Comparison of Soil Erosion Risks from Public Soil Maps with the Reality from Geophysical Surveys of Archaeological Sites in Bohemia

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Highlights:

• Soil and archaeological sites are endangered by agricultural activity in the long-term. A comparison of soil erosion maps with the results of geophysical surveys could help.
• Combination of data could separate different chances for preservation of archaeological terrains.

Keywords: agricultural activity, geophysical survey, landscape change, soil erosion, soil map.

INTRODUCTION

Changes in the intensity, extent and depth of agricultural cultivation lead to continuous degradation and erosion of the soil, playing a crucial role in the physical preservation of subsurface archaeological features, but also affecting the possibilities of archaeological prospection in the future. Changes in the thickness and composition of soil horizons can be monitored using a combination of several field and laboratory methods and current soil maps can be a good starting point. Publicly accessible soil maps include also current maps monitoring various factors of soil erosion and threats to the soil.

The aim of the paper is to present an alternative approach to the process of a two-way comparison of various soil erosion maps and the results of area geophysical surveys carried out at archaeological sites. Data on soil changes can provide a partial answer to questions regarding the presence, absence and sometimes the nature or intensity of the measured anomalies. Likewise, they can also contribute to an evaluation of real chances for reliable prospection at sites affected by soil erosion.

Several public web servers were considered for comparison with the geophysical data. The soil maps from the Research Institute for Soil and Water Conservation in Prague-Zbraslav (https://mapy.vumop.cz/) proved to be of greatest usefulness. The Institute makes available online a wide range of maps focusing on various aspects of water erosion (including long-term average soil loss [G], and slope length and slope factor [LS]), wind erosion, erosion by current tillage, hydrological soil functions, groundwater vulnerability and measures for soil protection.

EXAMPLES OF RESULTS

Different variants of soil maps were compared in greater detail with the results of magnetometer surveys at approximately two dozen surveyed sites. Some indicators turned out to be repeatedly recorded in different soil and landscape conditions. For the three examples selected for this article, the result from the magnetometer was supplemented with displays of the measured area on a base map, DMT

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from LiDAR, details of the erosion length and slope factor map, and erosion by current tillage map. The length factor (L) and slope (S) is a topographic factor that expresses the influence of terrain morphology on the origin and development of erosion processes. It is used to distinguish slopes either more or less prone to soil erosion (on the maps, the most endangered are indicated in pink and purple, the least in blue). This view is based on current agricultural land use, and the map shows the potential loss of soil due to erosion by tillage, which redistributes soil particles depending on the topography of the terrain (Govers et al., 1994; on the maps, maximum soil erosion is indicated in brown and maximum soil accumulation in blue).

**The case of Radim, Kolín district**

The agricultural area between the early medieval Radim hillfort and the remains of a blind terrace was investigated due to the anticipated course of the north-western part of a newly investigated large, double-ditch-fortified site. Rescue archaeological investigation dated this fortification system to the end of the Early Bronze Age (Beneš & Křivánek, 2019). A magnetometer survey confirmed the continuation of the fortification with two gates located in different agricultural areas. The results showed a different spatial distribution and intensity range of the magnetic anomalies (Fig. 1). The flat upper plateau east of the early medieval hillfort formed a bailey, fortified by a single ditch, with concentrated subsurface settlement features within the perimeter. The early medieval ditch is superposed on an Early Bronze Age double-ditch fortification. These ditches can also be traced in the steeply sloped area between the terraces, but without any shallow settlement features to accompany them. The absence of subsurface settlement features, as well as the presence of parts of some linear anomalies in the central, steeply sloped part, fully coincides with the maxima of the combined length and slope factor erosion map and the erosion by current tillage map. The intensity of magnetic anomalies changes on the lower and less sloped ground, where the superposition of the outer early medieval ditch and the Early Bronze Age double-ditch fortification becomes more evident again.

**The case of Chloumek, Mladá Boleslav district**

The north-south oriented hillfort is situated on a prominent promontory jutting out from a large plateau. It was fortified by a massive rampart and an outer ditch; the central inner part of the hillfort is now a cultivated field, and two smaller areas of fortified baileys were later forested. The first

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Figure 1. Radim, Kolín district – area of an early medieval hillfort bailey superposed on an Early Bronze Age double-ditch fortification: comparison of measured area on a base map (a), DMT from LiDAR (b), magnetometer survey result (c), detail of the erosion length and slope factor map (d), and erosion by current tillage map (e) (source: www.cuzk.cz; survey: Křivánek, 2019; surveyed area: approx. 3.1 ha; Sensys 5-channel push-cart fluxgate gradiometer system; sampling interval: 0.5 m x 0.2 m).
fortification apparently dates to the Bronze Age and today's relics of the once massive fortification come from the early Middle Ages. The site was tested archaeologically at the end of the 19th century. The magnetometer result confirmed the varied state of conservation of subsurface archaeological features and revealed two different lines of the internal division of the hillfort (Fig. 2). Several concentrations of magnetic anomalies can correspond to groups of structures. Settlement was probably the most intense on the elevated plateau in the middle of the hillfort, between the newly discovered fortification lines. Significant concentrations of magnetic anomalies are absent from the southern ridge and the northern part of the promontory. The most marked absence and simultaneous decrease in amplitude intensity of the ditch division is then evident at the eastern, heavily sloping edge of the inner area, where the soil was eroded and secondarily redeposited in a depression in the ground. The same area is safely distinguishable in the combined length and slope factor erosion map. The current and more extensive threat to the inner area of the site by soil erosion is shown on the erosion by current tillage map.

**The case of Vlastislav, Litoměřice district**

The Slavic hillfort is situated on elevated and sloped ground above the east bank of the Modla stream in the Czech Central Highlands. The site with three lines of fortifications and intensive internal settlement was partly excavated during the 1950s (Váňa, 1968). Ploughed fields are spread over the entire area of the hillfort. Two internal rampart-and-ditch fortifications were destroyed and scattered by ploughing. The results of a magnetometer survey (Fig. 3) confirmed the very poor state of preservation of all subsurface archaeological features. In the combined length and slope factor erosion map, the most serious destruction of the site coincides with the steepest slopes in the southern and western parts of the area (Křivánek, 2019). The last remains of the internal ramparts were identified only in the flatter and less ploughed areas, especially next to the field terraces. The outer ditches were detected only because of the burned claystone rubble from the destroyed ramparts, which had been ploughed into the depressions. The 1950s archaeological excavations indicated rather intensive
settlement inside the hillfort. However, ploughing has destroyed the bulk of shallow (and perhaps also medium-deep) subsurface archaeological features, and the magnetometer survey did not detect many magnetic anomalies that could be interpreted as images of such sunken settlement features. A current erosion by current tillage map for the area shows that soil erosion is the greatest real threat to practically all of the site.

**Discussion**

Sets of specialised soil maps focused on the evaluation of long-term soil erosion, slope factors and the current risks of agricultural use reflect varying degrees of soil changes in the landscape. Of course, the creation of these maps is time intensive. Therefore, their correspondence to the reality of the eroded terrain is different. In the given examples of comparison with surface magnetometer survey results, the places with an absence of anomalies and subsurface features coincide best with the maxima of long-term average soil washing influenced by the length and slope factor of the ground. By contrast, in the case of the recorded local occurrence of weak-to-fragmented anomalies and features, these best coincide with maps of erosion by current tillage. It would probably be appropriate to use these maps in the future selection of archaeological sites with a high degree of erosion risk, as well as the classification of sites where erosion has already occurred on a large scale.

**Conclusion**

The results and interpretation of geophysical measurements can often be subsequently verified by archaeological research to obtain valuable feedback for future archaeological research. However, the sequence of activities can also work in reverse. At sites already investigated archaeologically, broader geophysical feedback can be obtained for targeted research by subsequent geophysical measurements. However, specific geophysical feedback can also be obtained regarding the real state of archaeological sites by studying agricultural areas through other map data, such as soil maps. A targeted focus on the risks of soil erosion and accumulation can locate in the geophysical spatial data subsurface areas of archaeological sites with either better or worse state of preservation and can also distinguish areas where the more shallow remains are at the greatest risk.
References


