CEFN DRUM RESEARCH PROJECT.

ASSOCIATION OF SOILS DATA WITH PLATFORM HOUSES.

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SUMMARY.

Positive associations may exist between high levels of copper, zinc, cadmium and lead and evidence of human activity at sites with an established archaeology (Aston et al., 1998). With this in mind soils analyses for concentrations of these metals were undertaken using samples from sites excavated at the Cefn Research Project which investigates medieval settlement on the Gower Peninsula in South Wales. Correspondence analysis was applied to data from the chemical analysis soils taken from each site in order to explore the association of sites with one another and samples considered to indicate background concentrations of these elements. This paper reports the results of these analyses in the context of the aims of the Cefn Drum project.

INTRODUCTION

Cefn Drum is an upland area north-east of Pontardulais, in Gower, South Wales (Figs., 1a, 1b). Its summit rises to over 200 m OD. To either side of this summit lie the Camffrwd and Dulais valleys. A series of abandoned farmsteads lie on the side of the hill and those located at NGR SN 603044 (Fig., 1c) have been excavated and form the subjects of this report. One of these sites is thought to be of 13th or 14th century origin (Kissock, 2000). A brief account of the nature of these sites can be found in the Royal Commission on the Ancient & Historical Monuments Wales – *Glamorgan Inventory* (1976; 1982*).* Scattered remains of other structures, walls and cairns also lie here and these have a wide variety of dates, spanning a period from prehistory to recent industrial ruins. Whilst much is known about medieval settlement on the Gower Peninsula and of the fringe area (where the Peninsula and upland meet) when the project began very little was known about the upland area until archaeological survey and excavation and environmental analyses were carried out by Dr. J.A. Kissock and the author between 1995 and 2003.

The first programme of excavations focussed on a pair of structures thought to be house platforms – defined by the Royal Commission (1982) as PH6 and PH8 (*The Glamorgan Inventory).* The nearby house platform PH7 has been virtually destroyed by recent activity. The aim of the excavations was to confirm their nature as the remains of medieval farmsteads and to reconstruct the economy of these settlements. No structure of this type has been excavated in south Wales since the late 1930s (Fox, 1937 and 1939) and hence no structure has been excavated within the framework of the archaeological approaches which have been developed since. Figure 1c shows the location of the house platforms and the cairn field within which they lie. Excavation was initially limited to the platforms and their immediate vicinity. This was extended to an area measuring 10 m x 15 m alongside PH6 which revealed a wall, several pits and postholes. In the absence of prohibitively extensive, and consequently expensive, excavation around both PH6 and PH8, there was a need to identify a method of determining how far beyond each platform human activity extended.

Figure 1: Location maps (a) & (b) and (c) map showing the distribution of cairns and farmsteads of a presumed medieval date on Cefn Drum southern cairn field.

Aston, *et al.,* (1998) have noted positive associations between high levels of copper, zinc, cadmium and lead and with evidence of human activity. Analysis of soil samples for these elements was therefore considered a possible way to determine the extent of activity and so a series of samples for this purpose was collected during the 2002 excavation season. The aim of these analyses was to identify variations in the concentration of these elements along and across the excavated sites which might indicate breaks in the continuity of past human activity. The work reported here makes use of correspondence analysis to explore soil concentrations of cadmium, copper, zinc and lead in relation to the sites from where soil samples were collected.

Correspondence analysis (*CA*) is one of several related statistical procedures commonly applied to multivariate data. The literature describing these methods is extensive (Gauch, 1994 ; ter Braak, 1995 ; Johnston, 1998 ; Leps & Smilauer, 2003 ; van Tongeren, 1995). This type of analysis is commonly associated with the analysis of ecological data however, in principle, these procedures may be applied to any multivariate data set. In the present context, *CA* was used to explore the association of soil concentrations of cadmium, copper lead and zinc with sites of presumed human activity. The procedure uses weighted averaging techniques to compare the similarity of samples on the basis of several quantitative variables. The scores produced by these analyses are then used to graphically display samples in relation to each other in ordination space on the basis of their similarity. Of particular interest in this investigation was the similarity (as defined by soil sample analyses) between those samples taken from sites PH6 and PH8 and those samples taken along a transect defined by the 132 m contour line linking these two features. It was considered likely that samples taken from this transect would lie outside the boundaries of presumed human activity and thus, these might be indicative of background concentrations of the elements of interest. Whilst discrete 'within group' associations might be expected for each of the house platforms it seemed reasonable to suppose that there should be no association between with those samples provided by the 'background' transect.

METHODS

Soil sample collection : Soil samples were collected systematically from a grid established within the excavated areas PH6 and PH8 presumed to be sites of human habitation and activity (Kissock and Johnston, 1998). Figure 1c shows the southern cairn field with these sites identified as PH6 and PH8. Samples were also collected at 15 m intervals along a transect defined by the 132 m contour line linking these two features. These transect samples (hereafter referred to as BKGRND samples) were presumed (in the absence of intensive human activity) capable of providing background concentrations of Cu, Cd, Pb, Zn for comparison with those samples collected from the PH6 & PH8 sites (conversely presumed to have undergone intensive human activity).

Soil sample preparation : Soil samples were air dried at room temperature. Roots and stones were removed from the samples and each was then sieved through a 2 mm stainless steel mesh. Samples then underwent Inductively-Coupled Plasma-spectrometer (ICP) analysis for a range of elements including Cu, Cd, Pb, Zn at the Institute of Geography & Earth Sciences, University of Wales, Aberystwyth. The elements copper, zinc, lead, and cadmium, were the elements of most

interest to this study due to their known association with human activity as noted above (Aston, *et al*., 1998).

Statistical procedures: The mean and standard deviation for each soil variable in each of the three sampling groups PH6, PH8 and BKGRND was calculated. Whilst univariate analyses such as these provide useful information about the soil properties at the site overall for each element as well as at sampling point, due to the natural spatial heterogeneity of soil properties, a coordinated pattern showing the relationship between these variables and the excavated sites is difficult to determine. Therefore, correspondence analysis was used to explore the relationship between sites on the combined basis of the relative concentrations cadmium, zinc, lead and copper.

RESULTS

Univariate Analyses

Table 1 shows the concentrations of copper (Cu), zinc (Zn), lead (Pb) and cadmium (Cd) produced from analysis of all samples. Table 2 summarises these data showing the mean and standard deviation for sample groups PH6, PH8 and BKGRND. In Table 2, PH6 is shown to have the greatest mean concentration of Cu (38.80 ppm). This is considerably greater than in the other two groups PH8 (21.93 ppm) and BKGRND (22.3 ppm) which are quite similar to each other. Zn has the greatest mean concentration (16.22 ppm) in the BKGRND samples. However, the relatively high standard deviation for this result and also for the Zn concentration in the remaining groups detracts from the usefulness of these data. Consequently, the data for Zn does not contribute much to this enquiry in its univariate form. Nevertheless, the mean concentrations of Pb in PH6 (21.30 ppm) and PH8 (21.37 ppm) are both greater in comparison to the BKGRND samples. Both PH6 and PH8 show similarly low standard deviations (3.32 and 3.53 respectively) suggesting an homogenous distribution of this element throughout each of these sample groups. The mean concentration of Pb in the BKGRND samples is lower and also has a relatively small standard deviation. The constant concentration of cadmium (Cd) across all three groups of samples is noteworthy although a high standard deviation for the mean of the BKGRND samples indicates a greater ‘within group’ variation.

Table 1 : Full results of ICP analyses for Cu, Zn, Pb & Cd.

Table 2 : Summary of Cu, Zn, Pb & Cd concentrations μg/g

Correspondence Analysis

Figure 2 shows Axes 1 & 2 of the ordination diagram constructed from the scores produced by correspondence analysis of Cu, Zn, Pb and Cd concentrations produced from a analysis of all samples as shown in Table 1. These data describe the compete dataset which

includes data from both house platform sites as well as the BKGRND samples. The eigenvalues for this analysis are also shown in this diagram and from these it is clear that only axes 1 & 2 account for the great majority of the variation in these data. The BKGRND samples are clearly shown to be widely distributed along Axis 1, with only three of these eight samples showing any association with each other. This association appears as a small cluster in the upper left quadrant of the diagram. Axis 2 also shows a scattered distribution of BKGRND samples with minimal association with each other. In contrast to this, samples taken from PH6 and PH8 form two mainly discrete clusters within the upper and lower left quadrants of the diagram. Outliers to the clusters of house platform samples are PH6 sample 5 and PH8 sample 11 both of which appear to have little in common with their respective sampling groups.

Figure 2: Ordination diagram and table of eigenvalues showing results of correspondence analysis of soil samples (Cu, Zn, Pb, & Cd) collected from PH6, PH8 and BKGRND transect.

Figure 3 shows Axes 1 & 2 of the ordination diagram constructed from the scores produced by correspondence analysis of Cu, Zn, Pb and Cd concentrations associated only with PH6 and PH8. In this statistical analysis the BKGRND samples were removed from the dataset in order to emphasise the relationship between the two platform sites presumed to have been sites of human activity. Clusters of samples are clearly shown associated with each house platform site. PH6 samples are very obvious as a discrete cluster in the lower left quadrant of the diagram. Although the PH8 samples are slightly more dispersed along Axis 2 nevertheless, there is also a clear 'within group' association shown. However, samples 5 and 11 are still clearly shown as outliers to their respective groups.

Figure 3: Ordination diagram and table of eigenvalues showing results of correspondence analysis of soil samples (Cu, Zn, Pb, & Cd) collected from PH6, PH8.

DISCUSSION

These results are make an interesting contribution to the Cefn Drum project due to their ability to identify differences in the soil properties between the sites presumed to have been influenced by human activity and those sites considered to be indicative of background properties of the area. The task of interpreting several soil variables in the context of the sites in question appears to have been well addressed by the use of correspondence analysis. There is a clear separation of clusters of samples associated with PH6 and PH8. Unfortunately, since samples were not collected randomly from within each area of interest, tests of the statistical significance of these analyses are not possible. However, the working hypothesis was that, "*If human activities were restricted to those sites presumed to be house platforms then, the BKGRND transect samples might be expected to show no similarity with each other or those collected from PH6 and PH 8".* Whilst not statistically testable the results shown in Figures 2 and 3 strongly suggest a difference between the BKGRND samples and those samples drawn from the sites of presumed human activity. Another important feature of the analysis is that samples identified with the presumed house platforms show strong 'within group associations', not only in contrast to the BKGRND transect but also with each other. This suggests that each house platform site has characteristics peculiar to itself which are also different to the surrounding area.

Concluding Remarks

These results are encouraging in the strong divisions which they make between areas presumed to have been platform dwellings and those areas thought to possess typical background soil properties. In seeking to promote these results as supporting evidence for the existence of medieval platform dwellings it would be wrong not to acknowledge the argument that perhaps the divisions identified by correspondence analysis merely show that each sampling site is different. This can be refuted however, since there has been no grouping of the BKGRND samples as with the PH6 and PH8 samples. The notable difference in soil sample properties between PH6 and PH8 is also worth further comment with reference to Kissock (2000), who has already noted strong differences in the layout of the buildings uncovered at PH6 & PH8. A question which arises is that whilst both sites PH6 and PH8 might indeed be of anthropogenic origin might these results suggest that they also had different usages? Analyses for phosphate concentrations of samples taken from the sites discussed here are planned which may provide further evidence for this and other aspects of the Cefn Drum Project.

Acknowledgements.

The Cefn Drum Project is most grateful to the Llanelen Research Group who funded the chemical analysis of the soils on which this study is based.

The author also wishes to express his gratitude to Anne Leaver of University of Wales, Newport for her assistance in formatting the graphs and diagrams used in this paper.

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