CO-316

THE DANUBE MAP OF BELA VALYI AND ITS GEOREFERENCING METHOD

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INTRODUCTION

In the territory of Hungarian Kingdom, the most important flood-control projects passed off during the 19th century. These projects have highly contributed to establish and develop the Hungarian engineer training. The size of the projects is presented by the number of canals and cut-offs planned by the engineers and the area proof against flood (by the contemporary written records, the size of the area was the same then the territory of Netherland). The proof and preserver of the projects are the old flood-control maps which were made before the project, serve as the basis for planning, or were made after the project, which means, the maps were the graphical summary of the results. One of the latter flood-control maps is the Danube map of Béla Vályi, which gives us a general view of the projects made on the Danube and its catchment area.

DANUBE MAP OF BÉLA VÁLYI

The Danube map was made by Béla Vályi, Hungarian hydrological engineer in 1900, by order of Ignácz Darányi minister. The map contains 24 sheets and represents the Danube and its catchment area. During the drawing they took the sheets of the Tisza map, made in 1896, into consideration, because they wanted to fit the sheets together. In that way, the Tisza map and the Danube map give us a general view of the flood-control projects in Carpathian Basin in 19th century. The main topic of the map is the representation of the hydrological elements (flood gates, pumps).

Basically, the map represents the urban structure (towns, villages), the administrative borders, the roads and railways and the land-use (forests, grain-fields) of the area. As required by the cartographic practice, the hydrography (rivers, creeks and canals) and the hydrological artificial buildings (dams, bridges) of the area are presented with blue color. The water-gauges and the highest water level values measured on these water-gauges are represented separately with red color.

The information about the dimensions of these projects are represented in the tables on the 21st and 22nd sheets of the map. For example, the length of the dams along the Danube River is 2340 km.

The base of the Danube map (roads, railways, borders, towns, villages and names) came from the 1: 75 000 scale maps of the Third Military Survey, printed by the Military Geographical Institute (Militär-Geographisches Institut) in Vienna. This scale was transformed into 1: 125 000 scale with photolithographic method. Fit to basic map they drawn the main topics of the map, the hydrological elements and later they printed these to the basic map.

1000 copies of the map had been produced. From these 750 copies printed in Hungarian language, 100 copies translated to German language, 100 copies printed in Hungarian and French languages and 50 copies printed in Hungarian and English languages. (Fodor, 1952)

GEOREFERENCING METHODS

It is useful to georeference the old maps because the map-drawings can be compared and fitted to modern datasets easily with this method. More different procedure exists to complete it nowadays. The procedure (Timár, 2008) described in this paper is based mainly on the projection parameters which are unknown in general for old maps so it is necessary to carry out a geodetic or cartographic history research.

Georeferencing using the exact projection parameters

If the exact projection parameters exist, they will be easily definable in GIS software like ArcGIS or Global Mapper and after that the map can be georeferenced. If the defined parameters are appropriate, the physical shape (rectangle or square) of the map don't change. In case of old maps it is necessary to search these parameters as precisely as possible. If this is not possible, it is necessary to find the approximate values which give nearly the same result than the original parameters (Timár, 2008). As we can read in the technical description of the map, it had been drawn by the 1: 75 000 scale map sheets of the Third Military Survey (Biszak et al., 2007), carried out by the Military-Geographical Institute (Militär-Geographisches Institut) of the Austro – Hungarian Monarchy so the parameters of the Vályi map will similar. Two previously published articles (Mugnier, 2004 and Molnár – Timár, 2009) will help to find these similar parameters.

Ellipsoid and datum parameters

The geodetic base of the Third Military Survey (even the Vályi map) was the Bessel-ellipsoid (a = 6 377 397,155 m and f = 1 / 299,152815). The central point of the ellipsoid where the fit is the best to the geoid was the Hermannskogel point, near Vienna (Varga, 2002, Mugnier, 2004 and Molnár – Timár, 2009). It is necessary to define the ellipsoid in this best fitting position (definition of the geodetic datum). This datum (Hermannskogel) is predefined in some GIS software like Global Mapper, if not in another software we have to do this. Due to the small-scale mapping and the achievable non-geodetic accuracy it is sufficient to define the three parameters of the Molodensky – Badekas datum parameterization procedure (Timár et al., 2002). According to Molnár and Timár (Molnár – Timár, 2009) these three shift parameters are as follows:

dX = +600 m;

dY = +205 m;

dZ = +437 m.

Projection parameters

Unfortunately the Austrian military engineers chose a rarely-used and difficult or impossible to define in GIS programs projection to survey the map sheets of the Third Military Survey (Molnár – Timár, 2009). In the polyeder (or polyhedron) projection (Mugnier, 2004 and Molnár – Timár, 2009) the geographical grid lines give the margins of the individual map sheets. In this case the sheets don't fit together on the plane because they are geographic quadrangles. It is necessary to replace the original projection with another one which easily definable in GIS programs. This replacement projection is the well-parameterized Sinusoidal projection (Molnár – Timár, 2009). A sinusoidal projection had been parameterized for every column of the map sheets the origin of latitude is the Equator in every case but the central meridian always run through the centre of the column (Figure 1.).

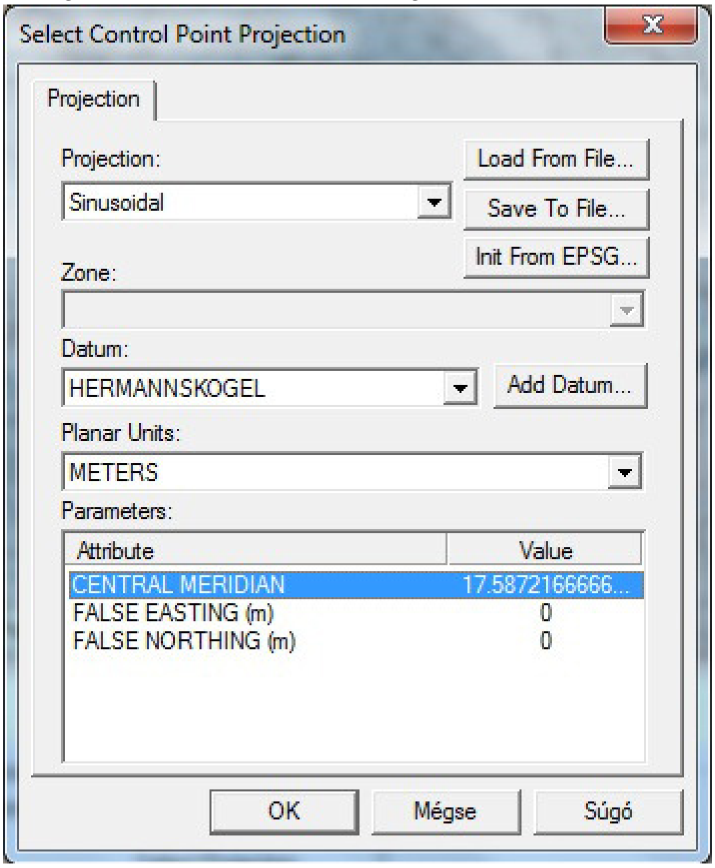

Figure 1. The parameters of the sinusoidal projection

After the definition of this special projection system every Vályi map sheet can be georeferenced with the coordinates of four corner points and transformed to a unified projection, like an oblique conformal conic projection.

Coordinates

Projection grid numbers can't be found on the map sheets of Vályi, only geographical coordinates but it is necessary to calculate these values to every corner points. To define the exact longitude of the corner points we have to know that in that time the Ferro (El Hierro) prime meridian had been used in the Austro – Hungarian Monarchy to surveying (Timár, 2007). So we have to compute the values from the Greenwich prime meridian. For this calculation it is worthy to use the Albrecht – adjustment (ΔL=17° 39' 46,020"), defined by Karl Theodor Albrecht German astronomer in the 19th century. For the georeferencing these calculated longitude values were been used.

Another problem is the difference between the sinusoidal coordinates which don't exist and the geographical coordinates. We define the four corner points with geographical coordinates but the map wasn't surveyed or printed in geographic (or longitude/latitude) projection. If we georeference the map sheets in geographic projection it will cause huge errors so it is necessary to solve this problem. First of all we mark the four corner points and define their coordinates with geographic coordinates (Figure 2.).

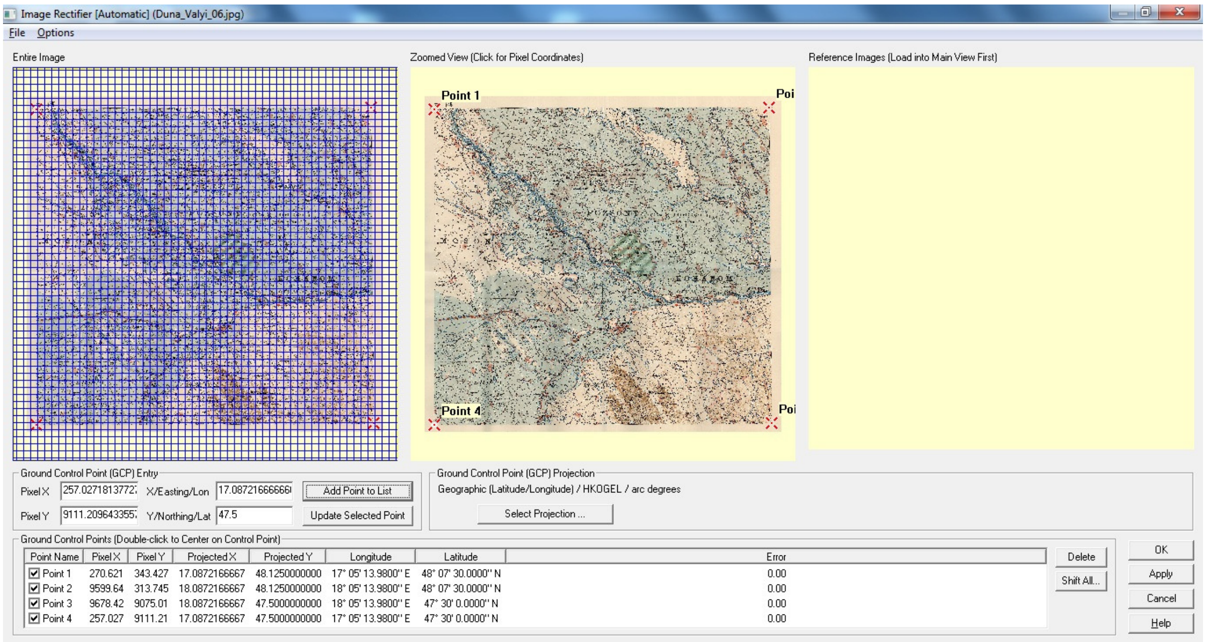

Figure 2. The image of one sheet and the marked corner points defined with geographical coordinates.

After that we can change the projection parameters in most GIS programs to the correct parameters and the software ask us to choose the correct method: reproject the coordinates to new projection or reinterpret coordinates as being in the new projection. The correct method is the first one because we need the coordinates in sinusoidal projection. After that we can easily georeference the map sheet and it will keep its original shape.

Georeferencing using ground control points

The map sheets can be georeferenced with the help of easily-recognizable and still-existing buildings (e.g. bridges, churches). The name of these points is ground control point in the GIS practice. In this case it is not necessary to know the exact projection parameters because the map sheets will be transformed into the projection of the georeferenced dataset. This method doesn't require any geodetic or cartographic knowledge or the difficult definition of these projection parameters so it might seem easier than the previously described method. The most disadvantages of this method are to define lot of control points to the better fitting on small-scale maps and in most cases it is difficult to ensure that the old map building is identical to the building what we see on the modern map. In this research this method had been avoided because of the disadvantages of it. (Timár, 2008)

ACCURACY

After the georeferencing of the map sheets, it is necessary to investigate the accuracy of the transformed sheets. The maximum value of the error is equal to 350 m and the minimum value is equal to 100 m compared to modern datasets, like satellite images of Google Earth (Figure 3.) or SRTM digital elevation model. If we assume that the distortion due to the printing technology and the scanning can occur to 1 mm in the scale of the map, this distortion causes the 30% of that error (125 m).

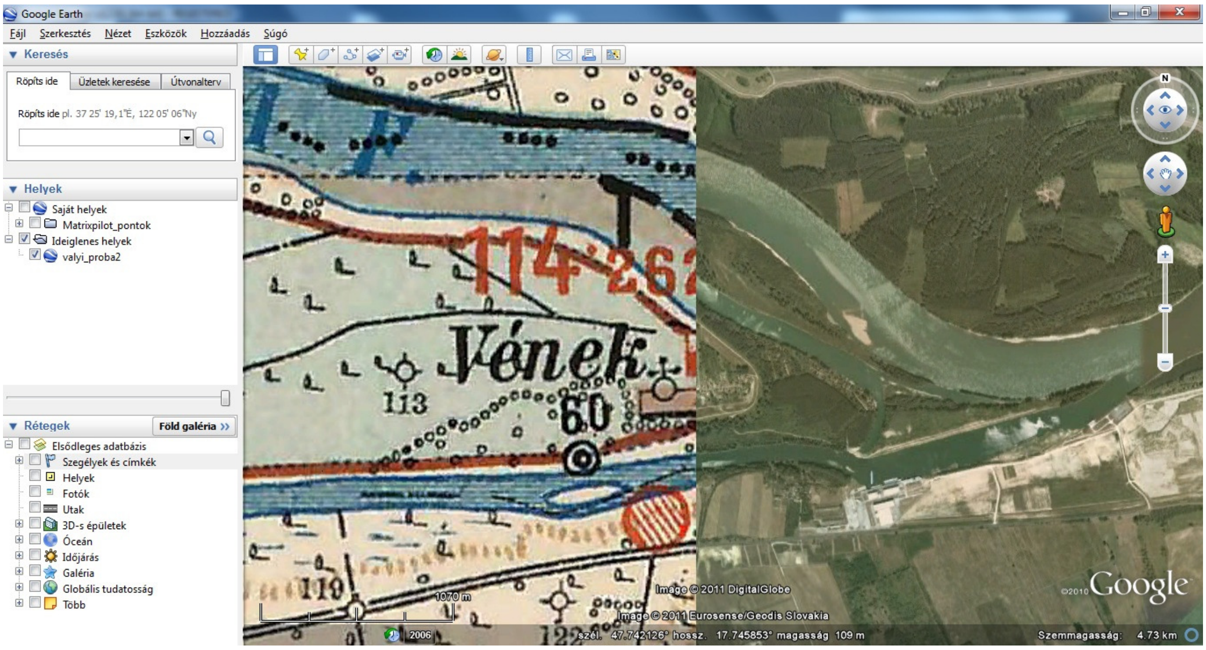

Figure 3. The Danube River near Vének village on the georeferenced map sheet of Vályi and on the satellite image of Google Earth.

SUMMARY

The paper gives the detailed description of the Danube map of Béla Vályi which not a well-known map of the Hungarian history of cartography but it is necessary to preserve to the future due to its importance and contents. The hydrological environment, preserved and shown by the old flood-control maps, is very useful information in some ongoing research to interpret and understand the complex hydrological circumstances of Hungary nowadays. The exact parameters of the georeferencing process (e.g. used ellipsoid, used projection), the problems of the georeferencing and their solutions are described in this paper. Finally it discuss the value of the horizontal error of the transformed map sheets which were compared to modern, frequently used datasets, like satellite images of Google Earth and the SRTM digital elevation model.

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