A GEOCHEMICAL STUDY OF BOLEHILL, RINGINGLOW, SHEFFIELD.

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The use of geochemical survey to identify and delineate activity areas on archaeological sites is well established in archaeology (Oonk et al 2009, Wilson et al 2008, and references therein), yet its use remains infrequent in routine fieldwork and especially in commercial practice. This is due to a number of factors including time and cost but the uncertainty that surrounds the meaning of geochemical variation is also an important issue to acknowledge in explaining its absence in most work. The processes and mechanisms by which soil is modified by human action is still poorly understood (Wilson et al 2008, Entwistle et al 1998, Middleton and Price 1996) yet geochemical patterning has been recognised as providing valuable insights into how past communities have spatially organised a range of activities (Haslam and Tibbett 2004). Interpretive challenges are not restricted to soil ecology but include basic understandings of how specific human practices imprint themselves on open soil contexts.

Conventional geochemical analysis operates with restricted sample numbers due to limitations of sampling time and costs of analysis. For these reasons it has rarely been employed to identify spatial patterning at a level of resolution commensurate with human practice, instead being used for broadly descriptive programs of soil characterisation. The ability of HHpXRF to undertake rapid analysis in a cost efficient manner means that such technology when used within an appropriate method and research framework can present new datasets for the archaeologist especially in the domains of research and cultural resource management.

Several scholars have noted that chemical elements vary in their interpretive value (i.e. Wilson et al 2008, Aston et al 1998) with most agreeing that the elements with the greatest potential to aid archaeological studies are: P, K, Ca, Cu, Zn and Pb. Although acknowledging the utility of these elements is an important first step, there remains an interpretive gulf in how their enhancement might relate to practice beyond broad categories of human activity. For instance, the work of Wilson et al (Wilson et al 2008) has done much work with ethnohistorical sites to demonstrate the relation between types of practice and soil chemistry yet in archaeological contexts soil chemistry is most frequently used to highlight increased human activity or simply the presence of 'archaeology' (Bintliff et al 1992).

A notable exception to such activities is non-ferrous metalworking (i.e Cu, Pb) and agricultural/disposal/fire-related processes which have enhanced phosphorus (P). Whereas the wide range of human activities might enhance heavy metal concentrations by small amounts the practice of metallurgy has the potential to enhance soil copper and lead (and other elements) significantly and certainly well beyond crustal or background levels. The characterisation of working areas has been accomplished through systematic soil sampling and laboratory based analysis (Grattan et al 2007, Andrews and Doonan 2003;42-44, Derhan et al. 2013). This is especially powereful when used in combination with geophysical survey (Doonan et al 2003).

New generation HHpXRFs offer the advantage easy portability with rapid sampling of multiple samples either in-situ or ex-situ. The advantages of the HHpXRF are its ability to undertake rapid sampling of multiple specimens and to provide data in real time to inform survey, excavation and wider field strategy, something not permitted by processes that involve the export of samples and subsequent laboratory processing (Frahm and Doonan 2013).

Bolehill, Ringinglow, Sheffield (N53.3473, W1.5455)

The survey reported here is centred on a field cared for my Whirlow Hall Farm and currently being investigated archeologically by ARS and Time Travellers. Recent geophysical survey has shown the presence of a rectilinear enclosure suggestive of a Roman period signalling station.

Apart from the obvious indication for lead metallurgy from the toponym, the presence of northerly aligned dipoles on the geophysical survey coupled with the exposed nature of hilltop suggested that lead metallurgy or bole smelting may have been practiced at the location.

To test this hypothesis, a campaign of in-situ geochemical analysis was undertaken using a NITON XL3T HHpXRF (50kV X-ray tube, and an Ag anode with a silicon positive intrinsic negative (Si PiN) detector). Survey involved a program of shallow coring (4cm Ø x 10cm) with cores being cleaned and extracted for subsequent analysis. In-situ analysis was conducted on the B horizon using the 'Main' filter for 32seconds in soil mode. Standard certified reference materials were used as a check on accuracy and precision. The following elements were Mo, Zr,, Sr, Rb, Pb, As, Hg, Zn, Cu, Ni, Co, Fe, Mn, Sb, Sn, Cd, Pd, Ag, Nb, & Bi.

Analytical Performance

Prior to undertaking field analyses a number of certified reference soils were analysed to determine the accuracy of the instrument under ideal conditions. The performance of HHpXRF is now well established for most heavy metals (Macrona Forthcoming, Doonan et al. Forthcoming) and the correlation graph shown in Figure 1 shows the results of a recent study on P.

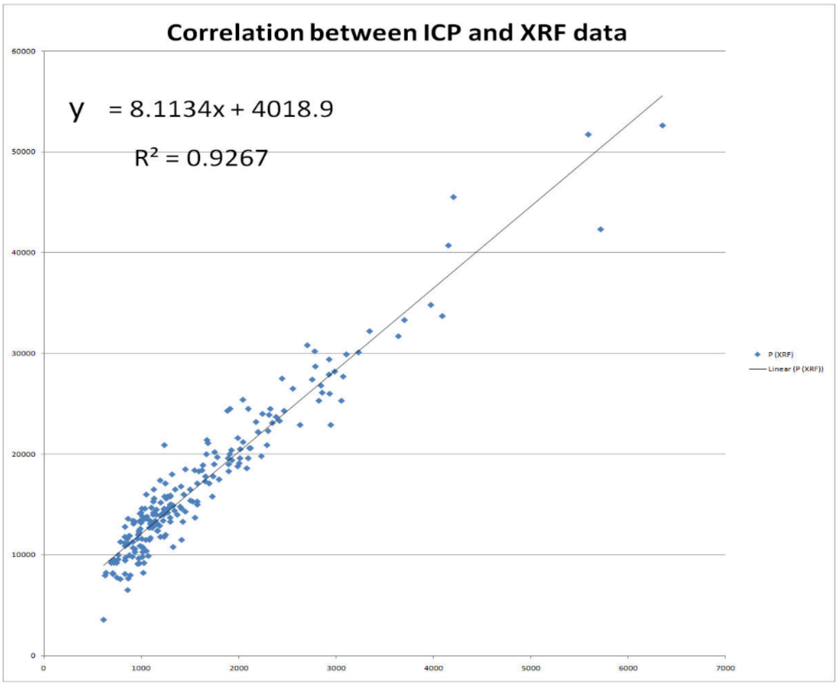

Figure 1. Correlation between ICP and HHpXRF data for P in soil.

Sampling strategy

All samples were analysed in-situ with an interval of ~10m.

RESULTS

Results for soil chemistry are reported in ppm and associated with a spatial coordinate as determined by HH-GPS. In producing representations of the distribution of soil chemistry no interpolation was employed, instead point data was plotted as a means to best represent the raw data.

The study reported here only returns values for lead (Pb). Enhanced lead is usually associated with anthropogenic activities and may range from 30ppm to 800ppm for routine activities associated with settlement. The range of results found at Bolehill were very high with results ranging from 181ppm to 3700ppm. These upper ranges are exceptionally high and can conclusively be associated with the deposition of lead metal, mineral and may well indicate the presence of lead metallurgy in the vicinity. Of specific interest is the structure of the lead anomaly. Instead of random high readings it is noted that the high concentrations are restricted to the SW of the site and that there is a steady rise and fall across the anomaly.

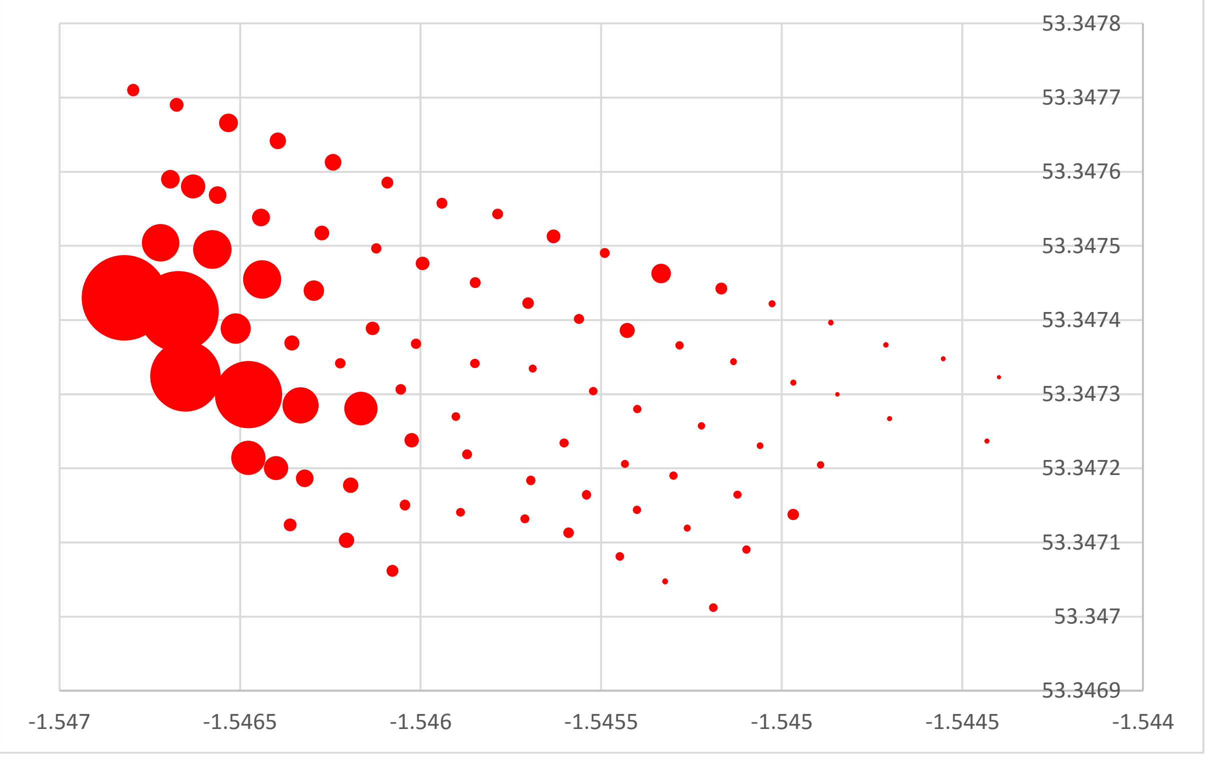

Figure One: Spatial plot of Pb values across Bolehill

Figure Two: Results of geochemical analysis (Pb) superimposed and georeferenced on Aerial photo.

CONCLUSIONS

The study employed in-situ analysis to determine the degree of variability in soil chemistry across the site of Bolehill.

The study has provided information on key issues. Firstly, it can be established that the variability encountered across the sites is of a magnitude that suggests significant anthropogenic impact on the locality. Preliminary review of a range of elements suggests that Cu, Zn and Pb are enhanced with lead being enhanced at very high levels. Pb is enhanced to the extent where it is possible that the results are indicative of some kind of metal processing.

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