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The potential and limitations of geophysical measurements on archaeological sites partly investigated in the past: case studies from the Czech Republic

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INTRODUCTION

Geophysical measurements at archaeological sites in the Czech Republic (and in former Czechoslovakia) started 65 years ago. The first pioneer resistivity prospection was carried out in 1950 by Prof. F. Běhounek on the middle rampart of the Old Kouřim hillfort and in the context of archaeological research (Šolle 1977). Most of the geophysical surveys before the 1980s were designed to precede rescue archaeological excavations or were carried out in connection with an ongoing systematic investigation of important sites. From the second half of the 1980s, geophysical methods were used to test results obtained from aerial archaeology. In the last two decades, geophysical investigations have been expanded to include monitoring of sites where archaeological investigations have already been carried out, resulting in a modification of the

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ground relief. Most geophysicists will consider such areas unsuitable for surveying (due to the risk of significant changes of measurement conditions). However, the number of such sites is growing, especially large sites where excavations cannot be continued for lack of funds. Non-destructive geophysical (other) surveying will be necessary at many such sites in the future. In this paper, selected sites will be discussed to draw attention to several problems inherent to these methods and their application characterized by varying degrees of effectiveness.

CASE STUDIES

Neolithic roundel near Bylany

Systematic archaeological research started in the settlement area of LBK and STK cultures near Bylany in the 1950s. The newly identified inner double-ditch enclosure of the roundel in the Bylany 4 area was tested in 1980 by M. Zápotocká. Other parts of the inner enclosure and also of the third outer ditch of the roundel were probed in 1991–92 by I. Pavlů. Connected with this were the first two stages of the geophysical survey. The inner double-ditch enclosure was surveyed in 1980 (Faltysová and Marek 1983) and the outer area with the third ditch of the roundel and a new segment of another triple-ditch enclosure in superposition were prospected in 1992–93 (Majer 1995). In 2012–13, the third stage of the magnetic survey was carried out with higher data density and measurement precision over the whole area. The entrances in the ditches of the STK roundel were mapped along with remains of many older LBK long houses in superposition and the second roundel, found in superposition, characterized by a different shape, construction and probably date (Fig. 1). It was also possible to identify the location and scope of earlier archaeological probes as well as typical local concentrations or linear alignments of highly magnetic anomalies (corresponding to metal items). The full scale geophysical survey of the site resulted in the first complete plan of the two Neolithic triple-ditch enclosures. Monitoring of the site after 32 (or 20) years from the present investigations should offer the opportunity of observing the impact of long-term ploughing on sloping ground.

Prehistoric and early medieval hillfort at Hradiště in Pilsen

The hillfort is situated on an elevated plateau between the meanders of the Úhlava river. This strategic location was fortified first in the Bronze Age, then in the Hallstatt and the early medieval periods. The inner area was investigated in the 1930s, when a sand quarry threatened to destroy the site. In the 1960s, the archaeological site was found to be a flat meadow without any visible changes or pits. The main rampart of the fortification was tested again in 2012–13 by a team from the University of West Bohemia in Pilsen (partnerships in research and presentation of archaeological heritage). The results of a parallel magnetic survey of accessible parts of the hillfort confirmed the destruction of at least one quarter of the inner area by the sand quarry (Fig. 2). The subsurface layers in the vicinity of the defunct quarry also appear to have been severely contaminated by metal objects, leaving less than half of the inner area free of recent landscape changes or contamination. The combined magnetic and resistivity measurements confirmed a heavily burnt rampart fortification around the perimeter, damaged in the southeastern part not only by the quarry, but also by a modern road. The geophysical survey traced the actual extent of earlier damage to an archaeological and natural site that is currently under protection.

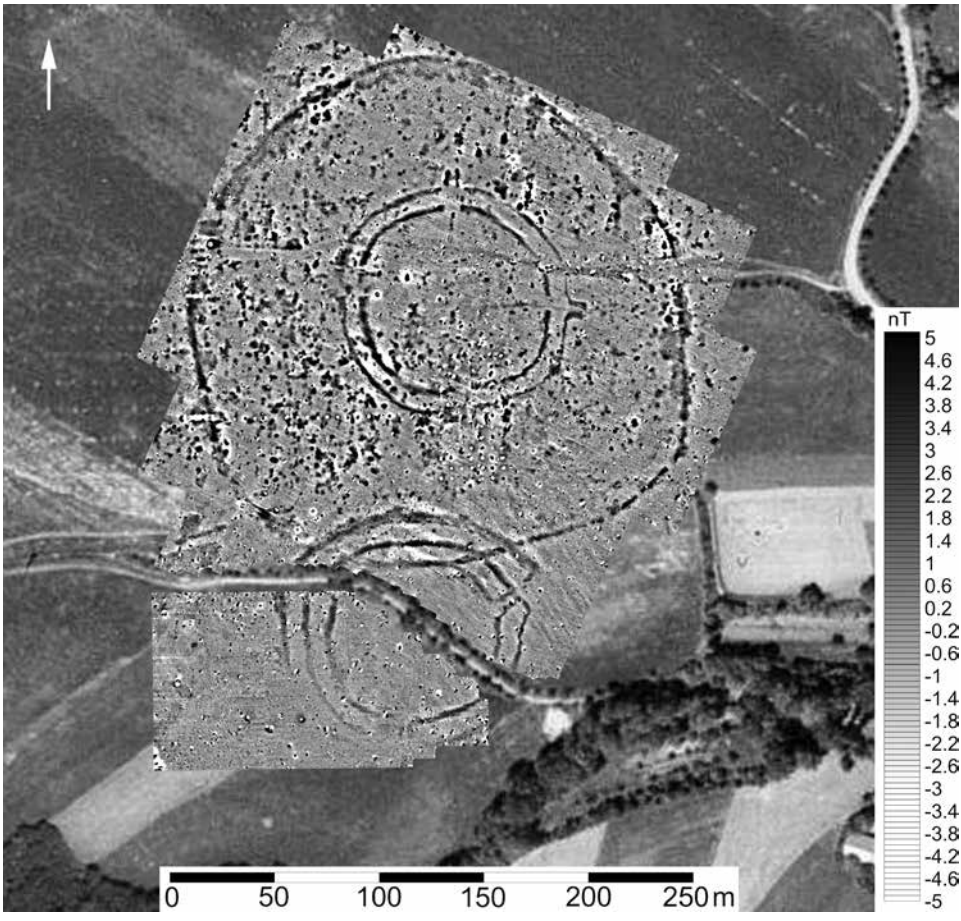

Fig. 1. Bylany, district Kutná Hora. Comparison of old aerial photography from 1954 and geophysical surveys of two Neolithic roundels (source: *http://www.kontaminace.cenia.cz;* surveyed area: approx. 7.5 ha; magnetic survey: R. Křivánek 2012–2013)

Medieval monastery at Podlažice

The Benedictine monastery at Podlažice in East Bohemia existed from the beginning of the 12th century until 1421, when it was destroyed by the Husites and never rebuilt. Only a new church of St Margaret was raised in the central part of the former monastery. The central area near the baroque church was investigated in 1908 and 1909 by prof. J Plaček; subsequently, in 2003, J. Frolík tested the narrow sections next to the St Margaret church. A geoelectric resistivity survey around the baroque church covered all of the accessible area, including earlier excavated ground. A comparison of resistivity results with a plan of the old and new archaeological excavations confirmed the larger extent of the monastery and the destruction of the stone perimeter

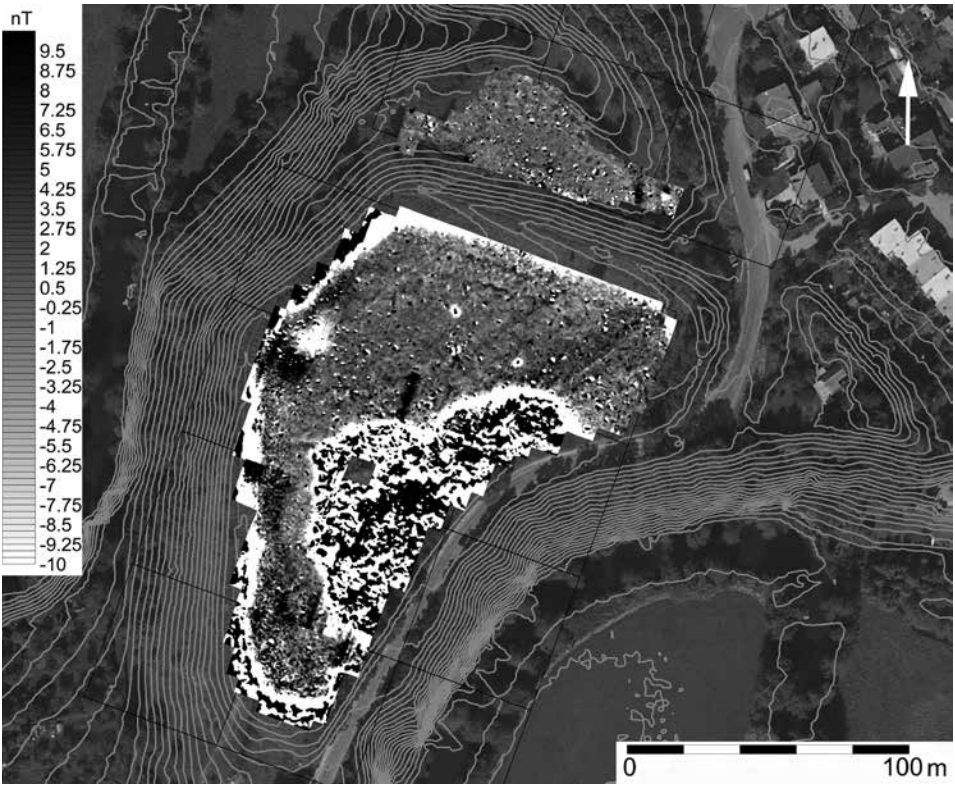

Fig. 2. Pilsen-Hradiště, district Pilsen-město. Comparison of aerial photography and contour plan with geophysical surveys of a prehistoric and early medieval hillfort (source of plan: University of West Bohemia in Pilsen; surveyed area: approx. 1.75 ha; magnetic survey: R. Křivánek 2012–2013)

wall, possible entrances and the original position of the older Gothic church (Fig. 3). Scattered remains inside the monastery showed that a great deal of the stone material from the monastery structures must have been removed following the earlier excavations and there was a landscaping of the area. A comparison of the resistivity results with an old cadastral map also confirmed extensive movement of the stone material to fill an extinct pond and water channel (Křivánek *et al.* 2011). The geophysical survey proved useful in identifying the limits of the former monastery and confirming serious local changes of the subsurface archaeological situation.

CONCLUSION

Each geophysical method has its advantages and limitations when applied to already investigated parts of archaeological sites. The biggest challenge for magnetometry is altered ground without layers preserved *in situ* and contamination of sites by metal items. Similar

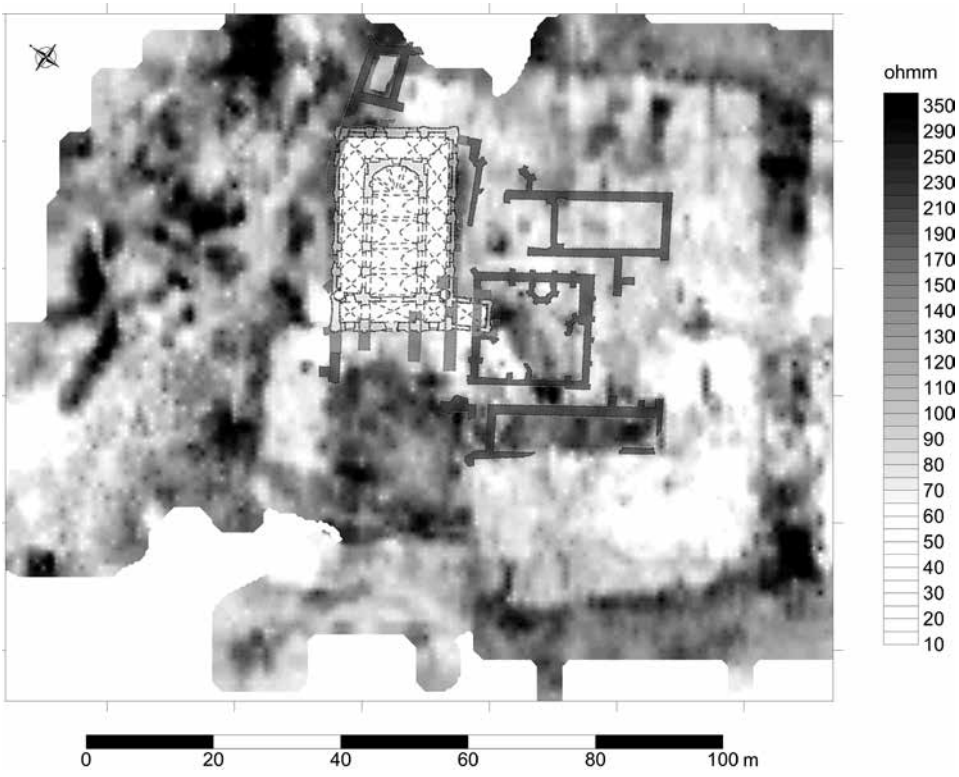

Fig. 3. Podlažice, district Chrudim. Comparison of a plan of earlier investigations and the results of a geophysical survey of a former Benedictine monastery (source of plan: J. Plaček, J. Frolík; surveyed area: approx. 1.1 ha; geoelectric resistivity survey: R. Křivánek 2006–2008)

limitations apply in the case of the electromagnetic method. For the geoelectric resistivity surveys, problems can be caused also by land use changes and modified humidity conditions in the subsurface layers of site. Radar application and its advantages can also depend on the depth and extent of terrain changes and the nature of the bedrock and of surveyed situations. Nonetheless, (post investigation) surveys of archeological sites with partly investigated and changed ground relief are possible in many cases. The extent, quality of results and informative value of particular geophysical method(s) reflect the specific type, condition and land use of the site.

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