Using of Old Maps within Landscape Changes Analysis

Assoc. Prof. Jiri Cajthaml*, Dr. Jan Pacina**

* Czech Technical University in Prague, Faculty of Civil Engineering
** Jan Evangelista Purkyne University in Usti nad Labem, Faculty of Environment

Abstract. Landscape changes are one of the most interesting outputs of old maps analysis. Especially, at the places, where human impact on the landscape is quite big, this kind of analysis can help us understand what is changing in our environment and how. North Bohemia, region in the Czech Republic, is known for its massive exploitation of the landscape. The most evident human impact can be found as brown coal basin. Supplementary industry connected facilities also covers large areas (power plants, factories, water dams). As North Bohemia is border region, it suffered not only from human industrial activities. During 1945 and 1989, the border area was depopulated, because of German inhabitants' expulsion after World War II and military border zone creation (iron curtain). Some villages disappeared and there are only a few evidences in terrain to identify them. On the other hand, last 20 years, there can be seen activities leading to landscape restoration. Some places are afforested; some open pit mines are flooded to become recreation areas. All these changes can be observed using old maps.

In cooperation of Czech Technical University in Prague, Faculty of Civil Engineering and Jan Evangelista Purkyne University in Usti nad Labem, Faculty of Environment the project focused on landscape reconstruction and creation of database of vanished municipalities in the Usti region has been established. The project is funded by Ministry of Culture of the Czech Republic in the Applied Research and Development of National and Cultural Identity Program.

Besides other technologies (aerial photogrammetry, chronicles, historical photographs, and remotely piloted aircraft systems) old maps are used as the main source of information. In the area of central Europe there exist several maps covering area of former Habsburg Empire. Middle-scale maps are represented by First Military Mapping Survey (1763-1785), Second Mili-

tary Mapping Survey (1807-1869), and Third Military Mapping Survey (1870-1885). In detail large-scale cadastral maps can be used – stable cadastre (from 1817). After creation of Czechoslovakia in 1918 older maps were used until new mapping in middle-scale (1953-1957) was completed. From this time middle-scale maps are updated in a period of maximum 10 years. Cadastral maps can be used in detail as well. From 1950's there appears The State map at 1 : 5000, very suitable for landscape changes analysis. Contrary to cadastral maps it contains contour lines and thus terrain analyses can be performed.

Our aim in the project is to georeference as many described maps as possible, create digital vector data model and perform analyses of landscape changes. Georeferencing methods are quite different for any of mentioned mappings. This paper is focused on georeferencing methods of maps used in our project. Second aim of the paper is to show how landscape changes can be analyzed, either in 2D (land use changes) or in 3D (terrain changes). Our results can be presented as classic paper maps, but most efficient way is to publish them as web mapping application, where user can work with individual layers and time axis. 3D changes can be visualized also as real physical models printed on 3D printer.

Keywords: old maps, georeferencing, landscape changes

1. Introduction

Usti region as a part of North Bohemia is of the most human-affected areas in the Czech Republic. During last 200 years landscape has changed a lot there. These changes, including industry boom in the mid-19th century, coal mining through 20th century, water dams' creation, German inhabitants' expulsion after World War II and later military border zone creation, are quite well depicted on the old maps. The aim of the project is to collect, digitize and analyze these maps to visualize landscape changes in the area.

The whole process of using old maps can be divided into several phases. At first, maps have to be digitized, then suitable maps are georeferenced into reference coordinate system, selected map features are vectorized, and these data are analyzed. Digitizing of old maps in well-known and deeply described process (Krejci 2009). Other phases are usually based on the work in geographic information systems. The most important part influencing quality of results is the process of georeferencing (Cajthaml 2012).

2. Georeferencing of old maps

2.1. Maps with unknown cartographic projection

If early maps are used for landscape changes detection we usually don't know original cartographic projection of the map. It means that we don't know coordinates of map sheets corners. In our project we followed procedure described in detail by (Cajthaml 2011). As we have middle-scale map series consisting of many map sheets, we had to solve creation of seamless map. In this case, we used 39 map sheets of First Military Mapping Survey in the scale 1:28,800. After overall adjustment we got standard error in position of about 500 meters. It is quite big value in comparison with other newer sources, but we see, that information on these maps are very interesting and cannot be found anywhere else.

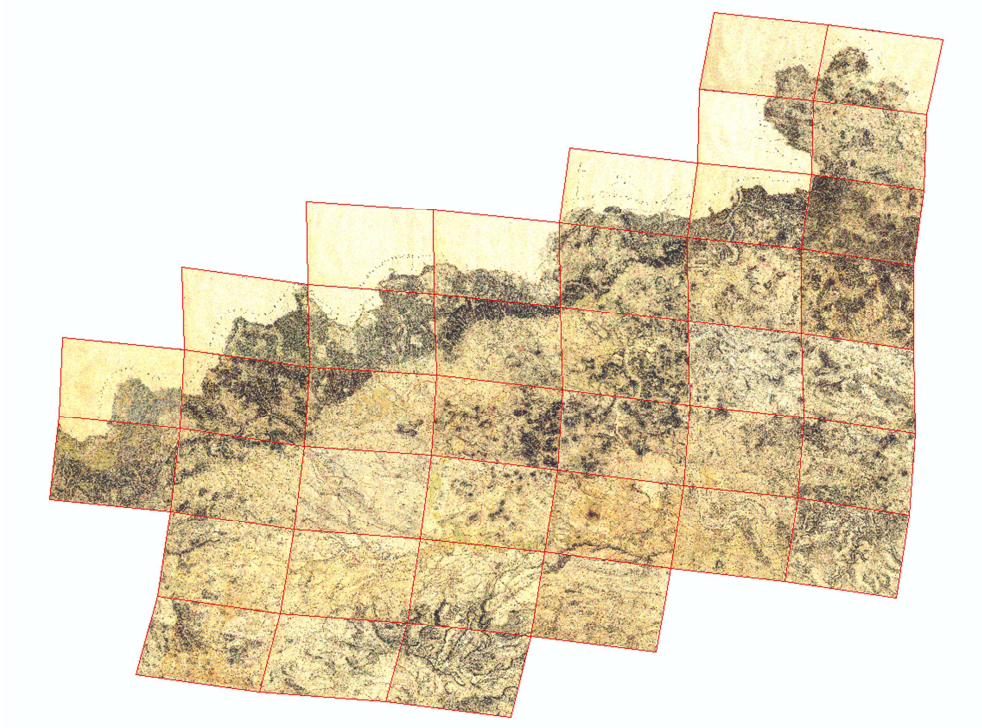

Figure 1. Seamless map of First Military Mapping Survey for studied area in Usti region; standard error of position about 500 meters

2.2. Maps with known map sheets layout

All other maps used within our project have well described cartographic projection and map sheets layout. Unfortunately, there cannot be used the same georeferencing method for all of them.

The most detailed old maps, which we worked with, were undoubtedly Imperial Imprints of the stable cadastre. These maps created in the scale 1:2,880 are colored copies of original cadastral maps. As these maps don't follow cadastral map sheets layout for all maps, it is not possible to use only corners of maps to georeference them. We were collecting sets of ground control points and transforming these maps separately into current national reference coordinate system. Affine transformation and/or 2nd order polynomials were the first choice of used method. Standard error in position of these maps is about 2-3 meters, what is an extraordinary precision.

For middle-scale maps (Second and Third Military Mapping Survey) coordinates of corner points were used and every map sheet has been transformed using projective (non-residual) transformation. Standard errors of these maps vary about 20-30 meters (Zimova, Pestak & Veverka 2006). The same method we used for georeferencing of The State map at 1:5000 created after World War II. This map was derived from cadastral maps and its precision is about 5m.

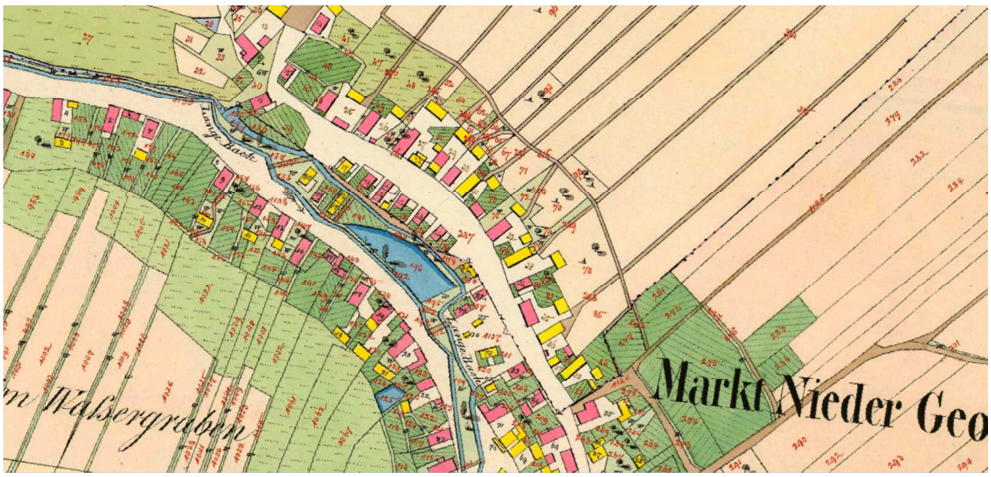

Figure 2. Example of georeferenced Imperial Imprint of the stable cadastre; standard error in position about 2 meters

3. Vector data

For analysis of landscape changes either depicted on a map or described by values of area changes it is necessary to have vector data. In the best case, the whole content of the map is vectorized into prepared data model. Then, having these data model from different time periods analysis of changes can be performed.

It is very time consuming to create full vector data model of the map (Cajthaml 2010). Usually, only selected features are turned into vector data. In our project we vectorized selected areas of villages to see how landscape has changed through years.

Figure 3. Example of vector data model of land use after analysis of changes; the layer shows changed areas with detailed information in attribute table

Besides vectorizing of planimetric part of maps, very interesting is to vectorize its hypsographic part, especially contour lines. For areas where changes of topography are quite big, we can compare 3D changes and create volumetric analysis. Unfortunately, contour lines are being used only from the beginning of 20th century. For project purposes we vectorized 3D model of selected parts of Usti region depicted on The State map at 1:5000 from 1950s'. This 3D model can be compared with contemporary data based on LIDAR measurement.

4. Visualization

Outputs of the project can be visualized by classic maps, but last years show that web mapping application has many advantages and is more user oriented. We developed application containing all georeferenced maps, created vector data models, and 3D models. It is based on ArcGIS for Server platform with ArcGIS Server API for JavaScript.

http://mapserver.ujep.cz/projekty/Zanikle_obce/

Quite new method was used for 3D models visualization. We created digital 3D model in two time periods (1950s', 2010s') and printed them on 3D printer. Models are about 1 by 1 meter and consist of several tiles because of maximum size that can be printed.

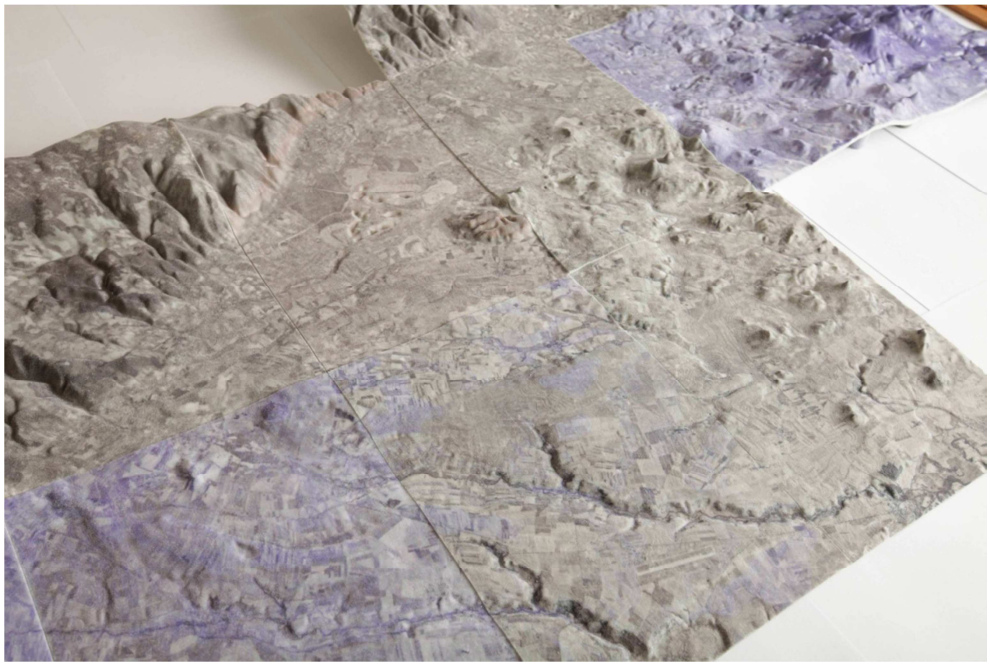

Figure 4. 3D model of landscape created from old maps

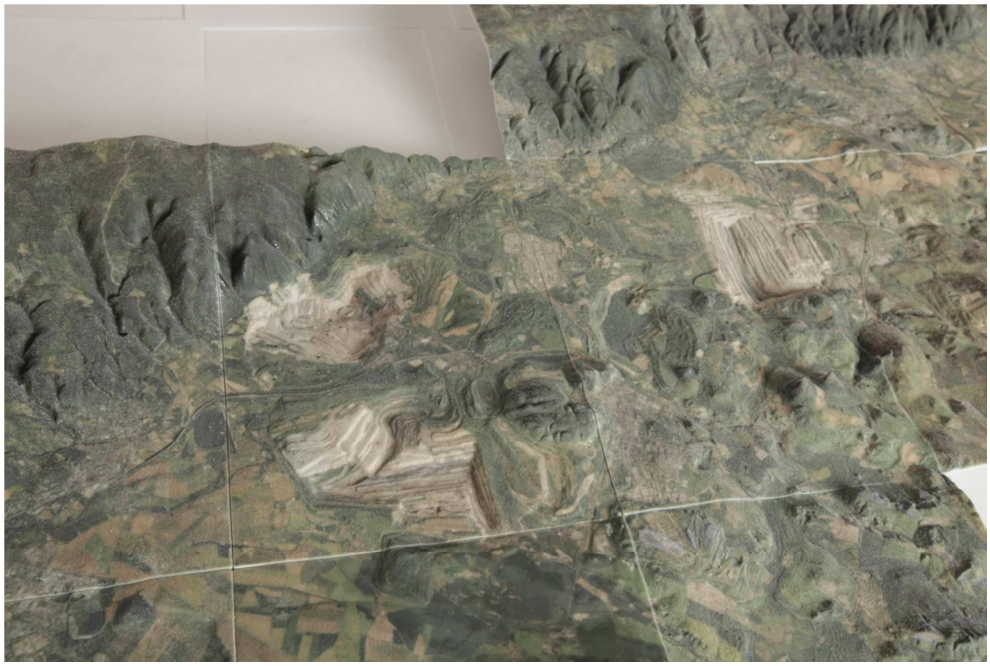

Figure 5. 3D model of landscape created from contemporary LIDAR data and orthophoto; human affected areas are well visible

5. Conclusion

Old maps provide huge amount of information about historical landscape. Our project shows that georeferencing, vectorizing and changes analysis can lead to impressive results. Changes can be presented as values of area changes, classic printed maps, or web mapping applications. 3D print of landscape is brave new method for user oriented visualization.

This work was supported by the Czech ministry of culture by the NAKI programme “Landscape reconstruction and vanished municipalities database for preserving the cultural heritage in the region of Usti nad Labem” no. DF12P01OVV043.

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