

HISTORICAL MILITARY MAPPING OF THE CZECH LANDS – CARTOGRAPHIC ANALYSIS

Ruzena Zimova, Jaroslav Pestak, Bohuslav Veverka

Abstract

The paper presents main aspects of the research project on geo-referencing and cartographic analysis of historical military maps of the Czech lands (from 18th and 19th centuries) carried out in co-operation of three Czech Universities. Within this project, a position accuracy of objects in the maps from historical military mapping has been tested. The coordinates of selected points on objects identified in raster files of historical map sheets were compared with the coordinates obtained from the current digital terrain model, from coloured orthophoto and from direct GPS measurements in the field. The results from the testing areas presented in the form of average deviations in the position of map object. The research may contribute to improve the conditions for using these map resources in current GIS applications.

INTRODUCTION

Maps from historical military surveys which were done on the territory of the present Czech Republic during the 18th and 19th centuries represent unique mapping products which comprise a lot of valuable information that can be used in many branches of human activities. The research project “Georeferencing and cartographic analysis of historical military mappings” is being solved by the team built-up in cooperation of three Czech universities: the Czech Technical University in Prague, J.E. Purkyně University in Ústí nad Labem and University of West Bohemia in Pilsen. The project aim is to contribute to establishing good conditions for the widest use of these unique maps especially within GIS systems. The following paper gives the characteristics of the 1st and the 2nd military mappings and main aspects of the research project focused on georeferencing and cartographic analysis of these old maps.

MAPS OF HISTORICAL MILITARY MAPPINGS

The 1st military mapping

The 1st military mapping was the first systematic military geodetic survey done on the territory of former Austro-Hungarian monarchy. Most of these military surveys were done during the reign of the Empress Maria-Theresia and the complete mapping was finished by the reign of her son Emperor Joseph I. The mapping was done in the Czech lands in 1764-1767, in Moravia 1764-1768 and in Silesia 1763-1764. During 1780-1783 some map sheets were rectified and improved. The mapping was done in a quite detailed scale 1:28 800 without any other geodetic control and with minimum of measurements. As a graphical base for the mapping supposedly the enlargements of Müller maps of Bohemia from the year 1720 (scale 1 : 132 000) were used for depicting important points transferred into the scale 1 : 28 800. Using these points the military cartographers drew the map image with help of the simplest measuring devices (measuring table and busole) or mostly „à la vue“, only some distances were measured by spacing. The content of coloured maps included settlements, roads and stone bridges, rivers, meadows, forests and grasslands. The altitude was presented by hachures, which indicated the topography of foots of significant terrain slopes. The territory involved in one map section of 62 x 41 cm represented the area of approximately 209 sq. km. There are 273 map sections for Bohemia, 126 for Moravia and 40 for the Moravian part of Silesia. A cut of a map section is shown at the Figure 1.

The 2nd military mapping

Insufficient quality of maps from 1st military mapping led to beginning new surveys in the 19th century, under the reign of the emperor Franz II. The second military mapping was done during 1819-1858 on the territory of current Czech Republic while the mapping works on the territory of the whole monarchy took much more (1807-1869). The mapping had been preceded by creation of a trigonometric network used also for cadastral survey used as a background for topographic survey. There were several coordinate systems used for the territory of the whole monarchy. The coordinate system for Bohemia referred to the trigonometric point Gusterberg, for Moravia and Silesia to the tower of the St. Stephen church in Vienna. The scale of the maps in transverse cylindrical projection equidistant in cartographic meridians (Cassini-Soldner) was again 1 : 28 800. Mapping was done using a measuring table, distances were derived from spacing or estimated. In those localities where cadastral surveys were already done the planimetry of topographic

maps could be based on a simplified planimetry of cadastral maps (“stable cadastre”) decreased to the scale 1 : 28 800. Therefore the mapping was done relatively very precisely. The height of important objects was derived trigonometrically, hypsometry was presented by slope hachure. The territory of Bohemia was covered by 267 map sheets (sections), Moravia and Silesia by 146 sections.



Figure 1. The 1st military mapping – a part of the map section No. 253 (South-East of Bohemia)

Availability of historical map sheets

Coloured originals of maps from historical military mappings are stored in the Military Archive in Vienna. Thanks to the grant project of the Czech Ministry for Environment realized by the Laboratory of Geoinformatics of the J.E. Purkyně University the sets of coloured copies of these maps had been bought (in 2001-2002) and transformed into digital form [Brůna et al., 2002]. The images of map sheets from the territory of the Czech Republic can be seen on the web site of the Laboratory of Geoinformatics at the address www.geolab.cz. Raster files of these historical maps have been used also as a background for the cartographic analysis made by the research team created by three Czech Universities.

THE PROJECT OF CARTOGRAPHIC ANALYSIS OF MILITARY MAP SHEETS

Main aims of the project

The research project “Georeferencing and cartographic analysis of historical military mappings” (2004-2006) is being solved by the team built-up in cooperation of three Czech universities: the Czech Technical University in Prague, J.E. Purkyně University in Ústí nad Labem and University of West Bohemia in Pilsen. The project involves a complete cartographic research of the accuracy of historical military mappings focused mainly on methodology of interpretation of old maps content, localisation of those maps sheet layouts into current coordinate systems, verifying the relations between cadastral mapping and the 2nd military mapping and also the development of web interface for making the images of map sheets available on Internet.

Interim project results

The detailed analysis of the cartographic language of the maps from the 2nd military mapping was made by the team of West Bohemian University in Pilsen [Vichrová, Čada, 2005]. The developed catalogue has been derived from the original list of symbols obtained in raster form from the Military Archives in Vienna. In the catalogue, the map objects

are fully described and sorted into several categories. The catalogue is linked with the catalogue of map elements of cadastral maps of the 19th century.

The task of georeferencing the maps of the 1st military mapping is quite complex. Due to the fact that the mapping was done without any precise geodetic control and cartographic projection, the transformation of raster files of those maps into the current coordinate systems is substantially highly inaccurate. The supposed relation between Müller's mapping and the 1st military mapping has been exercised by the members of the team from the CTU Prague [Mikšovský, Zimová, 2005]. For georeferencing of map sheets the best way seems to be a selection a set of identical points on separate sheet (which can be well identified on both historical and contemporary maps) and the use of suitable transformation the parameters of which would differ for each map sheet and each combination of identical points [Veverka, 2005].

In the case of the maps from the 2nd military mapping the initial conditions for georeferencing are much more reliable. Quite precise geodetic control and known parameters of used cartographic projection enable to calculate the coordinates of map sections corners (in fathoms). For the task of their transformation into current co-ordinate system it is suitable to use a global transformation key between the system of stable cadastre and the current S-JTSK system used in the CR by [Čada, 2003]. In the framework of the project a software module for calculations in map sheet layouts of the 2nd (and 3rd) military mapping based on this global transformation key has been developed within the software MATKART (autor B. Veverka).

The analysis of positional accuracy of map elements on maps from historical military mappings has been made for several testing areas at the territory of the Czech Republic. The results from two of these testing areas investigated by the team of the CTU Prague [Pešřák, Zimová, 2005], [Zimová, 2005] are presented in the following paragraphs.

POSITIONAL ACCURACY OF MAP ELEMENTS

Testing areas and selected map elements

The testing areas chosen for the research at the CTU Prague (2004-2005) are located at the South-West and South-East of Bohemia. The first (SW) area – the region Susicko – lies between the towns Susice and Horazdovice and basically it conserves its specific scenic nature. Most of the changes in landscape can be identified within towns and villages. The second (SE) area – Jindrichohradecko - is situated approximately between the towns Jindrichuv Hradec and Slavonice. This region belongs to so called Czech Canada and it is typical by wonderful nature with extensive needle-leave woods, granite boulders and numerous ponds. Substantial part of this region is located along the border with Austria where a number of villages were evacuated and destroyed after the year 1945.

Within the testing areas the sets of suitable map objects have been selected: these points had to be identified in corresponding map elements within old maps and current map sheets and preferably also on the real objects in the field. Suitable points were usually found on churches, village chapels, way-side crosses, corners of important historical buildings, pond dams, bridges, etc. The list of chosen points (objects) on particular map sections of historical mapping for both testing areas is presented in Tab. 1.

Table 1. Testing areas – map sections and chosen map elements

| Testing area: Susicko | | Testing area: Jindrichohradecko | |
|---|------------------|--|------------------|
| section of 1 st military mapping: 220 | | section of 1 st mil. mapping: 245, 253 | |
| section of 2 nd military mapping: W-14-III | | section of 2 nd mil. mapping: O-16-V, O-16-VI | |
| object | number of points | object | number of points |
| geodetic point | 1 | geodetic point | 2 |
| building | 29 | building | 12 |
| bridge | 3 | bridge | 11 |
| crossing of roads | 17 | crossing of roads | 25 |
| barrage | 3 | barrage | 2 |
| dam of pond (outlet) | 17 | dam of pond (outlet) | 21 |
| chapel | 4 | chapel | 6 |
| way-side cross | 4 | way-side cross | 22 |
| Total | 78 | Total | 101 |

Compared sets of coordinates

Raster files of particular map sections of historical mappings (TIFF, 200 dpi) were georeferenced by transformation into the current Czech national coordinate system S-JTSK using several identical points (4 – 6) at the border and in the middle of the testing area for each map section. For the testing area Jindrichohradecko the raster files of both map sections were at first fit together in the program Adobe Photoshop. The resemblance transformation and collecting the coordinates of chosen points of were done in the graphic system Kokes. The coordinates of selected points identified in raster files of historical map sheets were compared with coordinates of corresponding points obtained from the digital terrain model DMU25 (scale 1 : 25 000), from coloured orthophoto with resolution 1m and from direct GPS measurements in the field (GPS Garmin device with accuracy 10 m). Some examples of localization of corresponding points identified in different sets are shown on Fig. 2.

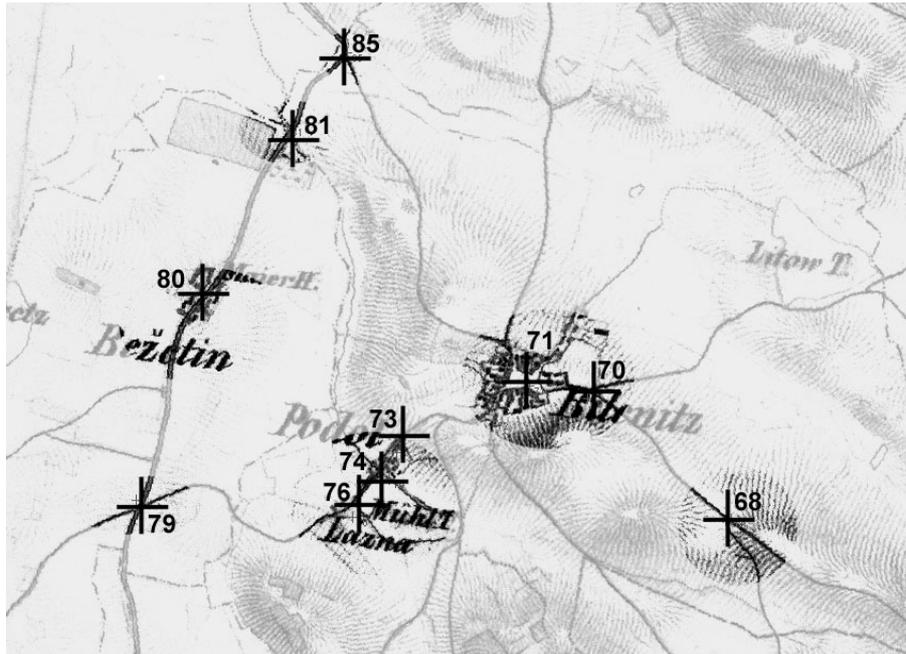


Figure 2. Example of localization of corresponding points – 2nd military mapping

Positional accuracy of map objects

For the sets of corresponding points in the S-JTSK the coordinates of elements on historical maps were compared with all the sets gained from contemporary sources (old map – DMU25, old map – orthophoto, old map – GPS). The comparison was presented in the simple form of a shift of point dP

$$dP = \sqrt{dX^2 + dY^2} \quad (1)$$

and consequently a standard deviation m_p for every set of shifts of n points

$$m_p^2 = \frac{dP^2}{n} \quad (2)$$

The results of positional accuracy analysis are presented in Tab. 2 for the region Susicko and in the Tab. 3 for the region Jindrichohradecko. The points that could not be well identified or could not fulfil the following condition were extracted from the investigated sets:

$$dP_{\max} < K_{1,\alpha} \cdot m_p \quad (3)$$

where dP_{\max} is the limiting shift of point, $K_{1,\alpha}$ the coefficient of significance for level of significance $\alpha = 0,05$ and m_p is the standard deviation. The number of points in the compared sets was influenced also by a different map sheet layout of 1st and 2nd military mapping. The comparison of the results from both testing areas is presented in the Table 4.

Table 2. Results of analysis – the region Susicko

| | 1 st military mapping | | 2 nd military mapping | | 1 st military mapping | | 2 nd military mapping | |
|------------|----------------------------------|-------------|----------------------------------|------------|----------------------------------|-------------------------|----------------------------------|-------------------------|
| | standard deviation m_p | | standard deviation m_p | | number of points | mean shift of point [m] | number of points | mean shift of point [m] |
| | reality [m] | map [mm] | reality [m] | map [mm] | | | | |
| GPS | 336 | 11,7 | 50 | 1,7 | 46 | 270 | 78 | 34 |
| DMU 25 | 333 | 11,6 | 49 | 1,7 | 42 | 262 | 66 | 33 |
| ortophoto | 339 | 11,8 | 47 | 1,6 | 45 | 272 | 78 | 32 |
| mean value | 336 | 11,7 | 49 | 1,7 | | 268 | | 33 |

Table 3. Results of analysis – the region Jindrichohradecko

| | 1 st military mapping | | 2 nd military mapping | | 1 st military mapping | | 2 nd military mapping | |
|------------|----------------------------------|------------|----------------------------------|------------|----------------------------------|-------------------------|----------------------------------|-------------------------|
| | standard deviation m_p | | standard deviation m_p | | number of points | mean shift of point [m] | number of points | mean shift of point [m] |
| | reality [m] | map [mm] | reality [m] | map [mm] | | | | |
| GPS | 173 | 6,0 | 40 | 1,4 | 75 | 157 | 71 | 29 |
| DMU 25 | 176 | 6,1 | 38 | 1,3 | 54 | 162 | 51 | 25 |
| ortophoto | 178 | 6,2 | 38 | 1,3 | 71 | 162 | 61 | 25 |
| mean value | 176 | 6,1 | 39 | 1,3 | | 160 | | 26 |

Table 4. Comparison of results from both tested regions

| | 1 st military mapping | | 2 nd military mapping | | 1 st military mapping | | 2 nd military mapping | |
|-------------------|----------------------------------|------------|----------------------------------|------------|----------------------------------|-------------------------|----------------------------------|-------------------------|
| | standard deviation m_p | | standard deviation m_p | | mean shift of point [m] | mean shift of point [m] | mean shift of point [m] | mean shift of point [m] |
| | reality [m] | map [mm] | reality [m] | map [mm] | | | | |
| Susicko | 336 | 11,7 | 49 | 1,7 | 268 | | 33 | |
| Jindrichohradecko | 176 | 6,1 | 39 | 1,4 | 160 | | 26 | |
| mean value | 256 | 8,9 | 44 | 1,5 | 214 | | 30 | |

As expected due to the different way of geodetic and cartographic background of the maps from both historical mappings, the accuracy of objects on maps from the 1st military mapping within tested areas is much worse than in the case of 2nd military mapping. We should also remind that the transformation of raster files of 1st military mapping into the contemporary coordinate system cannot bring enough precise results and even looking at the map sheet we can sometimes distinguish imperfections in location of some map objects.

An interesting difference has been obtained by comparison of the results from the two testing areas (Tab. 4). Within the region Jindrichohradecko the results of analysis show better accuracy of objects (for both 1st and 2nd military mapping) compared to the results from the region Susicko. To some extent the results may be influenced by the selected groups of identical points for transformation of raster maps, nevertheless almost double value of standard deviation for the case of 1st mapping in the region of Susicko (336 m) compared to Jindrichohradecko (176 m) may indicate possible differences in quality of field mapping or additional rectification works in the region of Jindrichuv Hradec.

The reliability of the results can be verified by approximately equal values of shifts / standard deviations obtained by comparison of objects on historical maps and present data sources (GPS, DMU 25 and orthophoto) – see the columns in the Table 3 and Table 4. In general, the mean values from both tested areas (Table 4) correspond to the results of similar analyses presented in last years.

CONCLUSIONS

The results of the analysis confirm that the position accuracy of the objects on the maps of 1st military mapping is much worse than the accuracy on the maps of 2nd military mapping which follows from the methods, background data and measurements done in 17th and 18th centuries. While the 1st military mapping was done without accurate geodetic control and cartographic projection and with use of „à la vue“ method or spacing, the maps of 2nd military mapping can be considered as a relatively accurate map product based on quite good geodetic and cartographic background. It can be supposed that the accuracy of those maps may differ with various mapping localities (different landscape parameters, quality of mapping work, various time periods of mapping, etc.)

Maps of historical military mapping, covering whole territory of former Austro-Hungarian monarchy and then the present Czech Republic, are irreplaceable information sources for study of history and landscape development which may be used by specialists from many areas as geographical sciences, environmental ecology, flood control, land management, cartography, history, archaeology, etc. The results of the research project focused on georeferencing and cartographic analysis of maps from historical military mapping at the territory of the Czech Republic may contribute to extending the possibilities of exploitation of these unique maps especially in current GIS applications.

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Map sections of historical military mappings were obtained from the following sources:

- 1st and 2nd Military Mapping, Sections No. 220, 253, 245, W-14-III, O-16-V, O-16-VI Austrian State Archive/Military Archive, Vienna;
- Ministry of Environment of the Czech Republic - <http://www.env.cz>;
- Geoinformatics Laboratory, University of J.E.Purkyne, Usti nad Labem - <http://www.geolab.cz>;

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Affiliation and biography of authors

| | |
|---|---|
| ZIMOVÁ Ruzena, MSc. (Ing.), Ph.D. |  |
| Czech Technical University in Prague, Faculty of Civil Engineering – Dept. of Mapping and Cartography | |
| address: Thákurova 7 166 29 Prague 6, The Czech Republic | |
| phone: +420 224 353 881, fax: +420 224 355 419 e-mail: zimova@fsv.cvut.cz | |
| <p>MSc. in Geodesy and Cartography (1981) at the Faculty of Civil Engineering of the Czech Technical University in Prague. 1981-1992 Czech Academy of Sciences, Geophysical Institute, Dept. off Seismology. Since 1992 assistant lecturer at the Department of Mapping and Cartography, CTU Prague. Ph.D. in cartography (2001). Member of the Cartographic Society of the CR, association Nemoforum. Teaching and research activities oriented on cartography, digital cartography, coordination of geoinformation, spatial data infrastructures.</p> | |

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|---|--|
| PESTAK Jaroslav, MSc. (Ing.) |  |
| Czech Technical University in Prague, Faculty of Civil Engineering – Dept. of Mapping and Cartography | |
| address: Thákurova 7 166 29 Prague 6, The Czech Republic | |
| phone: +420 777 155 098, fax: +420 224 355 419 e-mail: jarda.pestak@centrum.cz | |
| <p>MSc. in Geodesy and Cartography (2003) at the Faculty of Civil Engineering of the Czech Technical University in Prague. Ph.D. student at the Department of Mapping and Cartography, CTU Prague. In 2004 study stay at the Università degli Studi di Trieste, Italy (Master in GIS and Cartography). Member of the Cartographic Society of the CR. Research activities oriented on GIS and digital cartography.</p> | |

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|---|---|
| VEVERKA Bohuslav, Full Prof., MSc., D.Sc. |  |
| Czech Technical University in Prague, Faculty of Civil Engineering – Dept. of Mapping and Cartography | |
| address: Thákurova 7 166 29 Prague 6, The Czech Republic | |
| phone: +420 224 354 656, fax: +420 224 355 419 e-mail: veverka@fsv.cvut.cz | |
| <p>Education: 1960-1964 Technical School of Surveying in Prague, 1964-1969 Faculty of Civil Engineering CTU in Prague, study branch Geodesy and Cartography. Career: 1969-1970 Kartografie n.p., Prague, cartographer; 1970-1974 TERPLAN Prague - State Institute for Regional Planning, programmer analyst and GIS software developer; 1974 - present, Faculty of Civil Engineering (FCE CTU), Department of Mapping and Cartography, university teacher. 1989-1999 head of the Department; 1997 - 2002, Vice-dean for International Relations; 2004 - present, head of the Council of Geodesy and Cartography for doctoral study. Membership in Governmental Commissions: 1992 - present, State Commission for Accreditation of university study programmes in Geography, Cartography and Surveying; 2000 - 2002, head of the Commission 205 - Earth and Space Sciences, Grant Agency of the CR. Academic stays: Germany, Poland, Yugoslavia, Hungary, China, the Netherlands, UK, Russia, Egypt, USA, Canada, Sweden, Denmark.</p> | |