being 'learning while doing'. For primary school children (4 to13 years) the most accessible and cost effective methodology has been Kite Aerial Photography (KAP). This has been supported by West Lothian Archaeological Trust (SNAPS, 2015).

KAP at Mayo Abbey National School, County Mayo combined kite flying with downloading, processing and discovery of archaeological and landscape features recorded by a still or video camera **(Fig. 1)**. Advanced work involved an introduction to spatial data by manually digitising simple shapes and then inputting and displaying them using freely available software. This led to making simple 3D models of archaeological monuments using LiDAR data.

Fig. 1: *'Going solo'* Kite Aerial Photography at Mayo Abbey National School.

Fig. 2: *'Off to work'* Transition Year survey group on the BARS1 project.

Transition Year (TY) secondary school students (15 to 17 years) at Balla Secondary School in County Mayo, took part in KAP and ground geophysical surveys. Remote sensing techniques offered the possibility of cross-curriculum projects which interested both teachers and students in this school and one in County Meath. The initial project in Balla in 2013, the BARS1 (Balla Archaeological Remote Sensing1) project, used school facilities for an informal introductory class and for more formal processing, visualisation and interpretation. Fieldwork was carried out with the assistance of Balla No Name Club **(Fig. 2)**.

The project was presented at the K2U2 Conference (TotP, 2013). A BARS2 component in 2014 was the Archaeology Above and Below event which was a one-day schools invited seminar **(Fig. 3)**. and two-day community conference (ArcLand, 2014). The two-day conference was delivered by the community-run Rathcroghan Visitor Centre, Tulsk, Co. Roscommon (RVC, 2014).

Two projects are being carried out with Community Heritage Groups. Delivery is by two-day workshops over a series of weekends (Kilberry, 2015 & Sliabh Coillte, 2015). Both groups purchased LiDAR data and followed up anomalies by fieldwalking.

At Kilberry, County Meath the recently formed Heritage Group is part of an Amenity Group involved in village enhancement. Interest is in investigating a series of monuments in order to raise awareness, aid conservation and present the sites as part of possible tourism development. Each monument investigated has been the subject of local folklore or questions about its function **(Fig. 4)**. Sliabh Coillte Heritage Group, County Wexford has been active in heritage studies for over 20 years. The current project is investigating a large enclosure on Great Island for which substantial documentary evidence has been gathered. Analysis of the evidence has raised questions which are being addressed through remote sensing surveys.

Both groups have presented their work at local, national and international events or conferences thus raising awareness of their local archaeological heritage **(Fig. 5)**.

Fig. 3: *'Archaeology Above and Below'* An Taoiseach (Prime Minister) Enda Kenny TD with contributors to the BARS2 schools invited seminar.

Fig. 4: *'Electrode crew'* Kilberry Amenity and Heritage Group carrying out an Electrical Resistivity Tomography survey on Rathcoon Mound.

Fig. 5: *'Communicating heritage'* Sliabh Coillte Heritage Group present the results from their National Heritage Week public event at Kilmokea Enclosure.

ToTP 2013 | ArcLand 2014 | RVC 2014 | Sliabh Coillte 2015 | SNAPS 2015 | Kilberry 2015

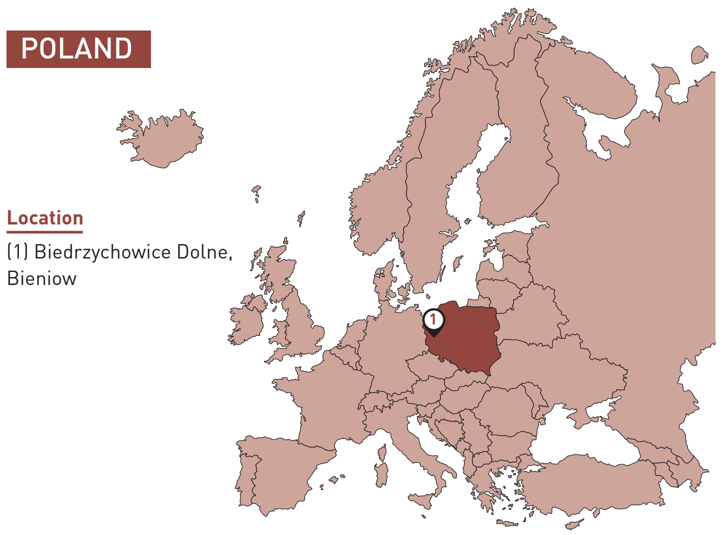
ArcLand HERITAGE · DATA · KNOWLEDGE Culture LGS LANDSCAPE & GEOPHYSICAL SERVICES

Archaeology involved. Promoting remote sensing archaeology through cooperation with local communities

Mikolaj Kostyrko[1] / Kornelia Kajda[1]
1. Adam Mickiewicz University Poznan, Poland

Introduction

Our project is a result of cooperation between the Institute of Prehistory at the Adam Mickiewicz University in Poznań (ArcLand) and the Association for the Villages' Development "Together" from Bieniów. It is a society-driven, community archaeology project which links archaeologists with the enthusiasts of history and children.



Its main aim was to promote non-invasive archaeology in the community and to develop awareness of the importance of archaeological heritage. The project was divided into two parts (according to the research methods): an ethnological study in the villages near the researched area, and the archaeological investigation of the medieval hill-fort in Biedrzychowice Dolne village (Lubuskie province) using not-invasive methods.

Ethnological survey – archaeology and heritage knowledge

In the ethnological part we carried out surveys and interviewed local people. They were asked about their knowledge of the history of the region, their interest in it, their knowledge of the historical and prehistoric monuments that exist nearby, and their frequency of visiting them. We also wanted to know how they perceive archaeology and archaeologists and what is the first association with archaeology for them. Before our field research we sent 150 questionnaires to the inhabitants of the villages near our research area. We received 54 complete questionnaires and analyzed them before starting our investigation.

Thanks to the analysis of our questionnaire we had information about the attitudes of the local community towards archaeology, archaeologists and heritage, and we could evaluate our own methods for the promotion of archaeology. During the field study we also made an additional 20 interviews with the members of the local community which brought us more information about the social role of archaeology.

Fig. 1: On the site - a field survey with children from the local school.

Fig. 2: CIR photography – an arrow indicating the damage done to the hill-fort due to deforestation.

Remote sensing and cooperation with local community

To promote archaeology and the non-invasive methods used by it, we invited local people and children from the local primary and secondary school to take part in our research of the archaeological site. The participants carried out measurements of the site using total station, and GPS RTK. Children also conducted a field survey during which they were taught how to distinguish the ancient pottery from the stones, flints, bricks and tiles **(Fig. 1)**.

We also carried out a small geo-physical survey which unfortunately did not bring positive results. The reason for this could be either too many metal objects (World War II provenance?) lying just beneath the surface, or lack of any archaeo-logical features that could be detected by a geophysical survey. We also obtained LiDAR data and aerial photographs (CIR) from the national resources.

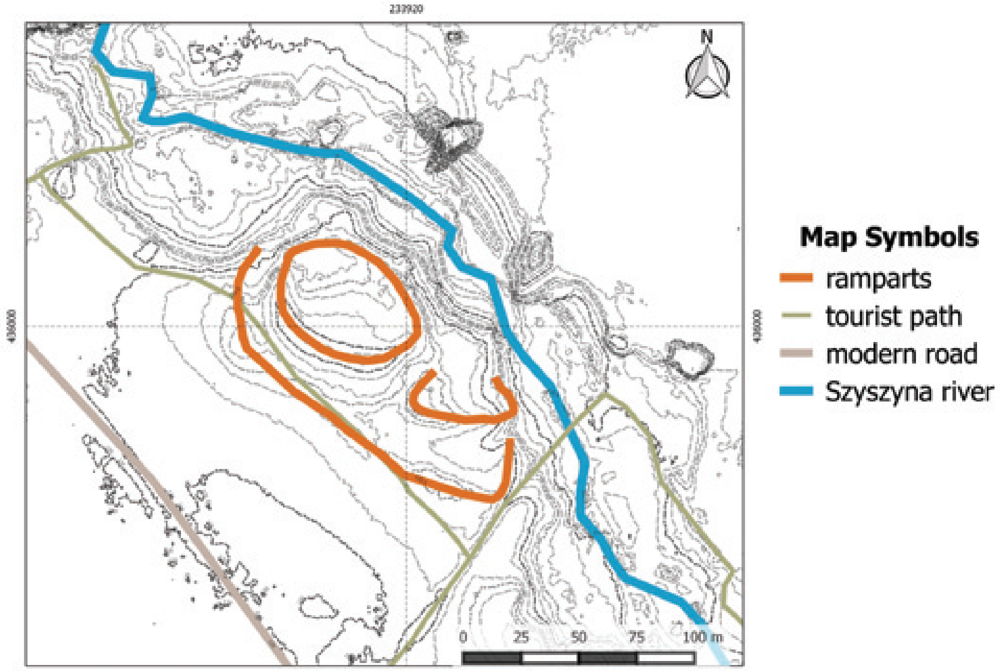


Fig. 3: LiDAR derivatives interpretation. No former interpretations exist.

Interpretation and presentation

LiDAR data derivatives brought us to the conclusion that the site structure is more complex than previously thought **(Fig. 2)**. The CIR photos clearly indicate the damage that was done to the site structure by forest management **(Fig. 3)**. Our third step was to promote the results of our studies. To achieve this goal we organized a conference to which we invited members of local communities and archaeologist **(Fig. 4)**. To enable permanent access to more information about our project and its results we also made a website available to all - archeolog.archeo.edu.pl **(Fig. 5)**.

Fig. 4: The conference with local community and archaeologists.

Fig. 5: The website of the project.

CARS: Community archaeology remote sensing

Anthony Corns[1] / Gary Devlin[1] / Ger Dowling[1] / Robert Shaw[1]
1. The Discovery Programme

Introduction

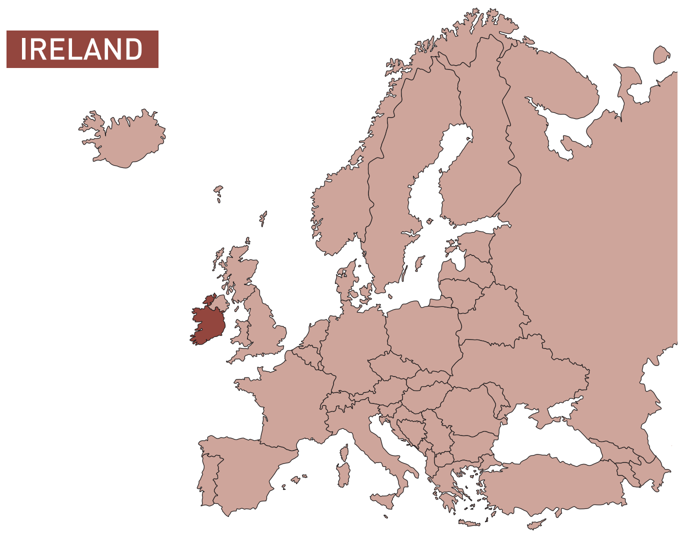
Archaeology has always taken place within the social, political, and ideological contexts of contemporary society. Over the past 30 years the development of community archaeology has encouraged public engagement within the archaeological process at a variety of levels. The reasons for this development include:

- an underlying altruistic belief that archaeology can make a difference to society
- a growing understanding by archaeologists of the need to provide a public service to society and develop social inclusion
- the diversification from the commercial archaeology sector following the economic downturn of 2008
- the popularity of archaeology in the media, generating a large public demand to become involved in archaeological activities
- increased education stimulating an appreciation of, and desire to protect the past
- the desire by the profession to legitimise and promote archaeology

The idealised model of community archaeology being 'by the people for the people' and controlled by the people for the people, is something of a naïve fantasy. Despite the aspirations for a 'bottom-up' democratised community which lots of projects advocate, many inevitably retain many 'top-down' elements, which both overtly and covertly influence the kinds of projects that receive funding and support. Top-down approaches often create a one-sided exchange of information: from the archaeologists to the community, and precludes real meaningful collaboration. If carried out successfully, the combination of professional and community archaeology can be exciting and empowering for both the academics that are brought into contact with new questions and ideas that feed their research, and community groups who can be exposed to new techniques that can help inform their activities.

Community remote sensing

Community remote sensing, or CRS, is an emerging field that combines remote sensing with citizen science, social networks, and crowd-sourcing to enhance the data obtained from traditional sources. It includes the collection, calibration, analysis, communication, or application of remotely sensed information by these community means. By integrating the methods of CRS to the archaeological process we can begin



to define a new model in which the public can become actively involved in the generation, processing, interpretation and presentation of archaeological remotes sensing data. The introduction and application of remote sensing techniques within community archaeology also enables the public to actively become involved in the fieldwork aspect of archaeological practise. Traditionally this has been restrictive as archaeological excavation usually requires licensed, professional supervision and is often prohibitively expensive.

Community experiences in Ireland

During the course of the ArchaeoLandscapes Project, the Discovery Programme has been involved with several initiatives to encourage the understanding and use of remote sensing practices within community driven archaeology projects.

Communities of local historians: "The longest day" research project

This community based project, supported by local and national government, aims to undertake a three-year programme of archaeological, historical, and geographical research into the events and expanse of the Battles of Enniscorthy and Vinegar Hill, important events in the Irish Rebellion of the late 18th Century. This project aims to not only further the understanding of the historic event, but also raise the profile of this battlefield of national significance. The Discovery Programme has provided support and expertise in sourcing and processing existing remote sensing data to the community group. A DSM generated from LiDAR has been particularly import to the project and has helped to design a further campaign of geophysical prospection to answer carefully framed research questions.


Shaded relief digital surface model of the summit of Vinegar Hill derived from National Road Authority (NRA) LiDAR survey.


Steering Group Meeting on the summit of Vinegar Hill discussing the battlefield landscape.


Teaching Glenstal Abbey students how to scan and model in 3D a detailed carved stone figure.

Communities of education: Glenstal Abbey School

In 2014 the Discovery Programme participated in a community education project at Glenstal Abbey School in Murroe, Co. Limerick. This outreach project aimed to teach the Glenstal Transition Year students about various methods used in archaeological practice today, and to give them an insight into the multidisciplinary nature of the field of archaeology. Students undertook both in-class and fieldwork modules in relation to archaeological remotes sensing including the application of laser scanning, historic building survey and geophysical survey at the various monuments on the school campus.

Communities of one: Simon Dowling

Engaging with community archaeology can also involve the participation of individual amateur enthusiasts who have become highly skilled in their own archaeological survey methods. One such group are the aerial remote control enthusiasts who are now carrying out highly successful aerial surveys of archaeological landscapes and monuments. One such person: Simon Dowling, has been participating in fieldwork with the Discovery Programme utilising kite and drone photography, producing detailed topographic 3D models and orthoimagery of monastic sites through the application of structure from motion (SfM) modelling methods.


Amateur aerial archaeologist Simon Dowling utilising kite aerial photography (KAP) at Ferns monastic site, Wexford.


Resulting orthoimage and digital surface model produced by Simon Dowling's KAP survey (Images courtesy of Simon Dowling).

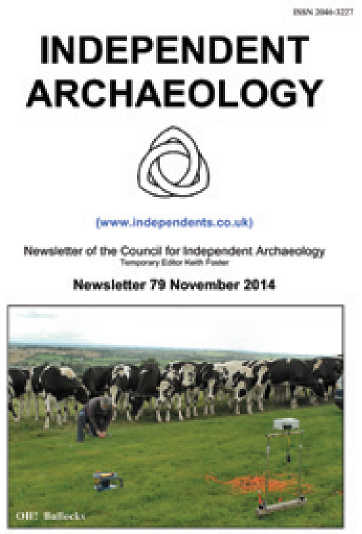
Council for independent archaeology: Community archaeology and remote sensing

Kevin Barton[1] / Keith Foster[1] / Gerard Latham[1] / Kevan Fadden[1]
1. Council for Independent Archaeology

Introduction

The Council for Independent Archaeology was formed in 1987 to educate the public in the study of archaeology by:

- Exploring and promoting ways in which amateur archaeologists and local archaeological societies can contribute more effectively to archaeology.
- Holding regional congresses, seminars and workshops.
- Supporting and assisting the archaeological work of societies and individuals.



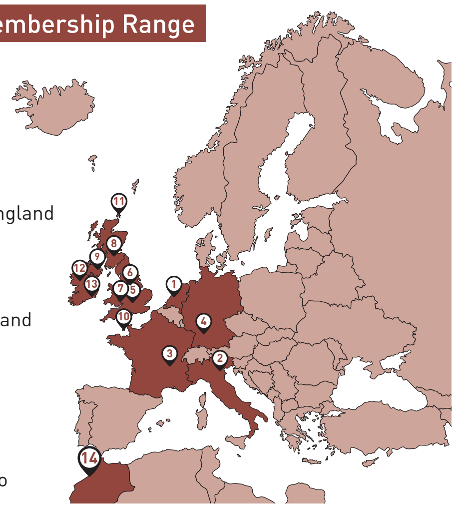
Left: Membership of the Council for Independent Archaeology in Great Britain. **Right:** The Newsletter of the Council for Independent Archaeology. (Keith Foster).

Council for Independent Archaeology Conference 2014 hosted by Wallingford Historical & Archaeological Society at Wallingford Methodist Church Centre. (Kevin Barton).

Poster Sites & Membership Range

Locations

(1) Leiden, Netherlands
(2) Padova, Italy
(3) Montchenu, France
(4) Monsheim, Germany
(5) Wallingford Castle, England
(6) Calke Abbey, England
(7) Monmouth, Wales
(8) Lanark, Scotland
(9) Belfast, Northern Ireland
(10) Grouville, Jersey, Channel Islands
(11) Orphir, Orkney
(12) Claremorris, Ireland
(13) Kilmokea, Ireland
(14) Casablanca, Morocco



The Council has approximately 2500 members, either directly or in its 50 affiliated Archaeological Societies from all over Great Britain and a small number in other parts of Europe and USA. The Council produces 3 newsletters each year and a conference over a weekend in late summer. The newsletters and conference keeps the membership informed of recent activities of other members. The Council also sponsors research and development of Earth Resistance Meters and the prototyping of affordable Fluxgate gradiometers and GPS equipment. The aim where possible is to use open source hardware and software.

TR/CIA Earth Resistance meter

In the 1990's the CIA wished to assist its members by making an accurate, durable resistance meter available at low cost. Members were consulted with the idea of a self-assembly kit. Bob Randall replied and suggested that he could produce an instrument with data logger to a high standard if the CIA supported him with frame design and provided a market to cover his costs. As an amateur archaeologist himself he was prepared to work at no cost in his spare time. More than a hundred Mark 1 instruments were produced which have been successfully used from the Arctic Circle to Easter Island.

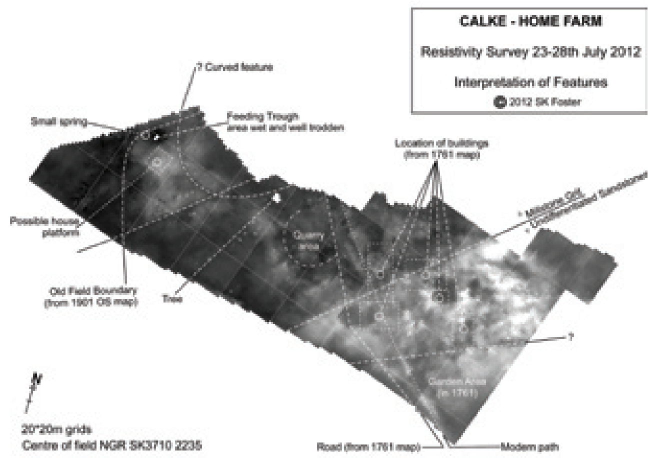
Production ceased due to new regulations on solder use. A Mark 2 instrument is nearing completion which incorporates the latest technology which will allow easier use with a real time display of results, greater accuracy and also the potential to add further geophysical applications in the future.

Left: TR/CIA Mark 1 Earth Resistance Meter. **Right:** Training session at Kilmokea Enclosure, Great Island, County Wexford, Ireland with the TR/CIA Meter mounted on a 0.5m frame and configured as a twin-probe array. (Kevin Barton/JohnFlynn).

Calke Abbey Earth Resistance survey

The survey covered most of the field (centre at UK OS SK3710 2235) that lies at the eastern end of Calke Park close to the junction between the exit drive from Calke Abbey and the unclassified road that runs north through Calke village to the reservoir. Documentary and map evidence from 1761 showed that a large house with outbuildings and a garden stood in the eastern section of the field and that the medieval Kings Highway from Derby to Coventry ran diagonally south east across the field as it wended its way from Swarkestone Bridge to Ashby and beyond. This part of the road continued in use until after 1761 when the park boundary was enlarged and the road was diverted to the east along the course of the unclassified road.

Vestiges of this road remain to the north and west of the survey. The aim of the exercise was to try and define the route of this road and to pinpoint the remains of the buildings. Archaeological excavation has since taken place and has definitively proved the location of the road and some of the buildings.



Calke Abbey, Calke, South Derbyshire, England – Earth resistance survey (Black = low) with interpretation overlay. (Derbyshire Archaeological Society).

Wallingford Castle Earth Resistance survey

Wallingford Castle was one of the first to be built by William I (William the Conqueror) and one of the largest. It is unique in that it had three baileys, moats & walls. The Anglo Saxon burh wall was used as part of the third wall. Most of the structure above ground was removed by Oliver Cromwell after the civil war. The earth resistance survey was conducted by the Wallingford Historical & Archaeological Society in 2009. The castle is a statutory monument and survey permission had to be obtained from English Heritage. This is the only geophysical survey of the castle that has been done.

The site is very steep in places and occasionally the surveyor had to be roped in order to obtain satisfactory results - ground penetrating radar & magnetometry would not have worked. The results show walls, ditches and some of the internal layout of the castle.

Wallingford Castle, Wallingford, Oxfordshire, England – Earth resistance survey (Black = low) overlaid on Google Earth image. (Wallingford Historical & Archaeological Society).

Council for Independent Archaeology Website

Exploring Europe's past landscapes: Current techniques and future developments

Michael Doneus[1,2] / Wolfgang Neubauer[2,3] / Immo Trinks[2]
1. University of Vienna, Institute for Prehistoric and Historical Archaeology, Franz-Klein-Gasse 1, 1190 Vienna, Austria / 2. Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology, Hohe Warte 38, 1190 Vienna, Austria / 3. University of Vienna, Vienna Institute for Archaeological Science (VIAS), Franz-Klein-Gasse 1, 1190 Vienna, Austria

Introduction

The mission of the *Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology* is to develop systematic, high-resolution, large-scale, integrated archaeological prospection approaches while at the same time focusing on novel methodological concepts for the archaeological interpretation of the great quantity and quality of collected data. By integrating traditional methods (systematic field-walking) with near-surface geophysical (magnetics, ground penetrating radar) as well as remote sensing techniques (aerial photography, Airborne Laser Scanning, imaging spectroscopy), entire landscapes are thoroughly documented at multiple scales. The generated data forms the basis for a four-dimensional GIS-based approach to interpretation.

Considerable advances have been made in the field of remote sensing data acquisition, both in terms of data quality as well as data quantity. For aerial photography, a cost-effective hardware solution (GNSS and IMU) allows the recording, during image acquisition, of all essential exterior orientation parameters for automated archiving of each photograph's footprint (Wieser et al., 2014). Airborne imaging spectroscopy (AIS) was previously characterized by an archaeologically-insufficient ground-sampling distance, but recently a resolution of 40 cm has been achieved, which allows the extraction of detailed, archaeologically relevant features. However, along with problems of data redundancy and the visualization of the large amount of generated data, the increased resolution also introduced a considerable amount of noise. Therefore, a MATLAB®-based toolbox (ARC-TIS – ARChaeological Toolbox for Imaging Spectroscopy) was developed for filtering, enhancing, analyzing and visualizing these imaging spectrometer datasets (Atzberger et al., 2014; Doneus et al., 2014) **(Fig. 1)**.

Utilizing green laser sources, airborne topo-bathymetric laser scanner systems are able to measure surfaces above and below the water table across large areas in great detail. By using very short, narrow green laser pulses, they can even reveal sunken archaeological structures in shallow water (Doneus et al., 2013). The radiometric calibration of full-wave-form ALS data can now be achieved both for single- as well as multiple wavelength data (Briese et al., 2014; Lehner and Briese, 2010).

In the course of the first four years of the LBI ArchPro several motorised multichannel magnetometer systems were developed and taken into operation.

AUSTRIA & BRITAIN

Locations
(1) Carnuntum, Austria
(2) Stonehenge, Britain

Thorough testing now permits the reliable use of magnetometry for high-resolution archaeological prospection on a very large-scale. Using a sample spacing of 25 cm crossline and 10 cm inline, daily coverage rates of over 20 hectares have been achieved. Two different novel multichannel GPR systems (MIRA and SPIDAR) have been evaluated (Trinks et al., 2010), motorized, adapted and optimized for their use for efficient large-scale prospection. Very dense GPR data acquisition with 4×8 cm, 4×10 cm or 5×25 cm has become possible at unprecedented daily coverage rates of up to six hectares **(Fig. 2)**.

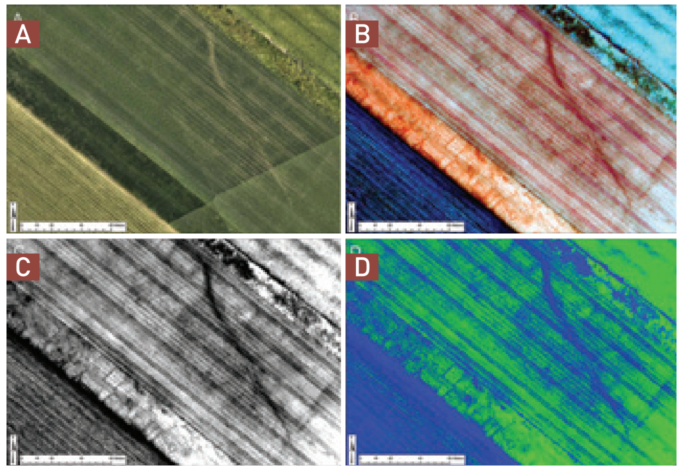


Fig. 1: Data from Carnuntum, Lower Austria, acquired on May 26th 2011. **(A)** Conventional orthorectified aerial image, acquired in the visible spectrum. GSD of 0.1 m; enhanced using contrast limited adaptive histogram equalization (CLAHE); **(B)** false colour composite created by means of the REIP algorithm (R= band 1 (wavelength), G = band 2 (slope), B = band 3 (reflectance value)). **(C)** Rate parameter b of the gamma distribution fitting; **(D)** normal distribution fitting (R = NONE, G = band 2 (σ), B = band 1 (μ)). GSDs of **(B)**, **(C)** and **(D)**: 0.4 m. **Fig. B, C, and D** were subject to the same histogram stretch by means of standard deviation (University of Vienna & LBI ArchPro, Michael Doneus).

By April 2015 the large-scale archaeological geophysical prospection within the LBI ArchPro case studies and associated projects (Carnuntum, Gokstad) has reached a total coverage of 42.7km² at the above-mentioned spatial measurement resolution (33.5 km² magnetics, 9.2 km² GPR) **(Fig. 3)**.

Based on the *ApMag* and *ApRadar* software packages, developed by Alois Hinterleitner at the *Austrian Central Institute for Meteorology and Geodynamics* for the processing of traditionally acquired geophysical archaeological prospection data, the new software suite ApSoft2.0 has been realized. This allows the processing of the very large prospection data sets that are acquired with motorized survey systems using automated positioning solutions. The new software is able to process and visualise magnetic and GPR data recorded along irregular paths and includes advanced processing steps such as GPR data migration in two and three dimensions, the output of coverage shape files and the automatic generation of geo-referenced data images for subsequent data analysis and interpretation in GIS.

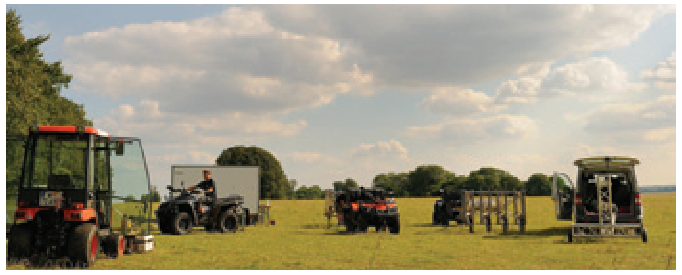


Fig. 2: Motorized LBI ArchPro fluxgate magnetometer systems and 16-channel 400 MHz MALÅ Imaging Radar Array (MIRA) in operation at Stonehenge (LBI ArchPro, Geert Verhoeven).

To aid future interpretation of all case study data, a comprehensive GIS-based interpretation workflow and tool-set *"ArchaeoAnalyst"* is being developed. It includes semi-automatic data classification algorithms for magnetic prospection data using multi-scale hierarchical data segmentation, object-oriented definition of semantic classes for data classification and an iterative classification workflow, resulting in data sets devoid of unclassified areas (Pregesbauer et al., 2014). This approach is being expanded to GPR depth-slice data, and possibly will include in the future even 3D GPR volume data **(Fig. 4)**.

All developments are systematically tested in the framework of international large-scale case studies conducted in Austria, Great Britain, Sweden, Norway and Germany (Draganits et al., 2014; Gaffney et al., 2012; Neubauer et al., 2014; Trinks et al., 2013). These case studies form an important and integral part of the LBI ArchPro research programme, testing theoretical and practical developments related to archaeological landscape prospection at an unprecedented scale and resolution (Trinks et al., 2012). The results demonstrate that it has become possible and affordable today to acquire high-resolution data across large areas, measuring square kilometres rather than hectares. In combination with modern interpretation techniques, this novel approach heralds a new era in archaeology, where archaeological excavation is no longer the primary source of information for archaeological research.

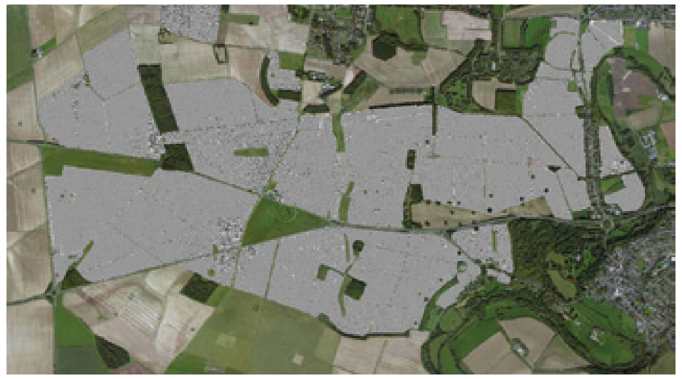


Fig. 3: Area of 9.1 square kilometres magnetically surveyed from 2010 to 2013 by the LBI ArchPro and the University of Birmingham within the Stonehenge Hidden Landscape Project. (LBI ArchPro & University of Birmingham, Klaus Löcker).

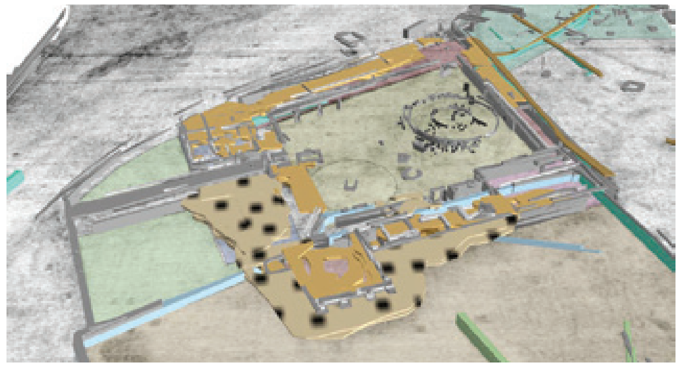


Fig. 4: 3D archaeological interpretation of the gladiatorical school at Carnuntum based on a high resolution ground penetrating radar survey. (LBI ArchPro, Wolfgang Neubauer).

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ArcLand HERITAGE · DATA · KNOWLEDGE
Culture
Ludwig Boltzmann Institute Archaeological Prospection and Virtual Archaeology

From ArcLand to emptyScapes: Filling 'empty' landscapes, mapping the archaeological continuum

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Introduction

Research in the Mediterranean area reflects a real gap between archaeological recording and broader aspects of interpretation. This was not just historically conditioned but also results from the natural characteristics of the Mediterranean landscape. Architecture and urbanism in the ancient cities lend themselves very well to investigation. By virtue of their monumental importance, artistic value and easy accessibility the ruined remains of ancient structures have always been a focus of research.

This is also true for preserved remains of Greek field systems and Roman centuriation, which have been recorded from the ground and from the air from as early as more than half a century ago. By contrast, sites and landscape features outside the ancient urban centres, most of them now completely buried and therefore invisible to the naked eye, have less frequently been investigated. From about the end of WW2 a new interest in landscape studies appeared in the Mediterranean area. Since mid '70s there has been an explosion of activity providing coverage of archaeological research in the majority of circum-Mediterranean countries (Alcock, Sherry 2004). The main approach in this revived research direction has been (and remains) field-walking survey, within a variety of project-based strategies. This pioneering post-WW2 and later field survey work has produced dramatic data that has made significant contributions to reconstruction of the past. Virtually every region that has been explored has produced results, which demanded the revision or review of existing ideas (Broodbank 2013). However, going into the detail after millions of hectares of Mediterranean landscapes have now been surveyed by terrestrial reconnaissance, it is legitimate for us to ask:

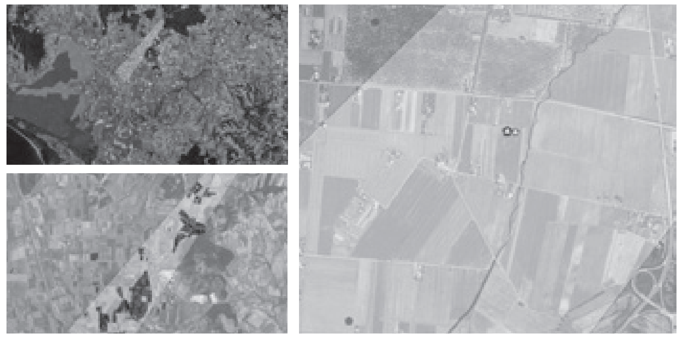
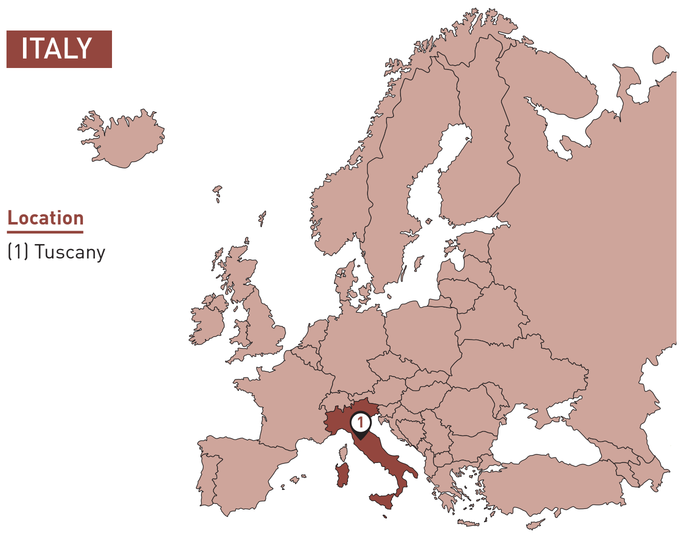


Fig. 1: The Rusellae/Grosseto study area. **Top left:** Distribution map (grey dots) of field-walking survey and Lake Prile (dark grey) which occupied part of the Rusellae/Grosseto study area during the first millennium BC and up to the end of the Middle Ages. The pale-grey area represents the sample transect now under study, with dark grey for the areas already covered by geophysical prospection. **Right:** Closer view of part of the sample transect showing the results of traditional archaeological survey.



which questions have been answered? In essence the general contribution is quite clear to summarize. There are two main fields where a substantial impact has been achieved: settlement and trade patterns both manly from the Mediterranean to the regional scale; and contributions to specific chronological phases, above all higher impact on to the Roman period should be recognized. By contrast, the surveys have produced generally poor results for the pre-Roman and mediaeval periods, though the degree of impact has varied from area to area.

Moreover, the reconstruction of settlement patterns represents only one element in landscape complexity; this framework, for instance, for generally reveals little about environmental transformations and human interaction (pedology, land-use etc). As a consequence a wide variety of questions belonging to the sphere of archaeology, history, anthropology and environment are seriously prejudiced by this approach. Furthermore, the reliability of field-walking survey has been debated for decades without much being achieved in resolving inherent methodological weaknesses in comparing the results of different surveys and establishing relationships between the survey results and demographic trends (Alcock, Sherry 2004).

There are further biases that affect the results of landscape study based on field-walking survey. Two decades ago Barker, in his introduction to the Biferno valley (1995), outlined how Braudel (1972) in his opening chapter (part one of La Mediterranée) lamented how the low land has tended to dominate most previous analyses of Mediterranean history. Archaeological survey has failed to confront or resolve this bias since the application of field-walking is strongly influenced by present-day land-use and is therefore mainly restricted to ploughed land which for the most part corresponds to the low land. Higher land is mainly wooded or put down to pasture, which are less responsive to field-walking survey.

Moreover, it is worth commenting in this context that about 50% of the European Mediterranean land-mass falls into this category (FAO 2006). Despite these obvious weakness historians as well archaeologists use field-walking data to support models, patterns and large-scale landscape transformations. The answers to big historical questions are still for the most part sought through textual analysis and archaeological excavation rather than through landscape studies (Witcher 2006).

In the last two decades a central role in the continuing debate about methodology within archaeology and landscape studies has been provided by at least three long-term European research projects: the POPULUS project (1995-2000), the Radio-PAST project (2008-2013) and the ArcheoLandscapes Europe project (2010-2015), all strongly associated with universities and other institutions belonging to both the continental geographic sphere and also the Mediterranean area. Emptyscapes, is a two year project funded by the European Union under the Marie Curie scheme. The research is designed and aimed to stimulate changes in the way in which archaeologists (in Italy in particular but also more generally in the Mediterranean world) study the archaeology of landscapes, moving from an essentially site-based approach to a truly landscape-scale perspective. The project focuses on the rural landscape between Rusellae and Grosseto **(Fig.1 and 2)** and the formerly-urban historical landscapes of Veii **(Fig.3)** in Italy and is aimed at prompting the development and wider application of new paradigms for landscape analysis. The aim is to help in the development and wider application of new paradigms for landscape analysis based on an interdisciplinary programme integrating 'traditional' approaches (field-walking survey, aerial photography etc), environmental studies (palaeo-environment, geo-archaeology, bio-archaeology) and new technologies in the form of high-precision, high-speed, large-scale geophysical survey and the collection and analysis of high-resolution LiDAR data.

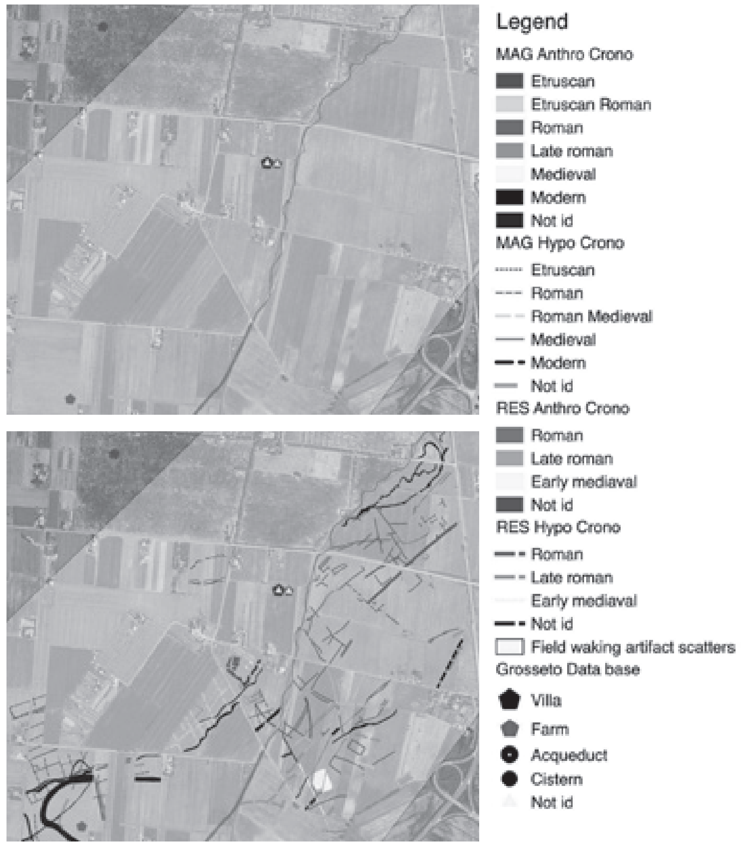


Fig. 2: The Rusellae/Grosseto study area. **Top:** Part of the sample transect with red to show the results of traditional archaeological survey. **Lower:** The same area showing integrated remote sensing survey and GIS based data mapping. Grey scale mapping drawings show the various kinds of natural and archaeological features identified so far. The quantitative and qualitative improvement in the landscape database is clearly visible, making it possible to ask, and eventually to answer, new archaeological questions about field systems, communication routes, settlement patterns, and former water courses that may have conditioned settlement and land-use within the sample area. The smaller-scale inset in the top left corner of the diagram shows the areas of completed geophysical prospection in dark grey, clearly demonstrating the correspondence between detected features and the adopted survey method.

The first year Emptyscapes project has clearly demonstrated the effectiveness of this approach to landscape studies also in the Mediterranean environment, showing that archaeological features are potentially present everywhere. Moreover, increasing research intensity gaps in time and space are progressively disappearing or significantly reducing: the absence of past human activity seems to be in reality the exception rather than the rule.

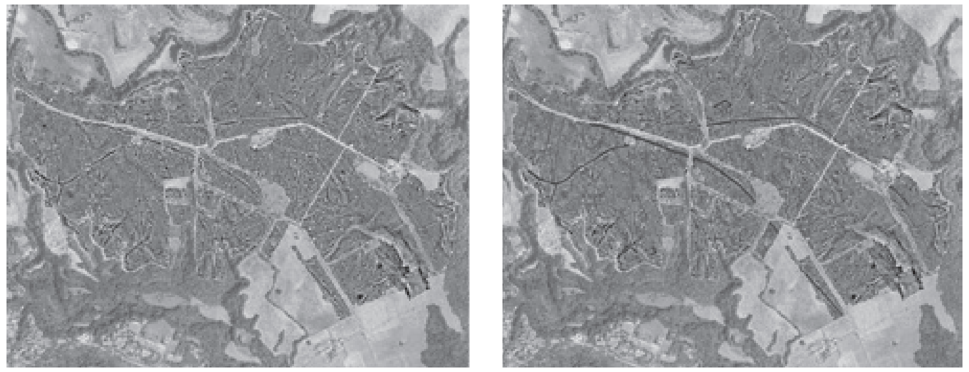


Fig. 3. Left: Magnetic survey of the plateau of the ancient city of Veii. **Right:** Archaeological interpretation.

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From integration to interpretation: Understanding the archaeological record from a multi-method perspective

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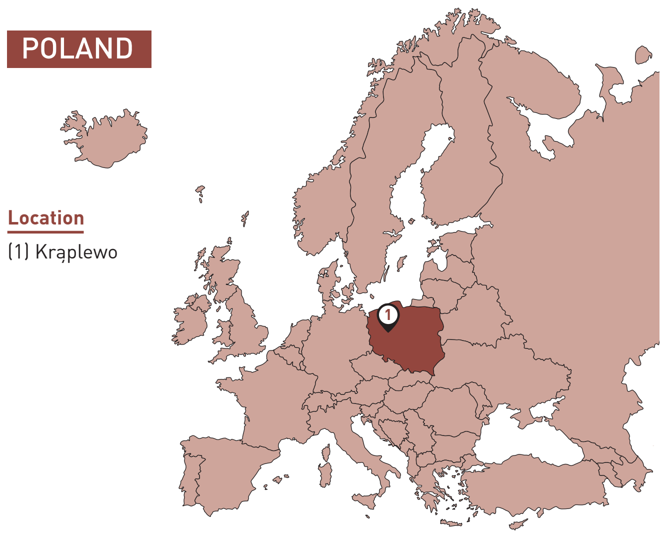
Introduction

Integration of data has become a buzz theme among archaeological prospectors and usually entails application of a range of non-invasive methods. Often these do little more than confirm what is already known but it is rare to question how, or if, they change our knowledge of a site. This poster does this using a site in Poland as a case study.



A range of methods was used at a site in Krąplewo which was identified during aerial reconnaissance in 2007 and interpreted as a medieval defensive enclosure **(Fig. 1).** It was undoubtedly a man-made feature but, due to heritage requirements and regulations, it had to be 'verified' using already approved field methods. In 2010 further investigations using fieldwalking, trial trenching and geophysics 'confirmed' the presence of the site and it was registered in site and monument records. Thus, the success of an integrated approach could be announced. However, rather than closing the process, numerous discrepancies which were noted within and between the results of different methods opened up new interpretative vistas.

Fig. 1. A: Krąplewo, Wielkopolska region. A well-defined, regular and broad ditch was identified during aerial reconnaissance, Photo: W. Rączkowski, 17.06.2007. **B:** Interpretation of photographs was carried out in 2009 and on the basis of site location and morphology it was interpreted as the remains of a defensive enclosure. Legend: 1-ditch, 2-possible internal structures. Drawing: L. Żuk.

Geophysics and trial trenching

Magnetic survey had two main objectives which stemmed from photo-interpretation: clarification of the ditch in its North-East and South-East parts where it is masked by deeper soils (greener crops) and identification of structural remains inside the enclosure which did not show very clearly on aerial photographs **(Fig. 2).** Magnetic response was poor and only in the South, North-West and East were parts of a possible ditch outline recognised but they were even less obvious than on aerial photographs. There was also no evidence for buildings inside the enclosure. Thus results did not meet expectations but rather than rejecting them, an insight into their nature may help direct further investigations. Trial trenching showed that the strongest magnetic responses occurred above deposits of charcoal in ditch fill that was otherwise dominated by organic material. This may explain a weak magnetic signal in other parts and indicate that the site went through a process of a natural collapse rather than rapid destruction.

Fig. 2. A: Magnetic survey carried out in autumn 2010. It did not provide the expected information about the site layout and internal structures but nevertheless indicated some stronger response in the South-East part which coincides with deposits of charcoal. Legend: 1-areas of strongest magnetic response, 2-trial trench. Geophysics: Ł. Pospieszny. **B:** Trial trenching showed that the ditch filling was predominantly organic material with random charcoal, which may explain the generally weak magnetic response and indicate site formation processes. Legend: 1-grey and yellow sand, 2-grey and brown organic layer, 3-brown organic layer with charcoals, 4-dark yellow sand with ploughing traces. Trial trenching: A. Klimowicz.

Fieldwalking and aerial archaeology

No data was recorded in 1987 from the low knoll where the enclosure is located. Only a few pieces of prehistoric and medieval pottery were registered as a 'settlement point' on a slope facing the enclosure (site 144). However, in autumn 2010 two major concentrations of potsherds were recorded **(Fig. 3).** In both cases medieval pottery dominated. It could be questioned whether the scatters as recorded represent the extent of past sites or if the occupation areas have been skewed by movement of artefacts, especially when they occur on slopes, but the evidence in itself was inconclusive. The number and distribution of potsherds neither confirmed an earlier interpretation of the site 144 nor the enclosure. New possibilities opened up when aerial photographs taken in July 2011 were analyzed **(Fig. 4).** Two groups of pits were recorded within the area called site 144 thus indicating a small open settlement of medieval date although the presence of prehistoric pottery still requires an explanation.

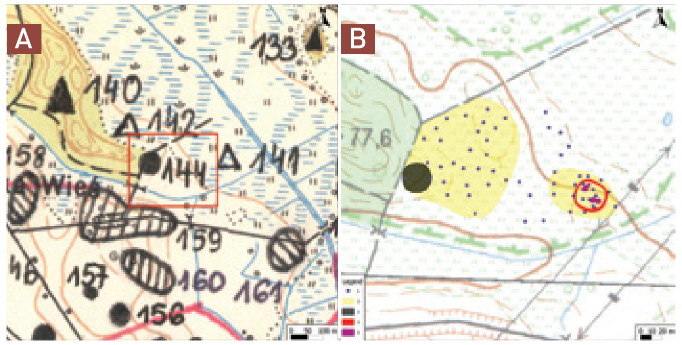


Fig. 3. A: Part of a map sheet showing sites recorded during the Polish Archaeological Record Programme (AZP) which was carried out in 1987. The only 'settlement point' was recorded as site 144. It was indicated by a conventional symbol on a slope facing the enclosure. **B:** Fieldwalking in autumn 2010 revealed two concentrations of potsherds. One covers and enlarges the already-known site 144 and the other coincides with the newly-discovered enclosure. Their date was predominantlymedieval but function could not be determined from the evidence. Legend: 1-potsherd scatters, 2- potsherd concentrations, 3-site 144 (as recorded in 1987) 4-ditch 5-possible internal structures. Drawing: A. Klimowicz, L. Żuk.

To be considered...

There are many reasons why fieldwalking in 1987 did not record a concentration of finds at the enclosure and so indicate the presence of a site. Information about the field conditions at site 144 indicated unfavourable conditions for observations, but no further details were provided. However, a vertical photograph taken in 1986 offers some clues about land management at that time **(Fig. 5).** Also, a hypothesis that a considerable increase of potsherds may indicate a rapid erosion of features was rejected by trial trenching in 2010. A top ditch layer showed a ploughing intrusion of up to 8 cm and an interview with the owner confirmed that deep ploughing had not occured (although the site location may also indicate soil movement as a factor).

Thus, the lack of record may suggest an unfavourable year for recording surface scatters or a careless observer. In any case, it shows the need for a cautious approach towards results of any singular survey (regardless of method) and a need for their multidimensional interpretation.

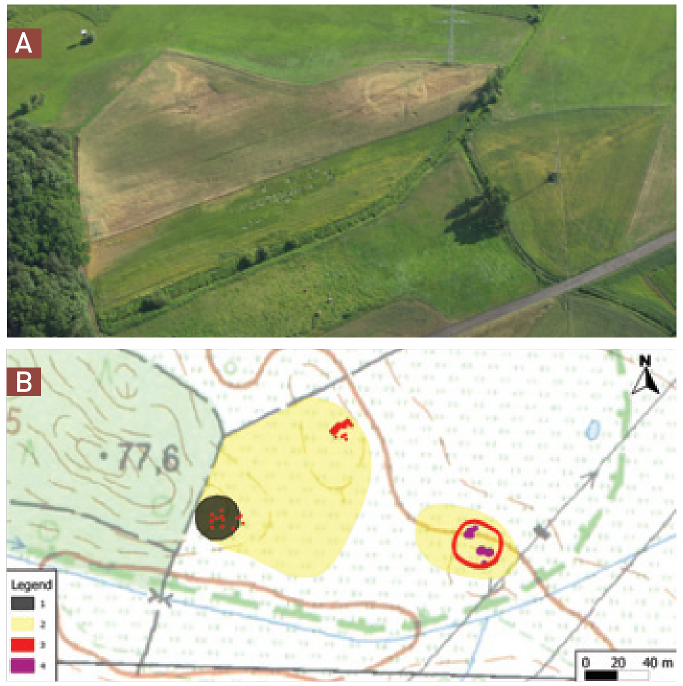


Fig. 4. A: Aerial reconnaissance in 2011 revealed additional information about archaeological features within the area of the site 144. Photo: W. Rączkowski, 23.06.2011. **B:** Results of fieldwalking show major concentrations of potsherds that include the pits identified on aerial photographs. Legend: 1-site 144, 2-potsherd concentrations, 3-ditch, pits, 4-possible structures. Drawing: A. Klimowicz, L. Żuk.

Fig. 5. A: Vertical photograph taken on 17.06.1986 shows land management at the period of fieldwalking. Legend: 1-site 144. Resources: CODGiK. **B:** A digital terrain model made by Ł. Banaszek shows the location of the enclosure on a small local knoll. Legend: 1-ditch, 2-height above sea level.

Geophysical survey of the viking age burial mound of Herlaugshaugen in Norway

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Introduction

In June 2012 the NTNU University museum undertook a geophysical investigation of the Viking Age burial mound of Herlaugshaugen at the island of Leka, in North-Trøndelag County (Fig. 1). This mound is mentioned in the Viking saga sources, where the Viking king Herlaug is said to have used three years to build the mound, and chose to be buried inside the mound instead of bowing to the rule of the King Harald Finehair (approx. 850- 931/932 AD), who wanted to be king of all of Norway (Gansum 2013).

NORWAY

Location

(1) Leka, in North-Trøndelag County

The geophysical investigation was undertaken on behalf of Leka municipality and the North-Trøndelag county council, and was performed by the NTNU University Museum, Department of Archaeology and Cultural History. By the means of a ground penetrating radar (GPR) and earth resistivity imaging (ERI), the aim was to gain additional insights into the way the mound had been constructed, its preservation conditions, and to seek answers to whether or not the geophysical methods could reveal a Viking ship or additional details about the presence of a burial chamber.

Fig. 1: The remains of the Herlaugshaugen burial mound. Photomosaic: Robert Fry.

Method

43 GPR profiles were collected over the mound, along with 22 electrical resistivity profiles, covering the main preserved parts of the mound **(Fig. 2).** It was possible, through extensive data processing, to visualize the data from both geophysical methods in three dimensions. The Earth resistivity data were corrected for topographical effects and, through a 3d-inversion in the software Res3dinv, we could import the data into the GPR-slice software for 3d-visualization as well as extracting isosurfaces. The GPR data were collected for tilt- and roll, making it possible to visualize depth slices and GPR sections with topographical effects being accounted for (Goodman et al. 2006, Loke 2015). As a result, we could perform a cultural historical interpretation of the collected data.

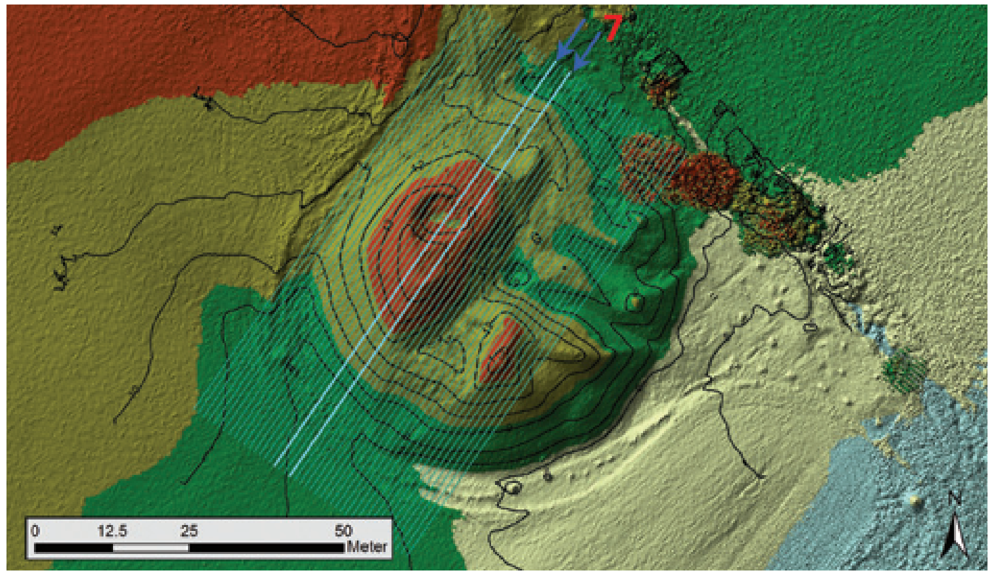

Fig. 2: Position of line 7 on the GPR and ERI-data.

Ground Penetrating Radar - Line 7 and 10

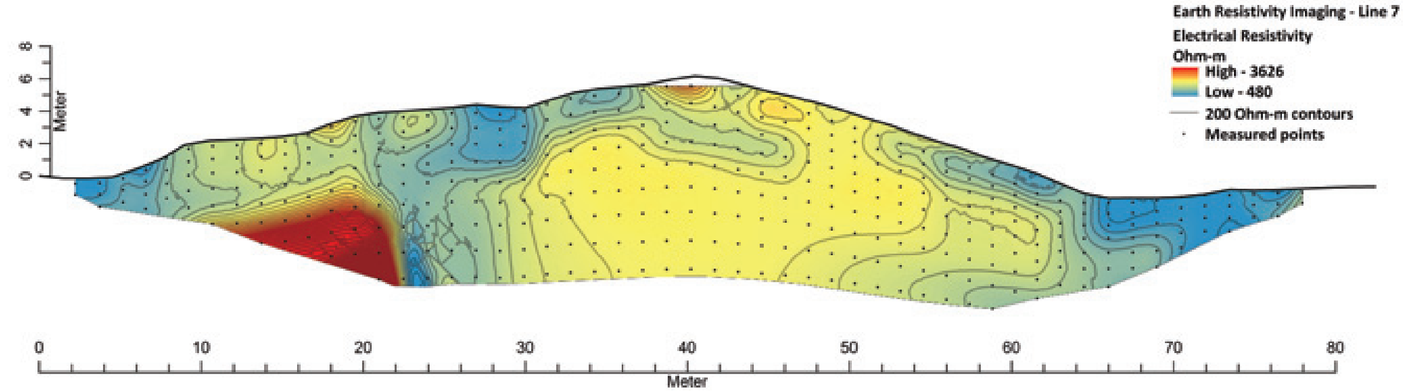

Fig. 3: Earth Resistivity section of line 7.

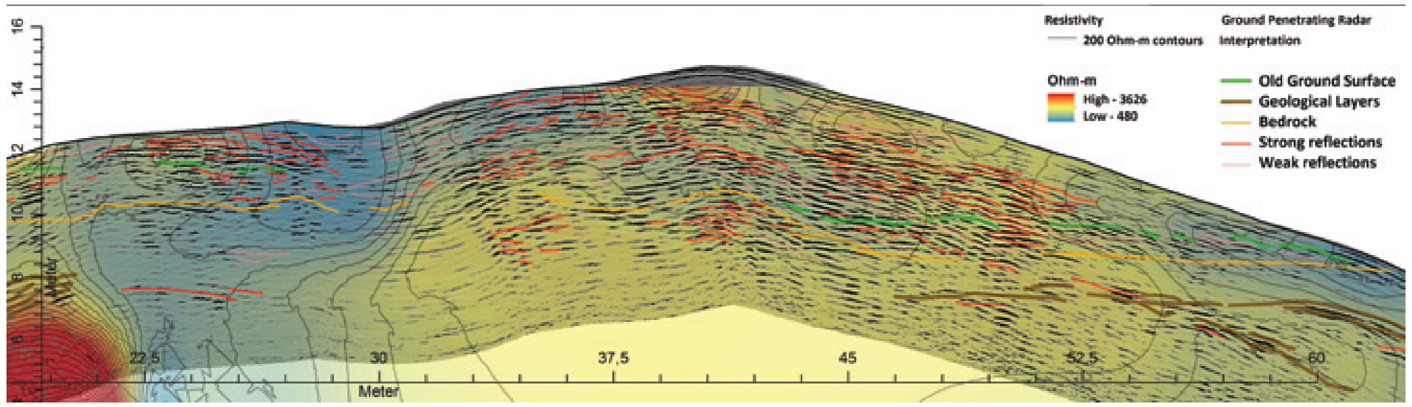

Fig. 4: Combination of GPR and ERI of line 7.

Results

The geophysical data indicates that the mound was constructed in several phases, seen as reflective layers with different angles in the GPR profiles **(Fig. 4).** It was possible to assess the depth of the former surface layers within the mound, where the combination of both GPR and ERI-data provided very useful information. It was also possible to characterize the materials of which the various layers were constructed, as the GPR reflection patterns and the earth resistivity measurements reflect the composition and layering of the materials within the mound **(Figs. 3 and 4)**. On the basis of this analysis, it would seem that the mound was constructed of layers of turf, clay or organic material piled against a construction in the centre of the mound. It is difficult to be certain if this construction is the central cairn or not. An area of low resistivity was also clearly delineated north-west of the centre of the mound **(Figs. 3-5).** The top meter or so of the mound surface, at least in the best preserved parts of the mound, is made up of relatively homogenous material – probably sand or gravel without any inclusions of larger stones. The central construction, possibly interpreted as a central cairn, was difficult to delineate in plan **(Fig. 5).** No clear indications of a ship burial were detected, but this does not rule out the possibility that the mound was a ship burial as the historical and antiquarian sources suggest. A good impression of which parts are well preserved and not, was gained through the analysis of topographical and geophysical data. Also, the effects of water intrusion, physical intrusion and other events could be assessed.

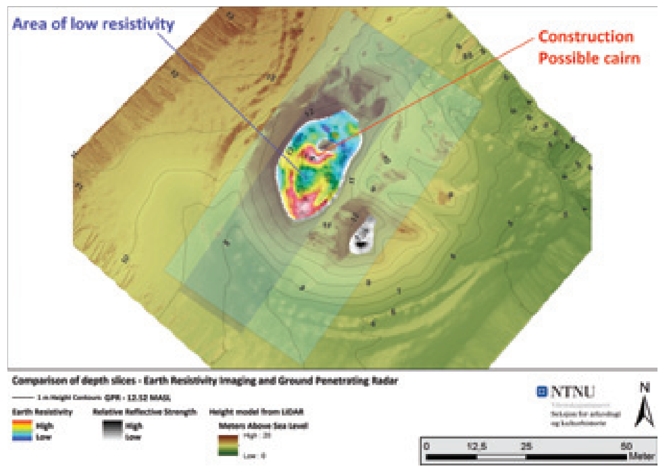

Fig. 5: Combination of GPR and ERI depth slice at 12.52 MASL.

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Kilmokea and Kilberry: Community-based archaeological remote sensing in Ireland

Kevin Barton[1] / John Flynn[2] / Justin Kenny[3]
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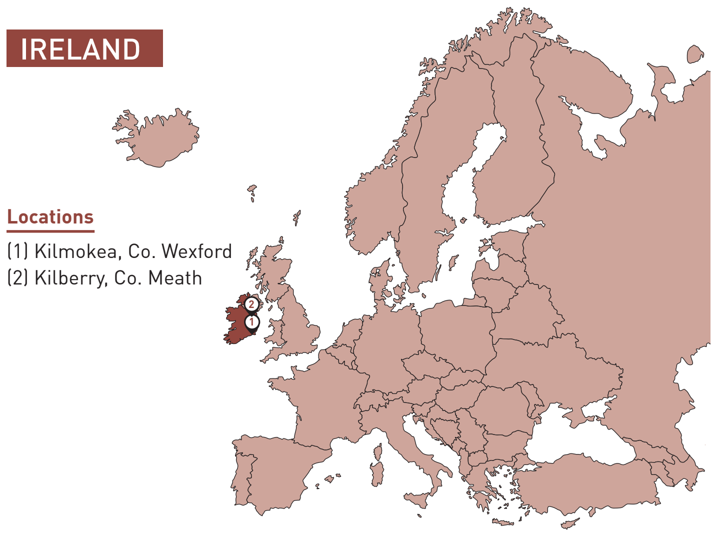
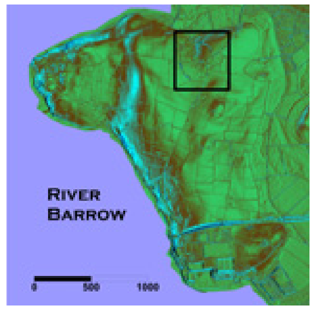
Introduction

We have been investigating archaeological monuments in our local landscape. Our motivation in initiating this work includes; a sense of, and pride in, our local environment, a wish to learn more about known monuments and our local landscape and a possibility in finding or confirming a new monument through carrying out our own original work. Outcomes from these initiatives include raising awareness of local heritage and heritage resource assessment/ management for possible local tourism development.

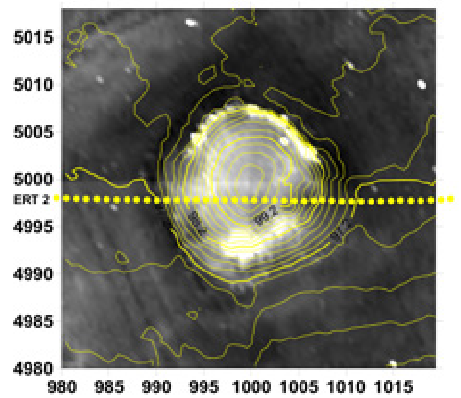
We have used LiDAR data to guide fieldwalking and geophysical survey. Use of LiDAR has enabled us to learn about archaeological remote sensing. Ordnance Survey Ireland (OSi) has made LiDAR data available to us at a reduced cost.

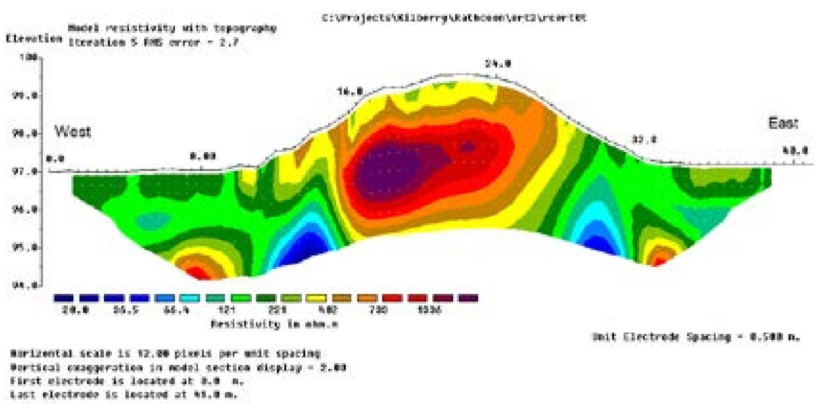




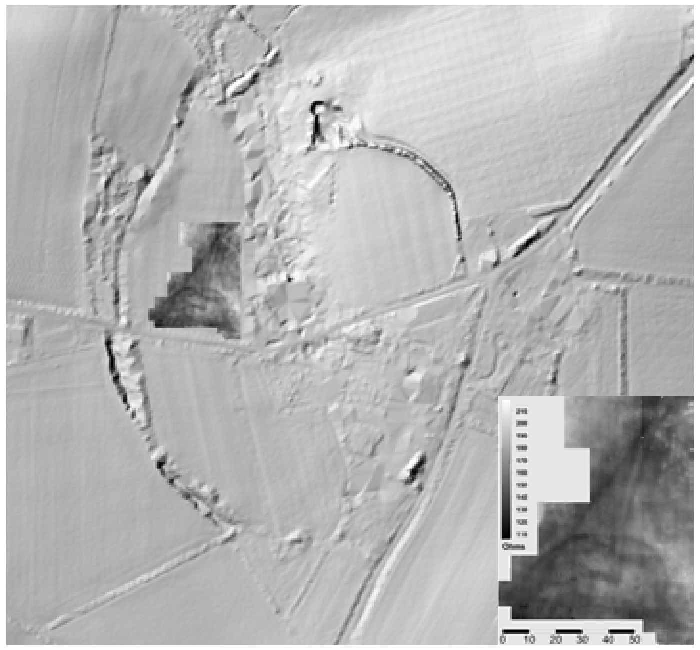
Left: Great Island - LiDAR Digital Elevation model with location of Kilmokea Enclosure (LiDAR data by kind permission of Ordnance Survey Ireland).
Right: Kilberry - Oblique aerial photograph of Rathcoon Mound with 40m x 40m survey area (Rhys Kellett).

Geophysical surveys have been carried out during training workshops. These workshops provided us with an introduction to the theory, technology and survey methodology. The workshop method was 'learning by doing'. At present we are funding these preliminary surveys through local fundraising initiatives. We are seeking more sustainable funding to extend the work to include publication, signage and cultural heritage tourism. Our communities are kept informed of progress with presentations and newsletter and newspaper articles. We reach a wider audience with participation in the Annual Heritage Week initiative sponsored by the Heritage Council.





Left: Rathcoon Mound - Earth resistance results with topographic contours and location of ERT 2. **Right:** West to East electrical resistivity tomography pseudo-section (ERT 2) across Rathcoon Mound.

Kilmokea Enclosure: Earth resistance results overlaid on a LiDAR image.

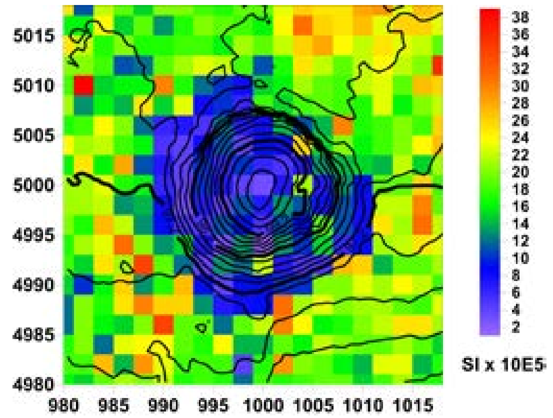

Upper: National Heritage Week public presentation at Kilmokea.
Lower: 'Leaning by Doing' - field briefing on carrying out an earth resistance survey.

Remote sensing at Kilmokea and Kilberry

Sliabh Coillte group are investigating Great Island in County Wexford. The Kilmokea Enclosure with possible bank and ditch is a major 7 ha feature and is recorded as an Ecclesiastical Enclosure from the Early Christian Period. Evidence from nearby excavation suggests Bronze Age settlement and there is also evidence for Viking and Norman activity. LiDAR analysis identified a rectangular-shaped anomaly in the northwest quadrant which appeared to be part of a larger, possibly square-shaped feature. An earth resistance image has revealed a complex series of overlapping linear and curvilinear anomalies likely to be due to trackways, small enclosures and possible building foundations. An electrical resistivity tomography section confirmed the presence of an outer ditch. Further work is planned to initially complete the geophysical survey of the northwest quadrant of the enclosure.

Kilberry is west of the Boyne Valley WHS in County Meath. Finding a lithic of possible Mesolithic age in a graveyard in addition to folklore on a souterrain discovery created interest in local history. LiDAR data, desk study and field visits have been used to assess local monuments. A local pilot and aircraft enabled a number of targets to be evaluated.

A prominent feature in the LiDAR data is an earthen mound 18m in diameter and 2.7m high. Rathcoon mound has been investigated using earth resistance, magnetic susceptibility and electrical resistivity tomography. The current results reveal the mound could be a barrow or possibly a passage tomb. Additional geophysical survey is being targeted to further investigate the mound. The investigation at Rathcoon is part of a programme of remote sensing surveys of other monuments in the area.



Top: Rathcoon Mound - Magnetic susceptibility results with topographic contours. **Lower:** Rathcoon Mound, viewed from the east.

Sliabh Coillte Heritage Group | Kilberry Amenity & Heritage Group | Rathcoon Video

Making ancient Mediterranean landscapes accessible

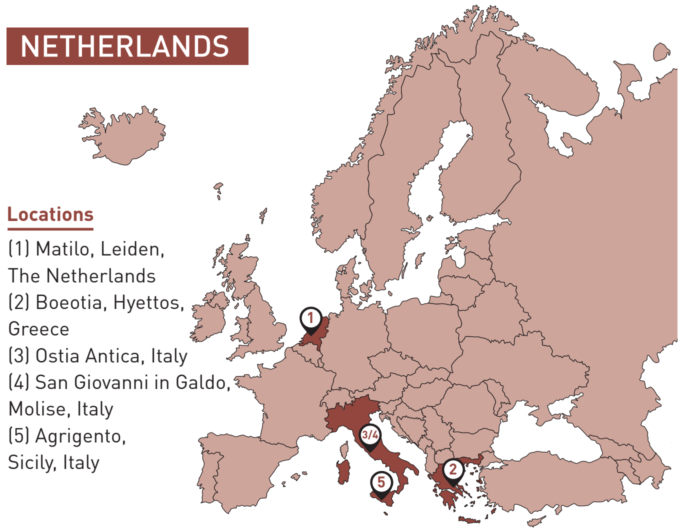
Hanna Stöger[1] / Hans Kamermans[1]
1. University of Leiden, The Netherlands

Introduction

During the last five years (2010 to 2015), the University of Leiden has been participating in the Pan-European Archaeo-Landscape programme with great enthusiasm and success. The Leiden team organised eight International technical fieldschools at five different archaeological key sites in the Mediterranean. These fieldschools provided excellent training opportunities for students of archaeology, as well as professionals active in the field of heritage protection and local resource management. In line with Leiden's commitment to the ArcLand action points 3, 4 and 6, these activities focussed on the exchange of expertise and the transfer of knowledge. The training programmes offered have been firmly rooted in Leiden's long-standing legacy of experience in Mediterranean landscape studies, and the available expertise in computer applications in archaeology.

The fieldschools concentrated on ground-based digital recording techniques for the assessment, interpretation and conservation of complex archaeological sites. The techniques and skills acquired in these courses are not site specific and can be applied to most time scales. The Leiden workshops also opened up opportunities to bring in expert knowledge offered by partner institutions within the network of Archaeo-Landscapes (e.g. IMS-Forth, Crete). Most fieldschools consisted of two parts: Part I took place in Leiden, where teaching focussed on methodologies and theories. Part II was concentrated on supervised practical work fully embedded in ongoing archaeological research conducted by Leiden staff members at key sites in Italy and Greece.

Fig. 1: Total Station Recording, Boeotia Survey Project 2011.



These complementary parts allowed participants to deepen their knowledge and apply their acquired skills to the archaeological field. Through the application and international sharing of skills and experience in the use of varied forms of remote sensing, including digital ground recording, geophysics and aerial photography, the Leiden training promoted non-destructive methods for the retrieval of archaeological data, and contributed to the enhancement and exchange of knowledge within the field of archaeology and heritage.

Key projects and expert knowledge

The Leiden fieldschools, organised at five different archaeological key-sites, offered first-hand experience in digital recording and remote sensing to about 90 students from different European countries. The first fieldschool took place in 2011 in Boeotia, Greece. It was hosted by the Boeotia survey project directed by John Bintliff. The project's research area comprises ancient cities, rural settlements and isolated architectural remains; in its diversity the landscape offered an ideal training environment for intensive total station and dGPS recording **(Fig. 1)**.

The specific aim of the 2012 Leiden fieldschool was to combine urban and rural environments to confront both archaeologists and the equipment with the challenges provided by densely packed standing architecture and dispersed single archaeological sites. After a thorough introduction in Leiden, at the Archaeological Park Matilo (part I), part II of the training took place in Italy. Ostia, the port-town of ancient Rome (research project into Roman Urban neighbourhoods, Hanna Stöger) , and the rural Samnite sanctuary and its surroundings of San Giovanni in Galdo, Molise (the Roman Colonisation Project by Tesse Stek) provided excellent environments for participants to acquire experience in digital recording **(Fig. 2)**.

Fig. 2: Fieldschool 2012, Differential GPS survey of architectural features at the Samnite sanctuary of S. Giovanni in Galdo, Molise.

Fig. 3: Fieldschool 2013, Akragas, Sicily: Introduction to the equipment and method by Jo Ann Kvamme.

In 2013 two fieldschools took place. One was hosted by the Leiden Project of Ancient Akragas, (Agrigento, Sicily) directed by Natascha Sojc. The area of a small extra urban sanctuary held yet a different set of problems in store for the Leiden fieldschool. In addition, the Akragas project offered the opportunity to invite experts in geophysical prospection: Ken Kvamme and Jo Ann Kvamme, from the Univ. of Arkansas **(Fig. 3)**.

The second 2013 fieldschool was hosted once more by the Boeotia Survey Project in Greece. The enigmatic site of ancient Hyettos was the focus of research. The fieldschool brought expertise from the ArcLand network into the project, when a team from IMS-Forth Crete joined the Leiden team. The fieldschools of 2014 and 15 were focussed on Ostia and Greece. The 2015 Ostia fieldschool allowed the Leiden team once more to co-operate with experts in geophysical prospection (Till Sonnemann, Leiden and TU-Delft) **(Fig. 4)**, offering the participating students first-hand training in a range of tools for non-destructive methods in remote sensing **(Fig. 5)**.

Fig. 4: Fieldschool 2015, Ostia, GPR survey, (students from Leiden, TU-Delft and Augsburg).

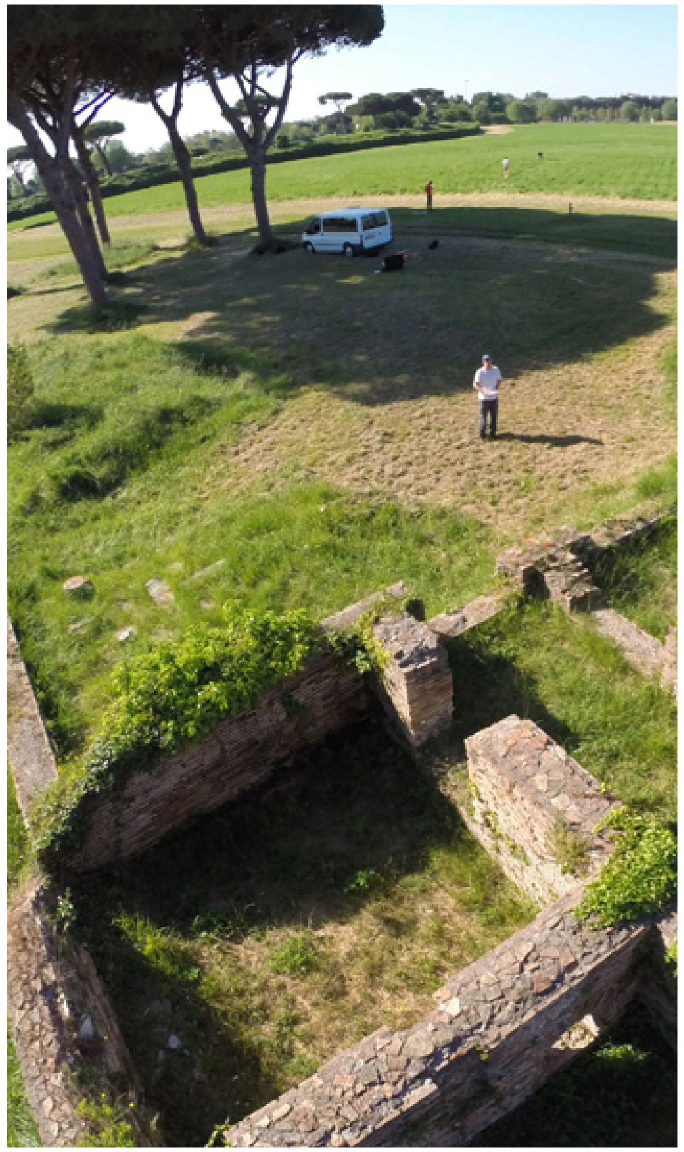


Fig. 5: Fieldschool 2015, Ostia, Low-altitude aerial photography (Till Sonnemann, Leiden).

Mapping archaeological landscapes in Central and Southern Italy: the urban context of Aquinum and the ancient route of Via Traiana

Giuseppe Ceraudo[1] / Immacolata Ditaranto[1] / Mariangela Sammarco[1]
1. University of Salento (Lecce, Italy)

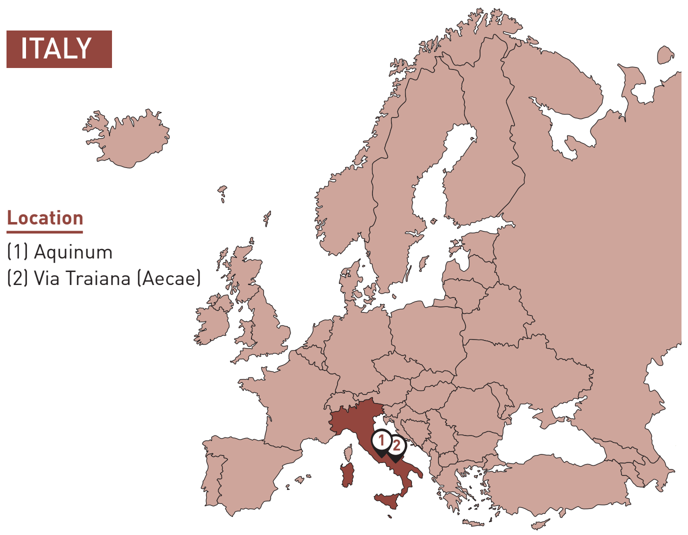
Introduction

The two projects presented here confirm the very fruitful experience of LabTAF (Laboratorio di Topografia Antica e Fotogrammetria) at the University of Salento within the ArchaeoLandscapes Europe Project. Both have involved a combination of aerial and ground-based survey along with small-scale excavation.

The main perspective was from the air: evidence from aerial sources can help to reveal the formation processes of archaeological contexts over long periods of time, combining airphoto-interpretation of historical vertical photographs with more recent images acquired from UAV platforms or from traditional light aircraft. Experiments have also been conducted in the 3D reconstruction of Roman public buildings, using orthorectified UAV images. Intensive geophysical prospection has helped to detect features buried beneath the surface.

In addition, a training school in geophysics and aerial archaeology in 2011, along with various initiatives in dissemination work, have enhanced public interest and appreciation of the shared archaeological heritage through the creation of digital content for websites and social media.

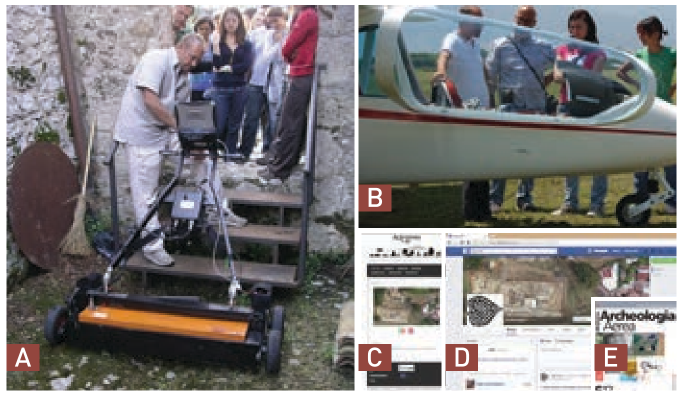
(A): Aerial image of the Roman mosaic at the public latrines in Aquinum taken from UAV platform (©G.Murro). **(B):** Results of the geophysical magnetic survey performed in the area of Aequum Tuticum, a statio along Via Traiana.



Aquinum

An assiduous program of archaeological field walking and aerial survey in the area of the Roman colony of Aquinum has helped to identify the traces of public and private buildings as well as a number of roads both within the urban layout and outside the city wall. Moreover, integrated programs of geophysical prospection have explored the central part of the city, especially close to the Via Latina, the road from Rome with Capua that crosses Aquinum from west to east.

Here, targeted excavations to ascertain the character of anomalies detected in aerial photographs and in the geophysical and archaeological surveys have uncovered the remains of the Roman Baths. Over the years, many students and graduates of the University's Department of Cultural Heritage have taken part in the work, creating an archaeological display area that has proved fascinating both to tourists and to schoolchildren.

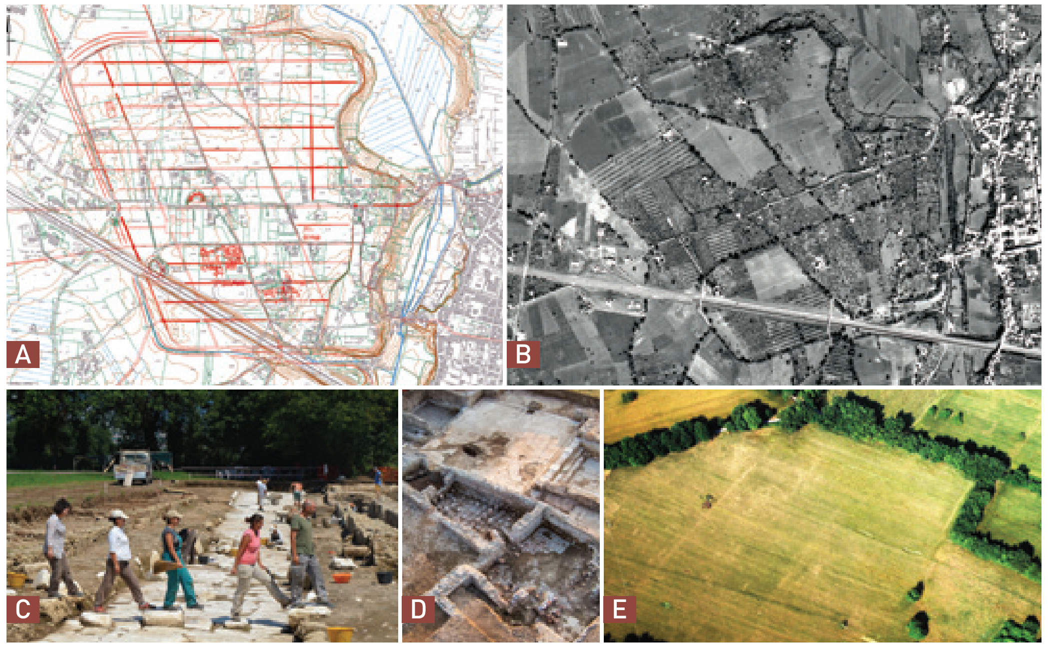


(A/B): Pictures of lesson time at the Training School in Geophysics and Aerial Photography in Archaeology, held in Aquino (Italy) in June 2011. **(C/D/E):** Dissemination initiatives to share scientific results creating digital contents for websites and social media.

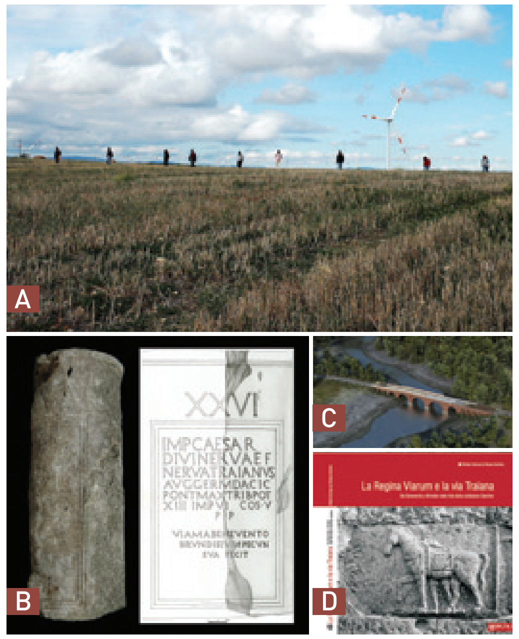
Via Traiana

This road was built by the Emperor Trajan in 112 AD to link Beneventum to Brundisium over a distance of some 200 miles. Much of its route has now been identified with the help of a large number of students, both from Italy and abroad. The project has employed systematic field walking and aerial survey as well as the analysis of multi-temporal and multi-scale aerial photographs. In addition to reconstructing the Roman road, the study has led to the discovery of numerous ancient settlements, ranging in date from prehistory to the Middle Ages.

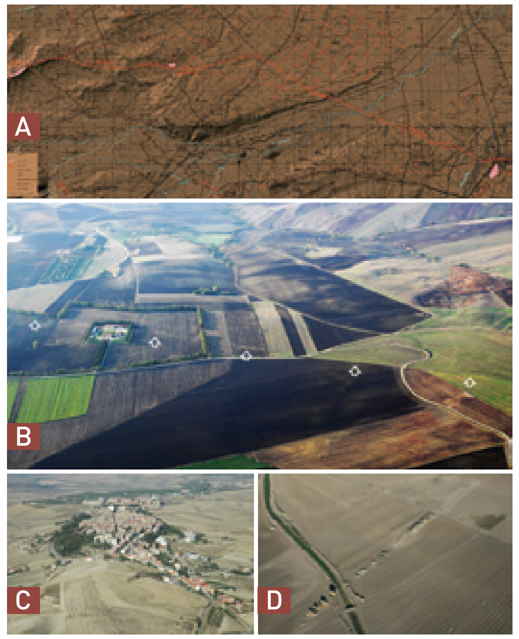
Moreover, the thousands of flights over the territory crossed by the road have enabled the reconstruction of important elements in the organization of the ancient landscape, such as land divisions and minor roads. Also important has been an analytical study, including 3D reconstruction, of one of the key bridges along the route of the Via Traiana.



(A): Archaeological map of Aquinum showing all archaeological evidence (pottery areas, structures, monuments, cropmarks and soilmarks) **(B):** historical aerial photo (1960) of the ancient city **(C):** students crossing an ancient urban road in the excavation area **(D):** detail of the Roman Baths **(E):** the Roman Baths, clearly visible in an aerial photograph before the excavations.



(A): Field walking close to Aecae **(B):** the XXVI millstone found during the archaeological field survey **(C):** 3D reconstruction of "Ponte delle Chianche" (©I. Ferrari) **(D):** one of the publications about Via Traiana.



(A): The route of Via Traiana between Aecae and Herdoniae **(B):** track of Via Traiana in an oblique aerial photograph **(C):** view of Aecae (modern day Troia) **(D):** the remains of the monumental bridge on the Carapelle river.

Conclusions

Aerial survey clearly represents a powerful basis for the integration and better understanding of data from a variety of investigative techniques, including ground-based survey, geophysical prospection and specific GIS applications. The results obtained in both urban and large-scale rural contexts have confirmed the huge potential of data derived from multi-temporal aerial photographs in the identification and mapping of archaeological sites for heritage management and protection as well as for enhancing public interest and understanding.

Old landscapes, new eyes: A summary report of English Heritage participation in the ArchaeoLandscapes Europe project

Pete Horne[1]
1. Head of Remote Sensing, Heritage Protection Department, English Heritage

Introduction

English Heritage has national responsibilities in heritage matters covering advice, legislation, teaching, survey, site monitoring, heritage science and public enjoyment. All strands of the ArcLand project have a direct relevance to our work but we have been particularly involved with matters relating to the use of aerial photographs and LiDAR for cultural heritage purposes.

The use of aerial photography to aid the discovery, understanding, enjoyment and management of heritage has a long tradition in England. Since 1965 there has been a national body encouraging the development and use of aerial photographs as well as actively amassing a public archive collection of photographs that now contains millions of images.

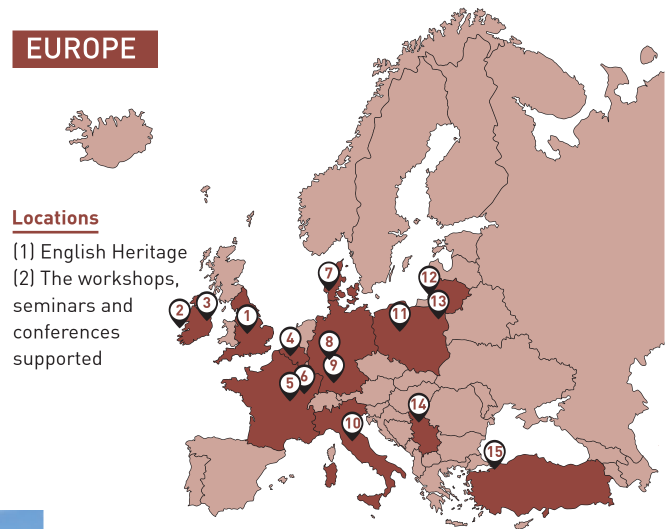


Fig. 1: Students and tutors at the International Aerial Archaeology School, Velling, Denmark July 2011.

Fig. 2: Students at the Aerial Archaeology School learning skills in photography - and flying! Velling, Denmark July 2011.

These roles continue within English Heritage, with an aerial reconnaissance programme, new research and photo interpretation projects that conform to our National Mapping Programme standards.

As part of the ArcLand partnership English Heritage experts have been involved in multi-national training schools in Denmark, Turkey, Lithuania and Poland, focussing on the use of aerial photography. Those in Denmark and Turkey included an introduction to flying for the students. Increasingly such training schools have introduced students to the use of Airborne Laser Scanning (LiDAR). LiDAR is a complementary tool to aerial photography, with many similarities in the way it can be analysed, but its ease of use, including through the use of new tools developed under the ArcLand banner, means it is rapidly becoming a preferred method of archaeological survey for some types of landscape.

The technology of LiDAR and the ways of analysing 3D data have been developing rapidly in the last five years. This is one area in particular where English Heritage expertise has been able to contribute to workshops and seminars in France (2), Poland and Germany but has also been learning from European partners who have developed their own ways of using this "Light Fantastic". English Heritage has also benefitted from sharing experiences with colleagues across Europe in other exciting new technologies for heritage purposes, including terrestrial laser scanning, photogrammetric techniques such as Structure from Motion, and the use of Small Unmanned Aircraft.

Valuable opportunities have also been provided through the ArcLand partnership enabling individuals or small groups to spend time working alongside professional staff in different countries, or benefitting from 1:1 tutoring. English Heritage has hosted visiting students and professionals from Ireland, Czech Republic, Romania and Denmark and benefitted from English Heritage staff visiting Austria and Ireland.

ArcLand activities have not only been related to the technology and techniques of archaeological research. English Heritage has actively participated in seminars and conferences in Italy, Serbia and Belgium, which have directly addressed cultural and philosophical issues of archaeological survey and heritage values. The value of engaging with wider audiences has also been clear through contributions and resultant feedback to the ArcLand website, publications, exhibitions and public facing conferences in Ireland and this event in Frankfurt.

As well as the straight forward teaching and learning elements of the schools, workshops, seminars and conferences, the bringing together of multi-national groups of tutors and students at these events and the regular technical meetings of the working parties have led to the sharing of new ideas and the building of new relationships. English Heritage staff have strongly valued this opportunity to share and develop a greater understanding of our common cultural historical landscape, that crosses modern political boundaries and extends into our deep ancestral past, and is helping to develop a truly European way to look at Old Landscapes with New Eyes.

Fig. 3: Tutors at the Methods of Non-Invasive Archaeology Summer School at Klaipėda University, Lithuania, August 2012.

Fig. 4. Above: Students learning the use of stereoscopes for the 3d analysis of historic photographs, Klaipėda Summer School, August 2012.

Fig. 5. Left: ArcLand supported exchange visits that allowed specialists from different countries to learn from one another. Here Dave MacLeod (English Heritage) discusses air photo interpretation with Mathias Broch a Danish post-graduate student.

References:

Crutchley, S and Crow, P 2009 The Light Fantastic: Using Airborne Laser Scanning in archaeological survey. Swindon: English Heritage

https://www.historicengland.org.uk/images-books/publications/light-fantastic/

Historic England

Since 1 April 2015, English Heritage has split into two organisations. The staff involved in the ArchaeoLandscapes Europe project remain in the parent body, now known as Historic England, the public body that continues the important service of protecting and championing England's historic environment, and ensuring it is understood and valued. A new charity, caring for the National Heritage Collection of more than 400 historic properties, has taken the name of the English Heritage Trust.

ArcLand HERITAGE · DATA · KNOWLEDGE Culture ENGLISH HERITAGE

Rathcroghan and the role of remote sensing in interpreting a unique archaeological landscape

Kevin Barton[1] / Daniel Curley[1] / Niamh Hanlon[1]
1. Rathcroghan Visitor Centre

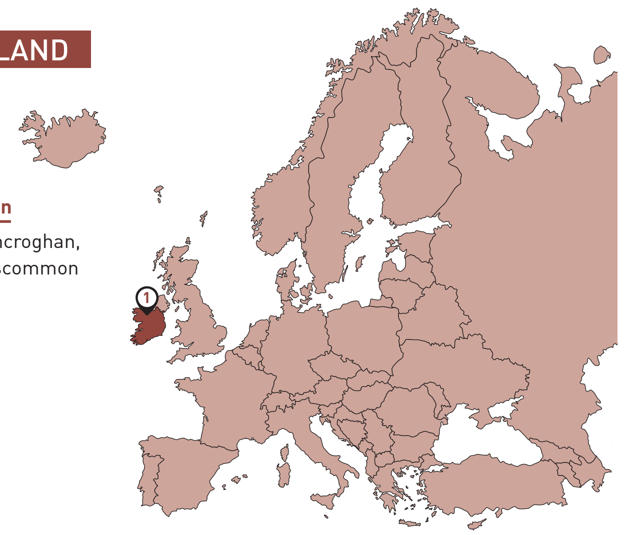
Introduction

The Rathcroghan Complex of over 240 sites is situated in an archaeological landscape extending over 6km². Monuments and landscape features range from the Neolithic to the Medieval Periods. The most significant monuments provide a sense of the machinations of daily Iron Age and medieval Gaelic life, symbolism associated with burial mounds and mystery connected with subterranean caves. The scale of the monuments shows they were designed for great ritual acts and public displays of power.

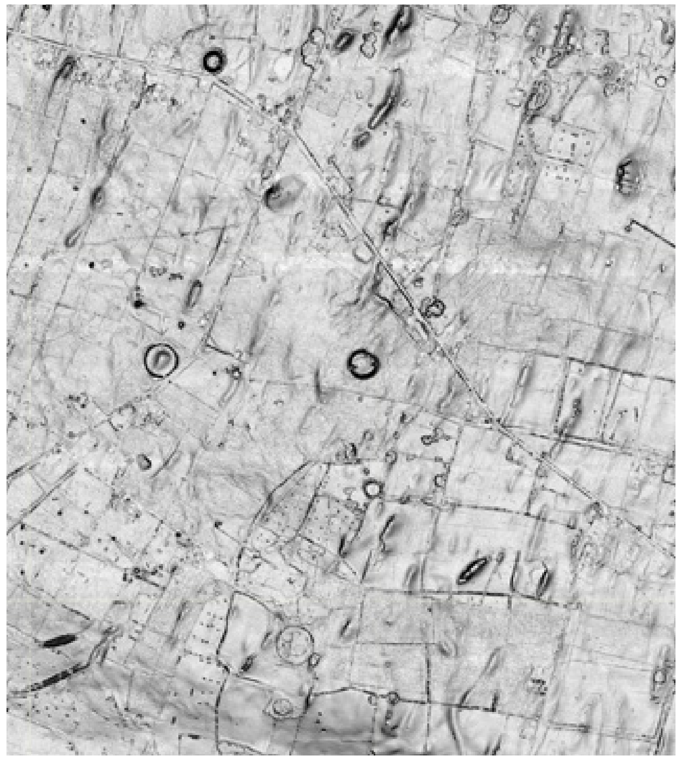
Whilst there are many visible monuments and features in this landscape there is much more archaeology hidden beneath the soil. Remote sensing has provided tools to investigate individual monuments, find new ones, interpret their relationship within the overall landscape and come to conclusions as regards their uses and periods of use. Simple fieldwalking and use of remote sensing techniques such as aerial and kite aerial photography, ground multi-method geophysical survey, and most recently LiDAR, has provided us with insights into various phases of activity in the Rathcroghan Complex. It is largely through using remote sensing techniques that we are able to visualize and present our interpretations to visitors to the sites and to our visitor centre.

Our non-invasive and non-destructive approach allows present and future generations to see and experience an archaeological landscape in its purest form. In addition it allows interested individuals and groups freedom to explore and imagine an enigmatic landscape which hosts a complex group of sites, and more tellingly, a living archaeological landscape. This poster, and its links to our Museum Website, illustrates how the use of remote sensing techniques has enabled us to research, interpret and present the Rathcroghan Complex to a wide audience.

IRELAND



Location
(1) Rathcroghan, Co. Roscommon

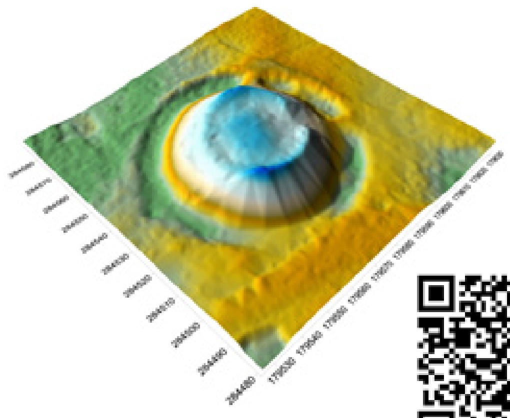


Rathcroghan Complex: Slope Shaded LiDAR data visualising the rich archaeological landscape. (LiDAR data by kind permission of Ordnance Survey Ireland).

The QR codes below link to video clips of low level aerial photography taken with a drone.

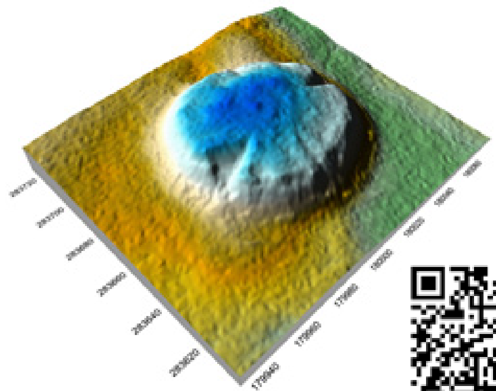
(Courtesy: Jonathan Mason Heritage Planning & Design Services).

Rathmore | Rathnadarve | Rathcroghan Mound



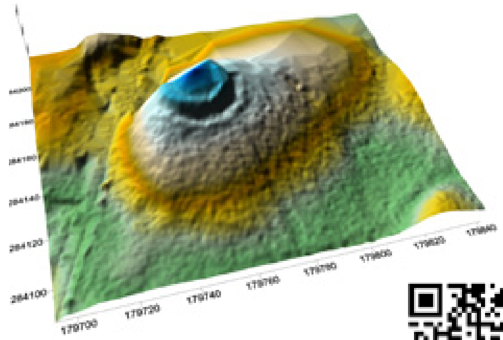
Rathmore

Raised ringfort, Medieval.
Diameter - approximately 75m.



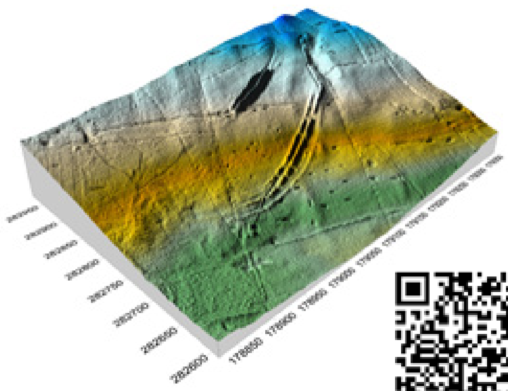
Rathcroghan Mound

Ritual sanctuary/inauguration mound.
Multi-period. Diameter -88m.



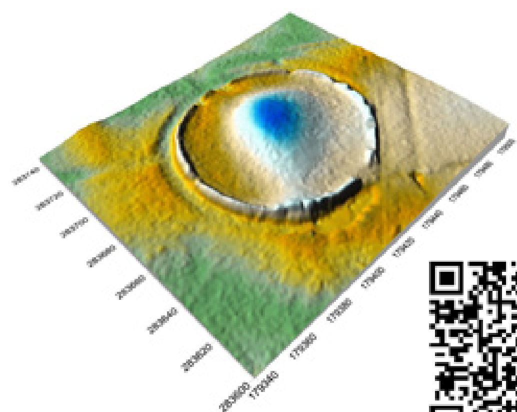
Rathbeg

Ring-barrow burial mound, Iron Age.
Diameter - approximately 36m.



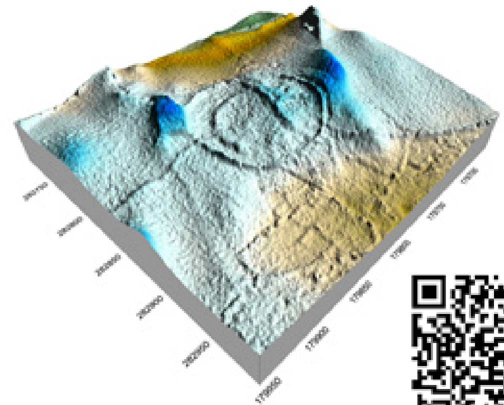
Mucklaghs

Ceremonial linear earthworks.
Multi-period. Length 100m & 280m.



Rathnadarve

Univallate ringfort, (early) Medieval.
Diameter - approximately 115m.



Relignaree

Univallate ringfort, (early) Medieval.

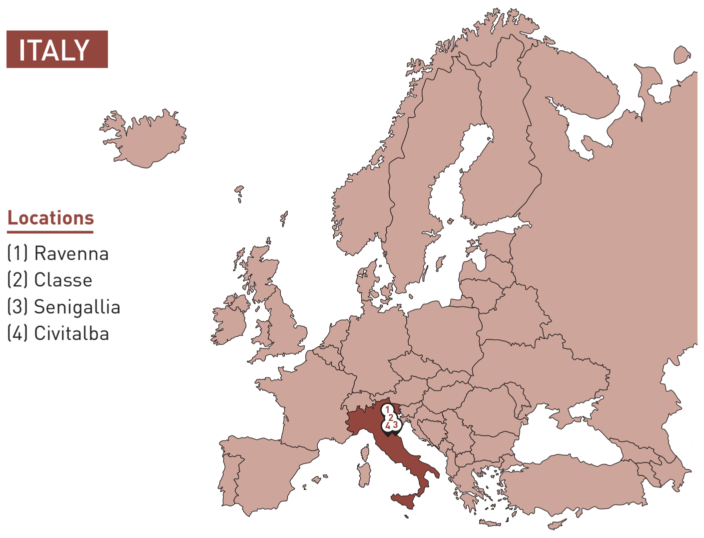
Rathcroghan Complex: Visualising some monuments in the landscape using 3D models made using LiDAR data. (LiDAR data by kind permission of Ordnance Survey Ireland). If your smartphone or tablet is enabled, please scan the QR code to obtain further information on the monument.

ArcLand HERITAGE · DATA · KNOWLEDGE
Culture
Rathcroghan Visitor Centre

The Erasmus IP summer school "Preventive archaeology. Evaluating sites and landscapes" (2013-2014)

Federica Boschi[1]
1. University of Bologna, Department of History and Cultures

Introduction



The University of Bologna became an associated partner of ArcLand in 2012. Already engaged in research and teaching activities, the Department of History and Culture coordinated a large network of partners to organize, between 2013 and 2014, two *Erasmus Intensive Programme Summer Schools in Preventive Archaeology. Evaluating sites and landscapes*; for two consecutive years benefitting from an important European fund directed to higher education (LLP-Lifelong Learning Programme).

In addition to Bologna, the team included the Universities of Bern, Birmingham, Bradford, Cassino, Ghent, Lecce, Leiden, Ljubljana, Lyon 2, Siena, Vigo, York, the Istituto Nazionale di Geofisica e Vulcanologia (Rome) and some independent companies (Geocarta Sa, Geostudi Astier Srl, So.Ing Srl, IDS Corporation). The IP also benefited from the support of local institutions (Fondazione Flaminia, Comune di Ravenna, Comune di Senigallia, Centro Studi per l'Archeologia dell'Adriatico).

The project supported several of the ArcLand key actions, promoting the pan-European exchange of people, skills and experience (WP3), enhancing teaching in aerial survey, remote sensing and landscape studies (WP4), as well as communicating the importance of these studies (WP2). The course, articulated both in lectures and assisted practical applications in the field, was dedicated to "Preventive Archaeology", focusing on the role of non-invasive techniques for evaluating the nature and potential of archaeological deposits prior to changes or development, and so properly informing the planning process and project designs.

Fig. 1: Didactic activities during the Erasmus IP Summer School.

The programme undertook a general survey of the current situation in Europe, considering in particular the countries involved in the project, comparing their different conditions in terms of rules and regulations, methods and traditions, and analysing the possibilities and limitations of non-invasive methods for the needs of preventive archaeology. Furthermore, the class tried to identify a general range of benefits for developing an approach based on multiple techniques and methodological integration, and to define good practices both in terms of research and for a teaching programme in this field of study.

Fig. 2: Training in the field: learning geophysics.

Fig. 3: Extensive geophysical mapping. ARP System (in collaboration with Geocarta, Paris and So.Ing, Livorno) and IDS Stream X (in collaboration with IDS Corporation, Pisa and Geostudi Astier, Livorno) in action on the field during the school.

Despite the hard work of organization needed by all the partners, the school had an extraordinary positive impact on the persons directly or indirectly involved in the activities, resulting in an attractive education and training programme; enabling students, academic and administrative staff to work together in a multinational and multidisciplinary group; encouraging dialogues and connections among people from different countries, the birth of collaborations and relationships among institutions, as well as prviding a stimulating environment for personal growth and challenges.

The four week long programme, attended by 66 students (across both schools), took place in Ravenna for the theoretical lectures and at different archaeological sites for the practical work: Ravenna and Classe (2013), Senigallia and Civitalba (2014). The case studies were selected in order to allow practical experience both on urban and extra-urban areas, and so give a perspective on preventative field evaluation in different environments. Here, the students had the opportunity to test innovative tools for non-invasive investigation (cutting-edge machines for extensive geophysical survey, remote sensing applications, UAV technology), to benefit from excellent know-how, specialist skills and expertise, and to achieve relevant results with the techniques applied.

The IP allowed us to draw the attention of many and different institutions, present in the territory and variously interested in the course (not only Universities, but also Authorities, Municipalities, Superintendencies, Foundations etc.). We tried to communicate to them the benefits of this new *"design-led archaeology"*[1] for their purposes, as well as the "power" of some non-conventional teaching in reaching a wide and varied user-base, and in terms of multidisciplinary employment and applications.

Fig. 4: Students in the field engaged with survey instruments and UAV technology.

Fig. 5: Teachers and students of the Erasmus IP course (edition 2014). On the right, group picture taken by drone.

1. Definition coined by Martin O.H. Carver during his lecture for the IP (Ravenna, 30th June 2014).

Bibliography:
A monograph and papers for several scientific reviews are in preparation.

The ODIT-CHEF Program: Observatory of industrial and territorial dynamics – Creation of historic forested landscapes

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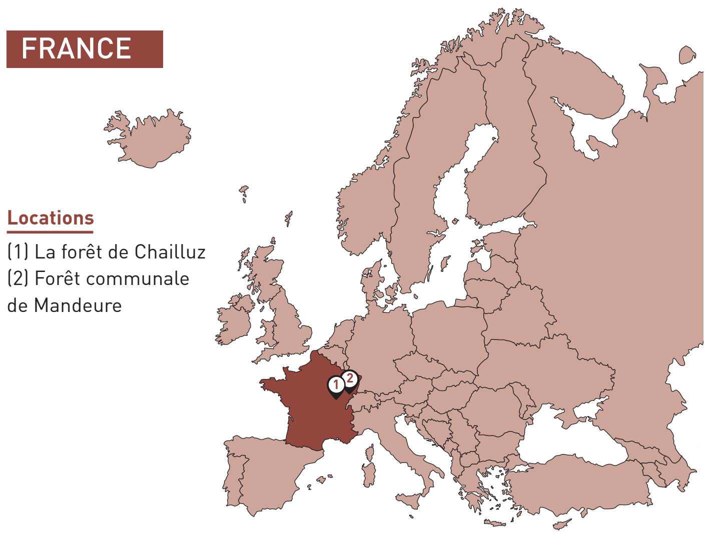
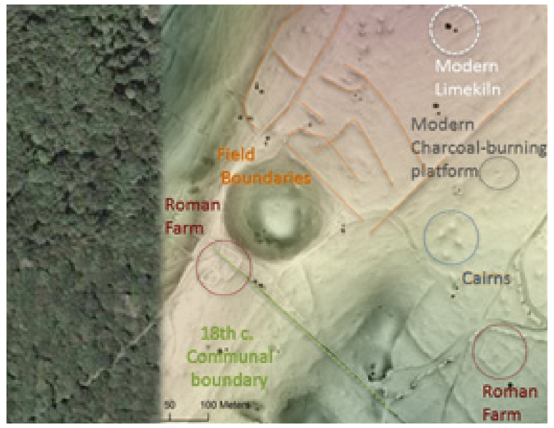
Introduction

Observatory of Industrial and Territorial Dynamics - Creation of Historic Forested Landscapes researchers at the ODIT-CHEF Program study forests in the Franche-Comté in their roles as energy, economic, and heritage resources, focusing on long term dynamics and sustainability.

The Franche-Comté region is 40% forested, and its woodlands play an important role in the regional economy as well as the cultural life and well-being of the population. Sustainable management of the forests must balance their economic and cultural roles. ODIT-CHEF researchers are using remote sensing, mapping and spatial analysis of historic data, and archaeological and environmental surveys to study the sources and rhythms of afforestation and deforestation, analyse the uses of forests by various social groups in different eras, and to assess the cultural and natural heritage potential of today's forest landscapes.





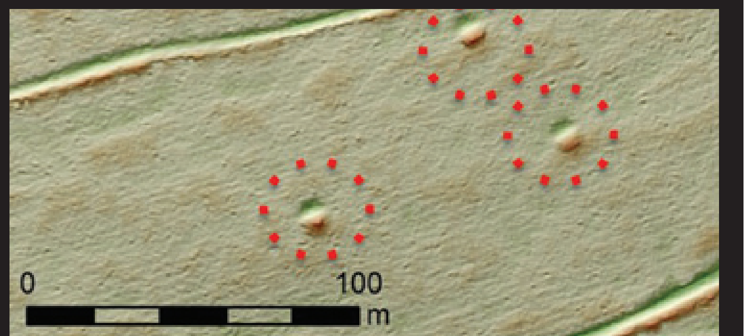
Archaeological remains from different eras concentrate together in the Bois de la Lave under the forest canopy.

Archaeology in the woods

The ODIT-CHEF Program grew out of the LIEPPEC (LiDAR for the Study of Past and Present Environments) Project. Building on the approaches developed under LIEPPEC, the project integrates Airborne Laser Scanning (LiDAR), geophysical, metal-detection, botanical and geochemical surveys, and the close analysis of historical maps and archival records to study the region's changing forest landscapes. Airborne Laser Scanning surveys revealed thousands of features including terraces, limekilns, charcoal burning platforms, field boundaries, farms, enclosures, and quarries - an assemblage reflecting the diverse activities that took place in woodlands over the past millenia. The continued impacts of these activities on today's forests is explored through on-the-ground surveys and cartographic studies, which reveal the long term impacts of human actions on present-day soils and plant communities.

Charcoal burning - Forêt de Chailluz

On the ground



In the LiDAR model

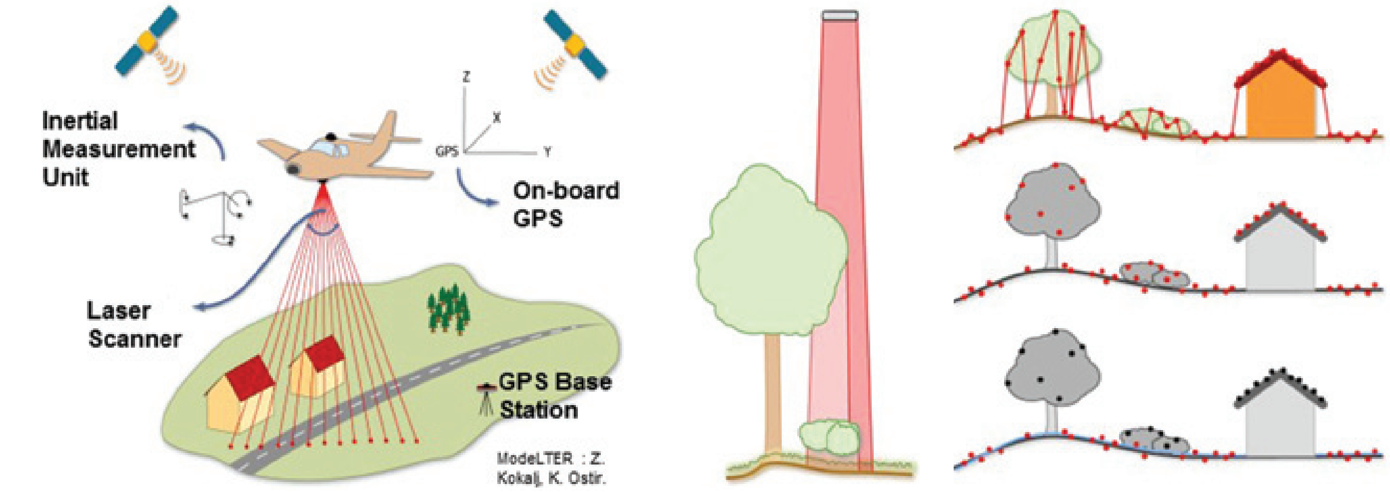
Charcoal burning platforms, viewed on the terrain and in the LiDAR data, are the result of economic activities in the recent past.

Connecting natural and cultural heritage

The LIEPPEC Project began with the study of the peri-urban Chailluz Forest situated north of Besançon, and the outlying forests surrounding the village of Mandeure-Mathay.
Today both forests are actively managed, combining timber production with the provision of sports and leisure areas. Both forests bordered important Roman centres, Vesontio and Epomanduodurum respectively, and contain evidence of habitation and production activity from the Neolithic to the present day. The cultural heritage of these forests often takes the form of subtle changes in the surface topography, the presence of different plants, or darker or stonier soil. Highlighting these windows onto the forests' past and emphasizing the close connections between natural and cultural heritage to the public is a key part of the ODIT-CHEF program as it expands this integrated approach to other forested areas in the region.

Living landscapes

Recognizing that forests are living landscapes, and that the protection and promotion of their cultural and natural heritage must be part of their active use and management, researchers from ODIT-CHEF work with officials from city and regional planning and forestry services to develop plans that minimize destructive impacts and to raise awareness among their staff, public officials, and the general public. Sustainability actions include leading workshops for officials responsible for forest management, organizing tours of forest heritage open to the public, and contributing materials illustrating the long term impacts of human activities on today's forests to public exhibits at the regional and national level. The integration of natural and cultural heritage into the recreational infrastructure of forests raises awareness and encourages a balanced approach to managing the economic and heritage aspects of forests.



Airborne Laser Scanning is a key technique for discovering and documenting cultural and natural heritage in forests.

The natural heritage of the forests is studied through soil and botanical surveys.

Soil coring survey is a collaboration between ODIT-CHEF researchers and Forestry Service officials.

Institutions

KU LEUVEN

PORTIVA Intergemeentelijke Archeologische Dienst

AERO KIEWIT 1909

Holstebro Museum

UCD DUBLIN

SPACE·SI

aarg Aerial Archaeology Research Group

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CENTRE FOR HISTORICAL & ARCHAEOLOGICAL AERIAL PHOTOGRAPHY

NIKU Norwegian Institute for Cultural Heritage Research

GeoSat ReSeArch Lab of Geophysical-Satellite Remote Sensing and Archaeoenvironment

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The Center for Advanced Spatial Technologies CAST U of A

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nka Nemzeti Kulturális Alap

JPM Janus Pannonius Múzeum Pécs

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incipit Instituto de Ciencias del Patrimonio

Baden-Württemberg STATE OFFICE FOR CULTURAL HERITAGE

ITE Ίδρυμα Τεχνολογίας & Έρευνας

erc

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