EXPLORING INTEROPERABILITY OF ARCHAEOLOGICAL AND AGRICULTURAL GEOPHYSICS. THE CASE OF EAST HESLERTON.

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Introduction

Over the past decades, technological innovation has revolutionised archaeological prospection, by enabling large-area geophysical surveys (e.g. Powlesland, 2006), and farming practice, through proximal soil sensing (Adamchuk and Viscarra Rossel, 2011). Hereby, both disciplines have deployed similar methodologies and encountered comparable challenges. While mutual benefits have been identified (Webber et al., 2019), truly interoperable archaeological and agricultural survey, requiring common (meta)data standards and workflows, is still afar. The Interoperable Precision Agricultural and Archaeological Sensing Technologies Project (ipaast-czo) pursues this by integrating in-place systems, stakeholder- and user surveys, workshops and interdisciplinary case-studies.

One case-study is East Heslerton, where Powlesland (2006) revealed an Iron age-Roman ladder settlement, Anglo-Saxon *Grubenhäuser*, and various fluvial features using magnetometer survey (MAG) (Fig.1-Right). Complementing gridded borehole survey mapped ploughsoil and sandy aeolian overburden thickness (Fig. 1-Left). To evaluate how archaeological prospection sensor data serve agricultural services, and vice versa, a multi method study focused on frequency domain electromagnetic (FDEM) induction and gamma ray survey.

Methodology

While in precision agriculture FDEM sensors are often used for creating management zones primarily based on the outputted apparent electrical conductivity (ECa), the in-phase magnetic susceptibility (IP-MS) is often also of interest for archaeological prospection (e.g. De Smedt et al. 2022). Because of this common interest, FDEM was selected, despite differing field and processing practices in both applications. Data were collected with a Dualem 21HS instrument at 1.2 m between- line spacing, and processed following Hanssens et al. (2020) to produce ECa and IP-MS maps. These were then used to develop a stratified random sampling scheme (Minasny and McBratney, 2006) linking electromagnetic variations to standard physicochemical soil properties. For all samples texture composition, OM, CEC, CaCO3, pH_KCl, P, K, Mg, Ca and C/N were quantified, alongside lab magnetic susceptibility (Bartington MS2B). Based on the ECa and IP-MS, agricultural management zones (AMZ) were defined using K-means clustering.

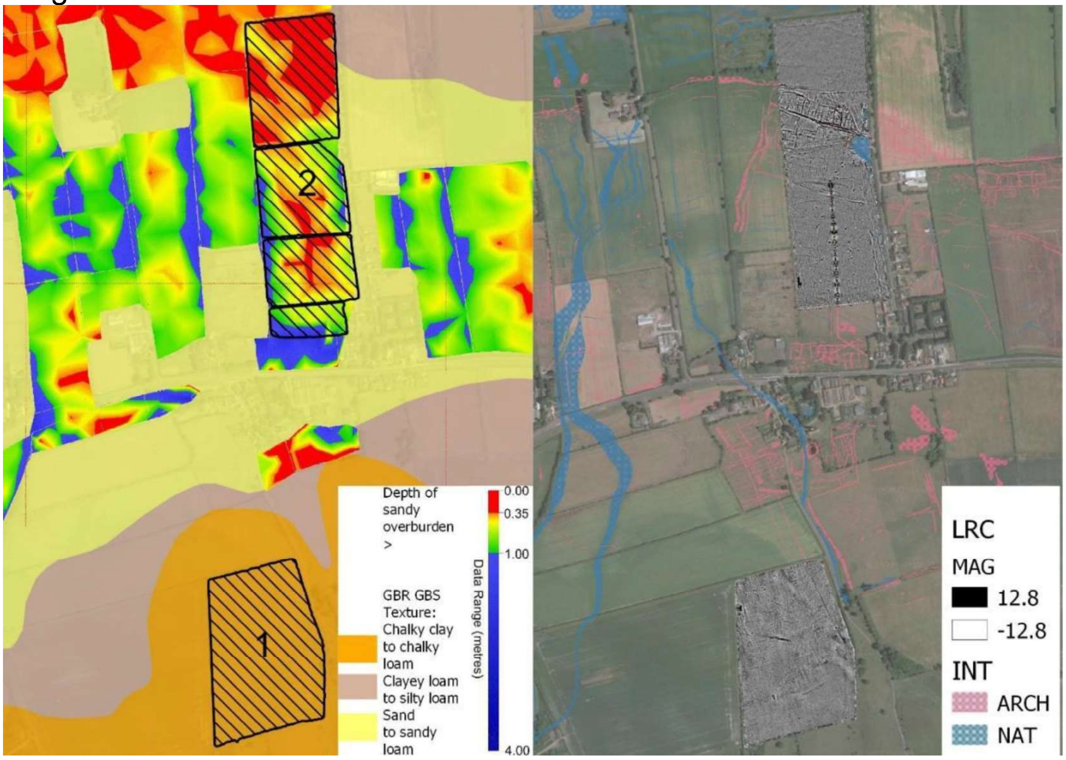

Figure 1: Left: Survey areas (dashed+numbered) and thickness of the aeolian sand deposits. Background: BGS Parent material-soil texture; Right: LRC MAG results and interpretations.

Results and discussion

Grubenhäuser appear as discrete, strong magnetic enhancements (e.g. Fig.2-Center: MS_4), both on the slopes and sandy valley floor. Linear enclosure ditches on the slopes (MS_5) exhibit lower IP-MS than to the drainage dyke, trackway- and enclosure ditches of the ladder settlement (MS_9). The latter exhibit increased ECa, indicating finer/organic infill (EC_7).

In area 1, the ECa reveals the variable bedding lithology and fault lines of the chalky geology of the valley slopes (Left: EC_1). Locally, these have been eroded by fluvial and/or slope processes resulting in a large dry valley with a low ECa (EC_2), indicating a coarser texture. The IP-MS is lowest on top of a steep ridge between two valleys (MS_1), representing a shallow/eroded topsoil. Downslope, increased IP-MS and ECa reveal where finer deposits have colluviated (MS-2, EC_3), while the dry valley also exhibits subtly increased IP-MS (MS_3).

In the area 2, the valley floor has very low ECa in the south, indicating the presence of coarse, dry sands (EC_4). The northern half is more conductive, suggesting finer and/or more waterlogged sediments (EC_5). A paleochannel contributes the highest ECa indicating loamy/organic rich soil conditions (EC_6). The large scale IP-MS seems to increase with a thicker sandy overburden (MS_8) compared to e.g. MS_6/MS_7. The differing spatial variability with the ECa suggests that the sandy sediments consist of a more magnetic overburden and less magnetic underburden.

Alternatively, the magnetic enhancement results from human land use, since it is higher near the ladder settlement and current town.

Compared to MAG, FDEM results contribute new information layer about soil and geology, which is valuable both in reconstructing archaeological landscapes; guiding soil sampling and creating AMZ.

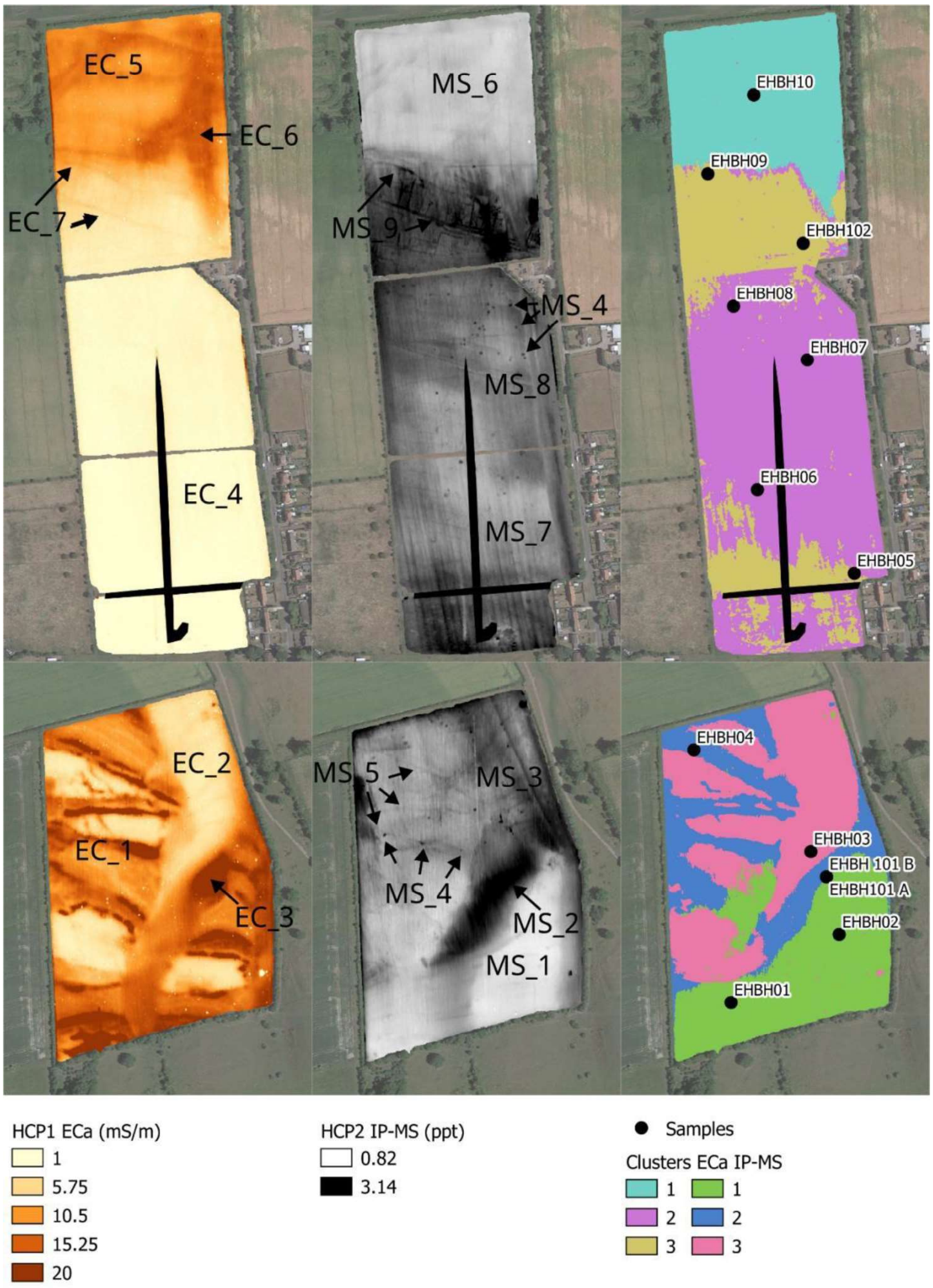

Figure 2: Left: ECa dataplot in 1 m HCP coil configuration; Centre: IP-MS dataplot in 2 m HCP coil configuration; Right: Sample locations and delineated management zones.

K-means clustering of the IP-MS and ECa classified each field in to three clusters, usable as AMZ (Fig.2-right). Texture analyses of the samples revealed textures from sand to clay-loam. A relatively good correlation (R= 0.71, p=0.071) was observed between low frequency MS and Phosphorous content (Fig. 3) within area 2, but was absent in area 1. The sample's mineralogy is under analysis to determine the origin, but this suggests IP-MS as phosphorous proxy.

Conclusion

This project demonstrates how a single multi-use dataset can be collected by surveying at a high spatial resolution, employing appropriate calibrations, and integrating physiochemical soil analysis.

Importantly, precise drift removal enabled archaeological IP-MS interpretations and established IP-MS as a possible predictor of P content. Furthermore, soil/geological variability is mapped in ECa and IP-MS, making gridded augering or sampling superfluous for mapping these variations. Instead, these should be implemented in a targeted manner.

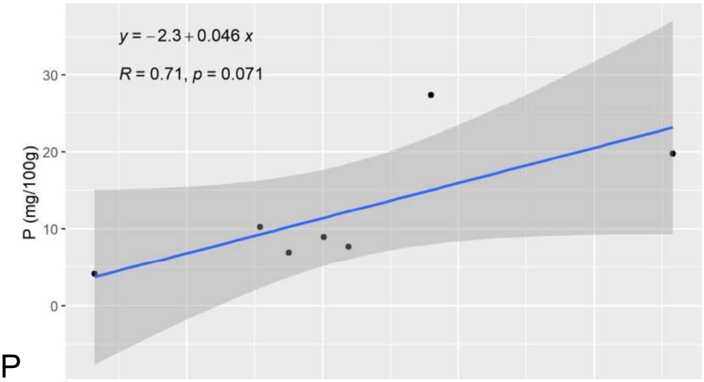

Figure 3: Linear regression plot between Low Frequency MS and Phosphorous content of the area 2 samples

This highlights the potential practical benefits of a collaborative approach: sharing costs between stakeholders in agriculture, environment and archaeology could make acquiring higher resolution, better quality soils data practical for all.

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