

Digital documentation and visualization of archaeological excavations and finds using 3D scanning technology

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Resumen

La medición es una acompañante imprescindible en cada yacimiento arqueológico. Tomar medidas sin tocar ó estropear el objeto medido, es una de las ventajas de una documentación tridimensional del lugar entero con la técnica de escaneo láser. La alta precisión y resolución de los sistemas modernos ofrece la posibilidad del registro tridimensional de la geometría con gran exactitud y la documentación de su textura con alta resolución. Comparativamente con los métodos tradicionales el escaneo permite medir al mismo tiempo mucho mas detalles de un objeto. Estos instrumentos de alta tecnología se utilizan normalmente para el control de formación de muros de presa ó para asegurar la calidad geométrico de la construcción de aviones ó motores. Y también supone un gran progreso en el futuro de la arqueología y en la protección del patrimonio cultural de la humanidad.

Palabras Clave: ARQUEOLOGÍA, PATRIMONIO CULTURAL DE LA HUMANIDAD, VISUALIZACIÓN, DOCUMENTACIÓN PARA INCREMENTAR EL VALOR, ESCANEEO LÁSER

Abstract

In 2007 the special research program HiMAT - History of Mining Activities in Tyrol and adjacent areas, focussing on environment and human societies, was established at the University of Innsbruck as an interdisciplinary and international research project, sponsored by the Austrian Science Fund (FWF). During late medieval and early modern times, the mining area of Schwaz in Tyrol became famous in Europe, due to the large scale exploitation of copper and silver bearing fables, going along with the development of high technologies in the field of mining and metallurgy. In that period, Schwaz was even called "the mother of all mines".

In the area of Schwaz/Bricklegg the main focus of our research project is on early traces of copper mining and metallurgy dating back to the late Bronze Age. Such traces are still preserved, especially in boundary areas of the main ore deposits. On the basis of previous surveys a little valley called "Maukental" was chosen for archaeological investigations, because within this small area the entire copper production process of the late Bronze Age can be studied in detail. During the past two years, the Institute of Archaeology and Surveying and the Geoinformation Unit of the University of Innsbruck worked together in this area. One object of interest was a late Bronze Age ore dressing site situated in a former peat-bog. In this place the advantageous environment preserved fragile wooden structures and artefacts which could be digitally documented in the condition of retrieval.

Key words: ARCHAEOLOGY, CULTURAL HERITAGE, VISUALIZATION, VALUE-ADDED DOCUMENTATION, LASER SCANNING

1. Introduction

Surveying is an important partner for every archaeological excavation. The advantage of a laser scanner is the three dimensional and comprehensive recording and the non destructive way of acquiring geometric data of sensitive and complex objects. The high resolution of modern equipment allows an accurate spatial documentation with a corresponding texturing. In comparison to conventional methods, the quantity of exact surveyed details could be increased at the same time. Normally the typical use for this hightech hardware is, for example, monitoring a barrage or for quality control of aircrafts and engine construction. Also for archaeology and cultural heritage various applications are possible.



Figure 1. During this year's field season a permanent surveying of an archaeological excavation was tested.

2. Data Acquisition

Laserscanning is another method of surveying. The advantage is the automatic, high speed measurement of a point grid with huge density. The used equipment mainly depends on the distance from the scanner to the object and the accuracy of the results. With a range from 2 to 200 meters the terrestrial Trimble Laserscanner GX is qualified for the three dimensional documentation of the excavations. The resolution for every excavation layer was selected between 3 and 5 mm. At an average distance of 5 m from the scanner to the object, the accuracy is approximately 3 mm.

The finds were digitized with a close up range scanner. The used Faro Laser Scanner is mounted on a Faro Scan Arm. While moving the scanner in 10 cm distance above the surface of the object, strips of 8cm width are measured. The flexible seven axis scan arm provides the exterior orientation of the Scanner. There is also no need to cover the surface of the object with reference points, which needs a lot of time and is not esteemed by archaeologist and conservation experts. The accuracy of the resulting point cloud is stated with 0.1 mm.

Additional images with a digital camera (Nikon D200 – 10 megapixels) allow an accurate texturing of the calculated models.

These methods could help to solve problems of archaeological scientists working in countries which forbid the export of artefacts. After the data acquisition the further modelling and analysis could be done at home under more comfortable circumstances.

3. Analysis of Archeological Excavation and Objects

In the frame of the Special Research Program HiMAT the main focus of archaeological investigations was on the prehistoric mining landscape “Maukental” near Brixlegg, Northern Tyrol, Austria. During the Middle European Late Bronze Age large scale ore exploitation took place in the whole region between Schwaz and Brixlegg. The aim of the project is to reconstruct the entire metallurgical process chain of the fahllore mineral and to prove the results by experimental archaeology. For that reason excavations were realized in an underground mine and at an ore smelting facility.

But the most impressive result was the discovery of well-preserved wooden structures of an ore processing plant situated in a former peat-bog. On this site the material of a nearby mine was crushed to separate the copper bearing ore from the waste rock. In a second step the leftovers were ground up to sand like consistence and put to a washing process. The aim was to produce an ore mineral concentrate suitable form smelting. The prehistoric miners collected the natural runlets of the bog in a propped ditch and used the water in combination with a wooden trough to divide the light and worthless mineral fraction from the heavy ore, accumulating at the bottom (Figure 3).

In connection with the use of the trough mentioned above a wooden artefact in the form of a knife was also recovered from Late Bronze Age layers. This tool was most likely used to remove the light mineral fraction from the trough (Figure 2).

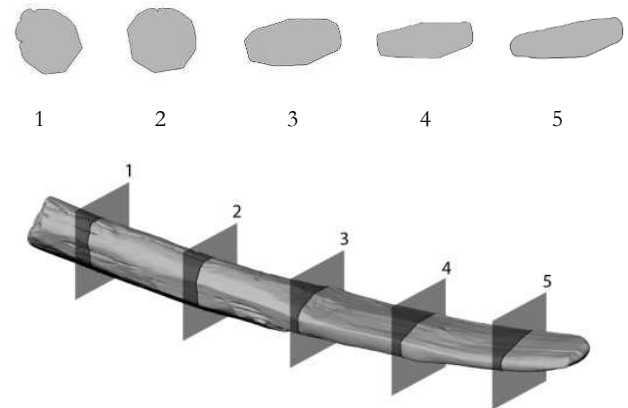


Figure 2. 3D-plot of the wooden „knife“ with cross sections showing the carved form of the tool: octangular profiles across the handle (1+2), transition profile between handle and “blade” (3), flat hexangular profiles of the “blade” (4+5) with rounded down traces of use (5).

In connection with the ore dressing plant within the peat bog several hammer stones were found during the excavation. The most noticeable attribute of hammer stones are intentionally picked notches or grooves, needed for attaching a wooden handle (Figure 5). The size of the boulders varies, between a few hundred grams up to 10 kg. These tools were used in underground mining as well as on this particular site for crushing.

4. Modeling

A known problem is the further calculation of the huge amount of data. The processing power of the so far available computers was not enough for modelling in highest quality. Through the continuous development and upgrade of the hard and software it is now possible to increase the processable data. The outcomes are many interesting applications for several fields. Due to accurate three dimensional surveying the objective documentation of archaeological excavations and finds could be relieved. Its most advantages are the following processing. Measuring millions of points, accurate to a millimetre, it is feasible to calculate a precise three dimensional model. For the following analysis by experts, the information content could be increased by using high-resolution images for texturing.

5. Data Preparation

Because of the protracted conservation procedures many finds are not available for an indefinite period of time. The analysis of geometry and texture with digital models can be done in two different ways.

Using a 3d-plotter or a milling-machine, copies can be produced in different scales. With these replicas it is possible to use known methods of analysis or reconstruction. The copies can also be used as exhibits, museum and teaching purposes.

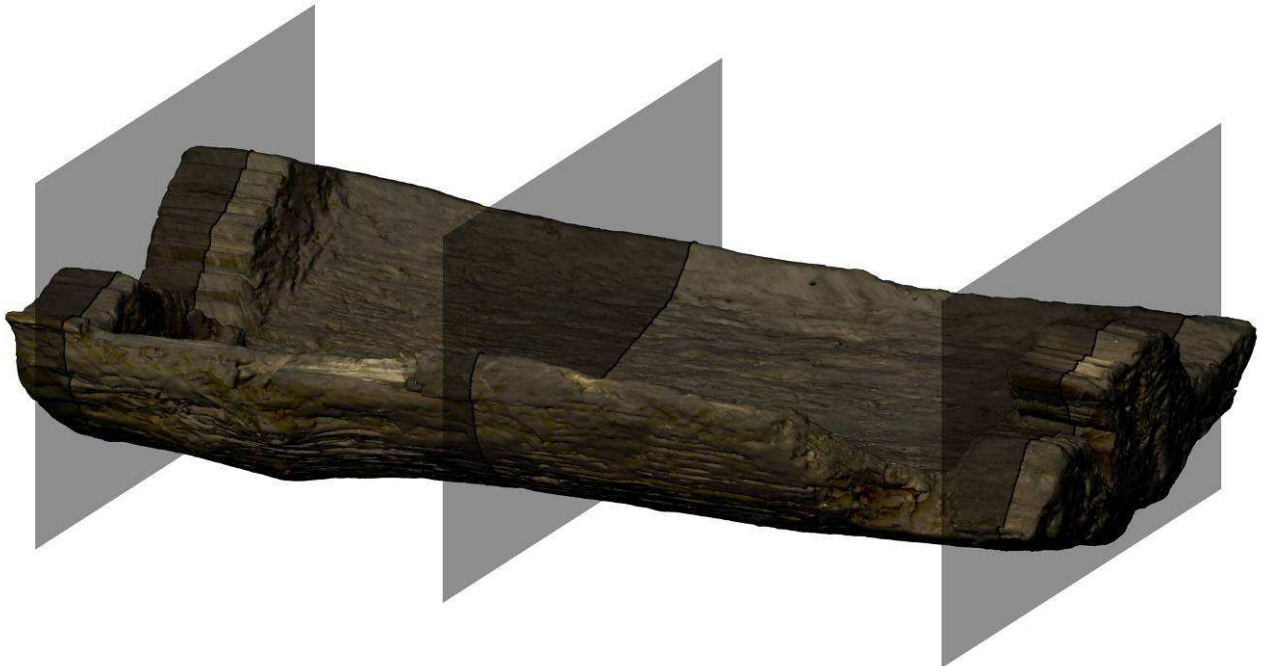


Figure 3. High-resolution 3D model of a 3000 year's old (Middle European Bronze Age) wooden washing trough, approximately 80 cm long.



Figure 4. Spatial documentation with several excavation layers.

The second method is a pure digital one. With a spatial model there are more and easier kinds of analysis available. Without an effort every view is feasible, a huge advantage, if the finds and places are no longer accessible. For the understanding of complex forms it is very helpful to construct sectional drawings (Figure 2) and counter lines for respectively developed views of the surface.

Maybe not all external forms are visible. They can be hidden by a texture or are just too small for human eyes. With a monochrome view, a slowly changing illumination or an enlarged view of hidden structures can be studied (Figure 3).

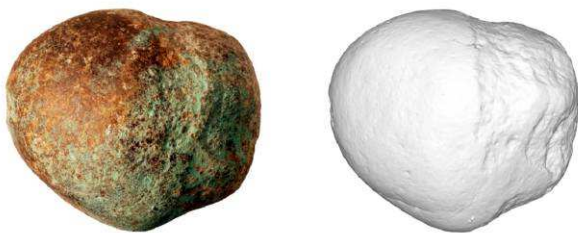


Figure 5. *photo documentation vs. 3D model.*

In addition to the analysis of the surface and texture, also the volume and volumetric weight can be determined.

A further benefit is to superimpose different development steps and data types. Due to the possibility to include all spatial information into the digital model, a combined analysis is very easy. By the three dimensional documentation of the excavations all different layers and ages could be combined to a total model. A reconstruction of the position of the digitized finds is also possible (Figure 4).

A digital reconstruction of objects shows more advantages compared to analogue methods. For a replica it is not necessary to produce a mould from the original find. By the assembling of sculptures and pottery fragments, all different versions can be non-destructive simulated with the computer. Dimension and weight is irrelevant for the work. The digital model is changeable anytime during its reconstruction and visualisation.

The last step is the visualisation of the spatial models. To increase the public interest it is possible to generate an easy interpreted graphic image of all the various results of research. Also the data and findings of the different levels of development are available on the internet for a favoured audience.

6. Conclusion

Due to the framework of the special research program HiMAT (History of Mining Activities in Tyrol) of the University of Innsbruck an intensive teamwork of the engaged archaeologists and surveyors evolved. The invaluable finds and interesting excavations of the late Bronze Age ore dressing installation have been digitized with different scanners with a dense resolution and a high accuracy. The produced 3D- models for example a hammer-stone, a wooden knife and washing trough were an important basis for the following analysis. With the new

technologies an area wide measurement is possible with less effort compared to the analogue methods.

The already mentioned methods and analysis due to assignment of 3D- models show essential advantages:

- Any rendering, drawing of cross sections and the determination of volumes and volumetric weights.
- During the conservation some finds are not accessible for investigations for several months. Through a second scan after the preservation the changes in geometry can be pointed out.
- Due to the high resolution of the spatial models and varied render techniques even surface structures became observable, which are not visible for the naked eye.
- All the data and findings could be available on the internet for a favoured audience. This is also important for countries with rigid export rules to transfer examination work to home.

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