ARCHAEOLOGICAL SURVEY OF A FIELD FORTIFICATION OF THE THIRTY YEARS' WAR

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ABSTRACT

Our research deals with the possibilities of finding and documenting the historical field fortifications of the Thirty Years' War (1618-1648) in the Czech Republic. The archaeological site that was investigated is located in the western part of the Czech Republic, between Třebel and Vysoké Sedliště villages in Tachov district. Terrestrial laser scanning, winged RPAS (Remotely Piloted Aircraft System) and geophysical instruments GPR (Ground Penetrating Radar) and a magnetometer were used to prospect and document the field fortification. The processed aerial images with a very high geometrical resolution allowed for the discovery of the soil or vegetation marks of the field fortification. Typical RPAS output is an orthophoto in visible or near-infrared range and DSM (Digital Surface Model). Geophysical instruments allow the documentation of objects located beneath the ground surface and can verify possibly detected objects from terrain reconnaissance or from RPAS. Magnetometers enables the detection of subsurface manifestations of the object based on small changes in the magnetic field based on the different magnetism of dissimilar materials.

RPAS and geophysical instruments enable the creation of a comprehensive documentation of archaeological objects, which in our case are the positions of the field fortifications. This paper describes methods of data processing and the results. Processed outputs from each technology are drawn into the plan, and the position and run of the field fortifications were detected and verified; in some cases the results aren't convincing because it was often only a light field fortification such as a trench without any construction parts.

Keywords: RPAS, Digital Surface Model, photogrammetry, GPR

INTRODUCTION

During the second half of the 20th century there was a significant change in the paradigm of the archaeological community. The complex understanding of large sites instead of focusing on detailed excavations wad demanded. Furthermore, non-destructive approaches have been brought to the centre of attention, since they are easily applicable to large areas and, in comparison to traditional archaeological techniques,

cause minimal or no damage to the investigated archaeological source (detailed description of methods in [1]).

Aerial photography and later airborne laser scanning (ALS) have been invaluable tools for archaeological prospection; aerial photography enables to discover manmade structures in the landscape through e.g. crop or soil marks in a deforested landscape and ALS helps in forested areas by obtaining precise digital terrain model (DTM). Discovered objects can be confirmed and mapped in detail by other close range non-destructive methods – terrestrial laser scanning (TLS), ground penetrating radar (GPR), RPAS (remotely piloted aircraft system) photogrammetry and others [2].

Application of previously mention methods in documentation of military objects created before and during Thirty Years' War is described in following sections.

Thirty Years' War

The Thirty Years' War was one of the most important themes of the first six parts of the publication Theatrum Europaeum, issued since 1633 by the Frankfurt engraver and publisher Matthäus Merian (1593-1650). The Swedish campaigns in Bohemia in 1647 is described in the volumes V and VI. 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. Analysis of these engravings was the described in previous work [3], [4].

SITES

Field fortification "Volarské šance"

First presented site is a well-preserved fortification formed before or at the beginning of the Thirty Years' War. "Volarské šance" is a square redute, each side is approx. 41 m long. The fortification relied on earthworks combined with wood, the redute was completed (enclosed?) by two bastions on opposite sides, each with small central depression interpreted as an ammunition dump. The most significant part of the fortification is approx. 6 m wide and up to 2 m deep surrounding ditch. There is another shallow ditch in the inner part of the redute. The fortification has been under archaeological prospection since year 1986 [5].

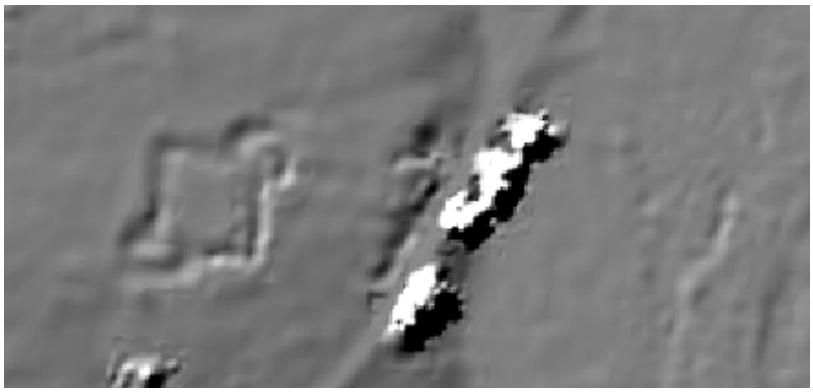

Figure 1. Shaded relief based on ALS, 2011, Czech Office for Surveying Mapping and Cadastre; the shape is very similar to the shape of the redute illustrated in Fig. 2

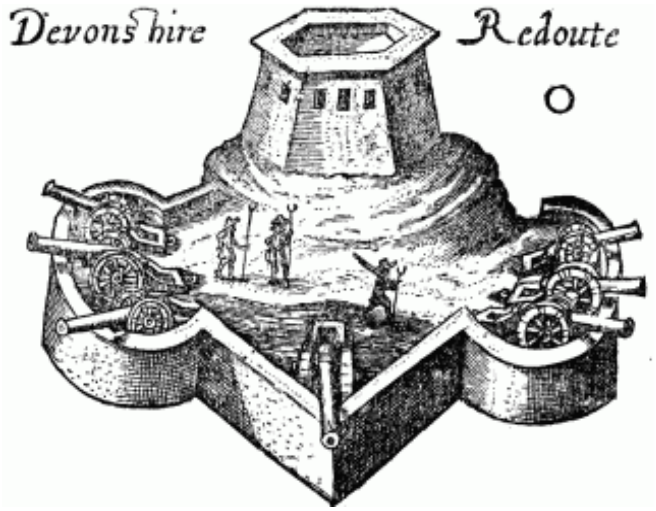

Figure 2. An illustration of Devonshire Redute, Bermuda, 1614, available at: http://www.gutenberg.org/files/14132/14132-h/14132-h.htm#toc_11

Earlier findings were accomplished by terrestrial laser scanning, using GPR and magnetometer.

After reconnaissance in March 2016, the redute and its surrounding was documented by terrestrial laser scanning technology (scanner Surphaser 25HSX). Scans were acquired from 46 different scan stations using tripod. The position of each scan station was chosen with respect to conditions on site (area is covered by forest) to ensure sufficient overlay of neighbouring scans. Data processing part consists of merging individual scans, terrain filtering and TIN (triangulated irregular network) generation. The process and the resulting model are displayed in Fig. 3 and 4.

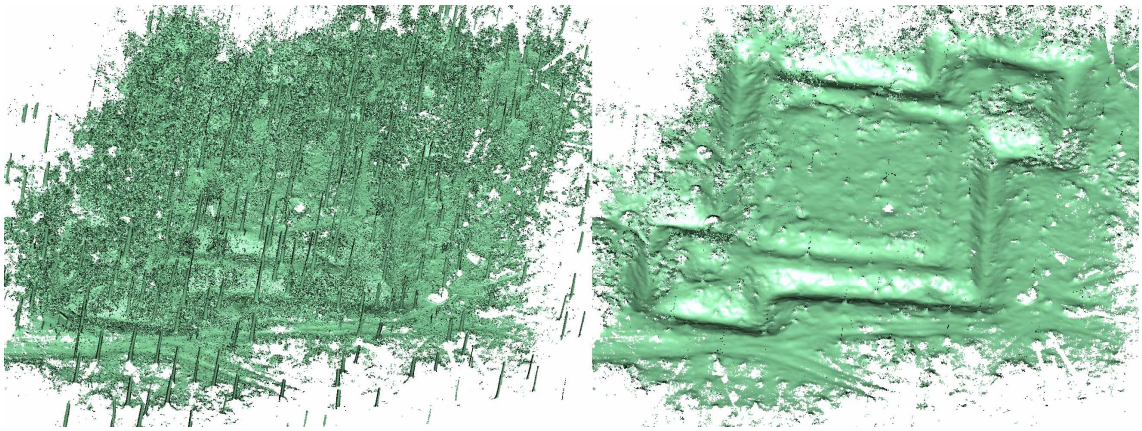

Figure 3. Product of terrestrial laser scanning – point cloud, left: data before elimination of vegetation, right: filtered terrain data (J. Šedina, P. Hanák, K. Pavelka, 2016)

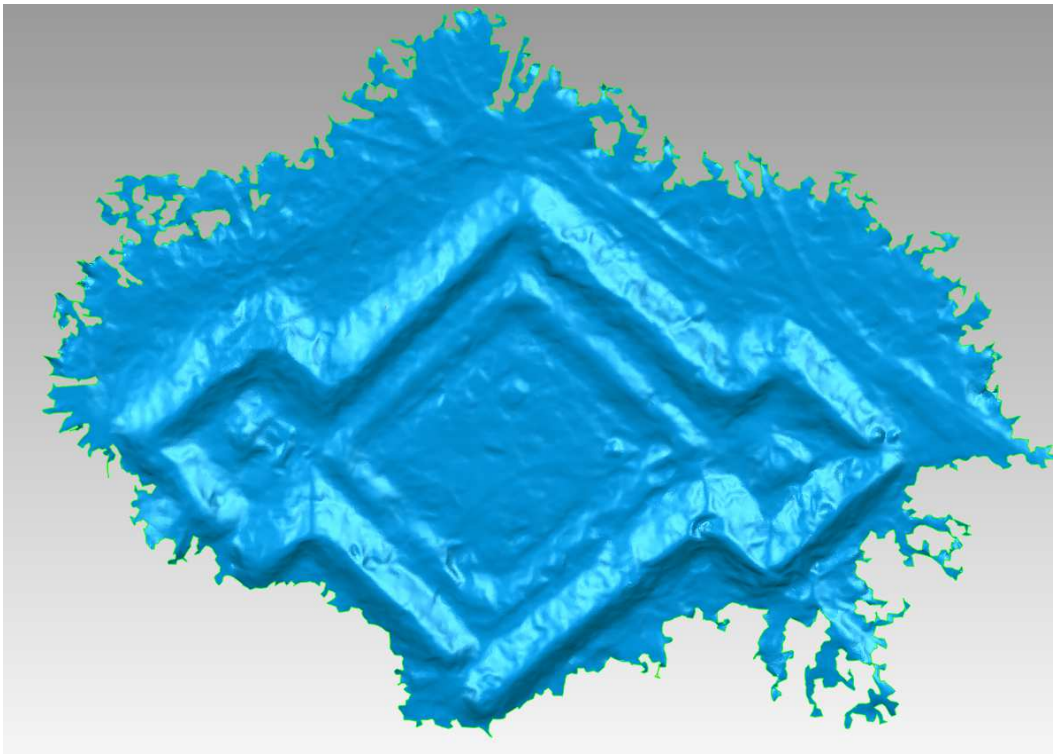

Figure 4. 3D model of redute based on terrestrial laser scanning (J. Šedina, P. Hanák, K. Pavelka, 2016)

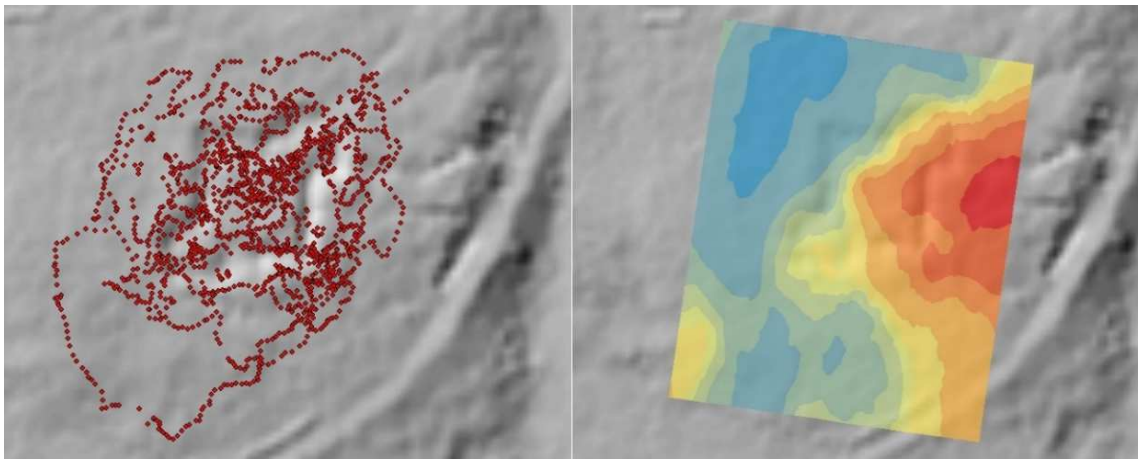

Figure 5. Measurements acquired by magnetometer GSM – 19; left: trajectory of measurement, right: **magnetic field intensity** – displays only the state of sub-soil (J. Šedina, P., Pavelka, 2016)

Additional measurements by magnetometer and GPR were taken. The datasets obtained by ALS and TLS technology provide significant results, contrary to results from magnetometer and GPR, which are unconvincing probably due to material used for construction (soil and wood).

Redute "Svahy"

An imperial redute near the village of Zliv was very well preserved due to its position in area which turned to forest during later time. Redute "Svahy" is a rectangular fortification with circumvallation. It was prospected by GPR and magnetometer, both results confirm that the field fortification was not of a permanent character, it has no internal structure and was probably made only of soil and reinforced by wooden poles. [6]

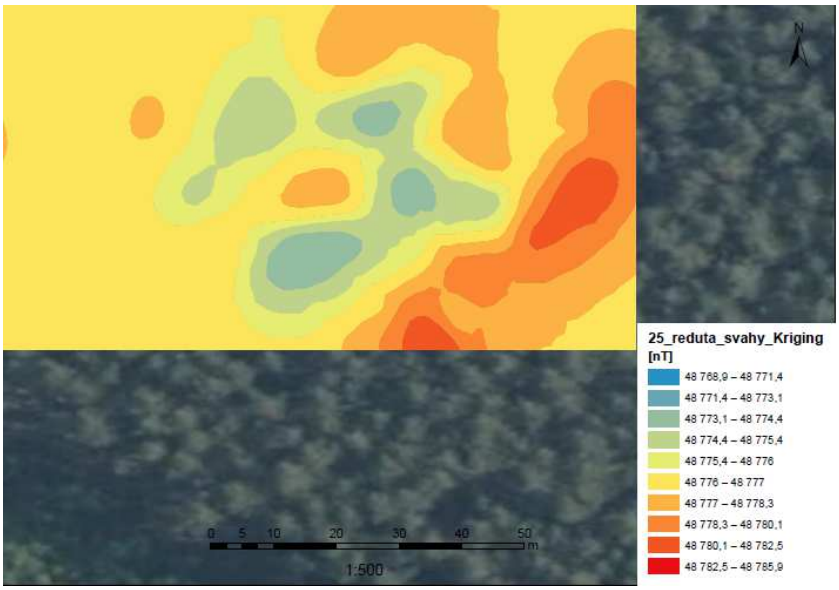

Figure 6. "Svahy" – field fortification and its prospection by gradiometer GSM – 19, background – orthophoto; circumvallation (blue colour) corresponds to the rectangular shape of the fortification (J. Šedina, P., Pavelka, 2015)

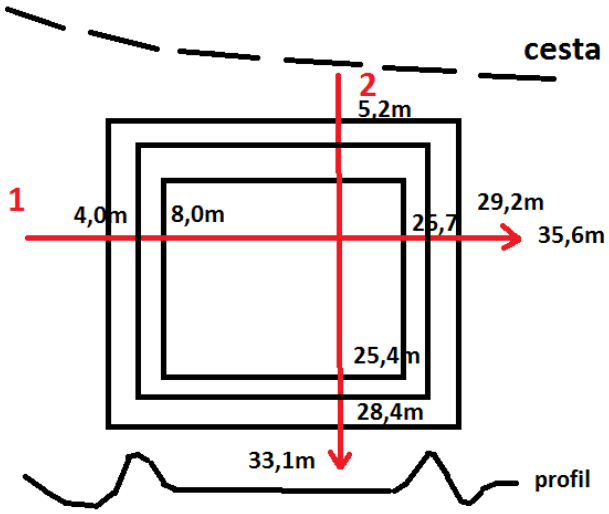

Figure 7. "Svahy" – scheme of the redute, red lines represent profiles measured by the GPR device

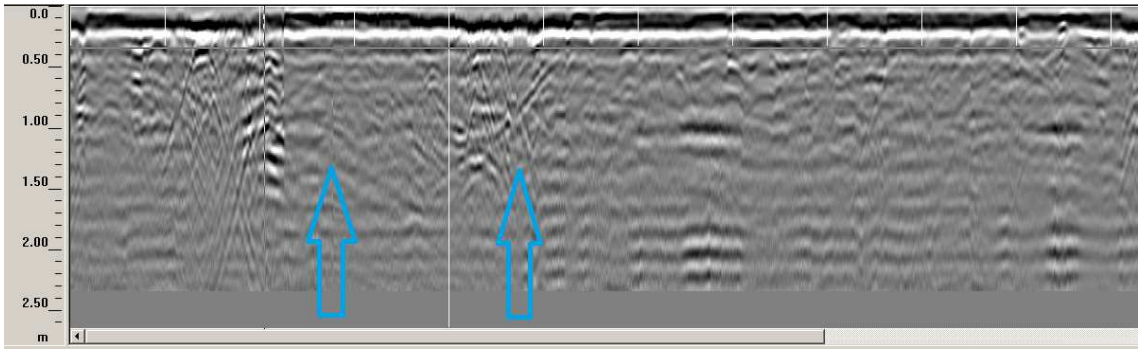

Figure 8. Profile No. 1 measured by GPR – blue arrows mark the local minima and maxima (the bottom and the top of the ditch), white vertical stripes mark each metre; there are no dissimilarities in inner structure of the fortification

Fortification "Zliv – Hrotek" – north from the highway

The site was prospected using RPAS, GPR and magnetometer. The orthophoto acquired by RPAS does not display any vegetation traces, which could help with fortification identification. The dDTM (difference Digital Terrain Model) gives better results. Images from RPAS were used for DTM generation. Original DTM was smoothed and the smoothed model was subtracted from the original one. Resulting model is called dDTM and enables to highlight small terrain variations (fig. 10).

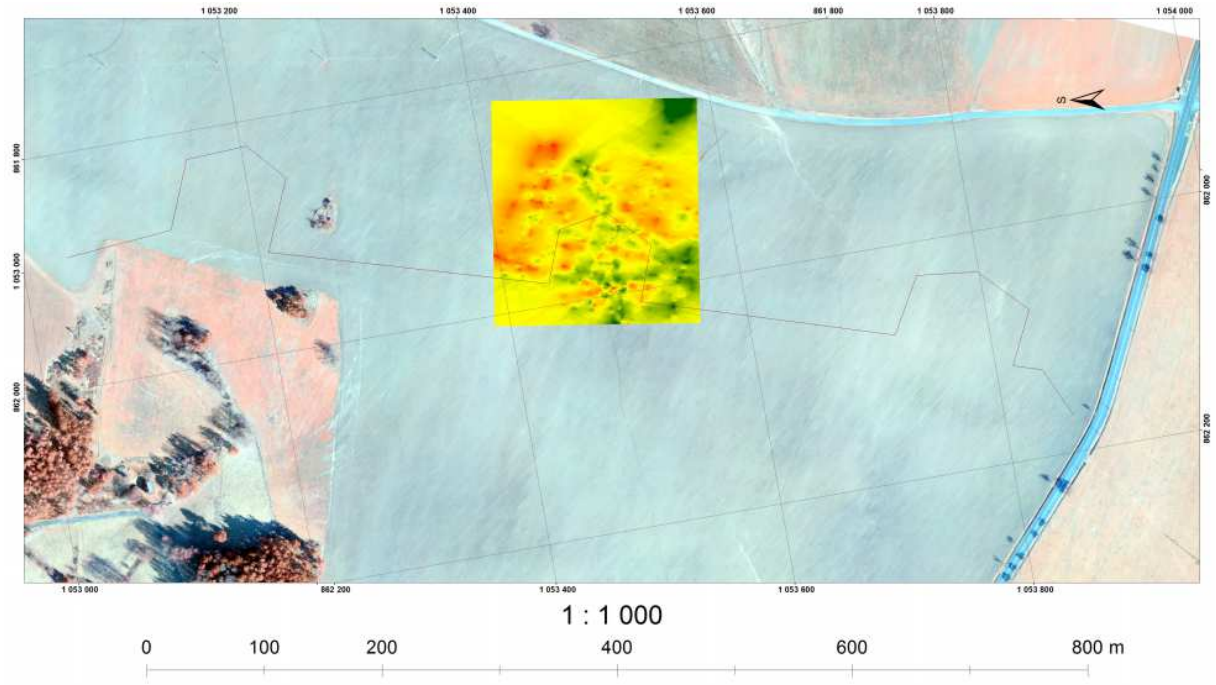

Figure 9. Measurement by magnetometer, background – NIR-GB orthophoto

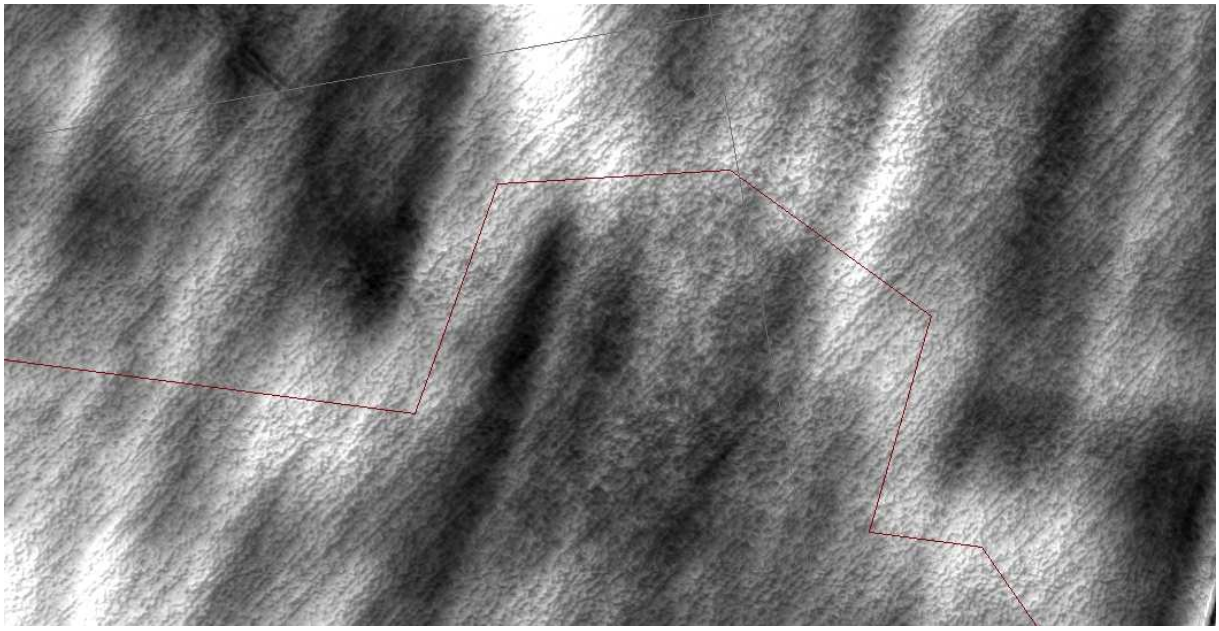

Figure 10. dDTM (difference Digital Terrain Model) obtained by RPAS – probable fortification diagram

CONCLUSION

Laser scanning, RPAS photogrammetry and geophysical methods, as representatives of today's non-destructive methods, were used for prospection of three selected sites. On each site, remains of field fortification were previously found.

The results of using aerial/RPAS photography in archaeology strongly depends on actual situation on the site, e.g. day time, season, vegetation cover and contrast between moisture present in archaeological features and within the rest of the soil. Unfortunately, the factors during the observations were not positive to visibility of soil or vegetation marks. However, cropmarks tend to show up differently particular years, thus repeated photography is a good practice.

DTM based on terrestrial laser scanning or RPAS photography shows its potential on two sites. In the first case, terrestrial LS was used for documentation of well-preserved redute hidden in the forest. The second fortification remains are situated in open field, which enables the use of RPAS photography for DTM generation. This fortification has almost disappeared during years of intensive agricultural use and dDTM was created to help highlight the remaining terrain variations.

The survey by geophysical methods gave the most unconvincing results, which were probably caused by the nature of the fortifications. The documented field fortification was of a temporary character and were formed from on-site material without any internal structure.

ACKNOWLEDGEMENTS

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