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Digitizing and georeferencing of the historical cadastral maps (1856-60) of Hungary

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Summary: In the historical Hungary, as a part of the Habsburg Empire, the first preserved and systematic cadastral survey was carried out between 1856 and 1859. Interestingly enough, this cadastral mapping, which was called in Hungary as 'Provisional' was surveyed simultaneously with the Stable Cadastre in the Austrian regions of the Empire. By the commission of the State Archives of Hungary, the Hungarian company Arcanum Ltd. scanned over 46,000 cadastral sheets of the Provisional Cadastre, mostly covering the present-day Hungary but also some copies covering parts of the present-day Croatia, Slovakia and Austria. The sheets were rectified by the calculated coordinates at the corner points. With the correct projection and datum parameters, the cadastral mosaic, based on the individual sheets and the digitized borders of the administrative units, is presented in any modern coordinate systems in GIS. Using this feature, the product is published as a DVD series by old counties as well as in the Internet.

Introduction

The cadastral mapping activity, as a base of the land taxation, has been started throughout the Habsburg Empire quite early, after the Napoleonic Wars. The first, so called 'Provisional' cadastral works were followed by the Stable Cadastres after 1850 (Hofstätter 1989; Kretschmer et al. 2004).

This agenda was somewhat delayed in the Hungarian parts of the Empire. According to the ancient Hungarian constitution, the nobles were free of taxation as a compensation of their role in the military preparations and services. All cadastral mapping attempts were seen as an action undermining this ancient right. Even the survey sheets of the cadastral works of Emperor Joseph II (1780-90) were destroyed immediately after the death of the emperor.

The fail of the Hungarian Independence War (1848-49) resulted in a new situation. The ancient constitution was abrogated by the new Emperor Francis Joseph I. Hungary was under direct Austrian occupation, which offers the possibility of the systematic cadastral works. The first cadastral survey was carried out mostly between 1856 and 1860 and was called 'Land Taxation Provisory' (in original ancient Hungarian terms: 'Földadó-Ideiglen'). This was followed by the Stable Cadastre later, mostly after 1880, after Hungary regained her partial independency in the frame of the dualist state (1867).

The geodetic basis of the survey was somewhat used the one of the Second Military Survey, which were compiled simultaneously with this first cadastral survey in the majority of the Hungarian territory. However, the geodetic fundamental points were different at the two surveys. For the Hungarian part (not mentioning here the lands of Croatia and Transylvania, which represented independent zones in the survey), the tower of the St. Stephan Cathedral of Vienna was used at the military survey (Timár et al. 2006), while the eastern pillar of the newly elected astro-

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nomical observatory on the Gellérthegey (Mt. Gellért, Budapest – this observatory was destroyed later, during the 1849 fights) was the fundamental point (Homoródi 1953). In the present work we assume that the reference level was the Zach-Oriani hybrid ellipsoid ($a=6376130$ m; $f=1/310$), similarly to the Second Military Survey, fit to the Gellérthegey in 1821 (Buda-1821 datum, see below for details).

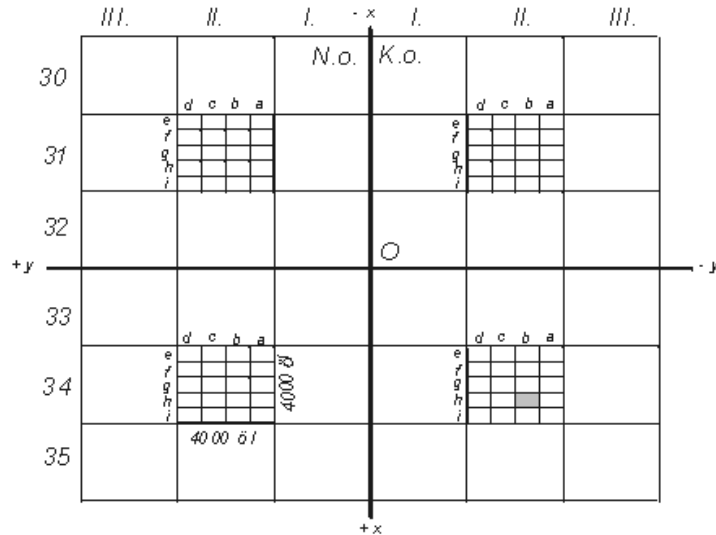


Figure 1: Labeling system of the historical cadastral system (Varga 2005). ‘N.o.’ indicates the western, ‘K.o.’ does the eastern columns. The sheet indicated by gray shading has the label of ‘K. o. II. 34. b.h’

The projection used for the survey was interpreted in GIS systems as a Cassini-Soldner one, similarly to the Second Military Survey (Timár et al., 2006), with a projection center at the Gellérthegey. The length unit was the Viennese fathom (1 fathom = 1.89648384 meters). The extents of the survey sheets was 1000 x 800 fathoms, the scale is generally 1:2880, while 1:1440 in the built-up area. The labeling system is quite complicated (Fig. 1), however, using the label of a sheet, one can easily compute the coordinates of the sheet corners from the Gellérthegey (the *origo* of the coordinate system). The sheets are organized to files according to the administrative units (cities and villages), each sheet is labeled by a single number in the file (Fig. 2), and an overview map is given for each file to make a correspondence between these numbers and the general labels.

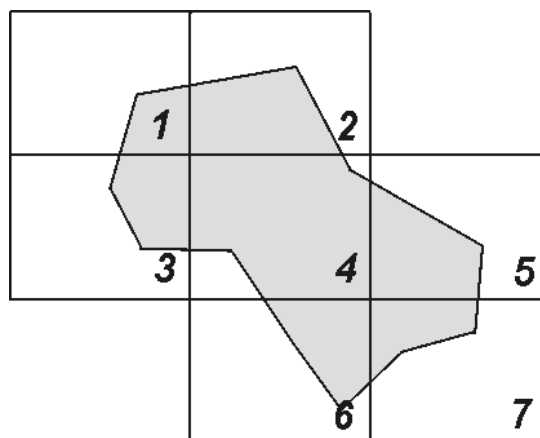


Figure 2: The local labels of the sheets belonging to one administrative unit (Varga 2005). One sheet (usually the first one) contains an overview map that connects these local labels to the global ones shown in Fig. 1.

The maps contain all objects that are important for taxation (property boundaries, buildings, important land use types). The whole territory is divided to labeled property units, which leads to interesting, sometimes funny representation of e.g. the water bodies (Fig. 3).

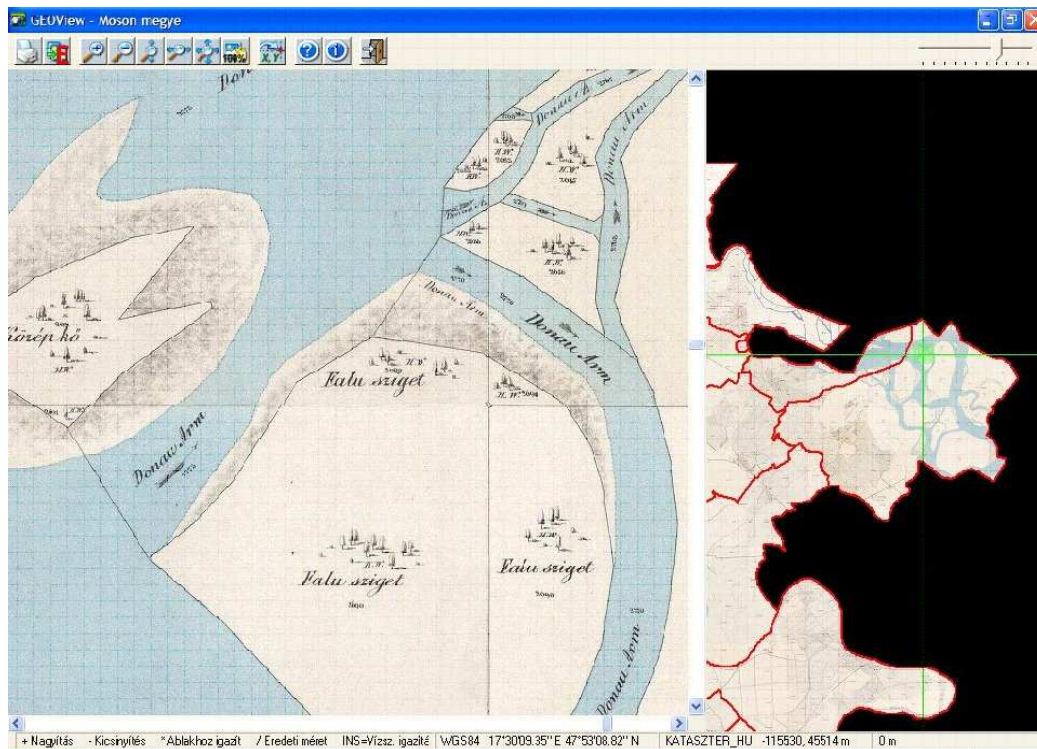


Figure 3: Interesting division of the water body of the anabranches of the Danube River into cadastral registration units (Biszak and Timár 2009a).

For the present digitizing and preservation project, it is important to know, where to find the original paper-based sheets of this survey. The majority is stored in the State Archives of Hungary but some of them are located in the county archives and the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) and a small amount of the maps can be found in some county land registration offices.

Methods of processing

The sheets were scanned at the offices of their original storage. 600 DPI lossless TIFF files were produced and archived for heritage preservation purposes, however, the final market products have decreased resolution and are in compressed format). The geo-reference was performed using the coordinates of the four corner points of each sheet. Using this method, we could avoid the time-consuming seeking for identical points in the old and modern maps. The corner points were selected manually but for future projects, an automated selection method is tested (Rus et al., 2010). For the coordinates, the coordinate system should also be given in GIS applications, which is the following:

- Datum: Buda-1821 (Base ellipsoid: Zach-Oriani; Molodensky-type location parameters: $dX = +1768$ m; $dY = +282$ m; $dZ = +568$ m.)
- Projection: Cassini-Soldner (Projection center: Gellérthegey; longitude= $47^{\circ} 29' 15,97''$; latitude= $19^{\circ} 3' 5,55''$ E. of Greenwich)

The similar parameters have to be defined for each modern grid system that is used in the displaying system, mentioned in the next chapter. However, the parameters of the modern systems are much more known and well-defined, while the ones for the old cadastral sheets were defined in the frame of the present project.

The resulted products

For the display of the sheets and the mosaics based on them, a new software tool, named GEOVIEW, was developed at the firm Arcanum. This roams and zooms the sheet mosaics, shows by the original sheets, indicates the WGS84 geographic coordinates as well as grid coordinates in a user-selected system, predefined in the program (Figs. 4 & 5). The user can also export a selected part of the mosaic in geo-referred format (GeoTIFF, Enhanced Compression Wavelet; ECW, or JPEG-2000) in any grid that is valid in the area.

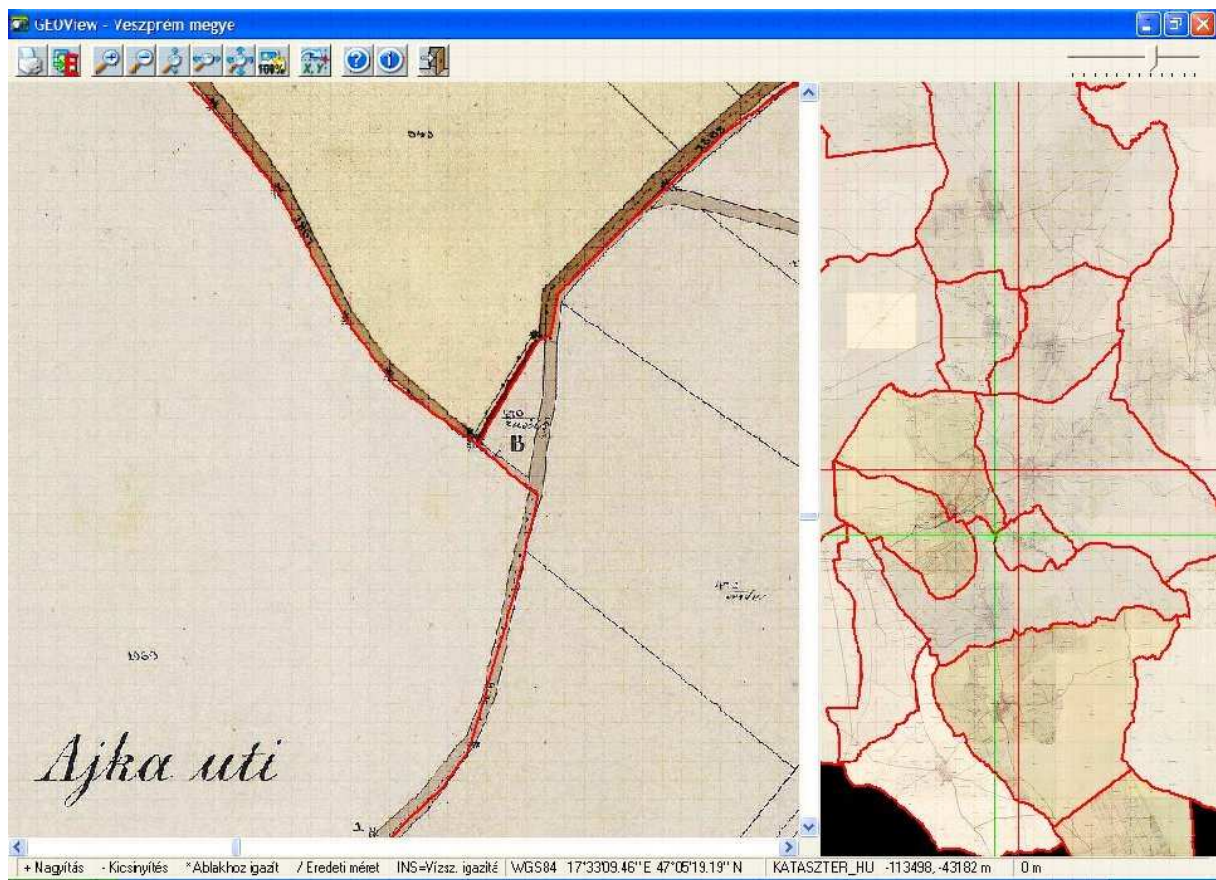


Figure 4: Fit of the sheets belonging to different villages at the border (Timár and Biszak 2009).

The horizontal accuracy of the fit to the modern maps and e.g. to the Google Earth satellite mosaics is better than 3 meters in the most places. However, in case of some blunders the error reaches the five meters, which can be corrected by a simple local shift without rotating the map content.

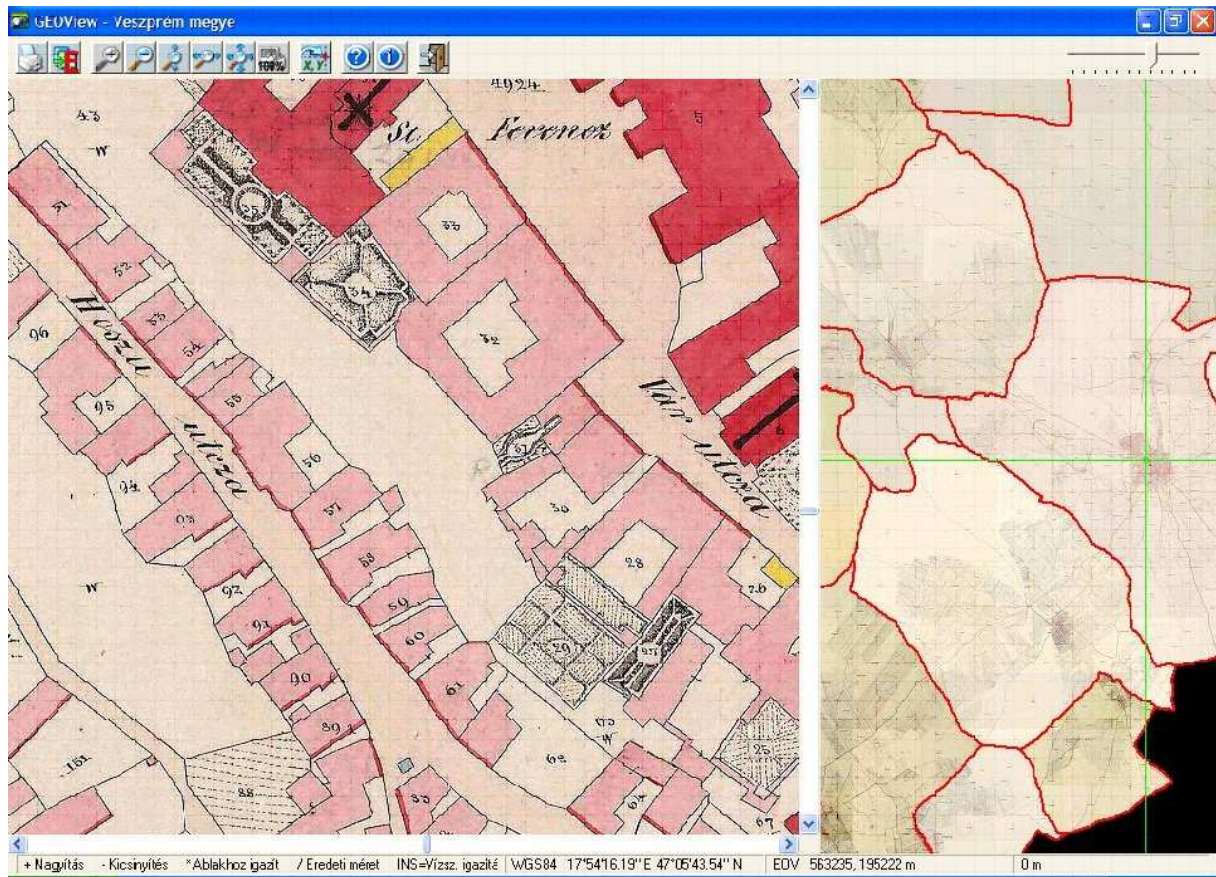


Figure 5: The full resolution shows very high data density in the historical downtown of the city of Veszprém (Timár and Biszak 2009).

In order to make a mosaic of a whole county, containing several hundred administrative units, a vector database of all unit boundaries have to be compiled. Thus, the final county mosaic is partly irregular; based not only on the original rectangular sheet boundaries but also the city and village borders.

There are some problems, arisen by the changing borders. In some places, the original county borders were changed from 1860 and nowadays. The final products, the county mosaics of the old sheets, are following the old county borders. The later defined international borders caused another problem, which was generally discovered by the present project: the archive sheets were not accurately distributed among the successor states. Therefore, the produced county mosaics does not follow the international borders (to Austria and Slovakia so far) at all.

The results of the project is of three kinds:

1. a high-resolution, lossless digital scan collection of the sheets;
2. a web-based database of the sheets combined with Google database (Arcanum 2009);
3. A DVD-series of the archive county cadastral map sheets. 3 of the planned 19 issues are published so far (Biszak and Timár 2009a; 2009b; Timár and Biszak 2009).

The first and second parts were funded by the Office of the Cultural Heritage of Hungary. Apart from the sheets covering the territory of the present-day Hungary, some facsimiles are found in the State Archive of Hungary, covering parts of Slovakia and Croatia. The project continues to digitize and geo-refer them. In case of Slovakia, the coordinate system is the very same that we describe above for Hungary, while the Croatian maps were mostly drawn in the Ivanić-centered system, whose parameters are the same with the ones of the Second Military Survey maps of Croatia (Timár et al., 2006).

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