Multi-element soil analysis to interpret space use on post-Medieval farmsteads, Tayside, Scotland

Summary

This study is an evaluation of how accurately models of multi-element soil concentration can be used to interpret the former function on similar sites, within the same geological region. The study was conducted on small post-Medieval townships in Scotland.

The results show that differences in human practice, such as cleaning out the hearth and byre at the time of abandonment, are more important that geological differences in determining the nature of multi-element signatures preserved in the floors and fields of this abandoned township. Models derived from multiple sites were better predictors of former function than models based on single sites as these are very sensitive to small differences in the history of use and the practices of individuals.

Introduction

Multi-element soil analysis is a relatively rapid and cheap means of determining a soils chemical composition. It has been used sporadically in archaeology for the past two decades, both to help locate sites and define the extent of activity surrounding them, and more recently as a means of interpreting activity areas and the use of space in and around archaeological structures. A previous study used six post-medieval abandoned farms scattered across the UK over a range of geologies as study sites; one of these sites was Balnreich at Ben Lawers. Coming out of this work has been a series of discriminant models of function based on soil concentrations of a range of elements that could help provide predictions and interpretations of function based on the soil chemistry on these historic rural settlement sites. Such models could be a useful addition to the prospection and interpretation techniques used on such sites.

This study aimed to test the predictive power of these discriminant models on an 'unknown' historic rural settlement site with the same geological and pedogenic (soil) background as the site of Balnreich. The ultimate goal was to develop an informed view on the potential of multi-element soil analysis as a tool for prospection and interpretation in the study of historic rural settlement sites in Scotland, and to produce refined statistical models for this purpose.

Methods

Sites

The sites of Balnreich and Easter Tombrek in North Loch Tayside, Perthshire were chosen for this study. Both sites are small townships abandoned in the late 19th Century. Both are underlain by glacial drifts derived from local mica schists in which peaty iron pan podzols have developed locally. A further five abandoned farm sites on contrasting geologies across the UK were also studied as part of a wider project. All were abandoned between 1880 and 1940, and all had been framed traditionally until they were abandoned. Differences between the two sites were that the hearth and byre at Tombrek appeared to have been cleaned prior to abandonment, whilst deposits were still in-situ at Balnreich, and the kailyard at Balnreich showed no evidence of

deepening compared to the deep profile at Tombrek (ca. 70 cm), which contained charcoal, pottery and bone.

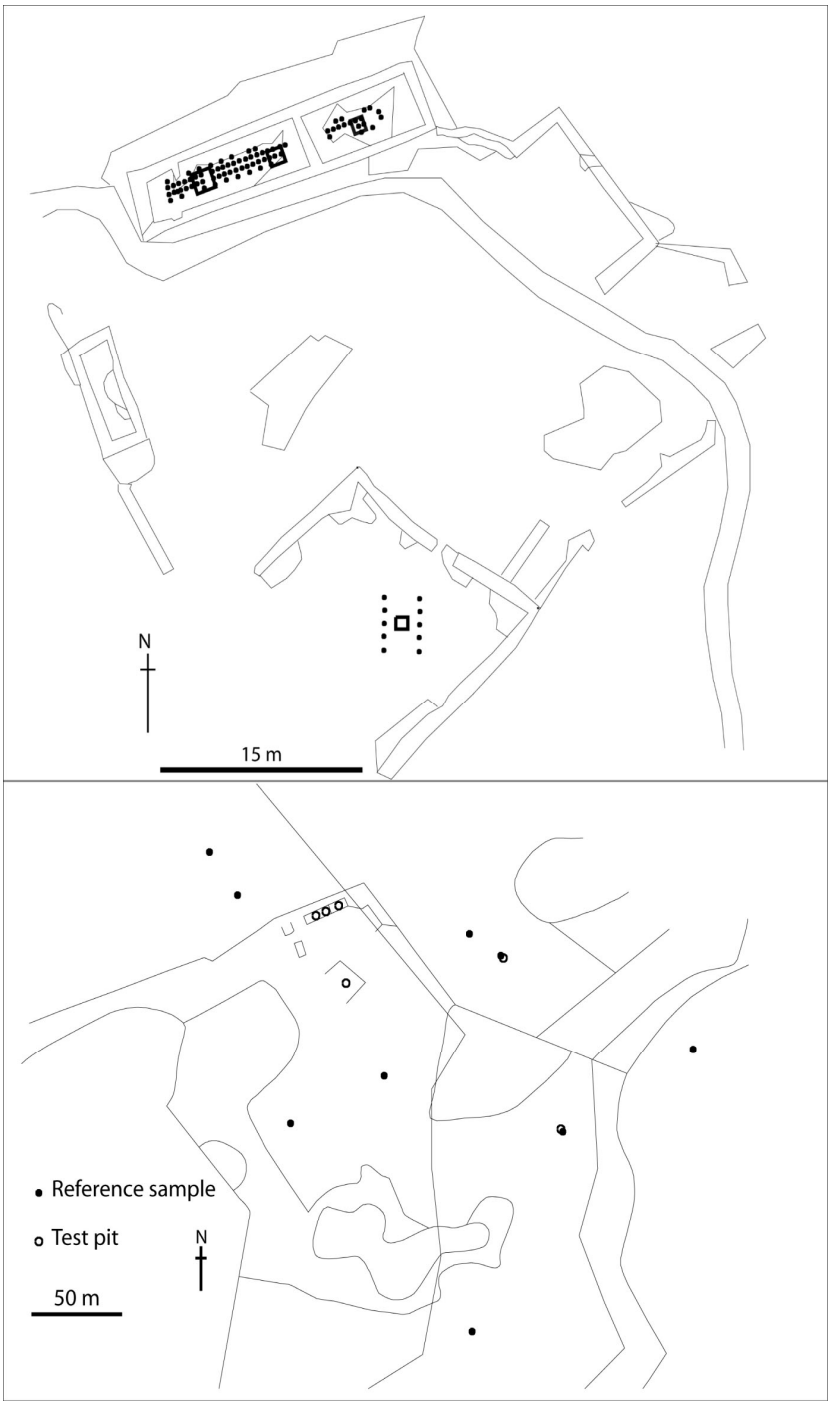

Figure 1: Sampling sites at Easter Tombrek

Laboratory Analysis

Soil samples were collected from the house, hearth, byre, kailyard, and arable fields - both the floor layer and the overburden were sampled in the houses. Overburden and

field top soils were sampled using an auger over a 0.5 or 1 m sampling interval respectively. Floor layers were sampled from between flags and cobbles in 1 m x 1 m test pits. Air-dried, sieved (2 mm), soil samples (5 g) were digested (120^{o}C, 1 h) in conc. HNO_3. Pb concentrations were analysed using ICP AES.

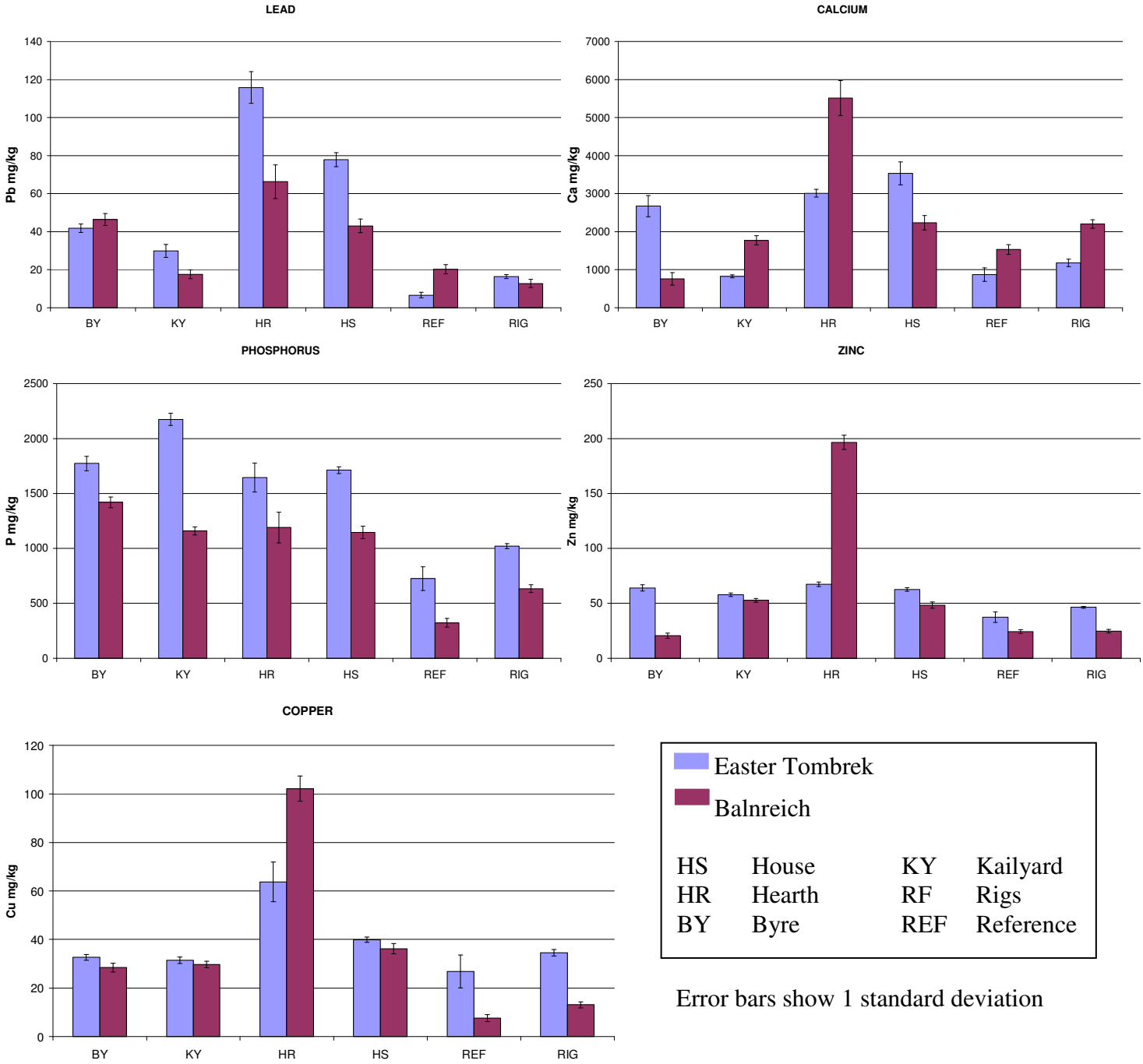

Figure 2: Patterns of Pb, P, Ca, Zn and Cu concentration in the soils of Easter Tombrek and Balnreich.

Results and Discussion

Figure 2 shows the pattern of enhancement of lead (Pb), calcium (Ca), phosphorus (P), copper (Cu), and Zinc (Zn) across Easter Tombrek and Balnreich. The hearth contains the highest lead concentrations followed by the house and byre. The kailyard and arable fields at Balnreich were not enhanced relative to the reference sub-soil, however at Easter Tombrek these soils do contain significantly more lead. The pattern of calcium enhancement shows greater differences between the two sites. At Balnreich the hearth showed very strong enhancement with significant, but much lower levels of enhancement in the house, byre, kailyard and arable fields (still limed by farmer). By contrast at Easter Tombrek the house contains the highest levels of calcium followed closely by the hearth and byre. The kailyard and arable fields show no significant enhancement of calcium. At both Balnreich and Easter Tombrek phosphorus is significantly enhanced in the township soils compared to the parent material. At Balnreich the highest concentrations were found in the byre, whilst at Easter Tombrek the kailyard soils contain the highest levels of phosphorus though the hearth, house and byre also contain relatively high concentrations. At Balnreich both zinc and copper were strongly concentrated in the hearth area. Whilst the hearth at Easter Tombrek is enriched in these two elements (particularly copper) the level of enhancement is much lower than at Balnreich.

Entering the Easter Tombrek floor and topsoil data into the regionally specific discriminant model resulted in 38.0% of the samples being correctly classified (Table 1). This rate fell further to 34.8% if overburden samples were used instead of floor samples for the hearth, house, and byre.

Table 1: Predicted group membership for Easter Tomrek data entered into regionally specific data.

	Predicted group membership					
Assigned group	**HR**	**HS**	**BY**	**GD**	**RF**	**REF**
HR		92.3		7.7		
HS	7.4	69.1	1.5	22.1		
BY	3.7	29.6		66.7		
GD		9.1		90.9		
RF		4		66		
REF				83.3	16.7	

REF, reference soil; RF, rig field; GD, garden or kailyard; BY, byre; HS, house; HR, hearth; MD, midden.

Entering the Easter Tombrek data into the generic model resulted in 59.3% of the samples being correctly classified (Table 2). All the hearth samples were incorrectly identified, predominantly (92.3%) as house. In total 85.3% of house samples were correctly identified, the remainder being assigned to byre, 70.4% of the byre samples were correctly identified and all the kailyard samples were correctly assigned. However, 96% of the arable field samples were incorrectly assigned either to kailyard or outfield samples, and all the reference sub-soil samples were incorrectly assigned.

Table 2: Predicted group membership for Easter Tombrek data entered into generic model

	Predicted group membership							
Assigned group	**HR**	**HS**	**BY**	**GD**	**RF**	**OF**	**REF**	**MD**
HR		92.3	7.7					
HS		85.3	14.7					
BY		14.8	70.4	11.1		3.7		
GD				100				
RF				48	4	48		
REF		16.7		33.3	33.3	16.7		

REF, reference soil; RF, rig field; GD, garden or kailyard; BY, byre; HS, house; HR, hearth; MD, midden.

A similar suite of elements (Ca, Ba, Sr, Zn, Pb, P, Cu and K) show enhancement in and around Easter Tombrek as at the previously studied abandoned farms. At Balnreich the hearth is a focus of contamination containing the highest levels of lead, calcium, zinc and copper. At Easter Tombrek too, the hearth contains the highest recorded levels of lead, zinc and copper, and amongst the highest concentrations of phosphorus, calcium, potassium, sodium, and strontium. However, the level of enhancement is much lower than at Balnreich because, unlike at Balnreich, the hearth at Easter Tombrek had been thoroughly cleaned our prior to abandonment.

The kailyard at Balnreich was somewhat atypical compared to the other Scottish townships as it consisted of a shallow soil profile showing no signs of deepening nor of the inclusions such as charcoal and pottery, which were found in the soils at Easter Tombrek. This suggests a more sustained manuring effort at Easter Tombrek than at Balnreich and this is reflected in the higher phosphorus levels in the kailyard at Easter Tombrek. This shows that manuring levels at Easter Tombrek were more than sufficient to maintain soil fertility. The byre at Easter Tombrek, however, contains lower phosphorus levels than that at Balnreich, and of the other sites analysed previously. This may be due to cleaning out of the byre at Tombrek prior to its abandonment. The house section at Tombrek appears to have remained in use after it went out of occupation, either as a store or an animal shelter, and the archaeologists also felt that Balnreich had been used as an animal shelter; this may also partially explain the relatively low phosphorus levels in the Easter Tombrek byre.

These differences in anthropogenic history mean that using the geologically specific model results in a success rate of only 38%, whilst this is considerably better than the 16.7% accuracy we might expect from blind chance prediction, it is hardly outstanding. Using a larger generic model based on the results of all six sites from the former study, produced a respectable 59.3% success rate for function prediction of soils from Easter Tombrek. Because of the cleaning of the hearth, no hearth samples were correctly identified base on the chemistry of the charcoal rich residues recovered from the other six sites, nor were any of the reference soils correctly identified as is to be expected from a model developed from six geologically diverse (limestone, sand, mica schist, shale, rhyolite, and gneiss) locations. However, identification of the house, byre and kailyard strongly supports the archaeological interpretation, and

suggest that elemental concentrations can support archaeological interpretation of former function on historic rural settlement sites.

Conclusions

This study has shown how the 'natural' baseline element concentrations of geologically similar regions are essentially the same, and that because of similarities in baseline concentrations and soil conditions the range of enhanced elements is also almost identical; in this case P, Ca, Sr, Na, K, Cu, Zn and Pb. However differences in anthropogenic processes, particularly those of abandonment and post-abandonment use, such as the cleaning out of abandoned sites, has a significant effect on the scale of enhancement and the within site spatial patterning. This means that one to one comparative models produce relatively poor results, better prediction rates are achieved through the use of a model derived from data from a range of sites. Presumably a better result again would be gained if multiple sites from a geologically comparable region were used, however, the model will always be limited by 'unusual' occurrences or practices.

This study suggests that multi element soil analysis:

- Is a relatively cheap, rapid and commercially available means of soil analysis which could provide useful supporting information about space use and former function at historic rural settlement sites where the archaeology is ambiguous.
- The technique provides a degree of certainty to each prediction, but should not be used to assign function based on single samples, replicate sampling is essential for interpretation.
- The best results are achieved from the analysis of the floor layers themselves, though similarities in chemistry between the floor layer and the overburden also mean that this technique has the potential to be used as a prospection technique, perhaps to add information to geophysical results.