

# DATABASE OF SETTLEMENTS AND ITS USAGE FOR LOCALIZATION OF OLD MAPS

Vaclav CADA<sup>1</sup>, Karel JANECKA<sup>1</sup>,

<sup>1</sup> University of West Bohemia, Faculty of Applied Sciences

Univerzitni 22, Pilsen, Czech Republic

[cada@kma.zcu.cz](mailto:cada@kma.zcu.cz), [kjanecka@kma.zcu.cz](mailto:kjanecka@kma.zcu.cz)

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**Abstract:** *When studying old maps and map series it may be appropriate to compare their content with other period sources. These archival documents can frequently serve for comparative studies of landscape structure in the past and nowadays. Therefore it is advantageous to process old maps and map series into continuous coverage of represented territory using particular system of coordinates. It is relatively easy to extract spatial information from the map series based on precise geodetic control and well-known cartographic projection. It is possible in the case of Stable cadastre maps of the Czech Lands (original map sheets and sets of “imperial” prints from 1826–1843 or original map sheets of revised Stable cadastre from 1869–1882) and the maps of former Land cadastre from 1883–192 as well. Above mentioned map sources are large scale maps (mostly in scale 1: 2880) at level of land parcel data model as far as content and accuracy concerned. Quite different access must be chosen in cases of old maps and map series without geodetic control and identifiable cartographic projection. In such cases a set of identical points whose coordinates in the reference coordinate system are at disposal must be identified in the map and their cartometric coordinates measured. The accuracy of location of identical points in the map depends not only on general quality and accuracy parameters of original map but also on technology of map compilation. Several map elements have had higher priority, other were represented only approximately or schematically. From all mentioned points of view manuscript Müller’s maps of regions of Bohemia from 1712-1718 are exceptional. Original maps represent the territories within regional boundaries (outside them only in general) in approximate scale 1: 100 000. Subsequently a well-known Müller’s map of Bohemia were derived in scale 1: 132 000. For purpose of old maps localization, query functions and displaying functions of web services a Database of settlements (DBS) was necessary to be created which contains the definition points and settlements’ geographical names. This database is based on the Territorial Identification Register of Basic Settlement Units (TIR-BSU) which has been created in 1992-2004. Originally the Czech Ministry for Regional Development was responsible for creating of TIR-BSU. At present TIR-BSU is maintained by the Czech Statistical Office as a part of Register of Census Districts and Buildings. Basic input data for DBS were contained in six database files of definition points, in particular definition points of municipalities and military training areas, cadastre units, urban districts and urban areas, parts of municipalities and basic settlement units. The fundamental part of DBS is the SETTLEMENTS table. This table contains information about basic settlement units including definition points and Czech geographical names. Other entity of DBS data model is the table for storing of definition points of settlements located in the Müller’s manuscript map series of regions including German geographical names. The DBS data model is normalized in order to ensure efficient processing of attribute and spatial queries.*

## 1. INTRODUCTION

When studying old maps and map series it may be appropriate to compare their content with other period sources. These archival documents can frequently serve for comparative studies of landscape structure in the past and nowadays. Therefore it is advantageous to process old maps and map series into continuous coverage of represented territory using particular system of coordinates. Accessibility of such archival documents by web technologies for general public offers new possibilities of knowledge extension and extraction of their information potential for various projects as well.

It is relatively easy to extract spatial information from the map series based on precise geodetic control and well-known cartographic projection. It is possible in the case of Stable cadastre maps of the Czech lands

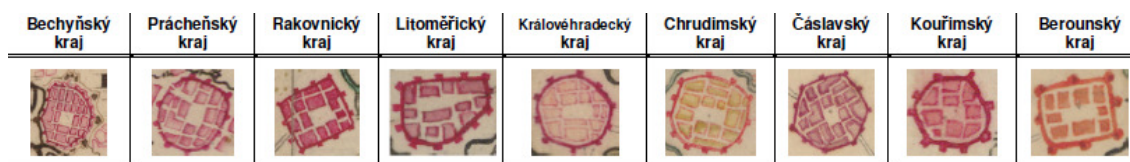
(original map sheets and sets of “imperial” prints from 1826–1843 or original map sheets of revized Stable cadastre from 1869–1882) and the maps of former Land cadastre from 1883–1927 as well. Above mentioned map sources are large scale maps (mostly in scale 1: 2880) at level of land parcel data model as far as content and accuracy concerned. Continuous coverage of the territory and localization of objects by chosen system of coordinates can be realized with meter accuracy. Similar conditions offer the map series of military topographic mapping in scale 1: 28 800 from 1808-1869. The accuracy of localization is up to 20 m with regard to smaller scale and other map type.

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From all mentioned points of view manuscript Müller’s maps of regions of Bohemia from 1712-1718 are exceptional. Original maps represent the territories within regional boundaries (outside them only in general) in approximative scale 1: 100 000. Subsequently a well-known Müller’s maps of Bohemia were derived in scale 1: 132 000. Discovered manuscript Muller’s maps of Bohemia are described in detail in [1] and analyzed in [2]. Other manuscript Müller’s maps are described in [3].

## 2. MANUSCRIPT MÜLLER’S MAPS OF REGIONS OF BOHEMIA










The basic planimetric content of the manuscript Müller’s maps of regions of Bohemia displayed mainly settlements divided according to their type on: fortified cities, unfortified cities, towns with markets, towns with castles, villages with churches and a castle, villages with a castle, villages without castles and abandoned villages. Furthermore castles, halls and knight settlements can be also considered as residential objects. The settlements are the most important planimetric objects suitable for localization of maps. An example of the map symbols of settlements which can be found in manuscript Müller’s maps and their changes are shown in figure 1. In particular figure 1 shows the symbols of fortified cities for selected regions.



**Figure 1:** Symbols of fortified cities for selected regions. The order of regions is given by the time scale as particular regions were mapped.

Basic content of planimetry comprehends royal roads, rivers and regional boundaries. However this content is displayed only schematically and it is not suitable for localization of manuscript maps of regions. Displayed roads serve for orientation overview only. They show how the most important settlements were interconnected. Similar situation is in the case of watercourses and systems of ponds. Significant deviations in position and geometry of these objects are evident.

Thematic content of planimetry consists of church objects and farm objects (pounds, pubs, water and wind-mills, bridges, posts, mines). An example of map symbols appearing on the manuscript Muller’s maps of Bohemia for selected regions are shown in figure 2.

Map symbol	Bechyňský region	Prácheňský region	Rakovnický region	Litoměřický region
Church				
Monastery				
Castle				

**Figure 2:** Map symbols of church, monastery and castle in selected regions

The map lettering is a major part of the content of manuscript maps of regions almost used for names of settlements, lonelies and farmsteads. At some villages (e.g. in Bechyňský region or Prácheňský region) a lettering in German is completed with the Czech name marked by letter B. The map lettering of countries and administrative regions (before the territorial revision in 1714) is distinctive as well as of boundary mountains and mountain ranges. Some watercourses including their springs and important regional localities like Ribenzahls Luft garden (see figure 3) are distinguished by the lettering. Names of some pounds in Bechyňský region can be also found. The Golden Path (*der goldene Steig*) in Prácheňský regio and small church structures are described as well. An important fact is that map lettering of objects is not in the area of individual regions.



**Figure 3:** Detail of the manuscript map of Hradecký region

The land cover is expressed by ichnograms which are collected into zones and give very good image of the vegetation at that time especially of the forest complexes (see figure 4). The design of ichnograms is different in various maps of regions and trend to simplification of the map symbols is evident. In the maps of Bechyňský and Prácheňský region the more complex symbols are used which evoke a deciduous wood or shrubbery in brown color. The same symbols in the map of Rakovnický region are expressed as simple grey oval-shaped dots. The areas of swamps and vineyards are demarcated in the map of Litoměřický region.



**Figure 4:** Detail of the manuscript map of Berounský region with marked woody Brdy Mountains



**Figure 5:** The areal symbols of swamps and vineyards in the manuscript map of Litoměřický region

The map frame of manuscript Müller's maps of regions is equipped with geographic network. In the maps of Bechyňský region, Prácheňský region, Rakovnícký region, Litoměřický region and Kouřimský region the geographic network is displayed in sexagesimal division (in one minute, each fifth minute is marked). The maps of Královehradecký region, Chrudimský region, Čáslavský region and Berounský region are also equipped with geographic network in sexagesimal division (in five minutes, each tenth minute is marked). The portrayal of geographical network is unfortunately less accurate and of good quality. Gross errors appear in the maps and it is evident that the portrayal is only schematical and the information about geographic coordinates was probably taken from other resources.

### 3. LOCALIZATION OF THE MANUSCRIPT MÜLLER'S MAPS OF REGIONS

Raster equivalents of manuscript maps of regions were produced with the agreement of The Museum of Czech Literature (PNP) in Prague. The CRYSTAL G600 scanner was used for this purpose. TIFF (Tagged Image File Format - true colour, 400 dpi) data format was used to data storage. These equivalents were consequently processed at the Geomatics section of Faculty of Applied Sciences, University of West Bohemia in Pilsen. Some large map sheets were cut in the past according to size of the region. The Bechyňský region was displayed in 15 independent parts. Královehradecký region was the biggest one and consists of 23 parts. The Prácheňský region, Litoměřický region and Kouřimský region were displayed in nine parts, the Rakovnícký region, Chrudimský region and Čáslavský region in six parts. The Berounský region was displayed in four independent parts only. These archival maps were furnished with a carton pad during their restoring in 80's of the last century. Some large map sheets like Bechyňský region and Královehradecký region [2] are put on two independent pads connected by book cloth. The maps sheets which were restored in this way have non-continuous drawing inside the map frame. Due to this reason it was necessary to restore raster equivalents of manuscript maps in such way that original drawing would be preserved.

Particular regions were transformed and connected each other by means of identical points located in overlapping areas. End points of line features (roads, watercourses) or other expressive features served as identical points for transformation. The non-residual transformation was used to match the drawing located in neighbouring map sheets. The KOKEŠ software (version 10) was used for this operation.





**Figure 6:** The drawing located on common boundary of maps of Královehradecký region before the reconstruction (on the left) and after reconstruction (on the right)

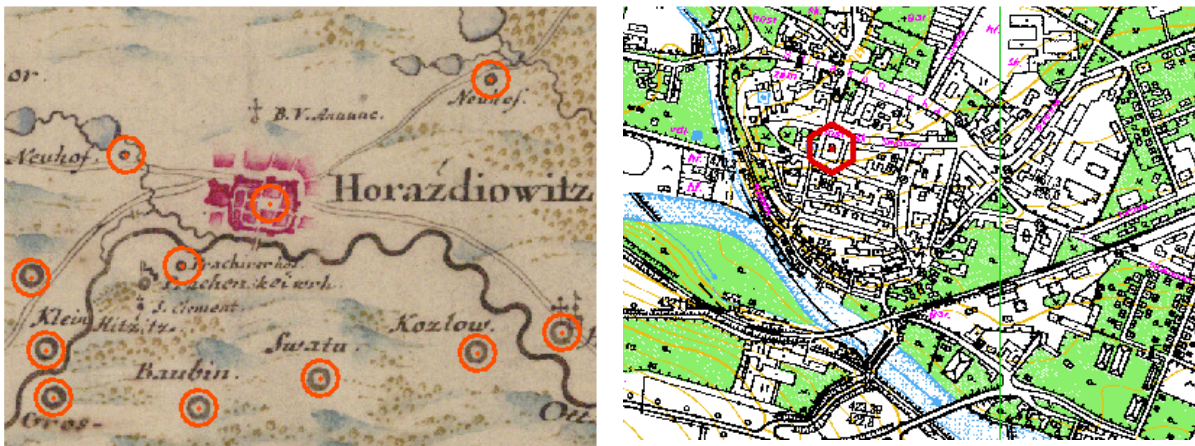
With regard to the content of manuscript Müller's maps, assumed method of surveying (without geodetic control) and unknown cartographic projection it was decided to localize these sheets using identifiable features of planimetric content of manuscript maps.

Coordinates of settlements have been determined by the means of cartometry. Only fortified cities can be located by a centroid very well as e.g. a square center, a cathedral, a church, a city hall eventually a crossing of important roads etc. Due to the fact that centers of medieval cities are very well preserved it is possible to match cartometric coordinates with centroids of settlements which are stored in the database of settlements. Other categories of settlements are displayed on the manuscript maps with a picture symbol equipped with marked centroid of circle shape. Cartometric coordinates of such types of settlements belong to the center of circle symbol.

Several authors consider that construction of Müller's maps was based on the results of astronomical measurements of selected objects. If this idea would be true then astronomically positioned objects should have better positional accuracy. In such a case these settlements could serve as a geometric control for a particular map and other settlements would be added later. This was the reason why the digitalization of the reference points of settlements has been done with respect to the category of settlement.

#### 4. DATABASE OF SETTLEMENTS

For purpose of old maps localization, query functions and displaying functions of web services a Database of Settlements (DBS) was necessary to be created which contains the definition points and settlements' geographical names. This database is based on the Territorial Identification Register of Basic Settlement Units (TIR-BSU) which has been created in 1992-2004. Originally The Czech Ministry for Regional Development was responsible for creating of TIR-BSU. At present TIR-BSU is maintained by the Czech Statistical Office as a part of Register of Census Districts and Buildings (RCDB). Basic input data for DBS were contained in six database files of definition points, in particular definition points of municipalities and military training areas (OBCE.dbf), cadastre units (KU.dbf), urban districts and urban areas (MCAST.dbf), parts of municipalities (COB.dbf and COBE.dbf) and basic settlement units (ZSJ.dbf). During the processing of input files the control of duplicities has been done in order to eliminate inconsistency in data before their importing into DBS. The position of some settlements were improved by their localization in the Base map of the Czech Republic in scale 1:10 000 (ZM10) in digital form.



**Figure 7:** Identification of centroids for fortified settlements

The fundamental part of DBS is the SETTLEMENTS table. This table contains information about basic settlement units including definition points and Czech geographical names. The coordinates of centroids of settlements which are stored inside the DBS are considered as a base for localization of map collection into Datum of Uniform Trigonometric Cadastral Network (S-JTSK) coordinate system with accuracy of ZM10. Next important entity of DBS data model is the table for storing of definition points of settlements located in the Müller's manuscript map series of regions including German geographical names, a type of settlement and other related information [9]. The positions of settlements in S-JTSK were obtained by transformation of cartometric coordinates upon the reconstructed maps of regions. For each region an appropriate transformation key was used. DBS also contains the code list of regions and types of settlements. The settlements appearing in several map sheets are stored with various coordinates and with the code of corresponding region and sometimes also with different names. The settlements behind the boundary of Bohemia are differentiated by special attribute.

Upon the DBS it is possible to make various analyses. The DBS data model is normalized in order to ensure efficient processing of attribute and spatial queries. It is possible to analyse an accuracy of localization of the settlements inside and outside the region. Furthermore it is possible to obtain information about disappearance of some settlements or reversely about origin of new settlements. It is also possible to analyze the growing of particular settlements. By simple SQL query it is possible to get the count of settlements per regions or type of settlements.



**Figure 8:** Portrayal of settlements from DBS via Web Feature Service (WFS)

Comparing the name of the settlement in the Müller's map with actual name taken from TIR-BSU (e.g. Radomißchl – Radomyšl) or investigation whether actual name from TIR-BSU is a translation of the German equivalent (e.g. Schweineßchlag – Sviňovice) can be realized and the information about using of both of German and Czech (completed by letter B) names, e.g. *Bohemice* and *Böemisch* respectively. Another important and interesting issue is a possibility to analyze the extent of German environment in the territory of Bohemia at the beginning of 18<sup>th</sup> century.

## 5. PROJECT CZ\_RETRO

A similar project to the DBS exists in the Czech Republic. It is called CZ\_RETRO – The database of settlements of Czechia, Moravia and Silesia. This project is maintained by The Society for the Renewal of the Village and the Small Town (SOVAMM). The CZ\_RETRO database contains cities, towns and villages which currently exist or existed in the past in the territory of Czechia, Moravia and Silesia. It contains also some castles. Each locality is identified by its unique identifier. The CZ\_RETRO project is a part of the integrated information system of state care of historical monuments maintained by the National Memorial Institute (referred to as NPU) [10].

As a contribution of this project its rich content covering selected time periods can be considered. The disadvantage of the current version of the CZ\_RETRO database could be a flat structure of database which disables to make advanced analyses. Simple selection for publication of selected datasets can be used.

## 6. DBS – FURTHER DEVELOPMENT

The DBS contains mainly the settlements appearing in the manuscript Müller's maps of regions of Bohemia and settlements from TIR-BSU. When taking the time aspect into account it seems to be useful to make a connection between DBS and the CZ\_RETRO database for additional analyses. Such a connection should bring many possibilities for further usage of DBS. There is a preliminary agreement between the authors of DBS and SOVAMM about future cooperation. The structure of DBS is going to be extended to support effective data storage from CZ\_RETRO. After removing of potentially common entries in DBS and CZ\_RETRO and importation of selected data from CZ\_RETRO into its extended structure the DBS will become a powerful source of information about historical evolution of settlements.

## 7. CONCLUSIONS

The result of cartometric analysis of the manuscript Müller's maps of regions of Bohemia is the localization of map series of old maps into the coordinate reference system S-JTSK for their publication in the map portal. For this localization selected settlements like fortified cities and some other types of settlements (displayed by a point map symbol) were used. The database of settlements (DBS) was created with the purpose for possibility to localize the map series without geodetic control and cartographic projection. DBS may be used in search and portrayal functions of web services of the map portal which is still in development. The accuracy of final localization was analyzed and cases of incorrect mapping of some settlements were described. The focus was also put on other content of manuscript maps and the reasons why objects like a drainage pattern, roads and boundaries of administration units or altimetry are not suitable for localization were formulated. As the geographic network was drawn approximately only and cartographic projection has unknown parameters a localization of those map series by means of known positions of settlements was evaluated as the most suitable. Based on the performed analyses it is possible to say that particular categories of settlements are displayed in Müller's manuscript maps with comparable accuracy. The positional accuracy is changing within the area of particular regions. Such areas can be easily determined by means of a cluster analysis.

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