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ENGRAVING OF THE 1647 BATTLEFIELD IN WESTERN BOHEMIA AS A SOURCE FOR THE ANALYSIS OF HISTORICAL LANDSCAPE USING GIS AND DIGITAL CARTOGRAPHY METHODS

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ABSTRACT

Iconographic sources depicting the Thirty Years' War battlefields in the area of current Czech Republic are represented mainly by the contemporary 17th century graphic arts published in Theatrum Europaeum. The research on the engraving of the 1647 battlefield near to the castle Třebel in Western Bohemia aims to reveal possible ways of origin of the sketch and to verify depicted objects and scenes according to their position within an historical context. The paper presents actual results of interdisciplinary studies combining historical approach with cartographic methods and tools for spatial data proceeding focused on digital terrain model representation and information derived from airborne laser scanning, analyses of the scale of the landscape image, identifying probable observation points used during the original sketch for the engraving, and a comparison of depicted objects with their imprint on other cartographic sources.

Keywords: engraving, cartographic analysis, GIS, historic battlefield, Thirty Years War

INTRODUCTION

A pair of engravings of the battle of Třebel is part of a detailed report on the Swedish campaigns in Bohemia at the end of the Thirty Years War in 1647. The report was published in an extensive journalistic work Theatrum Europaeum, issued since 1633 by the Frankfurt engraver and publisher Matthäus Merian (1593–1650). From the beginning, the content of publication was a diverse mix of information about the ancient world, especially about events in Europe. Topics include political, war and geographical articles as well as the reports of social life. Texts were often accompanied by illustrations - engravings, relatively high artistic and documentary value.

During the years 1988–90 and 1999–2004, a systematic archaeological research was conducted at the area of the Třebel battlefield [1]. The research included also the criticism of both engravings by confronting the engravings with a simple field observation. Subsequently, two engravings depicting the fights of Cheb were processed. The work was based on confrontation of engravings with cartographic and written sources [2]. Another engraving, of the battle near the town Teplá, was partially analyzed within a broader interdisciplinary collaboration [3]. Besides field archaeological survey and study of written

and cartographic sources, also the methods of geodesy and cartography have been applied. In a similar manner, using geoinformation technologies, illustrations of battles of the Thirty Years War from some other sites, for example engravings of the siege of Pilsen were investigated [4].

HISTORICAL BACKGROUND

The Thirty Years War was one of the most important themes of the first six parts of the publication Theatrum Europaeum. The Swedish campaigns in Bohemia in 1647 is described in the volumes V and VI. In the early summer the Swedish army under the leadership of General Carl Gustav Wrangel went up from Bamberg in Bavaria to east Bohemia. At the end of June Wrangel conquered Cheb and then defended the occupied city before the siege of the Imperial army, which tried to liberate the town from the Swedish occupation. After a short rest the Swedes advanced further into the heart of Bohemia. On August 13 they arrived to Planá (today in the district of Tachov, the region of Pilsen). About six kilometres behind Planá the Swedes stopped before a deep canyon-like valley of the stream Kosí potok, which intersected the path of Swedish route in the north-south direction. Soon after the arrival of Swedish troops, the eastern edge of the valley was occupied by the Imperial army. Above the eastern edge of the valley the castle named Třebel stood at that time. Therefore, the following conflict is still called the Battle of Třebel.

The two armies faced each other three weeks and built a large system of field fortifications in the landscape beneath the Třebel castle. Until now, the remains of several fortifications have been preserved in the landscape of the battlefield. In addition to numerous smaller skirmishes, Swedish and Imperial troops competed in a several-hour battle on August 22. The battle ended with a convincing victory of either army. However, in early September the Swedes understood that further move to Bohemia is impossible. Therefore, they turned to the north and along the stream Kosí potok dragged toward the monastery and the town of Teplá. Here, on September 9, they again clashed with the Imperial army. Albeit the Swedes won in the battle of Teplá, after the battle they finally retreated back into German territory.

ENGRAVINGS OF THE TŘEBEL BATTLEFIELD

The battlefield of August 1647 near the castle Třebel in western Bohemia is displayed on two time-related engravings. The sketches for engravings were probably drawn by a military officer – a direct participant in the battle of Třebel. The dating of martial images corresponds to the Julian calendar and therefore varies from used Gregorian calendar (introduced in Europe gradually during the 17th century and still used).

The character of both engravings is different. The first engraving (from August 19) shows the overall battle plan in times of relative calm, including landscape context, while the latter one (from August 22) focuses on the fight scene, illustrating the final part of the biggest battles of the entire conflict, when the formation of Swedish troops is turning to retreat Imperial units [1].

Engraving of the state to 19th August 1647

The engraving of dimensions equal to 357 to 240 mm depicts an area of ca 11.5 to 7 km (ca 82 square kilometres), in an oblique view from north-west to south-east. It was published in the Volume VI of Theatrum Europaeum, between pages 4 and 5.

The engraving displays a polygonal cut of landscape roughly between today Planá and Černošín. The plot impresses a faithfully rendered looking at the terrain surrounding the castle Třebel along with neighbouring settlements.

Figure 2 – A polygon area depicted on engraving of the 1647 battlefield near Třebel (the scene dated of August 19th), marked on the current topographic map.

Engraving of the state to 22th August 1647

The engraving of dimensions equal to 342 to 275 mm depicts a much smaller area of ca 20 square kilometres, in an oblique view from the west. It was published in the Volume VI of Theatrum Europaeum, between pages 6 and 7[1].

The engraving displays a polygonal cut of landscape roughly between current villages Zliv and Otín to the west and hills Kamenný vrch and Vlčí hora near today's Černošín to the east. Also this source impresses a faithful plot of the terrain surrounding the castle Třebel. In this engraving, only central part of the battlefield is depicted, which means an area to the north from the Třebel castle. It renders an action of the Empire in which they seized control of several Swedish redutes and footholds to the west of the valley of the separating Kosový potok.

The engraving of 22th August contains significantly less identifiable points and objects usable for georeferencing, thus for further analyses the first engraving, capturing comprehensively the battlefield, has not been used.

THE ANALYSIS OF BATTLEFIELD LANDSCAPE USING GEOSPATIAL TECHNOLOGIES

Source data

To create a digital terrain model, precise airborne scanning (LiDAR) altimetry data in the range of several map sheets were used as input. For other analyses, historical and current maps were used, especially maps of 1st and 2nd military mapping (1763–1785 and 1851–1852, respectively) or topographic sections of 3rd military mapping (1880s); current sources have been represented by raster files of state maps series map sheets or vector geographic data, mainly provided by the Czech Office for Surveying, Mapping and Cadastre. Contemporary sources have been supplemented by high-resolution digital orthophoto. For its clarity, for the purposes of overview maps the Topographic maps 1 : 25,000 (RETM25). Data processing was carried out in ESRI ArcGIS software.

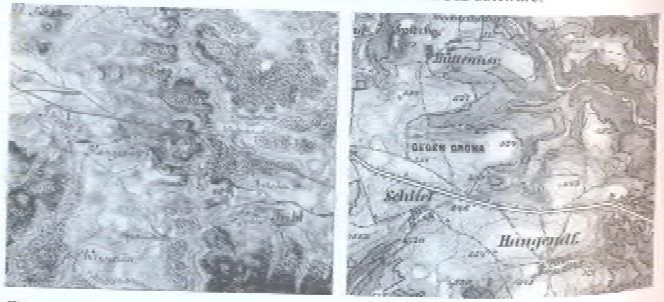

Figure 3 – Examples of the central part of the battlefield in the 1st and 2nd Military Mapping

[1] urn:nbn:de:bvb:384-uba000241-5

Identification of significant elements and georeferencing

For georeferencing, identification and other analyses, the first engraving (from 19th August) has been used. This engraving shows landscape around the castle Třebel and the town of Černošín, where apart from three streams also several settlements and isolated buildings are depicted. Upon closer examination, these settlements, the confluences of streams and two mills also plot are the only suitable objects usable for georeferencing of the engraving and were also used this way. When georeferencing the old map series, the knowledge derived from [5] has been practised. The following Tab. 1 shows results of performed transformations when georeferencing old map series and the engraving itself.

Table 1 – Transformations of used sources and their accuracy

Source	Id. points	Mean square error of transformation [m]
1st military mapping	19	87*
2nd military mapping	31	7*
3rd military mapping	9	16
Engraving	11	295

Digital terrain model

The creation of digital terrain model was facilitated thank to the use of LiDAR data. To achieve the best possible accuracy, only the partially filtered raw data of airborne laser scanning were used, whose density varies from 1.5 to 2 points per square metre. As mentioned in [6], the total RMSE of this scanning doesn't exceed 0.18 m on most types of the vegetation cover. The density of points is naturally lower in afforested areas as lower amount of beams is let to reflect off the ground.

From the data, a triangular irregular mesh has been computed which served as source for further computations. As the most important output of the following processes the raster of hill-shading with resolution of 0.2 metres has been created. The illumination of the shaded raster was chosen from the north-west according to common standards, but to prevent disappearing of objects situated in this direction, the complementary illumination from north-east was combined to achieve a reliable view on all terrain forms and contours.

An analysis of the visibility possibilities generated using the terrain model suggests that the most likely candidate for observational point, from which base sketches of the future engraving could have been created, is Hrotek hill, on which there also the Swedish headquarters was at the same time. It cannot be too much to assume that the former military engineer had free access to the Imperial parts of the battlefield, therefore he probably only watched the scenery from the right side of the Kosí Stream (Kosí potok) valley.

* based on global transformation of a larger set of map sheets

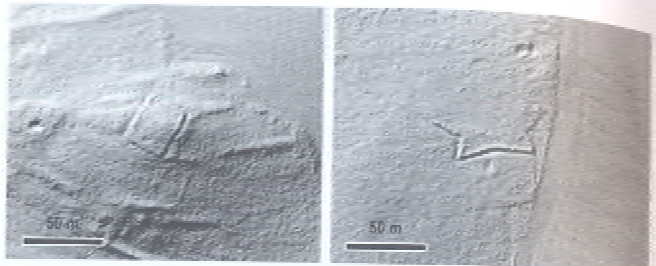

Figure 4 – An isolated Swedish redute and a part of fortification line as identified in the terrain shading raster derived from LiDAR data

Analysis of scale of the engraving

The drawing is rotated about 30 degrees counter-clockwise direction from the north, thus it is oriented approximately north-east. The accurate diversion of various parts of the engraving is difficult to determine because there is a lack of control points closer to the edges of the engraving, but in its central part the diversion is varying in a relatively narrow range from 27° to 34°. For the same reason it is also difficult to accurately determine the

Figure 5 – Approximate scale isolines (in cyan, interval of 200) and indication of positional deformation caused by the transformation of the engraving (yellow lines of 2km interval). Processed in MapAnalyst software.

extent of the captured territory. It is approximately plot in the Fig. 2. Consideration should be given to the low predictive value of the landscape at the edges of the area – it acts here more likely as an illustration of the situation and filling-out the rectangular area ready for processing the engraving by its publisher.

The total scale number of the engraving varies about 27,000 and surprises by its almost constant value size as well as the depiction of the landscape by its generally low distortion (Fig. 5). The overall quality of the engraving shows not only a high level of knowledge and skills of the military engineers of that time but may also indicate the possibility of utilizing older maps or sources (which is less likely) or simple surveying field operations, which had preceded the actual formation of the documentary depiction and could have provided its simple geometric basis.
No evidence documenting the use of older documents, however, survived to the present days as well as sketches which could be used when forming the image of the engraving.

CONCLUSION

The couple of engravings of the Třebel battle represents a certain case apart from the set of documentary engravings of the sites of the then Czech lands of the first half of 17th century. On the contrary – the results determined by analyses largely correspond with similar findings in the majority of the engraving set. It can be deduced, that the author focused primarily on the representation of the military situation and fortification elements (especially on the Swedish side), while the general "topography" of landscape was partially suppressed and only selected details of certain documentary importance have been plot in rendition of the landscape.

Cartographic analyses of the August 19, 1647 engraving revealed that depicted landscape of the battle surprisingly corresponds very well with the real position of topographic elements. The research will continue with application of geophysical methods using magnetometer and georadar which may confirm the existence of other remainders of the Thirty Years' War battlefield.

These include finding a continuation of small sections of the clearances, which were managed to identify in the field. The use of geophysical gauging will try to complete major part of the fortification lines network at least on the Swedish side of the battlefield, because under favourable conditions it is possible to detect the course of such lines that are in the LiDAR data or by simple field reconnaissance already invisible.

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2nd Military Survey, Section Čechy No. W_8_VI, res. 400 DPI, TIFF format

3rd Military Survey, Section No. 4049-4 and 4050-3, res. 300 DPI, JPEG format

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EXAMINING SPATIAL AUTOCORRELATION OF REAL ESTATE FEATURES USING MORAN STATISTICS

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ABSTRACT

Analysis of spatial data often indicate spatial relations. One of the examples of the said relations is so called spatial autocorrelation phenomena. Spatial autocorrelation implies that values of objects located in a close vicinity are more similar one to another contrary to distant objects values. This phenomena favours forming of spatial clusters characterised by similar values. Various measures are used in order to check if selected objects are characterized by similar values of a particular variable. The most frequently used statistics for spatial autocorrelation examination are Moran's I Statistics.

This study aim was to use methods of statistical spatial analysis for examining if spatial relations exist when it comes to distribution of particular morphometric features of landed property. Real estate data, being spatial data type, shall be analysed using methods that are adequate to its character. The following features were subjected to analysis: parcel's surface area and shape. The examination consisted in determining of Moran's I autocorrelation factors (global and local) for analysed real estate features. Based on the determined factors, it was estimated if spatial relations exist and how crucial they are, additionally spatial clusters were defined. Results of the examination were presented on a specially prepared clustering maps, presenting spatial distribution of landed properties, wherein the landed properties were clustered by value with reference to : parcel's surface area and shape.

Key words: real estate features, spatial autocorrelation, Moran statistics

INTRODUCTION

Spatial autocorrelation allows to acquire information on spatial structure of dependencies between objects and on interactions between values of tested variable, wherein the variable is tested for different locations. We can speak of spatial autocorrelation when particular process of one spatial unit influences probability of occurrence of the said process for neighbouring units [1]. According to Janc [2] spatial autocorrelation phenomena is a significant issue when it comes to analysis of spatial data, plus it is an integral part of quantitative methods group, wherein the said methods are comprised within spatial analysis.

Moran statistics is one of the most frequently used statistics for spatial autocorrelation. This statistic takes positive values when tested object are similar, and negative values when there is no similarity between tested objects. For random distribution of objects the values are close to zero [3]. As a consequence of such relation, similar values group into clusters, i.e. spatial grouping occurs. In order to examine spatial relations Moran's spatial correlation factors have been used, global and local. In accordance with [6] Moran's global factor is determined using the following equation: