ANNUAL REPORT
2010

Ludwig Boltzmann Institute
Archaeological Prospection and Virtual Archaeology

CONTENTS

1. LBI ArchPro – Overview

1.1 Objectives

Considering the massive threat of destruction and deterioration of buried cultural heritage and the need for efficient and reliable identification, documentation and interpretation methods, large-scale application of non-invasive archaeological prospection methods comprise a great potential. They are the most appropriate solution in order to provide archaeologists and planning authorities with the necessary spatial information for the protection and possible investigation of such threatened heritage at the appropriate scales: the archaeological site as well as the surrounding archaeological landscape.

Considering the state-of-the-art and the future demands for non-invasive professional archaeological prospection a consortium of European research institutes, heritage boards and public bodies supported by the Ludwig Boltzmann Society (www.lbg.ac.at) established in 2010 the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI-ArchPro). The LBI-Archpro is an innovative research centre for the development and application of advanced non-destructive prospection methods. It combines advanced remote sensing methods, high resolution near surface geophysics, sophisticated computer science, geomatics and archaeology. It is dedicated to the development of new and highly efficient technologies for non-invasive data capturing, data processing, virtual reality visualization and the advancement of theory and methodology. An important aim is the publication and dissemination of new developments and results of the conducted research and of exemplary international case studies in professional circles as well as to the general public.

Even though the Valetta convention (Malta treaty) has not been ratified by all member states of the LBI consortium, it is regarded by the consortium as the major basis and guideline for the future development of archaeological research and the LBI research programme.

1.2 Financial overview

1.2.1 Budget 2010:

The institute's total income for 2010 amounted to €1.437.765. The different types and sources of funding as well as the budgeted expenses for 2010 are presented in the following Fig. 1.

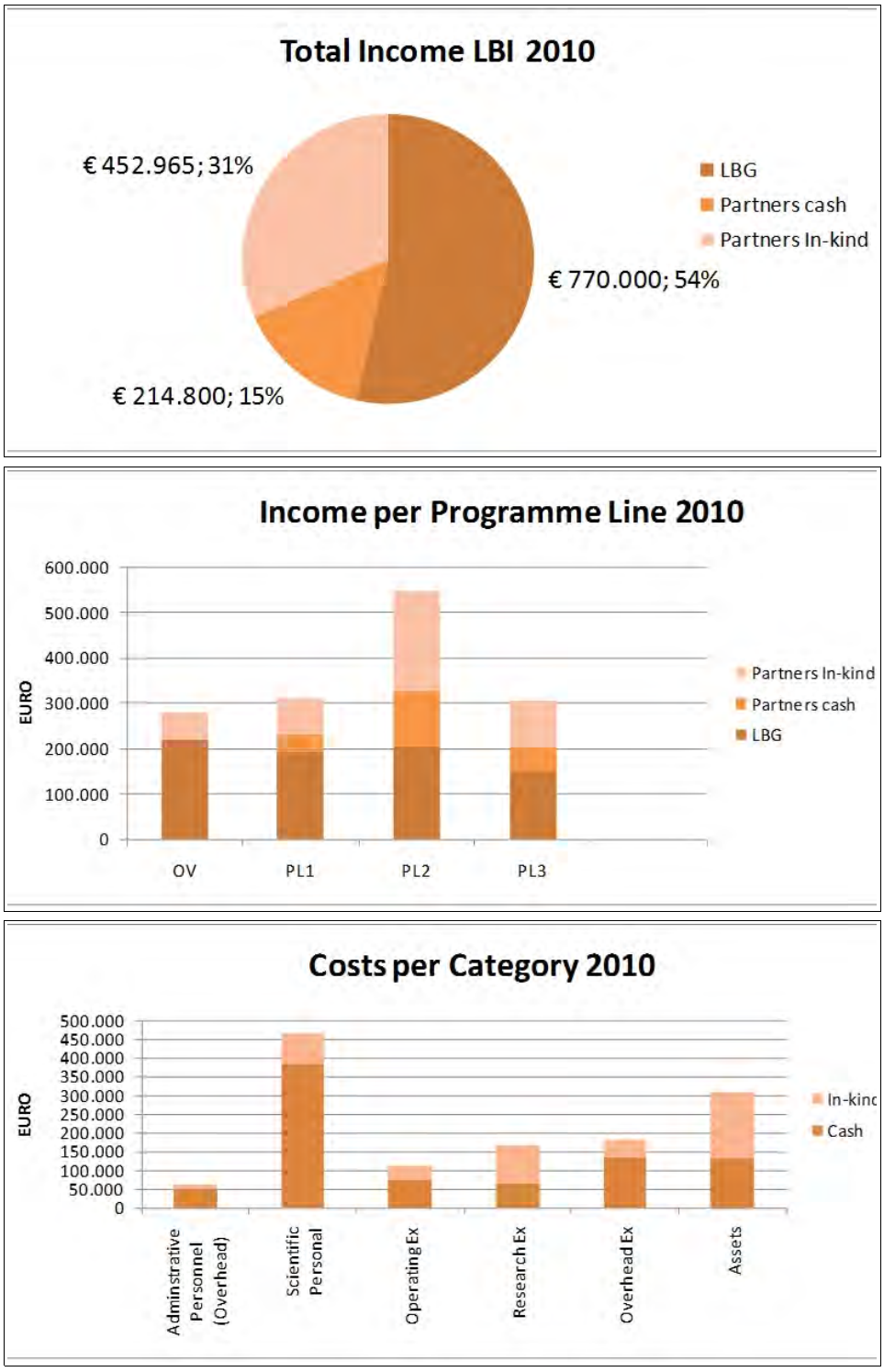

Fig. 1: LBI budget 2010 according to sources of income and types of expenses

1.2.2 Third party funding

On top of the fixed annual budget, the institute aims to acquire additional third party funding on a project base, in order to:

- address complementary research areas
- investigate additional case study areas
- employ additional researchers, particularly young scientists (PhD)
- obtain additional resources for research assets and research effort

In 2010 three proposals for funding of research projects were submitted:

Vienna Science and Technology Fund (WWTF)

Already in February 2010 a proposal was submitted to the WWTF Information and Communication Technology Call 2010. The requested funding for the institute was €465.000. The proposal received good reviews but in the end could not be funded because it was applied and not basic ICT research.

Initiative College at University of Vienna

In April 2010 the LBI was involved in the successful submission of a proposal to establish an Initiative College for Archaeological Prospection IC-ArchPro with a budget of over € 830.000. 10 young researchers will be employed in this college at the LBI-partner. They will be integrated into the research programme and case-studies of the LBI.

FWF

Building on the WWTF proposal and its good reviews a proposal was submitted to the Translational Research Call 2010 of the FWF in September 2010. The requested funding for the institute is €175.000 over three years. Evaluation results are due for April 2011.

FP7-People

In 2010, work on a proposal for a FP7-People Initial Training Network (call FP7-PEOPLE-2011-ITN) commenced which was submitted on in January 2011. The requested funding for the institute is around €650.000 over three years. Evaluation results are due for May 2011.

1.3 Partners

The LBI-ArchPro (http://archpro.lbg.ac.at) is based on a European partnership formed by:

LBG - Ludwig Boltzmann Gesellschaft (A)

NoeL - Province of Lower Austria (A)

NIKU - Norsk Institut for Kulturminneforskning (N) - The Norwegian Institute for Cultural Heritage - Archaeology Department

RAÄ - Riksantikvarieämbetet (S) - UV Teknik

RGZM - Römisch Germanisches Zentralmuseum (D)

VISTA - University of Birmingham (GB) - The Visual and Spatial technology Centre

Uni Vienna - University of Vienna (A) - Vienna Institute for Archaeological Science (VIAS) and Institute for Prehistory and Early Mediaeval History (UFG)

TU Vienna - University of Technology Vienna (A) - Institute for Computer Graphics and Algorithms (ICG) and the Institute for Photogrammetry and Remote Sensing (IPF)

ZAMG - Central Institute for Meteorology and Geodynamic (A)

1.4 Bodies

The *Scientific Board* of the LBI-Archpro consists of the following scientific staff members of the parnter institutions:

NoeL (Amt der Niederösterreichischen Landesregierung):

Michael Pregesbauer

NIKU (Norwegian Institute for Cultural Heritage):

Carsten Paludan-Müller
Knut Paasche

RAÄ (Swedish National Heritage Board):

Lars Z Larsson
Karin Lund

RGZM (Römisch-Germanisches Zentralmuseum Mainz):

Falko Daim
Detlef Gronenborn

VISTA - University of Birmingham:

Vincent Gaffney
Eamonn Baldwin

University of Vienna:

Otto H. Urban
Gerhard Trnka

Vienna University of Technology:

Norbert Pfeifer
Werner Purgathofer

ZAMG (Central Institute for Meteorology and Geodynamics):

Sirri Seren
Gerald Duma

The *Scientific Advisory Board* of the LBI-Archpro will consist of the following distinguished scientists:

Prof. Kay Kohlmeyer, Hochschule für Technik und Wirtschaft (HTW) Berlin, Germany

Prof. Julian Richards, University of York, UK

Prof. Joakim Goldhahn, Linnaeus University, Sweden

Prof. Maurizio Forte, University of California, Merced; USA

On May 16th 2011 these four members of the Scientific Board will meet in Vienna to select the Board's fifth and final member.

1.5 LBI-ArchPro Team

The Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology employs 12 researchers and technologists, as well as three purely administrative staff. The institute was fully staffed within 6 months of its start. More description (studies, competencies, nationalities etc.).

1.5.1 Coordination & Administration:

- Wolfgang Neubauer (Director)
- Michael Doneus (Deputy Director)
- Matthias Nöster (Operations Manager)
- Rosa Enn (Administration Manager)
- Karolin Kastowsky (Administration Manager), on maternity leave

1.5.2 Programme Line 1 - Archaeological Remote Sensing:

- Michael Doneus (Key Researcher)
- Christian Briese (Researcher)
- Geert Verhoeven (Researcher)

1.5.3 Programme Line 2 - Archaeological Geophysical Prospection:

- Immo Trinks (Key Researcher)
- Alois Hinterleitner (Researcher)
- Klaus Löcker (Researcher)
- Matthias Kucera (Researcher
- Erich Nau (Researcher)
- Thomas Zitz (Prospection Assistant, Technical Development)

1.5.4 Programme Line 3 - Archaeological Interpretation, Spatial Analysis & Virtual Archaeology:

- Nives Doneus (Key Researcher)
- Alois Hinterleitner (Key Researcher)
- Matthias Kucera (Researcher)
- Klaus Löcker (Researcher)
- Daniel Scherzer (Researcher)

1.6 Infrastructure

1.6.1 Measurement systems

Remote Sensing

- OPALS Software Package
- SCOP++ and TopDM Software packages
- Trimble GPS Geo XM S/N incl. accessories
- Camera systems: Hasselblad H2D, Nikon D700, Nikon D90NIR, Nikon D2X
- Scanner: Vexcel UltraScan 5000 - photogrammetrical high-resolution scanner
- Leica Photogrammetry Suite
- OceanOptics Jaz-Combo Spectrometer (LBI)
- ENVI Software Package (IPF)
- ERDAS Imagine Professional (UFG)

TLS (Terrestrial Laserscanning)

- 1 Riegl LMS 3D-LaserScanner Z210
- 1 Riegl LMS 3D LaserScanner Z420i

Fig. 2: The Riegl 3D-LaserScanner in operation at the ZAMG Sonnblick observatory, Austria 2010

Geophysical Prospection

Ground Penetrating Radar (GPR):

- Manually operated single channel Sensors & Software - PulseEKKOPro 500 MHz
- Motorized six channel Sensors & Software SPIDAR system (six PulseEKKO Pro 500 MHz) mounted on a custom built aluminum trailer; a similar second system is currently under construction
- MALÅ Imaging Radar Array (MIRA) - 16 cannel GPR 400 MHz system, mounted in front of a Kubota compact tractor

Fig. 3: MIRA and SPIDAR GPR systems in operation in Vestfold county, Norway 2010

Magnetics:

Fluxgate magnetometry:

- 15 Foerster gradiometer probe
- 10-channel Eastern Atlas digitizer
- 5-channel Eastern Atlas digitizer
- 2 SENSYS trailers

Cesium magnetometry:

- 1 AMMS8G Pico Envirotec magnetometer unit including 4 Scintrex CS3 Cesium sensors
- 2 AMAG-4 Pico Envirotec magnetometer unit including 4 Scintrex CS2 and 1 Scintrex CS3 Cesium sensors
- 1 AMAG-4 Pico Envirotec magnetometer unit including 5 CS2 Cesium sensors

Fig. 4: The two Foerster Fluxgate magnetometer systems in Schalkstetten, Germany 2011.

Motorized survey vehicles:

- 2 All-Terrain-Vehicles (ATV) - TGB Blade
- 1 Kubota compact tractor

RTK-GPS:

- 1 Leica GPS 1200 consisting of 1 Base + 1 Rover
- 3 JAVAD Triumph 1 GNSS receiver (1 base, 2 rovers)

Total Station:

- 1 Leica TCRP 1203
- 1 Leica Tachymat TCRP1205 R300 Smart Station (including GPS)

Vehicles :

- 1 Mercedes Sprinter
- 1 VW Transporter
- 1 VW Transporter
- 3 versatile trailers

Offices & Workshops:

- Aerial Archive of Partner UFG with 5 rooms (130 m²)
- ZAMG (125 m²)

Both locations provide basic infrastructure (internet access infrastructure, peripheral equipment such as printers, plotters, copy machine and telefax)

- Föllim (100m²) – Shelter for the vehicles

1.6.2 Development of measurement devices (part of research programme)

A cart for the SPIDAR Network Ground Penetrating Radar (GPR) system was designed, built, tested and modified, permitting the towing of six 500 MHz antennas with 25 cm cross-line spacing and RTK-GPS Positioning. The tow-vehicle, a 4 wheel All-Terrain-Vehicle (ATV), was equipped with cabling and mounting for a Panasonic-Toughbook for data recording.

The 16 channel MALÅ Imaging Radar Array (MIRA) was collected from Northern Sweden. The corresponding carrier vehicle, a small Kubota Tractor, and the front mounting frame were modified and a data logging computer, odometer, GPS and prism mounts installed and fitted for operation. The survey team underwent a short introductory course in the use of the MIRA system at Malå, which can operate both with total-station and RTK-GPS for data positioning. The GPR data processing software apradar developed by ZAMG was adapted in order to read and process data collected in random-walk mode across large areas, to generate shape files for GPS/prism and GPR-antenna positions, and GPR depth-slice images.

A new five channel Förster magnetometer system was setup based on a new A/D converter and data logging software developed by Eastern Atlas. Mounted on a large non-magnetic carrier frame the system is pulled by an ATV Quad. For data positioning RTK-GPS is used. An odometer control unit with was built and integrated with fibre optics into the system. The magnetic data processing software apmag developed by ZAMG was adapted to read and process the new magnetometer data and to account for irregular survey geometries and GPS positioning.

All systems were briefly tested prior to the first LBI case studies.

1.7 Highlights 2010

The discovery of a possible new henge structure near Stonehenge through magnetometer prospection resulted in very large, positive media exposure of the LBI and the British LBI partners. The collaboration with the British LBI partners was enjoyable and very successful.

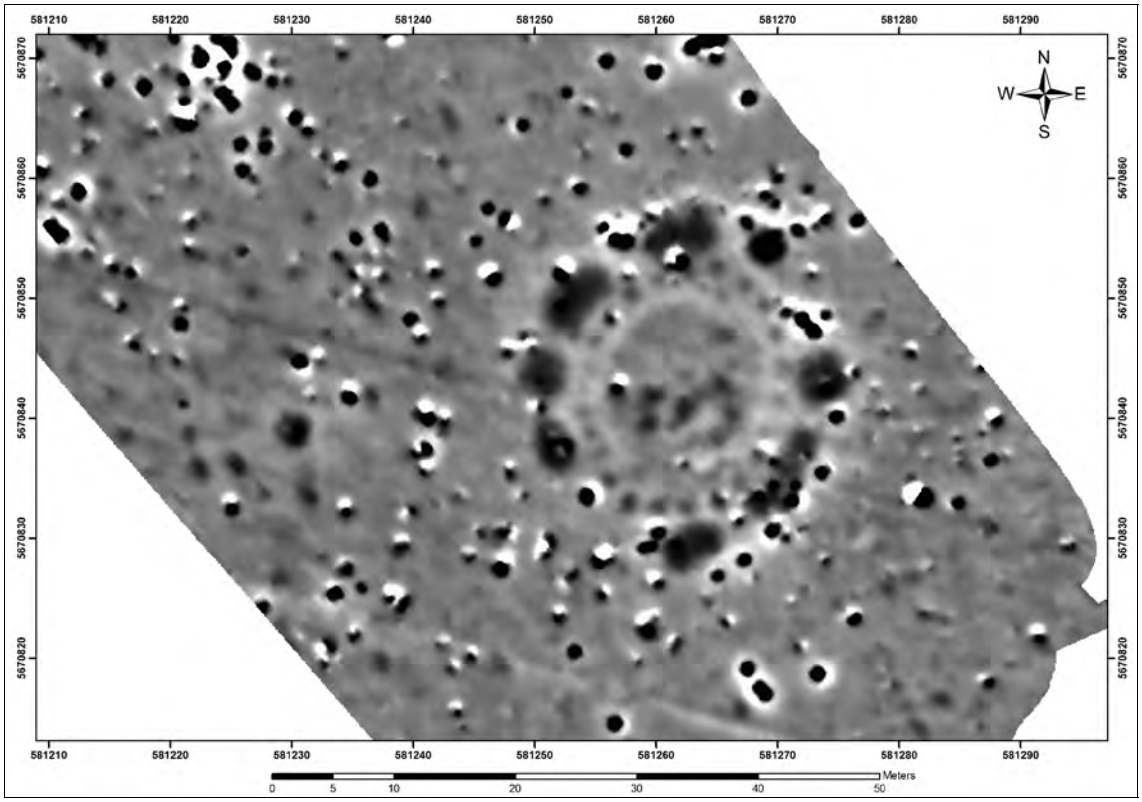

Fig. 5: The newly discovered hengyform monument in Stonehenge, UK 2010

In the case study area Vestfold (Norway), the detection of potential anomalies of ship-shaped structures had lots of positive response throughout the Norwegian media. Another highlight of the same case study area was the detection of a field of over 733 cooking pits.

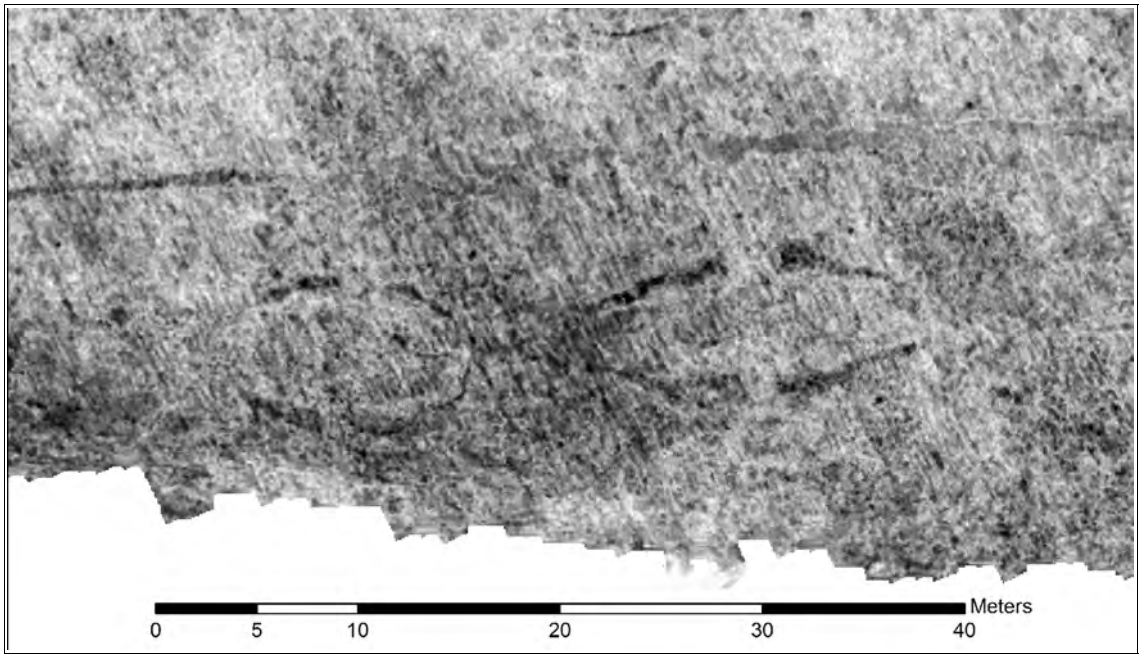

Fig. 6: Boat-shaped structures in the GPR data of Vestfold, Norway 2010

The LBI managed to simultaneously perform a terrestrial as well as an airborne laser scan of a forested area. Therefore it is first time possible to study the position of the derived ALS echoes and their parameters in the context of the terrestrially derived model. Due to the high ranking score of the peer-review of the abstract, the presentation of LBI-ArchPro was honoured by being moved to the plenary session on the last day of the Symposium of Commission VII, which took place during the celebration of the first centenary of the International Society of Photogrammetry and Remote Sensing (ISPRS).

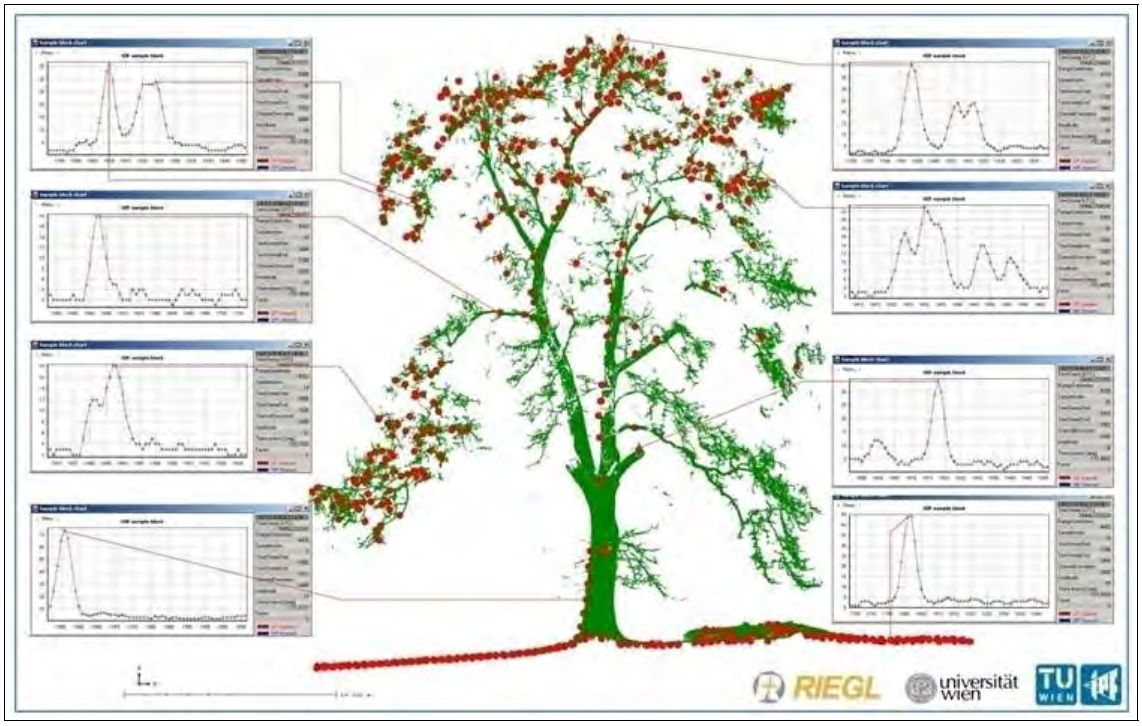

Fig. 7: Combination of ALS and TLS, St. Anna in der Wüste, Austria 2010

1.8 Public Relations

1.8.1 Press releases and press coverage summary

The detection of a new henge monument just 900 m next of famous Stonehenge had caused a worldwide run on news. An information package passed on to the press resulted in telephone calls from all over the world and in hundreds of emails and press articles. More than 200 of the most important articles were selected and archived for further documentation. A selection is also linked from the LBI website (http://archpro.lbg.ac.at/press-reports/press-reports).

The press-response regarding Stonehenge was overwhelming and came in an early stage of the LBI. Therefore, it was difficult to keep control on the information-flow. To avoid similar scenarios in future, a "guide of good practice" was developed. It gives guidance on handling press releases, face-to-face contact with the press and active promotion of our projects.

Also, to systematically collect relevant articles concerning the LBI and its international activities, programmed filters are in use.

Print:

Putting Stonehenge in Its Place (2 March 2011)

Final comment on geophysics survey (17 December 2010)

In defence of geophysics (12 December 2010)

Woodhenge: Is this one of the greatest discoveries of archaeology...or a simple farmer's fence? (12 December 2010)

Fant flere kokegroper (30 September 2010)

Hemmeligheter skal avdekkes (29 September 2010)

Gravhauger oppdaget på Aske (24 September 2010)

Vestfold kan bli verdensarvområde (24 September 2010)

Ny teknologi finner ukjente jernalderfunn (24 September 2010)

Glimrende forslag (24 September 2010)

Avtrykk etter vikingskip funnet ved Larvik (24 September 2010)

Dette kan være en ny skipsgrav (23 September 2010)

Ny teknologi finner ukjente jernalderfunn (23 September 2010)

Kan ha funnet to nye vikingskip (23 September 2010)

Fant virtuelt vikingskip (23 September 2010)

Hightech-Spielwiese virtuelle Archäologie (12 September 2010)

Virtuelle Archäologie wird institutionalisiert (4 September 2010)

Hightech unterstützt Archäologen (4 September 2010)

Analysing the new site near Stonehenge (6 August 2010)

Sister monument to Stonehenge may have been found (31 July 2010)

Wiener Archäologen: "Woodhenge" war erst der Anfang (23 July 2010)

Wood Henge - Experts discover Stonehenge twin (23 July 2010)

Pictures: Stonehenge "Twin" Revealed (23 July 2010)

Stonehenge Had Neighboring, Wooden Twin — More to Come? (23 July 2010)

Zweites Stonehenge, aus Holz (22 July 2010)

Found after 4,000 years: the lost wooden 'sister' of Stonehenge (22 July 2010)

Wiener entdecken neues Stonehenge (22 July 2010)

In pictures: Archaeologists make Stonehenge discovery (22 July 2010)

How significant is the 'new henge'? (22 July 2010)

Archaeologists unearth Neolithic henge at Stonehenge (22 July 2010)

Archaeologists virtually excavate Stonehenge (19 July 2010)

Academics to reveal ancient landscape (9 July 2010)

High-Tech-Archäologie: Forscherteam will letzte Geheimnisse von Stonehenge lüften (5 July 2010)

Österreichische Archäologen auf dem Weg nach Stonehenge (5 July 2010)

High-Tech-Archäologie in Stonehenge (5 July 2010)

Neues Ludwig Boltzmann Institut startet heute Forschungsprojekt "Die unsichtbare Landschaft um Stonehenge" (5 July 2010)

LBI ArchPro - fremtidens arkeologi (15 April 2010)

(q.v. http://archpro.lbg.ac.at/press-reports/press-reports)

"Kreisgraben-Forschung aktuell" – Newsflash after the paper at the Astronomische Verein. Österr. Astron. Monatsschrift "Der Sternenbote" 2010-11, Astronomisches Büro, Wien (ISSN 0039-1271).

Marianna Ridderstad: Ympyräkaivannoista tarkkailtiin Aurinkoa kivikaudella. In: Tähdet ja Avaruus 8/2010, pp30-35. This article in the most important Finnish journal on astronomy originated in a paper at SEAC2010 and involves information about the Kreisgrabenanlagen and some results of ASTROSIM.

TV:

Virtual Archaeology at Stonehenge [Video] (2 March 2011)

"Genie & Geometrie" (25 November 2010)

ARVEN: Virtuell arkeologi

Nye utgravinger Tjølling (29 September 2010)

Fant kokegroper på Tjøllingvollen (29 September 2010)

Schrödingers Katt: Avtrykk etter vikingskip funnet ved Larvik (23 September 2010)

Radio:

Verdt å vite (23 September 2010)

Museum: Fra Stonehenge til Kaupang (3 September 2010)

Wissen aktuell: Neue Entdeckungen in Stonehenge (29 July 2010)

Aside from press-releases PR is taking care of the institute's website (http://archpro.lbg.ac.at), presentations at public events (e.g. scientific festivals), active participations at conferences and the organization of seminars and conferences. A poster describing the LBI and its activities was designed for display at all kinds of events.

1.8.2 Wiener Forschungsfest

The 3rd Wiener Forschungsfest took place from the 18th to the 20th of September 2010 at the Kaiserwiese in front of the Ferris wheel in the Wiener Prater. Within those 3 days the work of the LBI was presented to a wide public. Especially the Riegl LMS 420i for 3D Terrestial Scanning and the new handheld Scanner Z700 were presented. Besides the communication with the public interesting and future collaboration promising discussions with other exhibitors (7 reasons, VRVIS)

were led. Finally the Ferris wheel and the exhibition tent were scanned, which impressed the organizers.

Fig. 8: The LBI ArchPro at the Wiener Forschungsfest 2010

1.8.3 Folder

A LBI-ArchPro information folder has been written and designed. This folder has been printed with a print run of 5000 copies and gets given out at conferences, workshops and in case study areas.

1.8.4 Opening Event

The LBI-ArchPro opening event took place on 14th September 2010 at the University of Vienna. More than 120 guests including the partners, politicians, scientist, and other special guests joint the celebrations.

1.8.5 Promotion Video

Together with Interspot Film a promotion trailer video has been produced. The shooting took mainly place during the case study works at Stonehenge 2010. The trailer has first been showed at the LBI's opening event on 14 September 2010. (q.v. http://archpro.lbg.ac.at/lbi-archpro-trailer)

1.8.6 Meet Science 2010

On 21 October 2010 the Ludwig Boltzmann Gesellschaft presented its 24 Ludwig Boltzmann Institutes and clusters and discussed with representatives of the LBIs. Meet Science 2010 was a science celebration of the Ludwig Boltzmann Gesellschaft.

Ten years ago the Ludwig Boltzmann Gesellschaft was a union of 130 small scientific institutes.

Today, fifty years after its foundation, it is a dynamic scientific organisation with flexible structures and notable scientists researching on essential topics and influencing the science community considerably.

Fig. 9: Wolfgang Neubauer presents the aims and research programme of the LBI ArchPro at the Meet Science 2010 event

2. Research Programme

The research programme of the LBI-ArchPro is aiming at the advancement of archaeological prospection into an exceptionally powerful theoretical and methodological tool for landscape archaeology, with a considerable effect on related cultural heritage management. We focus on the development and application of efficient techniques and devices for collecting remotely sensed and geophysical data with very high spatial resolution from and below the surface.

The requirements for non-invasive professional archaeology prospection are its ability to survey large areas quickly with very high spatial resolution and accuracy. New technology, both in the development of novel multichannel/multi-sensor instrumentation and advanced positioning and navigation systems, offers great possibilities to utilize archaeological prospection as a powerful toolbox for investigations covering large-scale archaeological sites and entire landscapes. The integrated LBI prospection approach is based on both technological and methodological development at the high-end of respective area of research. The complex and detailed 3D data sets generated by integrated archaeological prospection, require new techniques of combined data processing and visualization. These requirements are met by the application of Virtual Reality (VR) approaches and advanced GIS-technology to visualize and explore the data volumes in regard to their archaeologically relevant content.

One mayor objective is the development of new methods, algorithms and software for the processing, digital GIS-based description and three-dimensional visualization of the huge amount of data collected permitting a detailed understanding of these data. Sophisticated processing of the geophysical data is of crucial importance for the subsequent integrated archaeological interpretation and the production of complex data volumes as input for VR systems. A major goal is the development of an integrative platform for researchers to manage and work on these huge and complex datasets of archaeological landscapes, allowing investigations of new spatial analysis methods and concepts for archaeological interpretations using GIS. The question and challenge of digital data management and data archiving will be of considerable importance regarding remote sensing and geophysical prospection for large-scale archaeology due to the immense data volumes involved.

It is the integrated archaeological interpretation of archaeological sites and landscapes by standardized techniques and reflexive conceptual foundations constituting the main objective of the LBI-ArchPro research programme. It is not merely the visualization of prospecting data, but the derivation of interpretations and their adequate visualization based on dynamic access to the primary data which will form the comprehensive background for the archaeological conclusion and their dissemination to the scientific community and the public.

The main intention is to develop a comprehensive and standardized interpretation process and the elaboration of instant knowledge transfer between different user groups working on the integrated interpretation. For that purpose a GIS-based web-portal has to be developed, which will integrate interpretation tools and is able to manage multi-user data access expanded by a web-based research-wiki. Through a user-friendly GIS-Interface an interdisciplinary archaeological work can be provided because the new developed software will allow the interpreting archaeologist to employ high-end interpretation tools without the need of a deep understanding of technical aspects and algorithms. These tools can be directly accessed during the interpretation process, will work semi-automatic and are interactively controlled by the interpreting experts or specialized archaeologists. The direct access to the research-wiki will enable the partners to

exchange and improve the knowledge base working simultaneously on the same case studies. This complex and wide range application guarantee the close connection of the developed theoretical concepts, technical solutions, hard- and software tools with the practical needs of modern spatial archaeology from the micro-scale of an excavation up to extended archaeological landscapes with respective resolutions.

The case studies (http://archpro.lbg.ac.at/case-studies/case-studies) are set up to include a wide variety of different environmental settings, chronological foci, and archaeological topics. On all selected areas there exists primary data stored in the archives of the partner organization s forming a major input for the distinct case studies. The selected areas are investigated using non-destructive remote sensing, geophysical prospection, virtual reality and dynamic GIS-based integrated archaeological interpretation. The information gained by the non-destructive approach of the LBI is extended by additional information from destructive investigations (field survey, targeted excavations, augering, etc.) by the partner organizations.

The huge amount of data, which is produced by the various LBI case studies, demands new tools for efficient, integrated and comprehensive archaeological interpretation. The specification of these tools is derived from the prospection experts, interpretation process and downgraded to an integrated, easy-to-use multi-purpose toolbox for archaeologists.

2.1 The LBI-ArchPro Case Studies

Within the proposed research program, various geographical areas have been selected by the partners to provide different archaeological landscapes for distinct case studies as detailed below. The selected areas are investigated by the LBI ArchPro in close cooperation with the national partner organizations using a suite of advanced non-invasive, methods and techniques to be further developed by the LBI ArchPro, including remote sensing, geophysical prospection, virtual reality and dynamic GIS-based integrated archaeological interpretation.

Stonehenge "The Stonehenge Hidden Landscapes Project", United Kingdom

Stonehenge occupies one of the richest archaeological landscapes in the world, recorded in the course of intensive archaeological and antiquarian research over several hundred years, yet much of this landscape effectively remains terra incognita. This project aims to address gaps in our knowledge and understanding of the Stonehenge landscape by conducting a cutting-edge geophysical and remote sensing survey at an unprecedented scale. The results of the proposed work will be used to create a highly detailed archaeological map of the 'invisible' landscape, providing the basis for a full interpretative synthesis of all existing remote sensing and geophysical data from the study area, For the first time it will thus be possible to create total digital models of the Stonehenge landscape at a true 'landscape scale' that will not only transcend the immediate surrounds of individual monuments within the study area, but will also tie them together within a seamless map of sub-surface and surface archaeological features and structures.

Between July 5th and July 23rd 2010 the first geophysical archaeological prospection fieldwork for the LBI case study Stonehenge, as part of the Stonehenge Hidden Landscapes Project, was conducted by PL2 under the direction of the British LBI partner organization VISTA of the Institute of Archaeology and Antiquity at the University of Birmingham. Additional staff and students from the Universities of Bradford and St Andrews, as well as students from Vienna University participated in the fieldwork. The purpose of the case study was on the one hand the testing and

Fig. 10: The LBI PL2 team in Stonehenge, UK 2010

development of novel measurement devices, the improvement of measurement methodology and the development and adaptation of corresponding data processing software, and on the other hand the large-scale collection of high-resolution survey data for subsequent archaeological interpretation and research: the collected data will serve the development of novel processing algorithms for integrative archaeological interpretation and landscape archaeological research by PL3. The 2010 fieldwork campaign at Stonehenge was of importance in regard to future planning of fieldwork campaigns, both logistically and in regard to the scientific results.

At Stonehenge the MIRA system was used to cover an area of ca. 17 hectares with an unprecedented spatial resolution. Problems regarding exact positioning of the MIRA data were recognized and communicated to MALÅ Geoscience. While the system performed very well during the first week, random system failures occurred in week 2 and 3. It was recognized that these problems were caused by a loose cable connection and the problem was easily resolved. Initial hardware problems with the SPIDAR system were solved with the help of the system manufacturer Sensors & Software and quickly shipped replacement parts. The SPIDAR system was then used to cover ca. 13.5 hectares at Stonehenge. Single channel GPR measurements were used to survey five large burial mounds and a long-barrow (in total ca. 2.5 hectares coverage). The terrestrial laser scanning of the mounds by LBI Partner VISTA will permit the development of topographic correction algorithms and improved imaging of the GPR data. The size of the areas at Stonehenge covered with GPR measurements has been unprecedented in the field of archaeological prospection.

The magnetometer measurements at Stonehenge were limited in speed due to slow A/D conversion rates. Through communication with Eastern Atlas it was possible to obtain a new A/D converter and data logging software with up to 200 Hz sample frequency, permitting high-speed surveys of >50 km/hour and thus large coverage rates (10-20 hectares per day). At Stonehenge 28 hectares of area were surveyed with magnetometer prospection.

Uppåkra, Sweden

In the second half of August 2010 the first geophysical archaeological prospection fieldwork for the case study Uppåkra was conducted by PL2 in cooperation with the Swedish LBI Partner UV Teknik and the University of Lund.

The purpose of the case study is on the one hand the test and development of novel measurement devices, the improvement of measurement methodology and the development and adaptation of corresponding data processing software, as well as on the other hand the large-scale collection of high-resolution survey data for subsequent archaeological interpretation and research: the collected data will serve the development of novel processing algorithms for integrative archaeological interpretation and landscape archaeological research by PL3.

The 2010 fieldwork campaign at Uppåkra was the first in this specific case study and therefore of importance regarding the planning of future campaigns, both logistically and in regard to the scientific results.

A very successful first case study was conducted at Uppåkra in Sweden, setting new spatial coverage records of 15 hectares/day with magnetometer prospection, further testing and improving the hardware and resulting in very good data for use by PL3. A collaboration agreement with Prof. Lars Larsson from Lund University was prepared. The collaboration with the Swedish LBI partner RAÄ UV Teknik, as well as with the archaeologists on site, was very productive and harmonic. Within 7 days of fieldwork the team covered 10 ha with high-resolution GPR and 40 ha with magnetometer measurements. A novel navigation and data logging software for the magnetic prospection is being developed and tested with the goal to image the data in real-time on the screen in front of the operator.

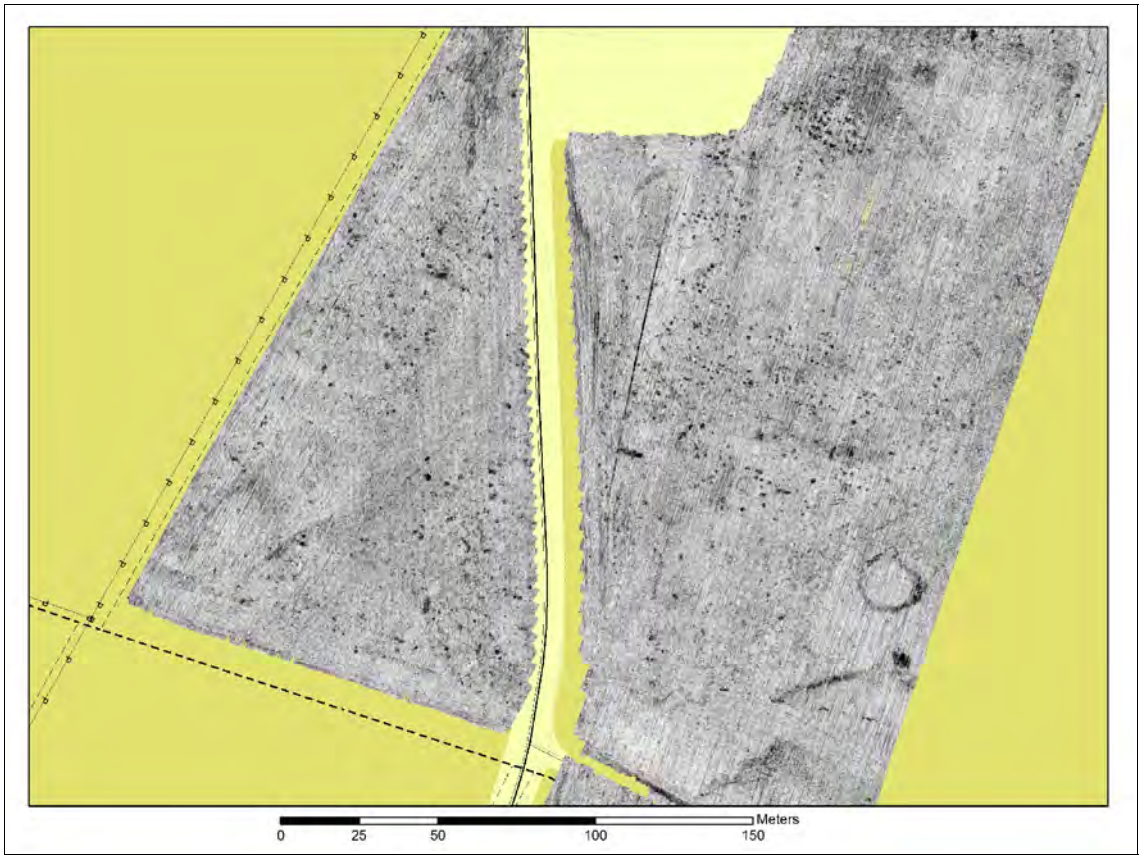

Fig. 11: GPR data from Uppåkra, Sweden 2010

Vestfold, Norway

Between August 30th and September 24th 2010 the first geophysical archaeological prospection fieldwork for the case study Norway was conducted by PL2 in cooperation with the Norwegian LBI partner NIKU and supported by staff from Vestfold County administration. The purpose of the case study was on the one hand the test and development of novel measurement devices, the improvement of measurement methodology and the development and adaptation of corresponding data processing software, as well as on the other hand the large-scale collection of high-resolution survey data for subsequent archaeological interpretation and research: the collected data will serve the development of novel processing algorithms for integrative archaeological interpretation and landscape archaeological research by PL3. The 2010 fieldwork campaign in Norway took place in the region around Larvik in Vestfold county. At the sites Kaupang, Lunde/Tjøllingvollen and Aske large scale ground penetrating radar (GPR) and magnetometer measurements were conducted. This first case study in Norway was of importance regarding the planning of future campaigns, both logistically and in regard to the scientific results.

Subsequently, the field team moved on to Vestfold County for the Norwegian Case study in collaboration with the LBI partner NIKU. The entire site of Kaupang was surveyed using the MIRA system, generating considerable media interest, nationwide news coverage and a 26 minutes radio documentary about the project, explaining the LBI and its research goals. For the first time all three survey systems (MIRA, SPIDAR, magnetic) were used in parallel. First data analysis indicates very good archaeological prospection results obtained at the site of Tjøllingvollen. The magnetic and GPR data processing software is continuously being tested and developed (daily updates). The collaboration with LBI Partner NIKU and their partners from VFK is very constructive and pleasant.

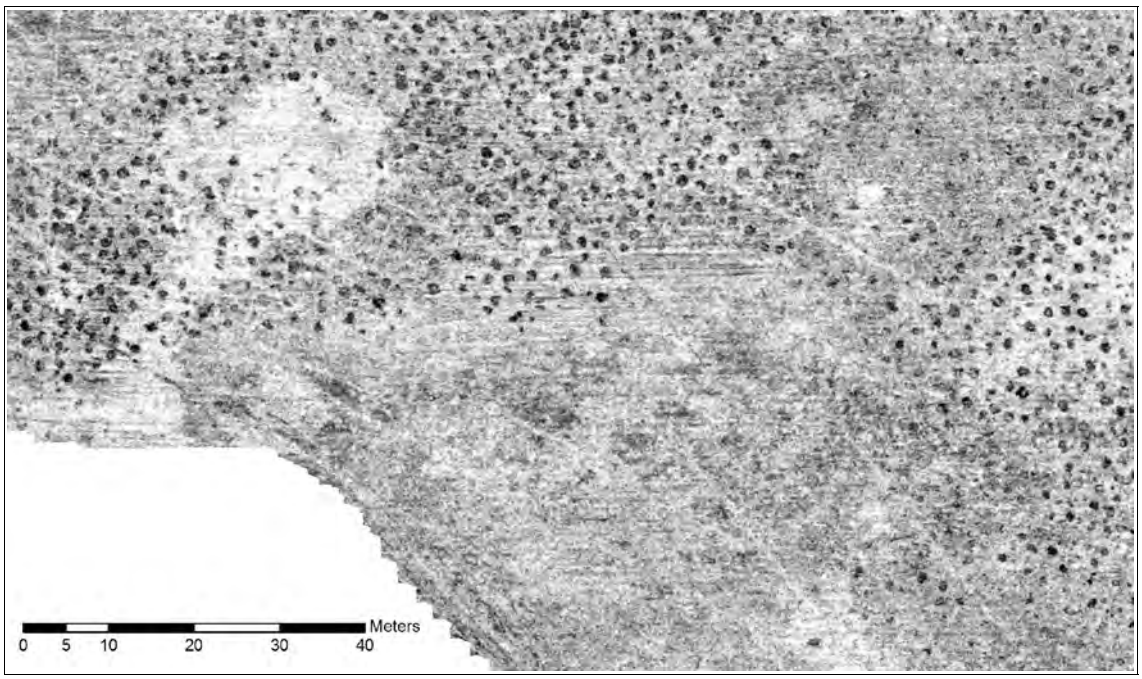

Fig. 12: GPR data from Vestfold county, Norway 2010

Within three days (18 May to 20 May 2010) the palace Herrensgården and the estimated area of the baroque gardens were scanned together with partner VIAS, University of Vienna using TLS (Riegl LMS 420i) and geophysical prospected using Ground Penetrating Radar (GPR).

Unfortunately the area of the former gardens is mostly covered with buildings. Only a few areas could be prospected. Nevertheless the presence of the LBI and first working contact with the partners of NIKU formed a successful start honored also by the presence of the media. Within three days the palace and the surrounding area were topographically documented and an overall area of 4706m2 prospected using GPR. Traces of former paths and basins were detected. As assumed, most of the structures must have been destroyed due to the construction of houses, new parks and roads.

Carnuntum, Austria

Two MIRA test surveys were conducted at Carnuntum in October 2010 and March 2011, resulting in valuable data for the assessment and solution of data positioning issues through close collaboration with MALÅ Geoscience.

On the 5th of June the study area Carnuntum (Austria) was simultaneously sensed by airborne laser scannig (ALS) and airborne hyperspectral scanning (AHS) by the company Airborne Technologies (Austria). Both sensors were mounted next to each other on the same sensing platform. For the ALS data acquisition a Riegl LMS-Q680 ALS sensor was in use, while for the AHS data the Specim Eaglet sensor was mounted in the airplane. The processing of the raw data (georeferencing, calibration, echo extraction, etc.) was performed by the company Airborne Technologies, while the subsequent processing and data analysis was performed by the LBI PL1 team. Next to the airborne data acquisition simultaneous radiometric ground control measurements with a spectrometer were performed. The analysis of the ALS and AHS data is still ongoing. Very interesting results can already be gained by the analysis of the radiometric information acquired by the ALS sensor.

Schwäbische Alb, Germany

As of writing this report in March 2011 the field tests in case study area Schwäbische Alb are underway.

2.2 Additional field tests

Sonnblick, Austria

Due to climatic changes the permafrost in alpine regions (approx. 3000m above sea level) is melting. This process affects the stability of high alpine regions and might be the cause of the increase of earth- and rockslides. Especially the meteorological station at Sonnblick (3106m) run by ZAMG is endangered by this process. During the last years several artificial stabilizing constructions made out of concrete had been set up. The actual project in cooperation with the University of Vienna (VIAS) and the ZAMG aims to monitor the change of the permafrost. Therefore the area surrounding the station was scanned using TLS, far range TLS and ALS. Additionally, GPR was applied at Sonnblick in 2010. Using TLS (Riegl LMS 420i) the change of the area could be documented compared to a scan carried out two years earlier. The recent survey lasted from 21st to 22nd of August 2010. The collected data can be seen as reference for the planned VIRTEX grant application.

Fig. 13: GPR prospection in 3050 m above sea level at the Sonnblick, Austria 2010

Hallstatt, Austria

In August the handheld Z-Scanner (ZCorporation) was delivered. After some hours of instructions it was decided to immediately test the scanner in a typical archaeological environment. From 7th to 9th of August the new hand held ZScanner 700CX was tested together with partner VIAS, University of Vienna in Hallstatt at the ongoing excavation (Langmoosbach). At the same time data was collected with Riegl LMS420i to compare the gained datasets and check the compatibility of the used software formats. Additionally Riegl LMS420i was tested concerning the current conditions of its noise. Within a distance of 3 to 4m it is below 6 -7mm, which is still satisfying. The new scanner proofed to be a very handy, accurate and fast tool for uncomplicated onsite documentation with a resolution down to 0.2mm and an accuracy of 50µm.

3. Scientific Contributions

3.1 Participation at conferences

Geert Verhoeven:

- AARG congress in Bucharest 2010

3.2 Presentations & active participation at conferences

Wolfgang Neubauer:

- Germany – Freiberg. "Digitale Dokumentation stratigraphischer Grabungen" - VDR Tagung: " Befund und Methode - von der Frage zur Aussage" 14 - 17 April 2010.
- United Kingdom – Cambridge. "Integrated archaeological prospection at Carnuntum" - Laurence Seminar: " Archaeological Survey and the City" 24 - 27 May 2010.
- Germany – Münster. „Archaeological Use of Airborne Laser Scanning for Woodland Survey - Prospects and Issues". 1. Niederländisch-Deutsche Tagung der CAA: Behind the scenes: New developments in archaeological remote sensing and geophysics. 19 - 20 November 2010.
- Austria – Vienna. „Potential of Archaeological Airborne Remote Sensing for the Reconstruction of Paaeoenvironments". Kolloquium der Forschungsplattform für Archäologie – VIAS: Die Archäologie der Landschaft – Flussverlauf und Hafenprospektion. 13 December 2010.

Michael Doneus:

- Wales - Cardiff. "Collaborative prospection methodologies: Geophysics, Aerial Archaeology and Airborne Laser Scanning. Digital Past 2010, New technologies in heritage, interpretation & outreach" in St Fagans: National History Museum, Cardiff. 16 - 17 February 2010.
- Island – Reykjavik. "Airborne Laserscanning in Forested Areas. Potential and Limitations of an Archaeological Prospection Technique". EAC Symposium: Remote Sensing for Archaeological Heritage Management in the 21st century, Reykjavik, Iceland, 25 - 27 March 2010 (Paper was read from manuscript by Dave Cowley, RCHMS).
- Austria – Vienna. "Analysis of full-waveform ALS data by simultaneously acquired TLS data: Towards an advanced DTM generation in wooded areas" (together with Christian Briese & Nikolaus Studnicka). ISPRS Symposium of Commission VII: "100 Years ISPRS - Advancing Remote Sensing Science", 5 - 7 July 2010.
- Portugal – Ammaia. "Oblique aerial photography for archaeology: applications". First Specialization Forum: "Integrated non-destructive approaches to understand and valorise complex archaeological sites" in Ammaia (Marvão - Portalegre, Portugal), 5 - 11 July 2010.
- Portugal – Ammaia. "Oblique aerial photography for archaeology: integration with other prospection methods". First Specialization Forum: "Integrated non-destructive approaches to understand and valorise complex archaeological sites" in Ammaia (Marvão - Portalegre, Portugal), 5 - 11 July 2010.

- Portugal – Ammaia. Airborne LiDAR: technology and applications (Michael Doneus). First Specialization Forum: "Integrated non-destructive approaches to understand and valorise complex archaeological sites" in Ammaia (Marvão - Portalegre, Portugal), 5 - 11 July 2010.
- Austria – Leoben. Aufnahme historischer Steinbrüche im Leithagebirge (Heinrich, M., Kollars, B., Moshammer, B., Rabeder, J. & Doneus, M.). PANGEO AUSTRIA 2010, Geowissenschaften, Grundlagen und Anwendung. Montanuniversität Leoben, 15 - 19 September 2010. [Poster]
- Rumania – Bukarest. "Perception, aerial photography and air-photo-interpretation". AARG Annual Meeting 2010, 16 September 2010.
- Rumania – Bukarest. "Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology". AARG Annual Meeting 2010, 17 September 2010.
- Rumania – Bukarest. "The impact of airborne laser scanning for landscape archaeology". AARG Annual Meeting 2010, 17 September 2010.
- Austria – Vienna. „Der Blick in die Vergangenheit – archäologische Prospektion aus der Luft". 17. Kulturwissenschaftlicher Dialog: „Archäologie und Militär". Institut für Human- und Sozialwissenschaften der Landesverteidigungsakademie, 21 September 2010.
- Austria – Graz. „Mit Hightech im Wald – neue Wege der archäologischen Prospektion". OVE-OCG-Vortragsreihe (OVE Österreichischer Verband für Elektrotechnik; OCG Österreichische Computer Gesellschaft), 14 October 2010.
- Germany – Münster. „Archaeological Use of Airborne Laser Scanning for Woodland Survey - Prospects and Issues". 1. Niederländisch-Deutsche Tagung der CAA: Behind the scenes: New developments in archaeological remote sensing and geophysics, 19 - 20 November 2010.
- Austria – Vienna. „Potential of Archaeological Airborne Remote Sensing for the Reconstruction of Paaeoenvironments". Kolloquium der Forschungsplattform für Archäologie – VIAS: Die Archäologie der Landschaft – Flussverlauf und Hafenprospektion, 13 December 2010.

Nives Doneus:

- Belgium – Ghent. "Roman rural landscape in west Pannonia: A Case Study of the Roman Site at Halbturn, Austria (2nd - 5th centuries AD)". Spatial Analysis Applied to Archaeological Sites from Protohistory to the Roman Period Workshop on Spatial Archaeology at the Ghent University Het Pand, 2 - 3 December 2010.

Christian Briese:

- Austria – Vienna. "Analysis of full-waveform ALS data by simultaneously acquired TLS data: Towards an advanced DTM generation in wooded areas" (together with Michael Doneus & Nikolaus Studnicka). ISPRS Symposium of Commission VII: "100 Years ISPRS - Advancing Remote Sensing Science", 5 - 7 July 2010.
- Austria- Vienna. "Radiometric calibration of Full-Waveform Airborne Laser Scanning Data based on natural surfaces" (together with Lehner H.) ISPRS Symposium of Commission VII:

"100 Years ISPRS - Advancing Remote Sensing Science", 5 - 7 July 2010.

- Hungary - Tihany. 1st FP7 EUFAR Training Course "Advanced Digital Remote sensing in Ecology and Earth Sciences Summer School" at the Balaton Limnological Research Institute (BLRI) of the Hungarian Academy of Sciences, 19 - 28 August 2010.
- Austria - Graz. „AirborneLaserscanning – Messprinzip und Anwendungen" OVE-OCG-Vortragsreihe (OVE Österreichischer Verband für Elektrotechnik; OCG ÖsterreichischeComputer Gesellschaft), 14 October 2010.
- Austria – Illmitz. "Reed mapping by unmanned aerial vehicles (UAV)" International Symposium on Advanced Methods of Monitoring Reed Habitats in Europe, 25 - 26 November 2010.

Matthias Kucera:

- Austria – Graz. Workshop on the philosophy of science: ARCHAEOSKILLS 2010, 3 - 5 June 2010 (organized by DASV).
- Austria - Vienna. "Bronzezeitliche Tragesäcke - eine Experiment?". Internationales ÖGUF Symposium 2010. Experimentelle Archäologie - Theorie, Praxis, Wissenschaft, Vermittlung, 27 - 30 October 2010.

Klaus Löcker:

- Austria – Graz. Workshop on the mining archaeology: ARCHAEOSKILLS 2010, 3 - 5 June 2010 (organized by DASV).

Daniel Scherzer:

Korea – Seoul. "Exploiting Temporal Coherence in Real-Time Rendering". Workshop at the 3rd ACM SIGGRAPH Conference and Exhibition on Computer Graphics and Interactive Techniques in Asia, 15- 18 December 2010.

Immo Trinks:

- Norway – Oslo. "High-definition geophysical archaeological prospection in Norway – Experiences of the past three years" CAA Norge Meeting 2010, 18 October 2010.
- United Kingdom – London. "The Ludwig Boltzmann Institute for Archaeological Prospection & Virtual Archaeology - a new perspective for landscape archaeology. Research programme and first results from large-scale, high-resolution archaeological prospection". 2010 NSGG Meeting: "Recent Work in Archaeological Geophysics", Burlington House, 15 December 2010.

Geert Verhoeven:

- Germany – Münster. "Redefining Limits - The (Invisible) Future of Archaeological Aerial Re-connaissance". CAA Germany-The Low Countries 2010 - Behind the Scenes: New

developments in Archaeological Remote Sensing and Geophysics", 19 - 20 November 2010.

- Belgium – Ghent. „Beyond Conventional Boundaries: nieuwe technologieën, methodes en procedures ten behoeve van dataverwerving en -analyse in de archeologische luchtfotografie". Symposium Archeologie 2010, 25 March 2010.
- UK – Cambridge. "New Ways of Dealing with Aerial Archaeological Imaging". Laurence Seminar 2010: Archaeological Survey and the City (Faculty of Classics, Cambridge University, 24 - 27 May 2010.
- Italy – Rome. "(Airborne) Digital Photography at Portus and Isola Sacra". Portus Workshop: Research during 2009/2010 at British School at Rome, 12 July 2010.

Partners:

- Norway – Oslo. "The Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology – First results and the road ahead" (Knut Paasche et al., LBI Partner NIKU). CAA Norge Meeting 2010, 18 October 2010.
- United Kingdom – London. "Methodological and Archaeological Challenges in the First Season of the Stonehenge Hidden Landscapes Project" (Christopher Gaffney (University of Bradford, Vincent Gaffney (VISTA), Wolfgang Neubauer) - NSGG meeting: "Recent Work in Archaeological Geophysics" 15 - 16 December 2010.

3.3 Scientific cooperation & third party founded projects

3.3.1 Austrian

University of Vienna: "Initiative College for Archaeological Prospection IC-ArchPro"

Key Facts: Initiative College at University of Vienna, budget € 830.000; duration 3 years.

10 young researchers will be employed in this college at the LBI-partner. They will be integrated into the research programme and case-studies of the LBI.

3.3.2 International

Collaboration LBI-ARCHPRO and Lund University

A collaboration agreement was signed with the Department of Archaeology at Lund University (ArchLund) of the University of Lund in Sweden that sets out the terms for cooperation at the Uppåkra case study to take place from 2010 to 2013.

3.4 Arrangements of workshops and conferences

ISPRS centenary celebration (1910-2010)

The International Society of Photogrammetry and Remote Sensing (ISPRS) was founded by Prof. Eduard Dolezal on 4th of July 1910 in Vienna. To celebrate its first centenary, the LBI partner Vienna University of Technology, together with ISPRS organized various events between 1st and

7th of July (http://www.isprs100vienna.org/):

1. 1 - 3 July: 3-Ländertagung, organized by the German Society of Photogrammety, Remote Sensing and Geoinformation - DGPF, the Austrian Society of Geodesy and Geoinformation – OVG, and the Swiss Society of Photogrammetry and Remote Sensing – SGPF.
2. 4 July: ISPRS Centenary
3. 5 - 7 July: Symposium of Commission VII: “100 Years ISPRS - Advancing Remote Sensing Science”

Altogether, there were more than 400 registered participants.

The LBI for Archaeological Prospection and Virtual Archaeology was present during all of these events with a poster-stand and several presentations of PL1. Due to the high ranking score of the peer-review of the abstracts, our presentation:

> Analysis of full-waveform ALS data by simultaneously acquired TLS data: Towards an advanced DTM generation in wooded areas (Michael Doneus, Christian Briese, Nikolaus Studnicka)

was honored and moved to the plenary session on the last day of the Symposium of Commission VII.

Fig. 14: LBI staff Briese and Doneus at the ISPRS in Vienna.

3.5 Teaching activities

Wolfgang Neubauer:

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060014 UE Stratigraphische Praxis
- 060083 PV Privatissimum
- 060095 UE Vermessungskunde für Archäologen (together with Michael Doneus)
- 060101 PR Praktikum Geophysikalische Prospektion (together with Erich Nau)
- 060023 PV Privatissimum
- 060024 VU GIS-Anwendungen in der Archäologie (together with Michael Doneus)
- 060138 VO Grundlagen der geophysikalischen
- 060139 UE Grundlagen archäologischer Stratigraphie
- 060143 VU Geophysikalische Prospektion
- 060145 UE Interpretation archäologischer Prospektionsdaten
- 060149 SE Archäologische Prospektion

Michael Doneus:

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060021 SE Landschaftsarchäologie
- 060023 PR Photogrammetrische Anwendungen in der Archäologie
- 060024 PV Privatissimum
- 060095 UE Vermessungskunde für Archäologen
- 060020 VO Grundlagen der Luftbildarchäologie
- 060024 VU GIS-Anwendungen in der Archäologie
- 060031 VU CAD für Archäologen
- 060096 VU Luftbildarchäologische Interpretation
- 060163 VU Flugzeuggetragenes Laserscanning (LiDAR) für Archäologen

International:

- Oblique aerial photography for archaeology: applications.
- Oblique aerial photography for archaeology: integration with other prospection methods.
- Airborne LiDAR: technology and applications.

Christian Briese:

University of Technology Vienna:

- Grundzüge der Photogrammetrie
- Spatial Data from Photogrammetry and Remote Sensing
- Topographische Modelle

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- Flugzeuggetragenes Laserscanning (LiDAR) für Archäologen

Matthias Kucera:

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060140 UE Naturwissenschaftliche Methoden in der Archäologie: Geo- und Bioarchäologie
- 060141 VO Grundlagen der Experimentalarchäologie

Daniel Scherzer:

FH Hagenberg:

- Advanced Computergraphics

Geert Verhoeven:

Ghent University (UGent), Faculty of Arts and Philosophy, Department of Archaeology:

- Prospectie- en opgravingstechnieken (prospection and excavationtechniques)
- Informatica toegepast op de archeologie (Archaeological IT)
- Geoarcheologie: principes en onderzoekspraktijk (Geo-archaeology: principles and guidelines to good practice)
- Sharon Van Hove – UGent: Master thesis: “Een kijkpunt op archeologische landschappen” (Viewsheds of archaeological landscapes)
- UV und Infrarot Fotografie von das Gemälde „Het Lam Gods“ (Ghetty Project).
- Webdesign von http://www2.radiopast.eu/

4. Outlook 2011

The LBI-ArchPro research fields are highly relevant for all spatial aspects of landscape archaeology, and mutual benefits can be seen in the use of high-resolution terrain models obtained by remote sensing with airborne laser scanners, integration of large scale, high-resolution geophysical prospection improved VR data processing, visualization and analysis, and a holistic interpretation within the framework of a dynamic ArcheoGIS for the further development of non-invasive archaeology. It is GIS-technology that provides an interface between prospection and excavation, requiring a standardization of methods based on logical and comprehensive data retrieval from the various aspects of the archaeological stratification. Expanding the LBI case studies into large scale applications combining non-invasive and conventional archaeology, the research at the LBI will provide scientific access to GIS-based virtual and scalable archaeological data.

Among these implements, VR will function as an important interface technology, making data and results graphically accessible to the scientific community and the public. Scientific archaeological prospection requires the implementation and adherence to the highest technical standards for instrumentation, spatial sampling intervals, positioning accuracy, data processing and visualization, as well as new methodological concepts for the archeological interpretation of individual sites and archeological landscapes. In order to derive archaeologically relevant information from the data collected with advanced technologies, the development of adequate interpretation tools based on the implementation of existing and new concepts for spatial analysis applicable to any kind of spatial archeology will be necessary.

5. Publications 2010

5.1 Monographs

1. **Doneus, M., 2011.** Die hinterlassene Landschaft. Monographie Mitt. prähist. Komm.: Verlag ÖAW (to be submitted).
2. **Doneus, N., Lange, A. (Eds.), 2010.** Golden Words. An Ancient Jewish Amulet from Austria and the Jewish Presence in Roman Panonia. Journal of Ancient Judaism 1/2, Vandenhoeck & Ruprecht.
3. **Doneus, N. (Ed.), 2011.** Halbturn I. Das kaiserzeitliche Gräberfeld von Halbturn, Burgenland: Archäologie und Geschichte (Band 1), Intention, Abfall oder Zufall - naturwissenschaftliche Untersuchungen (Band 2). Monographien RGZM: Verlag RGZM (in Press)
4. **Gugl, C., Doneus, M., Doneus, N., 2011.** Die Canabae von Carnuntum – ein Modell für römische Lagervorstädte? Von der Luftbildprospektion zur siedlungsarchäologischen Synthese. Römischer Limes in Österreich 47: Verlag ÖAW (to be submitted).
5. **Melichar, P., Neubauer, W. (Eds.), 2010.** Mittelneolithische Kreisgrabenanlagen in Niederösterreich. Geophysikalisch-archäologische Prospektion – ein interdisziplinäres Forschungsprojekt. Mitt. prähist. Komm 71: Verlag ÖAW.

5.2 Peer-reviewed papers

6. **Doneus, M., Briese, C., Studnicka, N., 2010.** Analysis of Full-Waveform ALS Data by Simultaneously Acquired TLS Data: Towards an Advanced DTM Generation in Wooded Areas. In: Wagner, W., Székely, B., 100 Years ISPRS, Advancing Remote Sensing Science. ISPRS Technical Commission VII Symposium, Vienna, Austria, July 5 – 7, 2010. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVIII, Part 7B, 193-198.
7. **Doneus, M., Kühtreiber, T., 2011.** The fertile Desert. Monastic Landscape Conceptions at the Austrian-Hungarian Border in Counter-Reformation Period (submitted).
8. **Kucera, M., Pany, D., Boyadjian, C.H., Reinhar, K., Eggers, S., 2011.** Efficient But Destructive: A Test Of The Dental Wash Technique Using Secondary Electron Microscopy; Journal of Archaeological Science (accepted 21 August 2010) (in Press).
9. **Lehner, H., Briese, C., 2010.** Radiometric calibration of Full-Waveform Airborne Laser Scanning Data based on natural surfaces. In: Wagner, W., Székely, B., 100 Years ISPRS, Advancing Remote Sensing Science. ISPRS Technical Commission VII Symposium, Vienna, Austria, July 5 – 7, 2010. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVIII, Part 7B, 360-365.
10. **Verhoeven, G., 2010.** It's All about the Format – Unleashing the Power of RAW Aerial Photography. International Journal of Remote Sensing 31 (8), 2009-2042.
11. **Verhoeven, G., Schmitt, K., 2010.** An Attempt to Push Back Frontiers – Digital Near-UltraViolet Aerial Archaeology. Journal of Archaeological Science 37(4), 833-845.

12. **Verhoeven, G., 2011.** Taking Computer Vision Aloft – Archaeological Three-dimensional Reconstructions from Aerial Photographs with PhotoScan. Archaeological Prospection 18 (in Press).
13. **Verhoeven, G., 2011.** Crop mark Archaeology Should Be Colourful – Imaging the Blue Shift of the Reflectance Curve Red Edge to Detect the Stress Related Loss of Green Chlorophyll in Vegetation. Journal of Archaeological Science (submitted).
14. **W. Neubauer, M. Doneus, I. Trinks, G. Verhoeven, A. Hinterleitner, S. Seren, K. Löcker:** Long-term integrated archaeological prospection at the Roman Town of Carnuntum/Austria. Laurence Seminar Publication [in press]
15. **Verhoeven, G., 2011.** Near-InfraRed Aerial Crop Mark Archaeology: From Its Historical Use to Current Digital Implementations. Journal of Archaeological Science (submitted).
16. **Verhoeven, G., Doneus, M., Briese, C., 2011.** Detectable versus Recognizable – Airborne Hyperspectral Imaging at Archaeologically Relevant Sampling Intervals. Archaeological Prospection (to be submitted).
17. **Trinks, I., 2011.** Mapping the Viking town Birka using high-resolution geophysical prospection (to be submitted).
18. **Trinks, I., 2011.** Lightning and thunder over Graborgen on Öland - an alternative explanation of an archaeological sensations. Archaeological Prospection (to be submitted).
19. **Trinks, I., 2011.** The anomaly that wasn't there - on the visibility of anomalies in geophysical archaeological prospection Geophysical Archaeological Prospection (to be submitted).
20. **Trinks, I., Johansson, B., Gustafsson, J., Emilsson, J., Friborg, J., Gustafsson, C., Nissen J., and Hinterleitner A., 2010.** Efficient, large-scale archaeological prospection using a true three-dimensional ground-penetrating Radar Array system. Archaeological Prospection, Special Issue: Special Issue on Selected Papers from the 8th ISAP Conference and 7th Colloque GEOFCAN, 175--186. Article first published online: 2 JUL 2010 | DOI: 10.1002/arp.381
21. **Viberg, A., Trinks, I., Lidén, K. 2011.** A review of the use of geophysical archaeological prospection in Sweden. Archaeological Prospection (in Press).

5.3 Non peer-reviewed papers

22. **Doneus, M., 2010.** Flugzeuggetragenes Laserscanning in der archäologischen Prospektion. Neues zum Burgstall von Purbach am Neusiedlersee. Purbacher Jahrbuch, 7, 2010, 39-53.
23. **Doneus, M., Briese, C., 2011.** Airborne Laser Scanning in Forested Areas - Potential and Limitations of an Archaeological Prospection Technique. In: In: Cowley D. C. (ed.) 2011, Remote Sensing for Archaeological Heritage Management, proceedings of an EAC Symposium, Reykjavik, Iceland, 25 –27 March 2010, Archaeolingua (in Press).
24. **Doneus, M., Gugl, C., 2011.** Zur Wasserversorgung der Canabae legionis und des Legionslagers von Carnuntum. In: Thermen-Symposium Hainburg 2009 (in Press).
25. **Doneus, M., Gugl, C., Klein, M., 2011.** Das neue Gesamtmodell von Carnuntum. Katalog

zur NÖ Landesausstellung 2011 (in Press).

26. **Heinrich, M., Kollars, B., Moshammer, B., Rabeder, J., Doneus, M., 2010.** Aufnahme historischer Steinbrüche im Leithagebirge. Journal of Alpine Geology 52, 137–138.
27. **Doneus, M., Neubauer, W., 2010.** LBI for Archaeological Prospection and Virtual Archaeology. AARGNews 41, 11.
28. **Doneus, N., 2010.** Am Rande der Gesellschaft? Römische Säuglings- und Kinderbestattungen aus dem Gräberfeld Halbturn I, Westpannonien. Mitt. Anthr. Gesellschaft 140, 2010, 141-153.
29. **Doneus, N., 2010.** The Roman Childe and the Jewish Amulet. Journal of Ancient Judaism 1/2, 2010, 146-153.
30. **Doneus, N., 2011.** Roman rural landscape in west Pannonia. A Case Study of the Roman Site at Halbturn, Austria (2nd - 5th centuries AD). Proceedings of the Conference: Spatial Analysis Applied to Archaeological Sites from Protohistory to the Roman Period. Workshop on Spatial Archaeology at the Ghent University, Belgium (2 & 3 December 2010) (submitted).
31. **Doneus, N., 2011.** Halbturn I – Ein römerzeitliches Gräberfeld aus dem Burgenland. Struktur und Grabrituale eines ländlichen Gräberfeldes im Hinterland von Carnuntum zwischen dem 2. und 5. Jh.. In: Doneus, N. (Ed.), Halbturn I. Das kaiserzeitliche Gräberfeld von Halbturn, Burgenland: Archäologie und Geschichte (Band 1). Monographien RGZM: Verlag RGZM (in Press).
32. **Gugl, C., Doneus, M., Doneus, N., 2011.** The Canabae Legionis of Carnuntum: Modelling a Roman Urban Landscape from systematic, non-destructive Prospection and Excavation. Proceedings of the XXIst International Limes (Roman Frontiers) Congress 2009 (in Press).
33. **Lobisser, W.F.A., Kucera, M., Neubauer, W., 2010.** 11 Years of the Celtic Festival in Schwarzenbach/Lower Austria and the EU-Project Researchers´Night 2007, LiveARCH – Living history in archaeological open air museums, Markdorf, 50-58.
34. **Mandlburger, G., Pfeifer, N., Ressl, C., Briese, C., Roncat, A., Lehner, H. and Mücke, W., 2010.** Algorithms and tools for Airborne LiDAR data processing from a scientific perspective. ELMF World Forum 2010, November 30 – December 1, 2010, The Hague, Nethderlands.
35. **Mücke, W., Hollaus, M., Briese, C., 2010.** Reed structure mapping in airborne laser scanning data. In: Operational Tools in forestry using remote sensing techniques, 286-288.
36. **Neubauer, W., 2010.** Archäologische Auswertung der systematischen Prospektion. Mitt. prähist. Komm. 71, 2010, 56-135.
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