

Interdisciplinary Knowledge Transfer within Surveying Higher Education

Guido Heinz, Jörg Klonowski, Hartmut Müller, Germany

Abstract

At Mainz University of Applied Sciences, Department of Geoinformatics and Surveying, a long experience is available in co-operation projects with partners from the humanities for the purpose of archaeological and cultural heritage documentation and preservation. This paper focuses on a subset of about 40 diploma thesis which were executed within archaeological and cultural heritage documentation projects outside Germany. Besides the location of the project area, another selection criterion was the overall importance of diploma work for the respective project. While conducting such work in close co-operation with students and professionals of other disciplines, surveying students gain valuable knowledge from those other fields. In such projects, students of all participating disciplines have the chance to augment their disciplinary knowledge with knowledge from other disciplines.

Keywords Higher Education, Surveying, Students work, Humanities

1. Introduction

Surveying as a discipline most often offers services to other natural or engineering sciences like architecture or mechanical engineering. However, a wide range of opportunities to establish fruitful co-operations is available in the humanities, too.

i3mainz , Institute for Spatial Information and Surveying Technology, has knowledge and experience in the fields of image processing, photogrammetry, remote sensing, surveying, 3D-visualization, internet applications development and software engineering. The institute is

Fig. 1: Recording of archaeological findings using tachaeometry

equipped with a wide range of devices for data recording and processing. Besides own software, it can rely on the leading software products for the above mentioned fields. Members of pi3mainzp have collected considerable experience with appropriate surveying methods ranging from simple hand surveys, tacheometry, satellite navigation systems up to aerial and close range photogrammetry, terrestrial and airborne scanners, remote sensing using satellite images in many cooperation projects with partners from the humanities. A large number of publications deal with surveying methods for archaeology and cultural heritage documentation ([1], [2], [3], [5], [8]).

The professors and scientific co-workers of the institute are involved in Surveying Higher Education, as well. In the last semester of their studies, students at the Department of Geoinformatics and Surveying usually prepare their diploma theses or their bachelor and master thesis, in the near future ([10]). Each diploma thesis is supervised by a member of the teaching staff. It must be finished within 6 months. About more than 10% of these theses on average are prepared outside Germany and some are written in English. A good overview of all the aspects of internationalization of education at the Department of Geoinformatics and Surveying in cooperation with i3mainz is given in [6].

Following the defined selection criteria, namely to present only projects from outside Germany, where students' work yielded an essential part of project deliverables, projects from the five countries China, Turkey, Yemen, Israel and Ukraine will be presented.

2. China since 1993

In Shaanxi province of People's Republic of China 18 Mausoleums of Tang Emperors covering up to more than 100 km* are located. Within an international research project at the Roman Germanic Central-Museum in Mainz, Germany, the tasks of geometric documentation of the sites and findings were performed at Mainz University of Applied Sciences. Documentation work started in 1993; besides the work of scientific collaborators up to now 10 diploma thesis with field work were executed. The measurement field work (see Figure 1) was carried out in close cooperation with archaeologists and additional local staff.

The area of the internal part of one single mausoleum covers more the 10 km*, which demands the application of modern techniques from geoinformatics and surveying. As the connection to the official reference system wasnot possible in the field, a local, user defined coordinate systems was established. Each complex is recorded in a rectangular coordinate system; the astronomical azimuth was measured for each of them. The single mausoleums are connected using total station and GPS measurements. At the precession ways more than life-sized sculptures of humans, animals and mythical creatures are present, at the corners the remains of towers are preserved.

Most important task for the documentation in the beginning of the project was the generation of topographic maps in various scales for the whole Mausoleums and special parts of them containing the positions of findings. Most of this work was done based on tacheometric measurements. Terrestrial photogrammetry was used for the

Fig. 2 and 3: Photogrammetric recording of a stone sculpture and line drawing of a mythical creature

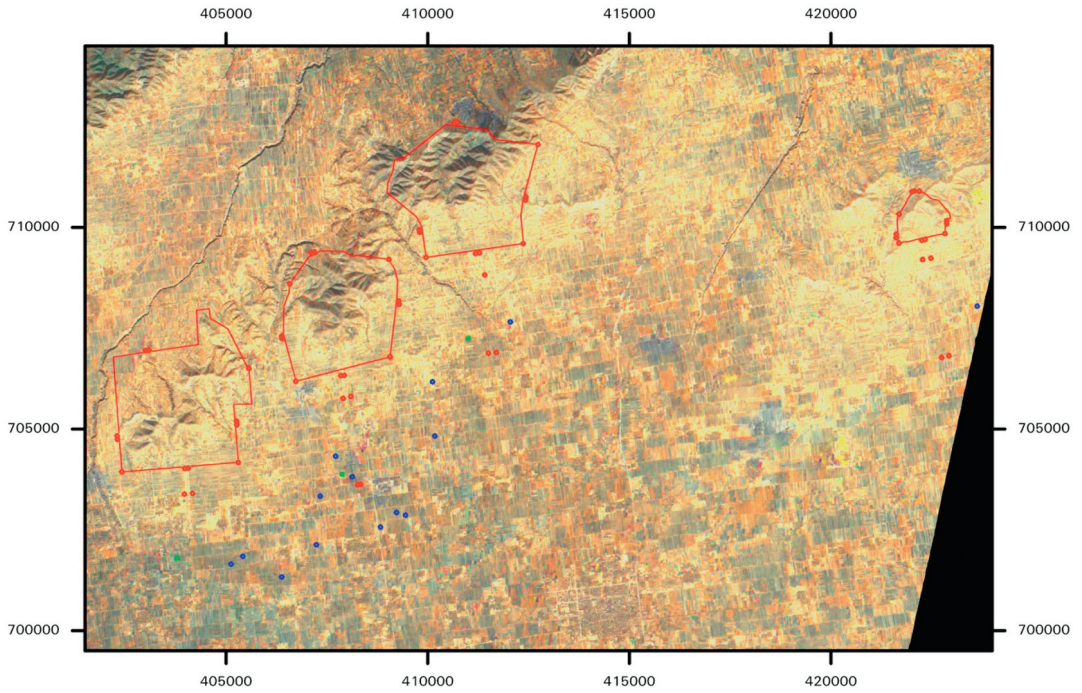

*Fig. 4: Image map with four mausoleums using satellite imagery (from [9]). Satellite images: * Space Imaging and CNES/Spot Image*

documentation of selected stone sculptures (see Figure 2 and Figure 3). All geometric data was processed in a CAD environment generating up to 40 maps in different scales from 1/5 up to 1/10.000 for each complex.

Due to the lack of aerial images to an increasing degree satellite images were used within the project. The usability of various systems with different geometric and radiometric resolution was evaluated. Landsat and SPOT data with 30 m respectively 10 m resolution was used especially for the generation of lower resolution elevation models and overview maps (see Figure 4). Over the years the geometric resolution of the available satellite image data increased enormously. With this imagery image maps and 3D-views could be generated in bigger scales. The information content of the plans was increased and the field work could be reduced with this new data source.

The interdisciplinary character of the project, the exotic environments in terms of area and features to record as well as the spectrum of techniques to use made this project interesting for the students and their diploma thesis.

3. Turkey since 1998

Documentation work in **Turkey**, Tavium, Central Anatolia started in 1998. Till now, 11 diploma thesis were executed there. Besides extensive large scale tacheometric surveys of the terrain surface animated 3D scenes of the landscape were generated from existing maps. An overall web presentation was developed to present the Tavium Research Project in much detail.

The ancient Galatian city of Tavium is located at the present-day village of Büyüknefes, 150 km east of Ankara, 20 km from the Hittite capital of Hattusha. The site being occupied from the 4th millennium BC had its flourishing phase during the Hittite period. In the 3rd century BC the Trocmii, a Celtic tribe from the Danube area occupied the site of Tavium ([15]). Since 1998 the area of the city has been surveyed by a team led by Karl Strobel of the University of Klagenfurt and supported by i3mainz, concentrating on the extensive Roman and Byzantine remains which are still available. Geophysical work has shown the citadel and lower city had a total extent of 150 hectares, pre-classical remains have been found at a number of places within the survey area ([16], [17], [18]).

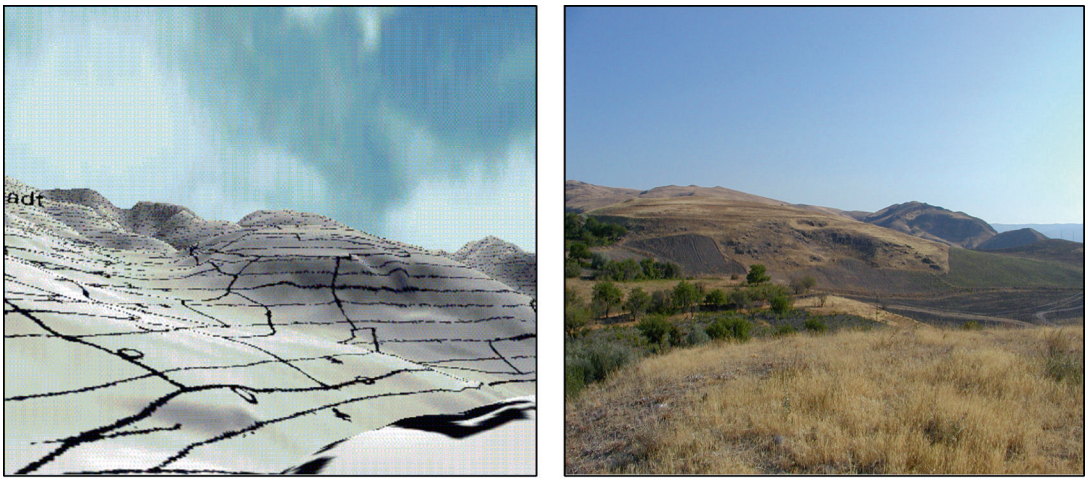

Fig. 5: Terrain representation generated from cadastral map and Digital Height Model (left) in comparison with the real life scenery (right).

Fig. 6: Web site of the Tavium Research Project.

i3mainz provides for the cartographic representation of the modern terrain surface at different scale. The produced digital spatial datasets are the geospatial base for the documentation of the location of archaeological findings. First field work was done in 1998. A spatial reference system had to be established, 1/500 large-scale documentation of wide areas was performed. Use of GPS technology yielded the base to introduce new methods and techniques into on site archaeological field survey. While 1/500 scale documentation concentrated on the core areas of archaeological interest, 1/5000 scale documentation of surroundings was achieved by using existing maps ([11]). Due to special properties of the analogue original map sheets considerable efforts were needed to convert the analogue maps into high-quality digital data sets. Once completed, many features of digital height model analysis like creation of perspective views of and virtual flights through the research area, calculation of cross sections could be used to support archaeologists' work substantially (see Figure 5).

To present the Tavium Research Project to the professional community as well as to the broad public an extensive project website was created (see Figure 6).

4. Yemen since 1998

In Yemen work started in 1998 with 13 diploma thesis since that time dealing with surveying and mapping of the antique City of Zhafar/Dhu Raydan, the ancient capital of the Himyarite Kingdom. Tacheometric acquisition of the terrain surface and of archaeological findings, generation of high quality digital height models, creation of digital orthophotos derived from satellite imagery, construction of animated 3D-scenes and reconstructions, pilot applications of geographic information systems were executed within diploma work.

Zafar lies some 130km south-south-west of the Yemenite capital, Sanaa in the mountain at 2800m altitude (see Figure 7). The ruined city Zafar, capital of the Himyar Empire (sovereignty 115 BCE – 525 CE) has a great historical meaning. Zafar was the capital of the tribal confederation known to the outside world as Himyar, which for some 250 years dominated the entire Arabian Peninsula politically and militarily. In the 6th century the 110 hectares large Zafar was one of the most important cities in the Near East.

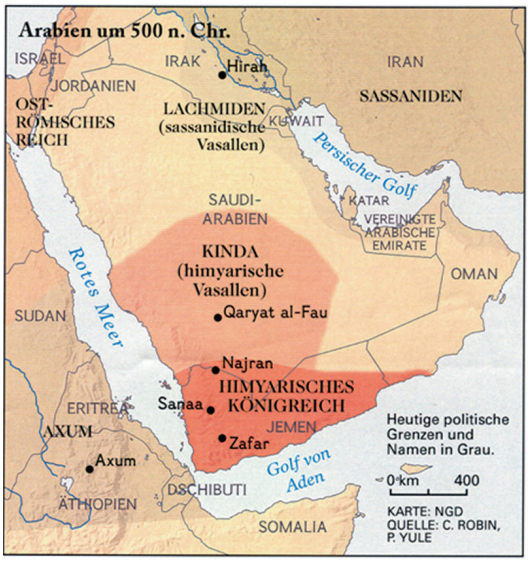

Fig. 7: Location of the ancient city Zafar.

Fig. 8: Workers at the excavation site.

In 1998, the Heidelberg University Expedition to Zafar, in the Yemenite Highlands, initiated a programme of excavation, mapping and training ([19], [20]). The mapping showed the ancient walled city with a core area comprising some 1000 x 1200 m. The core of Himyarite Zafar spreads over the southern and western slopes and the summit of the Husn Raydan, the fortified al-Gusr, and the present-day village. The ancient city extends eastward and southward outside the city walls. Till now some 1000 Himyarite inscriptions and relieves are being catalogued. They date predominantly to the 3rd – early 6th centuries. A late Himyarite cemetery on a mountain slope and a foundation at the southern foot of the Husn Raydan was excavated, the site museum was newly installed and all of the inscriptions were photographed. Other excavation started on the south-western flank of the Husn Raydan in what appears to be magazines; parts of a large limestone building came to light as well as a life-size king's sculpture (see Figure 8). Parts of the site were investigated by means of magnetometer survey.

As part of an interdisciplinary team i3mainz joined the field campaigns of the years 1998, 2000, 2002, 2003, 2005, 2006 und 2008. Documentation of the terrain surface and of archaeological findings was performed (see Figure 9 and Figure 10).

Fig. 9: Transport of measuring equipment.

Digital orthophotos, digital height models, virtual three-dimensional reconstructions were generated from satellite images (see Figure 11). A first prototype of a geoinformation system was developed.

5. Israel since 2004

Mainz University of Applied Sciences started its work in Israel in 2004 within the Kinneret Regional Project, a European expedition to the north-western shore of the Sea of Galilee in Israel (see Figure 12). The aim of the project is to explore the site of Tel Kinrot – ancient Kinneret – and its surroundings. The history of large excavations at this site started in 1982 after preliminary investigations ([13]). Despite several field campaigns of excavation only a fraction of the site is known so far. A detailed description of Kinneret Regional Project is given in [14] and in [12].

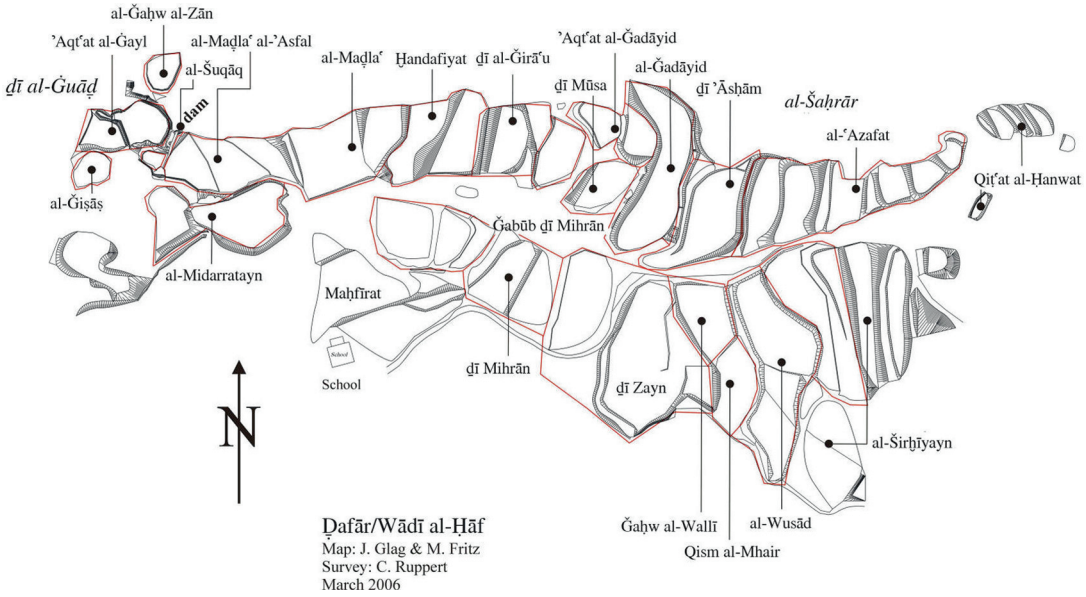

Fig. 10: True scale map of field names in Arabic language.

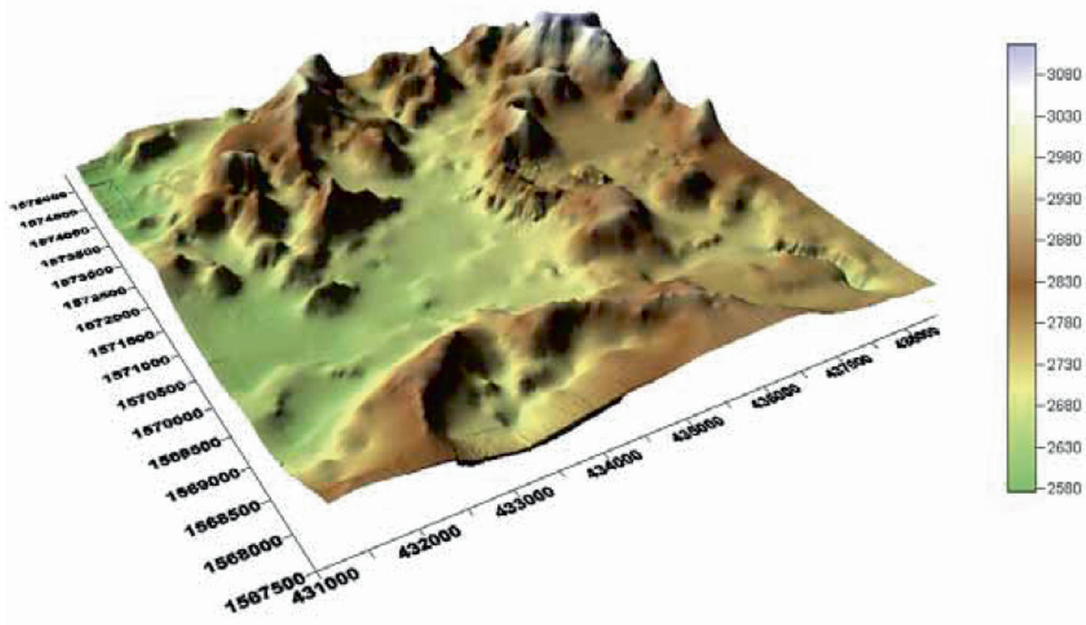

Fig. 11: 3D view of the surroundings of Zafar

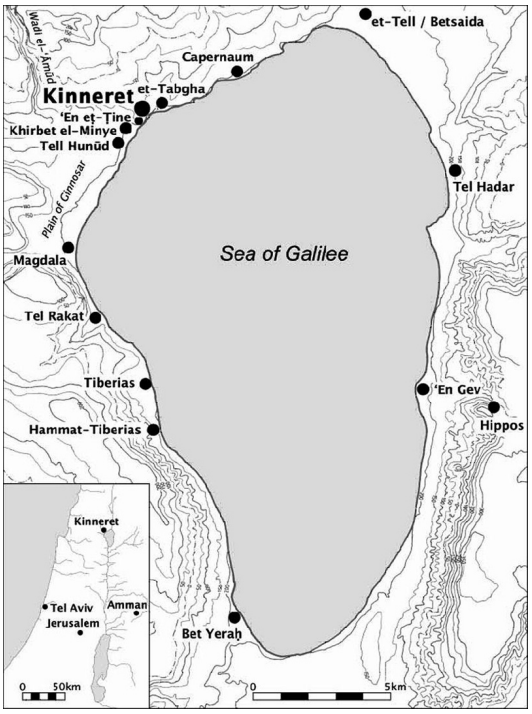

Fig. 12: Sea of Galilee with major sites (from [14]).

In the meantime 4 diploma thesis were completed in the context of this project. The goal of the first diploma thesis in 2004 was the establishment of a spatial reference system connected with the official Israel reference system. Thus, geo-referencing of local surveys made by the archaeologists in a common spatial context had become reality. In addition the site of Tel Kinrot with an expansion of 10.000 m* was completely re-surveyed using the latest surveying technology. This comprehensive survey resulted in a consistent spatial data base of the excavation site.

2005 two further diploma thesis started with a surveying campaign to complement and to expand the results of 2004. The collected data were the basis for a three dimensional precise geometric documentation of the excavation site in order to be able to derive 3D landscape models and longitudinal or cross profiles. The processing work took time until 2006.

Precise differential GPS was the clue to an acceleration of the work of the archaeologists in 2007. The fast and precise survey of findings and local excavation areas the archaeologists worked on antemeridian were processed noontime and offered to the archaeologists in the afternoon in their databases. This procedure led to an increased productivity because several of the former working steps could be omitted now.

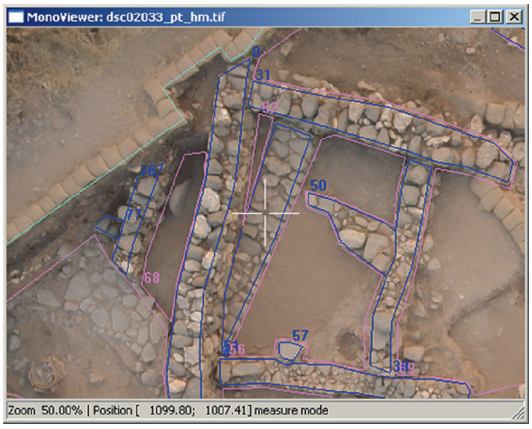

Fig. 13: DISTA with the representation of the coloured 3D objects with respect to the different thematic layers.

Another investigation for the development of an optimized work flow for both surveying and archaeological field work was done by using photogrammetric recordings. Aerial photos of the excavation site were taken by a consumer camera which was fixed to a small hot-air airship. Using DISTA (digital stereoscopic evaluation architecture ([4])) – a photogrammetric evaluation system used for the precise determination of 3D-coordinates from blocks of large metric images developed at i3mainz it was possible to build up stereo models and to register 3D objects described by points, lines, poly-lines and polygons. A thematic differentiation of the 3D object was done by the introduction of the layers “wall”, “floor” and “breakline” (see Figure 13).

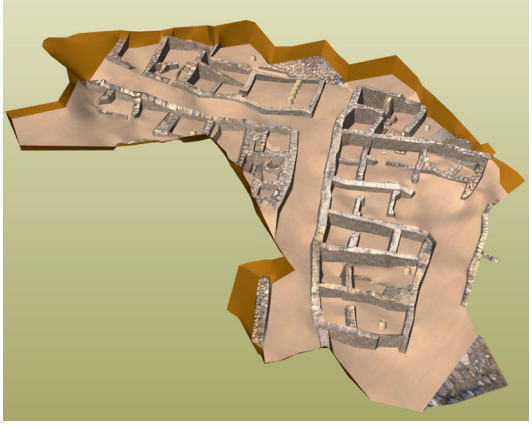

Fig. 14: Photo-realistic 3D model of the excavation site.

3D models of the excavation site using photo-realistic textures were derived based on these results (see Figure 14). An impressive visualization was generated by a walk and a flight through the virtual 3D model of the site.

In addition 3D archaeological objects like pillars, oven or door lintel were virtually reconstructed and implemented into the 3D scenes (see Figure 15).

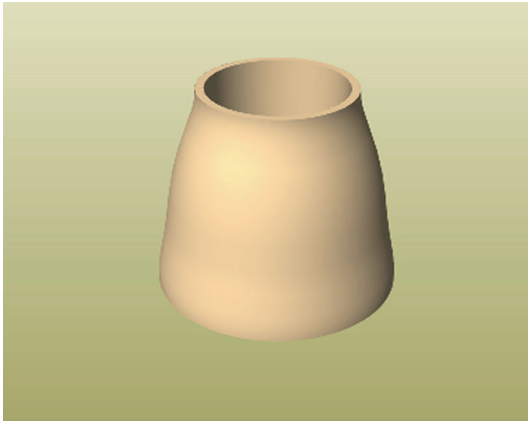

Fig. 15: Virtually reconstructed oven.

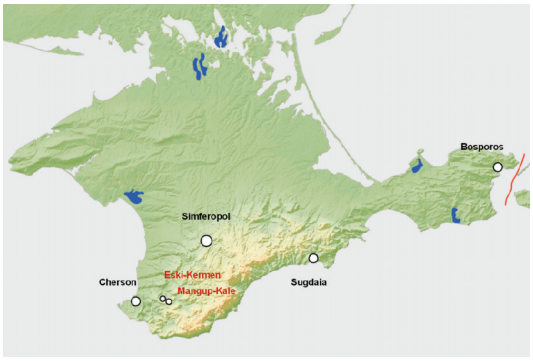

Fig. 16: Map of the Crimean peninsula with the two hill fortifications of Eski-Kermen and Mangup-Kale.

6. Ukraine since 2006

Starting from 2006 3D-documentation in archaeology is being applied in the Crimean highlands in Ukraine. The project is carried out within the cooperation of Mainz University of Applied Sciences with the Roman-Germanic Central Museum in Mainz. In the focus are two hill settlements, Eski-Kermen and Mangup-Kale (see Figure 16), with more than 600 artificial caves. Of main interest for the archaeologists in the project is the settlement-history which started in the 6th century AD.

Main tasks of the surveying work are the realization of a common reference system for all findings and the efficient use of methods for geometric documentation in archaeology. GPS, total station, close range photogrammetry and 3D-laserscanning are being used to meet the requirements.

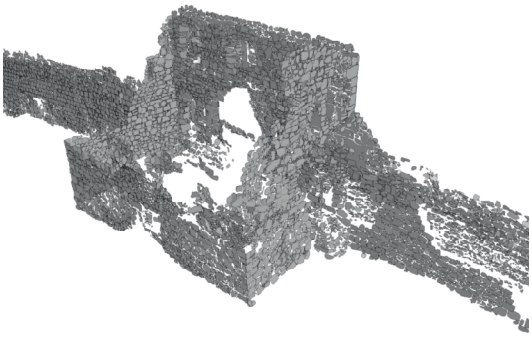

Fig. 17 and Fig. 18: Recording of the citadel and view of the 3D-model.

3 diploma thesis were completed so far within this project. Two of them deal with a comparative investigation and optimization of different measurement techniques for the documentation of antique constructions. For this purpose the ruin of a middle-aged citadel was recorded using analogue and digital close range photogrammetry and processed for each single stone in a 3D-CAD-model (see Figure 17 and 18). 3D-laserscanner data and an in-house solution for stereo imagery based on standard DSLR cameras were compared to this approach. Within another thesis, the 3D-recording of structures using reflectorless

total stations inside and outside artificial caves was optimized. The data is recorded using a simple point numbering system providing all information for the semi-automated generation of 3D-CAD data of the point and vector objects. Currently another thesis is prepared concentrating on the integration of old maps with the modern data and using old landscape marks in combination with the results of archaeological field surveys.

The spatial data is collected and processed in a common reference system as basis for a GIS-System. The GIS is used for storage, administration and analysis of all project data. The collection of attribute data is carried out in close cooperation with German and Ukrainian archaeologists. The data is used as well for generating maps in various scales, visualization and reconstruction tasks.

7. Conclusions and further work

Virtually all surveying students who decided to join an interdisciplinary team reported valuable experiences from their expeditions not to be missed, seen both from the personal and the professional view points. In that way, the well-established close link between institutional research and higher education at Mainz University of Applied Sciences proves to provide for a stable knowledge transfer base for different disciplines.

Special challenges exist in projects with partners from different professional cultures involved, like from different engineering sciences and, at the same time, from the humanities. Consequently, Mainz University of Applied Sciences, Department of Geoinformatics and Surveying, and Gutenberg University Mainz are cooperating to establish a new study programme in Archaeology (Master) with a special attention to spatial information and surveying technology and its application in archaeology ([7]).

References

[1] *Böhler, W., Heinz, G. (1997):* Recording and Visualizing Topography and Object Geometry for Archaeological Documentation. Archäologisches Korrespondenzblatt, 27, 1997, Heft 2, Verlag des Römisch-Germanischen Zentralmuseums Mainz, pp 355 – 373.

[2] *Böhler, W., Heinz, G., Scherer, Y., Siebold, M. (2001):* Topographic Information in Cultural and Natural Heritage Visualization and Animation. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XXXIV, Part 5/W1, pp. 56-61.

[3] *Böhler, W., Bordas Vicent, M., Heinz, G., Marbs, M., Müller, H. (2004):* High Quality Scanning and Modeling of Monuments and Artifacts. In: Proceedings of the FIG Working Week 2004, Athens, Greece, May 22-27, 2004, Workshop – Archaeological Surveys, WSA2 – Modelling and Visualization, paper number WSA2.2. . http://www.fig.net /pub/athens/wsa2/WSA2_2_Bohler_et_al.pdf.

[4] *Boochs, F., Müller, H., Neifer, M. (2001):* DISTA – a portable software solution for 3D-compilation of photogrammetric image blocks. In: Conference-Proceedings SPIE Digital Library Volume 4298 – Three-Dimensional Image Capture and Applications IV, San Jose, CA, USA. 24 January 2001.

[5] *Boochs, F., Heinz, G., Huxhagen, U., Müller, H. (2006):* Digital documentation of cultural heritage objects using hybrid recording techniques, In: EPOCH Publication The e-volution of Information Technology in Cultural Heritage, edited by M.Ioannides, D. Arnold, F. Niccolucci, K. Mania, 2006, pp 258-262.

[6] *Boochs, F., Klonowski, J. (2008):* i3mainz und die Internationalisierung in der Lehre, Schriftenreihe Informations- und Messtechnik, Band 7, Shaker Verlag, Aachen, 2008.

[7] *Bruhn, K.-C., Klonowski, J. (2008):* Master-Studiengang Archäologie – Einrichtung eines gemeinsamen Studiengangs der Johannes Gutenberg Universität Mainz und der Fachhochschule Mainz, Schriftenreihe Informations- und Messtechnik, Band 7, Shaker Verlag, Aachen, 2008

[8] *Boos, S., Hornung, S., Jung, P, Müller, H. (2008):* GIS based processing of multiple source prospection data in landscape archaeology. Proceedings of the 1st International Workshop on "Advances in Remote Sensing for Archaeology and Cultural Heritage Management",Rome 30 September – 4 October, 2008, S. 113 -117.

[9] *Gong Qiming, Koch, A. (2002):* Das Qiaoling. Harrassowitz-Verlag, Wiesbaden, ISBN 3-447-04575-2.

[10] *Klonowski, J., Müller, H. (2008):* Status and Perspectives of Geomatics Education at Mainz University of Applied Sciences. SICEHE '08 Symposium on International Cooperation Experiences in Higher Education, International Meeting for Networking and Partnership, 13th and 14th June 2008, Valencia, Spain, Conference Proceedings CD ROM, ISBN 978-84-691-3877-9.

[11] *Müller, H. (2003):* Spatial Information Technology for the Archaeological Research Area of the Ancient City Tavium, Central Anatolia. In: Proceedings of the XIXth International Symposium CIPA 2003 ‚New Perspectives To Save Cultural Heritage', Antalya (Turkey), 30 September – 04 October, 2003, Published by the CIPA 2003 organising committee. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXIV, Part 5/C15, pp. 719-724.

[12] *Münger, Stefan, Juha Pakkala, Jürgen Zangenberg, Wolfgang Zwickel:* Das ‚Kinneret Regional Project' – eine europäische Expedition an das Nordwestufer des Sees Gennesaret. Jerusalem: Gemeindebrief – Stiftungsjournal 4/07 (2007): 19-22.

[13] *Fritz, Volkmar, Kinneret und Ginnosar:* Voruntersuchung für eine Ausgrabung auf dem Tell el- 'Orēme am See Genezareth, Zeitschrift des Deutschen Palästina-Vereins 94 (1978) 32-45

[14] *Pakkala, Juha, Stefan Münger, and Jürgen Zangenberg. Kinneret Regional Project:* Tel Kinrot Excavations. Tel Kinrot – Tell el-'Oreme – Kinneret. Proceedings of the Finnish Institute in the Middle East. Vantaa, 2004.

[15] *Strobel, K. (2002):* State Formation by the Galatians of Asia Minor. Politico-Historical and Cultural Processes in Hellenistic Central Anatolia. Anatolica 28, 2002, 1-45.

[16] *Strobel, K., Gerber, C. (2000):* Tavium (Büyüknefes, Provinz Yozgat) – Ein regionales Zentrum Anatoliens. Bericht über den Stand der Forschungen nach den ersten drei Kampagnen (1997- 1999). Istanbuler Mitteilungen 50, 2000, 215-261.

[17] *Strobel, K., Gerber, C. (2003):* Tavium (Büyüknefes, Provinz Yozgat) – Bericht über die Kampagnen 2000-2002,. Istanbuler Mitteilungen 53, 2003, 131-195.

[18] *Strobel, K., Gerber, C. (2007):* Tavium (Büyüknefes, Provinz Yozgat) – Bericht über die Kampagnen 2003-2005. Istanbuler Mitteilungen 57, 2007, 547-621

[19] *Yule, P., Franke, K., Meyer, C., Nebe, W., Robin, C., Witzel, C. (2007):* Zafar, Capital of Himyar, Ibb Province, Yemen. Deutsches Archäologisches Institut Sanaa, Sonderdruck aus Archäologische Berichte aus dem Yemen, Band XI, 2007, Verlag Philipp von Zabern, Mainz am Rhein.

[20] *Yule, P., Galor, K. (2008):* Zafar, Watershed of Late Pre-Islamic Culture. http://archiv.ub.uni-heidelberg.de/propylaeumdok/volltexte/2008/134/pdf/Yule_Zafar2008.pdf

Contact

M.Eng. Guido Heinz, Prof. Dr.-Ing. Jörg Klonowski, Prof. Dr.-Ing. Hartmut Müller, Mainz University of Applied Sciences,
Lucy-Hillebrand-Strasse 2, D-55128 Mainz, GERMANY
Email: heinz@geoinform.fh-mainz.de,
klonowski@geoinform.fh-mainz.de,
mueller@geoinform.fh-mainz.de
Web site: http://www.i3mainz.fh-mainz.de