

Interdisciplinary archaeological prospection at unprecedented scale and resolution. The first five years of the LBI ArchPro Research Initiative 2010–2015

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The Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) together with its partner the Central Institute for Meteorology and Geodynamics (ZAMG) has developed motorized magnetic prospection systems to survey entire archaeological landscapes within reasonable time at high spatial sampling resolution. With these novel prospection systems the LBI ArchPro has successfully surveyed in total more than 32 km² over the past five years, resulting in magnetic maps containing millions of anomalies. While data collection, data positioning and the processing of the data have been automated (with exception of the operation of the survey vehicles), the outlining (data segmentation and classification) and interpretation of the prospected magnetic anomalies has become in regard of large amount of generated data a tedious, very time consuming, so far manually conducted task. In order to speed up the interpretation process we have therefore developed a workflow and algorithms for the automatic detection, outlining and classification of magnetic anomalies. Relevant magnetic prospection anomalies are automatically classified into two classes, which are “iron litter” objects that are located closed to the surface, and deeper reaching individual “pit” objects. Based on this classification we calculate several physical and geometrical properties for each object and export this data to a Geographical Information System (GIS) for further interactive classification and subsequent data interpretation.

KEY-WORDS: arge-scale, high-resolution, near surface geophysics, remote sensing, interpretation, virtual archaeology, digital documentation

The Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) was founded by the Austrian Ludwig Boltzmann Gesellschaft in Vienna in April 2010. The institute is dedicated to the development of new techniques and methodological concepts for landscape archaeology, combining high-resolution geophysics, aerial imaging and remote sensing, computer science and geomatics in order to develop efficient and universally applicable tools for the non-destructive detection, documentation, visualisation and interpretation of cultural heritage at unprecedented scale. Having started with 15 employees in 2010, the institute now employs 33 young scientists and support staff. 17 PhD projects are connected to the LBI ArchPro through close collaboration with the Initiative College for Archaeological Prospection of the University of Vienna.

An important part of the LBI ArchPro are its twelve European partner organizations, representing academic institutes, national archaeological and geophysical research departments, governmental cultural heritage agencies as well as commercial archaeological prospection service providers and

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Fig. 1. Staff of the LBI ArchPro and PhD students of the Initiative College for Archaeological Prospection in Vienna

SMEs. Partners are the Norwegian Institute for Cultural Heritage Research (N), Vestfold County administration (N), Province of Lower Austria (A), Archaeological Contract Service of the Swedish Central Heritage Board (S), Roman-Germanic Central Museum in Mainz (D), Vienna University of Technology (A) with the Institute for Computer Graphics and Algorithms and the Institute for Photogrammetry and Remote Sensing, University of Vienna with the Vienna Institute for Archaeological Science and the Department for Prehistoric and Historical Archaeology (A), IBM VISTA laboratory at the University of Birmingham (UK), Airborne Technologies (A), Central Institute for Meteorology and Geodynamics (AUT), and 7reasons Medien GmbH. Collaboration agreements exist with academic institutions, museums, as well as manufacturers of latest measurement technology, prospection sensors and survey systems.

The LBI ArchPro studies and develops non-invasive archaeological prospection and digital documentation methods in a wide range of research areas. In the field of airborne archaeological remote sensing the topics of aerial photography (e.g. auto-rectification of ortho- and oblique photographs), airborne laser scanning and specialized data processing and airborne imaging spectroscopy are researched in detail.

Regarding geophysical archaeological prospection, highly efficient motorized survey systems consisting of dense arrays of Fluxgate and Cesium magnetometers, and GPR antennae as well as electromagnetic sensors are developed and applied at unprecedented scale and resolution.

In the field of archaeological data interpretation and virtual archaeology, the semi-automatic data segmentation and classification as well as integrated data analysis and interpretation and virtual/augmented reality simulations are the foremost research focus. For the purpose of digital site and landscape documentation, multi-scale data capturing methods, such as terrestrial and airborne laser scanning and image based 3D modelling, are being investigated and advanced.

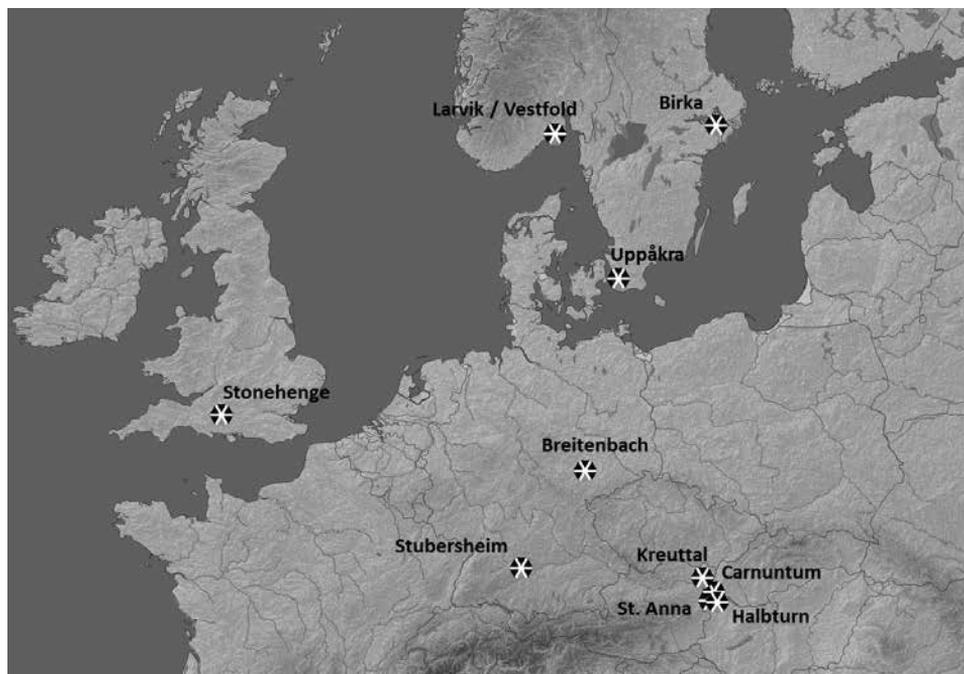


Fig. 2. Overview of the LBI ArchPro case study areas

Within the LBI ArchPro research programme various geographical areas have been selected together with the partners in order to provide different archaeological landscapes for distinct case studies, in which the technological and methodological developments are tested and applied on a large scale.

Investigated case study areas are the UNESCO World Cultural Heritage sites Birka-Hovgården (S) and Stonehenge (UK). In the latter case, the entire area within the so called “Stonehenge Envelope” was prospected within the frame of the Stonehenge Hidden Landscapes Project. Furthermore, the Iron Age and Viking Age sites of Borre, Kaupang, Gokstad and Oseberg, among others in Vestfold County (N), as well as the central Iron Age site of Uppåkra in Sweden, the Roman town of Carnuntum in Austria, the Kreuttal region north of Vienna, the rural landscape of Stubersheim on the Swabian Alb in Germany and of Halbturn in Austria are being investigated. Additionally, pilot studies have been conducted at Flavia Solva (A), St Anna (A), Kilianstädten (D), Bassianae (SRB), Bisenzio (I), Osor (HR), Tanum (S), Akrotiri (GR) and Hala Sultan Tekke (CY).

The following research and development results have been achieved so far.

- Highly efficient motorized magnetometer and GPR survey systems have been developed and tested under harsh conditions on an unprecedented scale and resolution.
- Software for motorized magnetic data acquisition and smart navigation has been developed, tested and optimized.

- Appropriate, highly efficient data processing software for large-scale near-surface geophysical prospection data has been developed, involving exact data positioning algorithms, new processing algorithms for the removal of vehicle-induced noise, and smart interpolation of irregularly sampled GPR and magnetic prospection data.
- Algorithms for automatic and semi-automatic data segmentation, classification and interpretation for the efficient treatment of large quantities of high-resolution prospection data have been developed.
- Novel GIS tools for efficient data management, handling and archaeological interpretation have been developed.
- Numerous new important archaeological discoveries have been made within all case study areas.
- Efficient workflows for comprehensive case study management have been designed.
- A number of large third-party funded research projects have been generated and realized.

Highlights of 2010–2015 include the discovery of a school of gladiators in Carnuntum (listed among the top ten archaeological discoveries of 2011 by the Archaeological Institute of America), the detailed mapping of the hidden Stonehenge landscape and numerous known and only presumed prehistoric monuments (n. 1 on the Archaeological Institute of America's list of top ten archaeological discoveries of 2014), a high-resolution integrative prospection of all accessible parts of the Roman town of Carnuntum, detailed digital documentation of the archaeological site of Akrotiri on Santorini with support from the National Geographic Society, using laser scanning (850 scan positions) and thousands of photographs, mapping of a total of more than 33.5 km² with high-resolution Fluxgate magnetometer measurements (with 25 cm crossline and 10 cm inline sample spacing), coverage of a total of 9.17 km² with ultra-high definition GPR surveys (8–10 cm crossline and 4–8 cm inline trace spacing), and a honorary mention for best poster presentation at the 2012 Society of Exploration Geophysicists Conference in Las Vegas.

The work of the LBI ArchPro has so far resulted in 31 peer-reviewed scientific papers, 24 non-peer-reviewed articles, 27 book chapters, two edited volumes, 121 conference proceedings, 53 talks of which 24 were invited talks, 20 poster presentations, three master theses, eight movie productions (including a comprehensive documentary aired on BBC/Smithsonian TV) and countless media reports. Over 111 academic courses related to archaeological prospection have been taught by LBI ArchPro staff at university departments since 2010 and 13 visiting researchers have been hosted. The 10th International Conference on Archaeological Prospection 2013, as well as the first workshop on “Pioneering Archaeological Prospection” were organised by the LBI ArchPro.

For more information on the LBI ArchPro and its activities and publications see <http://archpro.lbg.ac.at>