Experimental examination of the possibilities of geophysical methods in wooded and rugged terrain: case study of the defunct medieval glasswork Vysoká Jedle in the Ore Mountains

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Abstract
Rugged and wooded terrains of mountains limit possibilities of archaeological prospection. Various production or exploitation areas are typical for Czech mountain regions. Magnetometer survey of medieval glassworks has been standard geophysical method for decades. The other geophysical methods could be also successful in glass furnaces identification or study. Magnetic susceptibility survey with a Multi Kappa instrument observes the state of production feature.

Keywords
archaeological prospection limitation; glasswork; magnetometry; rugged forested terrain; testing of different geophysical methods

Introduction

The mountain terrains of the Czech Republic contain many archaeological remains of specific production, mining areas or communications. However, many such sites are situated in very rugged and forested terrain. These conditions limit possibilities of application, extent of survey and interpretation of geophysical methods (Křivánek 2007).

Nevertheless, there are already a dozen of successful examples of the application of geophysical surveys of production or exploitation areas of iron, non-ferrous metals and tar production sites. However, defunct medieval glassworks belong to the most numerous geophysically investigated production areas.

Goal and methods

High magnetic anomalies caused by significant thermoremanent magnetization of materials in the places of destroyed glass furnaces, but also on glass waste, are typical for most situations at the defunct glasswork (Venclová and Křivánek 2021; Podliska et al. 2021). Different types of magnetometers have been used in the medieval glass production areas for four decades (Křivánek 1998; Křivánek 2001). Several of defunct glassworks have also already been archaeologically verified (Černá and Steppuhn 2012; Černá 2016), when an additional measurement by a kappameter was also used.

The goal of the new complex geophysical measurement was to practically test the possibilities and limits of several other geophysical methods in the case of the defunct Vysoká Jedle glasswork. From the larger area of magnetometer measurement (with a five-channel fluxgate gradiometer Sensys in a network of 0.25 x 0.2 m), a segment of the area 15 x 15 m above the place of the supposed relict of the glass furnace was deliberately selected (Fig. 1). Considering the sloping terrain with mature trees and

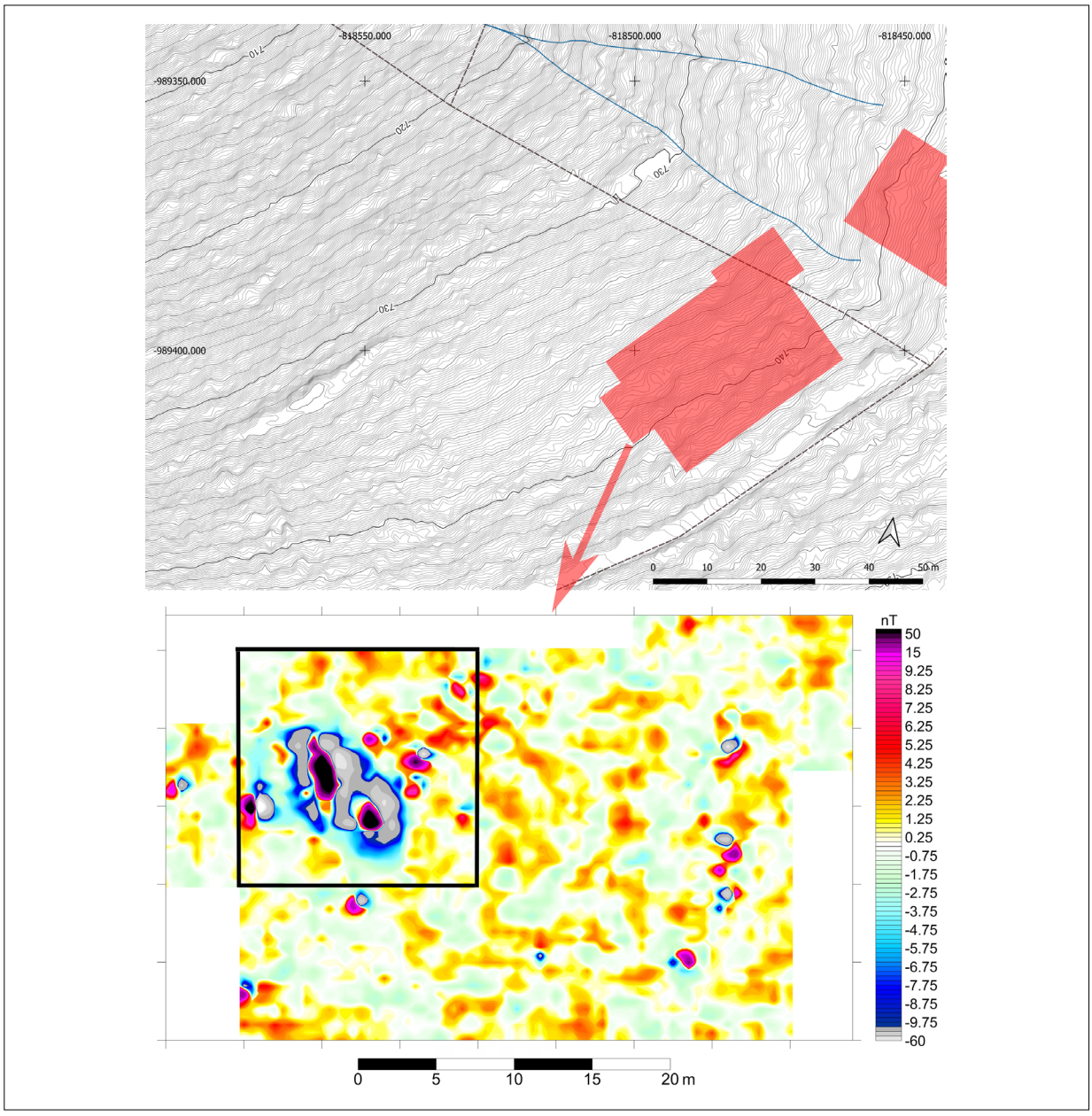

Fig. 1: Example of location of glasswork in variable terrain of Ore Mountains with magnetometer survey result. Red – area of magnetometer prospection, black line – detail for complex measurements.

many scattered stones, the area was repeatedly measured only in a 1 x 1 m grid. A repeated survey was carried out by a resistivity measurement (RM-15, Geoscan Research), an electromagnetic measurement of apparent conductivity and magnetic susceptibility (EM-38B, Geonics), and two depth levels of 0.5 m and 0.25 m of magnetic susceptibility (apparatus Multi Kappa, GF-instruments). The surveys were also supplemented with test measurements by GPR (Cobra-Wifi II, Radarteam) on several available profiles.

Results

The potential of various applied geophysical measurement methods can best be seen from a mutual comparison of the results of an identical examined area with a uniform profile orientation (Fig. 2). Heavily burnt materials from the destruction of production features of the glasswork (and one place of metal additionally confirmed by a detector survey) can be seen both in the results of magnetometry,

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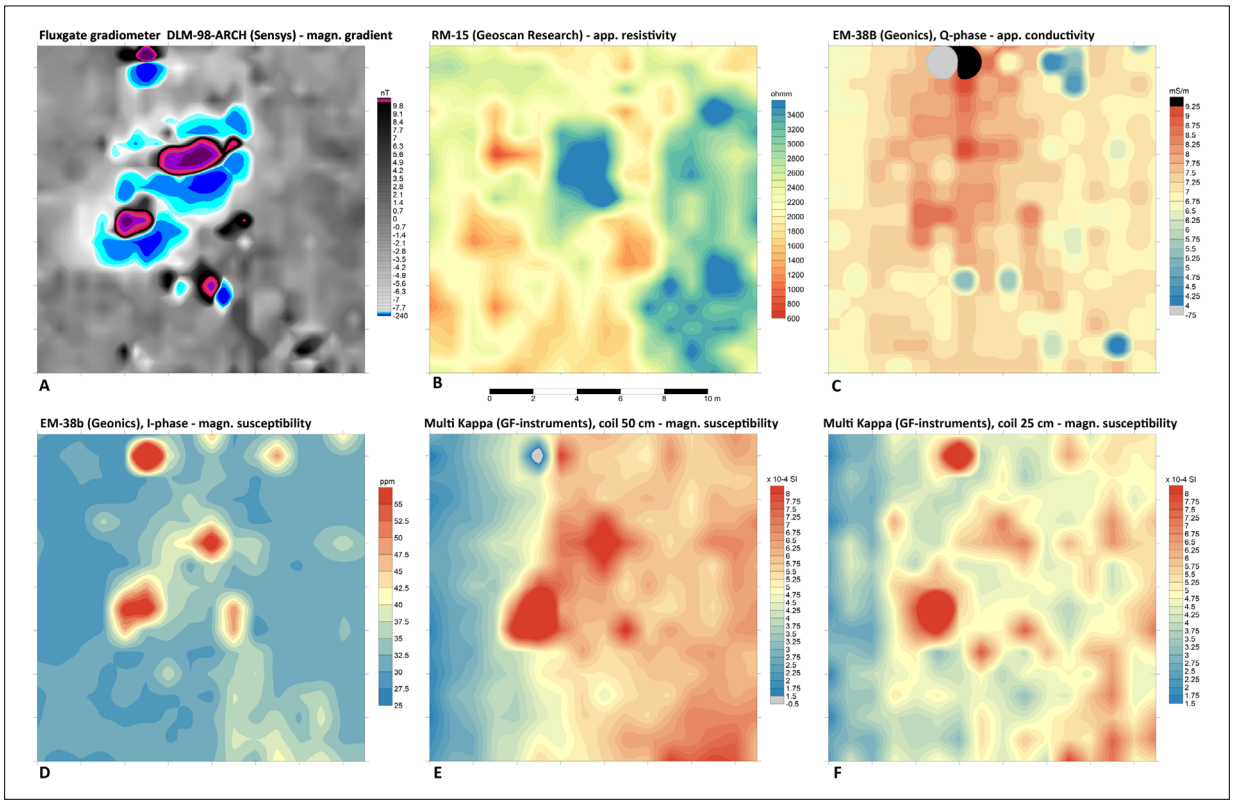

Fig. 2: Comparison of the results of different applied geophysical methods. a) detail of fluxgate magnetometer measurement, b) resistivity, c) EM-conductivity (Q-phase), d) EM-magnetic susceptibility (I-phase), e) magnetic susceptibility from Multi Kappa and coil 1 m dimeter, f) magnetic susceptibility from Multi Kappa and coil 0.5 m diameter. tometer prospection, black line – detail for complex measurements.

in the results of the I-phase electromagnetic measurement and in the results of the magnetic susceptibility with the Multi Kappa instrument. The changes in magnetic susceptibility reminiscent of drift (Fig. 2 e or 2 f) were caused by changes in the sloped relief and contamination of a part of the surface by glass production waste. Stone destruction from the construction of the glass furnace can best be seen in the result of the resistance measurement, less so in the result of the Q-phase electromagnetic measurement. From the difficult-to-realize profile measurements by radar, only on a few profiles across the elevations with the destruction can we detect significant reflections at the base of the disappeared furnaces (Fig. 3).

Discussion

I-phase measurement of magnetic susceptibility by EM-38B has a maximum depth penetration of about 75 cm. In case of Vysoká Jedle site we used Multi Kappa coils with maximum depth penetration 50 cm and 25 cm. This combination could bring us information about the subsurface state of preservation of burnt features (and on the dispersal of burnt waste material). In case of destroyed glasswork it can identify the most heated center (probable heating channel) of glass furnace. Remarkable changes in results of apparent resistivity and minor changes in Q-phase electromagnetic measurement of apparent conductivity we can explain by different influence of local terrain relief changes (stones) on contact (electrode) and non-contact (coil) measurement. For profile measurements by radar on a given type a significantly rugged site (with many of stones on the surface), the possibilities of effective measurements were very limited, even from the point of view of the interpretation.

Conclusion

The presented comparison of experimental measurements shows the well-known fact that strongly fired production features can be reliably identified both in the results of magnetometry and in the results of various magnetic sus-

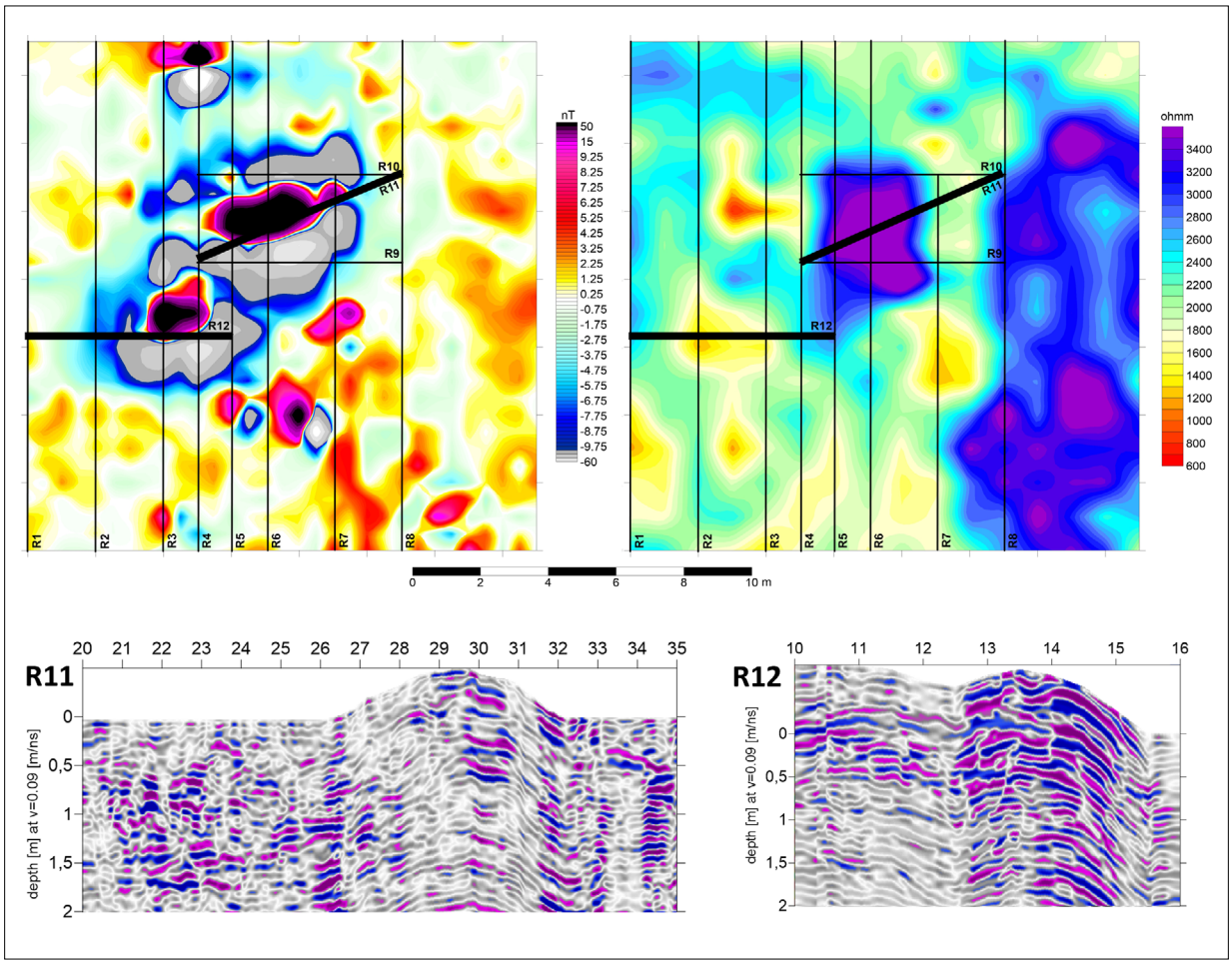

Fig. 3: Example of comparison of the results of the detail of fluxgate magnetometer measurement and two profile measurements by GPR (black lines) over accessible terrain elevations of glasswork.

ceptibility measurements. By combining several methods of measuring magnetic susceptibility with different depth penetration, we can monitor the state of preservation of the feature and the changing range of fired components. Contact resistance measurement is the most suitable for assessing the extent and quantity of the stone construction of production features. Electromagnetic conductivity measurement or radar measurement in rugged, forested and variable stony terrain is locally affected by terrain changes and the state of surface preservation of the production feature and can be more beneficial under conditions of more homogeneous and less rugged terrain of sites.

References

Černá E, Steppuhn P. Glasarchäologie in Europa: Regionen - Produkte - Analysen : Beiträge zum 5. Internationalen Symposium zur Erforschung mittelalterlicher und frühneuzeitlicher Glashütten Europas, Seiffen - Erzgebirge 2012. Most: Ústav archeologické památkové péče severozápadních Čech; 2014. 303 pp. German.

Černá E. Středověké sklárny v severozápadních Čechách : přínos archeologie k dějinám českého sklářství = Mittelalterliche Glashütten in Nordwestböhmen : Beitrag der Archäologie zur Geschichte des böhmischen Glashüttenwesens. Most: Ústav archeologické památkové péče severozápadních Čech; 2016. German/Czech.

Křivánek R. Ergebnisse geophysikalischer Messungen von mittelalterlichen Glashütten im Erzgebirge. In: Materialhefte zur Archäologie Band 41, Unsichtbares sichtbar machen - Geophysikalische Prospektionsmethoden in der Archäologie, Kolloquium vom 27. Oktober 1994 in Leipzig. Landesdenkmalamt Baden-Württemberg, Stuttgart: Kommissionsverlag, Konrad Theiss Verlag; 1998. p. 147-159. German.

Křivánek R. Specifics and limitations of geophysical work on archaeological sites near industrial zones and coal mines in NW

Bohemia. Archaeological prospection. Vol. 8. John Wiley & Sons, Chichester - editors: Pollard, A.M. - Aspinall, A., University of Bradford 2001: p. 113-134.

Křivánek R. Possibilities and limitations of surveys by caesium magnetometers in forested terrains of archaeological sites. Študijné zvesti Archeologického ústavu SAV 41, 2007; Archaeological Prospection (I. Kuzma ed.) - Topics and Abstracts, 7th International Conference on Archaeological Prospection, 2007 Sep 11-15, Slovakia:Nitra; 2007. p. 202-204.

Podliska J, Černá E, Zlámalová Cílová Z, Kozáková R. Sklo z archeologických výzkumů: archeologie, technologie a metody průzkumu, konzervace a restaurování = Glass from archaeological excavations : archaeology, technology and methods of survey, conservation and restoration = Glas aus archäologischen Grabungen : Archäologie, Untersuchungsverfahren und -methoden, Konservierung und Restaurierung. Brno. Technické muzeum v Brně; 2021: 250 pp. German/Czech.

Venclová N. (with contribution of Křivánek R.). Němčice and Staré Hradisko: Iron Age glass and glassworking in Central Europe. Přeložil David Joseph GAUL. Praha: Archeologický ústav AV ČR; 2016: 317 pp.