CONTRIBUTION OF LASER SCANNING, PHOTOGRAMMETRY AND GIS TO AN INTERDISCIPLINARY SPECIAL RESEARCH PROGRAM ON THE HISTORY OF MINING ACTIVITIES (SFB HIMAT)

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ABSTRACT:

Mining plays a very important role in the history of man. From the very beginning man's development has been accompanied by the extraction, processing and utilization of mineral substances. In the past, mining often exerted influence on economic, social, legal and cultural structures within society. The technological aspect must be emphasized as well, for the technical achievements in mining and metallurgy in combination with a far-reaching technology transfer were always an innovative and driving force - a motor of progress that has decisively influenced and furthered the development of a modem industrial society.
The mining boom of the 15th/16th century in the Tyrol repeated a sequence which had already occurred with similar intensity and far-reaching consequences many centuries before. During the Bronze Age, between 2200 and 800 B.C., dynamic changes took place in the fields of mining and metallurgy in connection with alpine copper ore exploitation driven by the eager demand for crude copper on the newly established European metal market for bronze production. The all-time peak of copper mining was achieved with the formation of "early industrial" production structures in the Middle and Late Bronze Age. Alongside numerous further mining centers in the eastern and southern Alps the Tyrolean region still played a significant role.
The existence of excellent preliminary studies of the historic mining activities in Schwaz conducted at the University of Innsbruck presents ideal prerequisites for researching the above-mentioned epochs from the Neolithic to the early Mediaeval Times, from which hardly anything is known.
This article describes the cooperation of different scientific fields on this item and especially the role of surveying and geoinformation to integrate and support all these groups in their work to achieve that focused goal.

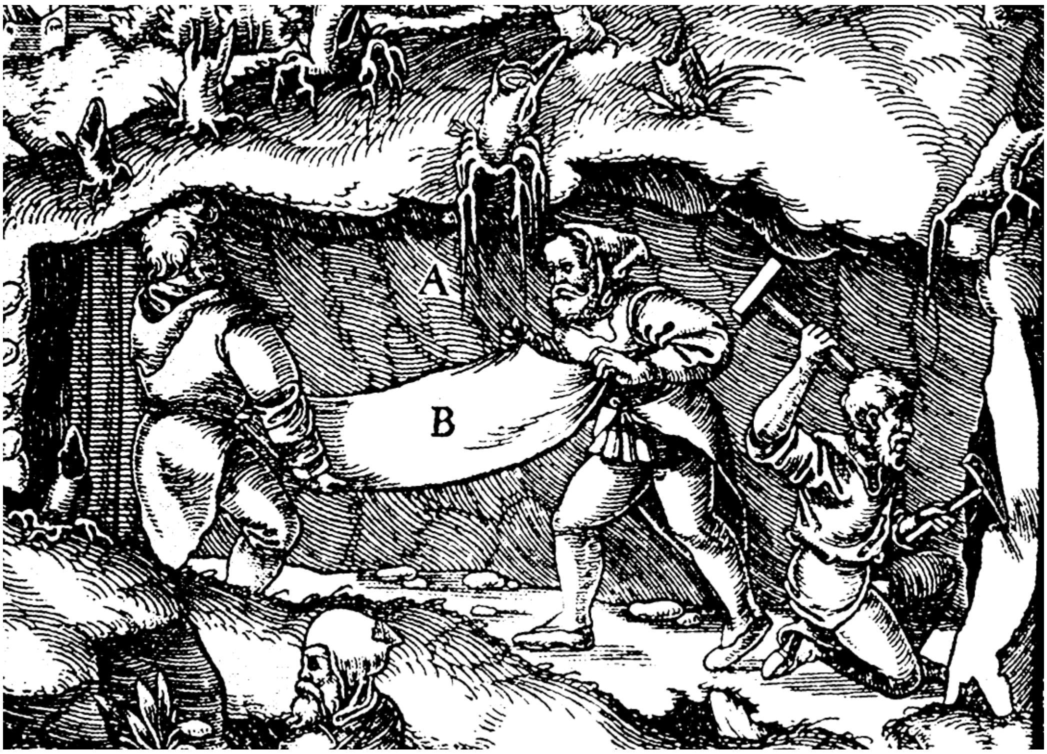

Fig.1: Miners during work (detail from Georgius Agricola's book "*De re metallica libri XII*", Basel, 1556)

1. INTRODUCTION

The introduction of metallurgy into prehistoric Europe led to substantial changes in human culture and in the environment. In this context supra-regional producer landscapes for ores (e.g. copper) developed in the Eastern Alps in the 2nd and the early 1st millennium BC respectively. Thereby mining shows conformity in many technological aspects which exceeds single domains and reveals an area of communication and economy, which co-operates in a manner of its own, e. g. logistic concepts, exchange of experts. The long-lasting development of settlement in connection with mining let also assume the generation of similar subsistence strategies. These aspects can be studied in various mining districts in a variable way because of different primary data discriminated by different states of preservation.
A crucial factor constitutes the variability of ores, which – expressed in a simplified way – resulted in resource networks using fahlores and chalcopyrite alternately. Based on existing provenience studies different chronological focuses are discernible which are caused much more in internal designs and developments of single mining districts than in the preference of the variety of metals.
The socio-economic and environmental reasons for the rise and fall of mining districts as well as its surroundings are manifold. Up to now none of the existing scenarios is validated by archaeological data, thus it is the objective of this special research program ***Hi**story of **M**ining **A**ctivities in the **T**yrol and Adjacent Areas - Impact on Environment and Human Societies (SFB HiMAT)* to evaluate and analyse these facts.
The development of mining as seen in a long term perspective is characterized by phases of expansion, consolidation and regression. This pattern is described and analysed in a mutual network by archaeologists, archaeometallurgists, archaeozoologists, dendrologists, ethnologists, historians, linguists, mineralogists and palaeoecologists in the course of concerted actions.
The research strategy envisages i) time-vertical studies dealing with changes in a long-term perspective as well as ii) time-horizontal studies dealing with selected periods of special importance for changes in society and landscape. Both study types are conducted in specific key areas in the course of a multi-disciplinary networking of researchers in mining of the University of Innsbruck and international experts in the field from the Universities of Basel, Frankfurt and Tübingen as well as the Deutschen Bergbau-Museum in Bochum.
This integral project is focused in Schwaz/Kitzbühel (Tyrol) connecting all project parts by mutual networking. Concrete interfaces are: to study the archaeology and palaeoecology of mining, the development of mining areas, compilation of technological standards, archaeo-metallurgical and provenience analyses. The mutual networking of the disciplines enables to evaluate the socio-economic and environmental constraints promoting the development of mining areas and mining landscapes. Additionally the design of a historical analogue for mining in multidisciplinary collaboration and mutual calibration with archaeologists, historians, linguists and palaeoecologists allows a better understanding of prehistoric mining and creating new methods to provide evidence for mining activities applicable in areas where archaeology of mining is unknown so far (Oeggl, 2006).
The Austrian Science Fund (FWF) decided to support this concept with a sum of over 3 Mio Euros for the first 4 years and after evaluations the program can continue up to an overall duration of 10 years. 70 scientists at the University of Innsbruck are now able to work together on these topics and 40 young scientists and PhD students can be additionally employed and educated in the various fields.

2. ROLE OF SURVEYING AND GEOINFORMATION

Surveying and GIS have definitely to accompany the entire process of acquisition of both thematic as well as geometrical data throughout the whole duration of this special research program HiMAT.
The integration of such diverse sciences as archaeology, dendrochronology, botany, zoology, ethnology, onomastics (e.g. family names and topographic names), medieval history, metallurgy and geology requires cartographic and GIS based support for their interaction and subsequent data fusion.

2.1 Archaeological prospection

Before the excavation starts, surveying of the topography of the genuine surface will be necessary. The archaeological applications of airborne laser scanning (LIDAR) so far showed that it is extremely useful to detect archaeological sites showing in relief.
Various authors demonstrate that using LIDAR helped to depict micro-topographic details in shaded relief, which are hardly detectable and not comprehensible when surveying terrestrially. Recent publications examined the possibility to survey sites in relief even under dense vegetation.

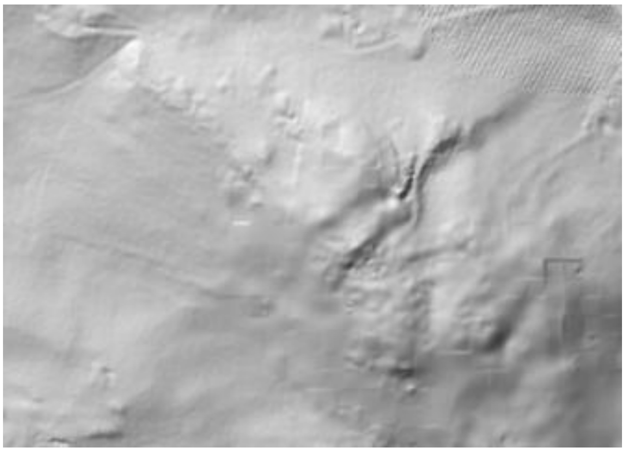

Fig.2: Detail of fig. 4 (LIDAR shaded DTM Vorarlberg)
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The latest generation of full-waveform recording airborne LIDAR scanners seem to be extremely useful to detect previously unknown sites (Doneus, Briese 2006).
As the provinces of Tyrol and Vorarlberg both decided to have area-wide LIDAR-based DTM and DSM for their own various governmental applications, these data have been made available by these authorities to our project too.
So we are in the very good position to use these area-wide 3D data for prospection purposes within SFB HiMAT to hopefully detect new mining related archaeological sites.

2.2 Documentation

Following the excavation progress, the area will be measured in layers, thus delivering the detailed surface referring to the different excavation epochs. Surveying methods are well known and proofed in context with archaeological excavations. The new (terrestrial) laser scanner technologies (TLS) widen the use and usefulness of this task. One of the direct advantages of laser scanning is that it can be applied in almost any archaeological environment where 3D recording is desirable due to the complexity or large size of the feature. Geodetic data from tacheometry, photogrammetry and laser scanning must be combined and edited in order to be able to yield results, being indispensable for further processing. This guarantees that the process of archaeological excavation is permanently and objectively documented.

It is obvious that three-dimensional models of the excavation and a three-dimensional assembling of the results of different surveying-periods (excavation-layers) make interpretation much easier (Schaich 2002).

The finds will be three-dimensionally registered online in the reference-system documenting the horizontal situation as well as the relation to the vertical, an epoch-connected layer-structure. The laser scanning technique enables comprehensive and reliable 3D records of existing conditions that describe a feature exactly as it was at the time of surveying and thereby ensure optimal and objective preservation of evidence.

The technique is well suited to the fields of archaeology and heritage where complex, amorphous objects often must be recorded. Otherwise surveying under these circumstances can be extremely difficult.

Although large and complex areas can be recorded in a very short time using this procedure, it should be noted that the post-processing of the resulting data takes much longer than the duration of the surveying process itself. (Doneus et al, 2003, 2005, 2006).

2.3 Geodata

For many purposes in the context of multidisciplinary work - as it is in SFB HiMAT - geodata are necessary in different kind, resolution, scale and accuracy.

Maps, orthophotos, DTM, DSM and plans of different sources have to be made available for all involved groups and applications (see Fig 3, 4 and 5). Sometimes these data are needed only as background of thematic mapping but also very often as tools for discussion and planning or even to locate a common point in situ.

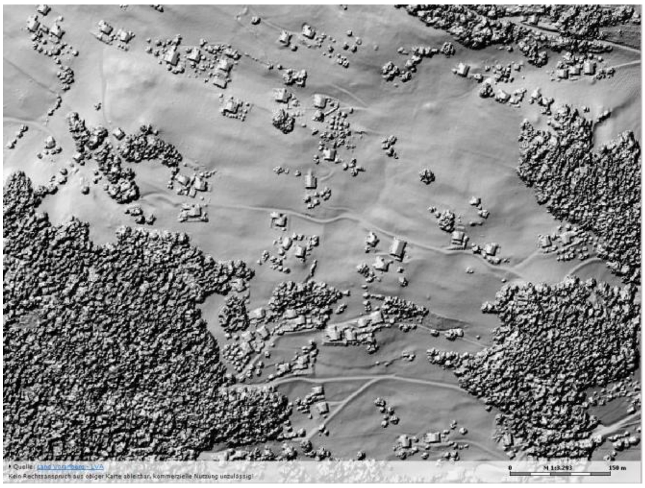

Fig.3: Digital surface model (DSM) from 1m LIDAR data
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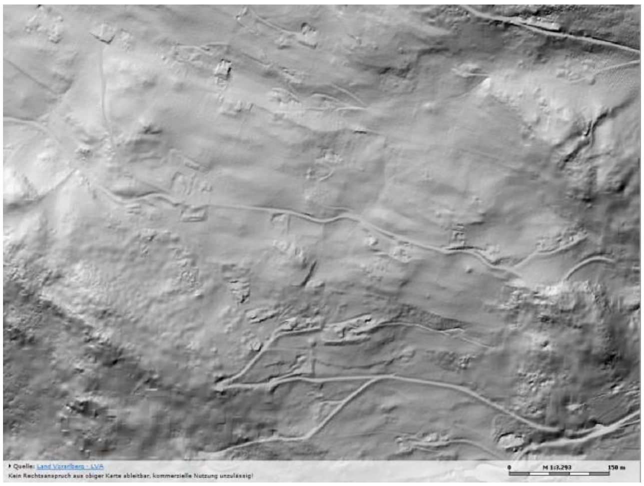

Fig.4: Digital terrain model (DTM) from 1m LIDAR data
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Fig.5: Orthophoto, 0.25m resolution with cadastral map overlay
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Once more the governmental authorities and local colleagues support us in a generous way and provide us with their whole capacity of available map work and geodata for our scientific group. This support also includes LIDAR data (DSM and DTM) in a very high resolution of 1 up to 6 points per square meter.

2.4 Other surveying tasks

Tasks independent from excavation are topographic surveying of deposits, dumps and the wider surroundings of excavation fields. Surveying of historical tunnels aims at the documentation of the geometry (e.g. profiles) of the tunnels, caves and domes as well as the documentation of tunnel-devices (struts, water-wheels etc.).

Fig 6: Georeferencing local measurements by GPS

Georeferencing and embedding of local archaeological measurements into the geodetic reference frame, georeferencing and cartographic adjustment of historical maps (sometimes even of medieval perspectives and sketches) were other demanding tasks for our group.

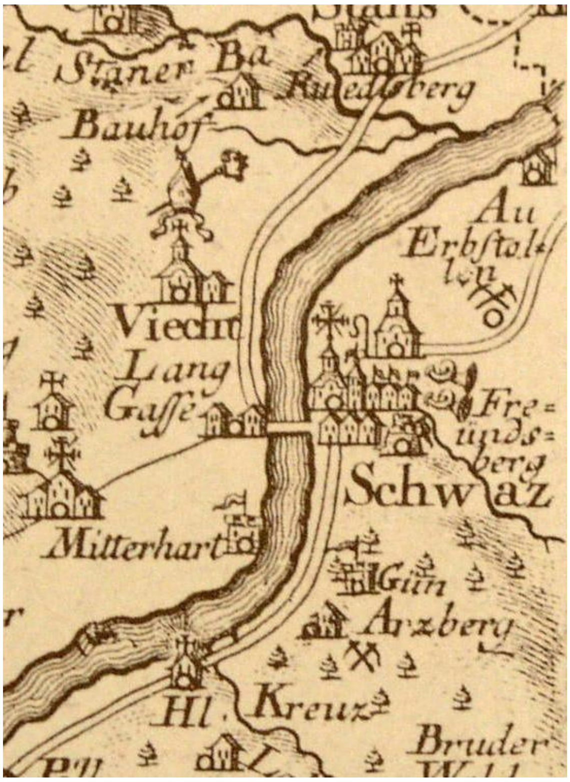

Fig.7: Historic map (Peter Anich’s Atlas Tyrolensis from 1774) showing the mining area of Schwaz, Tyrol, Austria, original scale 1:103.800

2.5 Database and Geoinformationsystems

All data resulting from the above mentioned measuring works are to be prepared as input to a geoinformation system (GIS).
Assembling such a GIS is necessary to store and administrate all resulting (georeferenced) data. From recording to editing, analysis and presentation of data the system should offer all wanted functionality to all participating groups. Geoinformationsystems are “state of the art“ for administration of large datasets with spatial reference. Off-shelf systems have been already used successfully for certain well-defined fields like communal (local) information systems, channel information systems and line-IS for several years.
When requirements to a GIS come from such different directions as in the SFB HiMAT, this will necessarily lead to a development of tools specialized to fulfil the specific task. Scientific work is done in this field worldwide but always only aligned to a certain well-defined purpose.
So one of the first tasks was to set up a kind of Thesaurus to guarantee a homogeneity of words, descriptions and use of descriptives as it showed very soon that all of our colleagues use different wordings for similar and equal facts and homogenisation of this items was a “conditio sine qua non”, a substantial requirement, for further data processing and data fusion. A common data base would never succeed without a common language. So all colleagues from all different fields such as humanities, natural sciences and technical sciences will work on this problem, which – in all consequences - has not been obvious to all groups before.
The consequent storing of all produced data in connection with metadata describing the data content, was another consequence of this broad cooperation. Items that were absolutely clear inside a group proved to be totally misunderstanding for even close related sciences. So even between the 4 archaeological groups this harmonisation was indispensable.
In cooperation with Bundesdenkmalamt Tirol (Bodenarchivar) and the Institute of Archaeologies several documentations of finds and excavations have been made and its possibilities for archiving and graphical presentation have been tested and realized during the last years (e.g. Hanke 2000).
Data fusion und complex analyses will nevertheless be the target of all these efforts. On the other hand simple viewers at the system’s lower end do not support complex analysis, but they are optimal suited for representing complex facts. At the end of the SFB a fully integrated “HiMAT-GIS” could be available, which would be able to provide georeferenced and linked access to all data of all groups for the future.

3. CONCLUSION

The contribution of surveying, photogrammetry and GIS to such an interdisciplinary research program is a really challenging task and requires the whole palette of skills and tools available in this profession. The forthcoming of the entire project can be followed up at the HiMAT website: http://himat.uibk.ac.at/

ACKNOWLEDGEMENT

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