Geochemical Survey at Woodbridge, Northumberland 2006

by

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1 Geochemical Survey at Woodbridge, Northumberland.

1.1 Study Area

Excavations at the eastern edge of Cheviot Quarry, adjacent to Woodbridge Farm, Northumberland revealed a number of areas identified as buildings. Soil samples were taken for geochemical analysis from five of these areas in order to inform on the level of anthropogenic activity within the areas. The area of building one covered 93.6 m^2; building two, 104.5 m^2; building three, 97.4 m^2; building four, 159 m^2; and building seven, 50.5 m^2. The samples analysed were taken on a 0.8 metre grid for building areas 1, 2 and 3 and a 1 metre grid for building areas 4 and 7. Samples were also taken from outside the survey areas to act as controls.

1.2 Analytical techniques

The analytical techniques and the methodology are detailed in the appendices.

2 Survey Results

2.1 Display

Summary colour coded plots of the analytical data are produced at a scale of 1:350 for the elements magnesium, aluminium, silicon, phosphorus, sulphur, potassium, calcium, titanium, manganese and iron in addition to the results of the magnetic susceptibility measurements. The results for sodium are not included as the concentrations were below the minimum detectable levels. Trend surface analysis (see appendix) was not deemed appropriate as the sampled areas were not contiguous. A colour scale accompanies each plot showing the maximum and minimum percentage element concentrations.

2.2 Discussion of Results

The present discussion of the results of the survey is based on the observed distribution patterns for the elements. From these observations a number of areas of archaeological activity have been identified and within these areas a variety of levels and type of activity. These are shown in the interpretation plot, figure 2.

2.2.1 Aluminium, titanium and iron (figures 3, 4 and 5)

The distribution patterns for these elements are generally similar in relatively undisturbed soil and can give an insight into the general nature of the soil and any changes across the sampled area. They can therefore highlight areas of erosion, removal of soil horizon, provide evidence as to the extent of disturbance within deposits and identify any changes in the underlying geology. Considering the distribution of these elements is also particularly useful in assessing and interpreting the distribution of the more well defined anthropogenic indicators e.g. phosphorus.

It can be seen that the plots of these elements are very similar across all five areas. They show a fairly homogeneous distribution across the site with typical concentration ranges indicating little change in the general characteristics of the soil.. A number of discrete areas of enhancement or depletion are present particularly within the plot of iron concentrations and these will be considered within the later discussion.

2.2.2 Silicon (figure 6)

As with the aluminium and titanium this shows a reasonably homogeneous distribution across the site with a typical concentration range. This supports the evidence that the general soil characteristics within the five areas are similar. Areas showing lower concentrations generally correlate with more mineral rich deposits (see later discussion and interpretation).

2.2.3 Calcium (figure 7)

The areas of building one and three show a reasonably even spread of calcium values with depleted areas within the south east corners A number of discrete high values occur towards the north edge of the areas. Building two however shows a clear division between high and low values following a north south divide. These features may be due to natural drainage systems or indicate the presence of anthropogenic deposits.

The areas of buildings four and seven show clear discrete areas of enhancement which correlate well with the distribution of the elements phosphorus, sulphur iron and magnesium suggesting significant anthropogenic deposits. Calcium rich material includes bone of which some quantity was excavated from features within these areas.

2.2.4 Phosphorus (figure 8)

There is a clear difference in the phosphorus distribution across the five areas. When considering this in light of the previous discussion of aluminium etc (section 2.2.1 and 2.2.2) the evidence suggests that these areas of high concentrations reflect the extent and high level of anthropogenic activity particularly within the area of building four and seven.

Within the building two area the higher values extend along the north edge showing a very similar distribution to that of calcium. Values are much lower within building areas one and three which could well reflect less extended period of activity than say building four and seven. There are two spreads of higher values within building one whilst building three shows small discrete features which could be related to post hole deposits.

2.2.5 Manganese, sulphur, potassium and magnesium (figures 9, 10 and 11)

The distribution of these elements is difficult to interpret in terms of the archaeology. It is probable that the general variations are due to factors such as drainage and soil coverage across the areas. There are however a number of anomalies which may be associated with archaeological features.

Manganese - depleted manganese values have been found to be associated with long term occupation sequences and there is a suggestion that a similar pattern can be seen across the areas here particularly in defining the circular structure in area 4. The high anomalies occur as discrete spots indicating mineral rich deposits.

Sulphur - in many respects the sulphur follows a similar pattern to that of manganese and phosphorus with broad concentrations occurring in areas 1, 4 and 7. Again the particularly high values are present as discrete spots suggesting presence of individual mineral rich features.

Potassium and magnesium - both these elements are often associated with hearths or areas of burning due to their relatively high concentrations in wood ash. From the distribution plots however there appears to be little correlation between the two elements with the exception of an area to the east of centre of building three. The concentration level and range for magnesium is however low and narrow and most probably reflects the variation in the natural soil matrix. The concentration range for potassium is much greater and the delineation of areas of enhancement much clearer suggesting areas of activity (possibly hearths) within building 2, 3 and 7.

2.3 ***Magnetic Susceptibility*** *(figure 12)*

Enhancement of magnetic susceptibility of soils can be attributed to heating or burning and to a lesser extent by fermentation caused by bacterial action on organic deposits and can therefore indicate anthropogenic activity. The distribution plot for magnetic susceptibility correlates well with areas identified in the previous discussion of the geo elemental signatures particularly in a broad sense with that of phosphorus. There is also correlation with a number of discrete area/features such as those identified by high potassium concentrations.

Enhanced magnetic susceptibility is clearly seen across areas 4 and 7 (cf. phosphorus) and also across a substantial area of building 1 whilst smaller discrete areas of enhancement can be identified in buildings 2 and 3.

2.4 Investigation of control samples

As phosphorus appears to be the prime indicator of anthropogenic activity the relationship between the samples from inside the surveyed area and the controls was undertaken by plotting the mean and standard deviation of this elements concentration from each area and control set. The results are shown in figure 1. It can be seen that there is a clear difference between the interior of buildings 1, 2, 3 and to some extent 7 and the control samples from the exterior of the buildings. With building area 4 however there is less distinction and it is probable that the anthropogenic deposits extend slightly to the north east of the area.

2.5 Conclusion

The survey has detected a number of areas of potential archaeological activity and within these areas a variety of levels and types of activity. There was however no consistent pattern across the building areas. The main indicators for suggested areas of anthropogenic activity have been shown to be phosphorus, magnetic susceptibility, potassium and manganese. Calcium and magnesium have provided some supporting evidence whilst aluminium, titanium and iron have shown the nature and variation in the soil coverage across the area. The identified areas of activity are shown in the interpretation plot (figure 2) and are defined as follows:

2.5.1.1 General areas of archaeological activity.

These are zones of activity that suggest a concentration of archaeological features and material. These zones may exist *per se* or may have been produced by the movement of material from discrete features through, for example ploughing.

2.5.1.2 Areas of intense archaeological activity.

These are discrete areas or features that are potentially archaeologically rich through either very intense or lengthy use. Typical features would be pits, rubbish deposits, middens, the remains of ditches etc. Area 4 in particular shows a broad spread of intense activity which could be attributed to material from a number of archaeological rich deposits. These have been identified at around positions C and D (area 4) whilst another potentially rich area is at position B (area 7) and possibly A (area 2).

2.5.1.3 Possible hearths or areas of burning.

Areas in which the chemical fingerprint particularly enhanced potassium, magnesium and magnetic susceptibility suggests some form of pyrotechnological activity most probably the presence of hearths.

2.5.1.4 Discrete features.

These are small areas which show a slightly different chemical fingerprint to the general background and may be features of archaeological origin. The majority of these would appear to be post holes.

2.5.1.5 Mineral rich deposits

Areas where the chemical signature shows enhanced levels of a number of elements suggesting a significantly different deposit type from the immediate surroundings. This could be due to the build up of sediments within cut features.

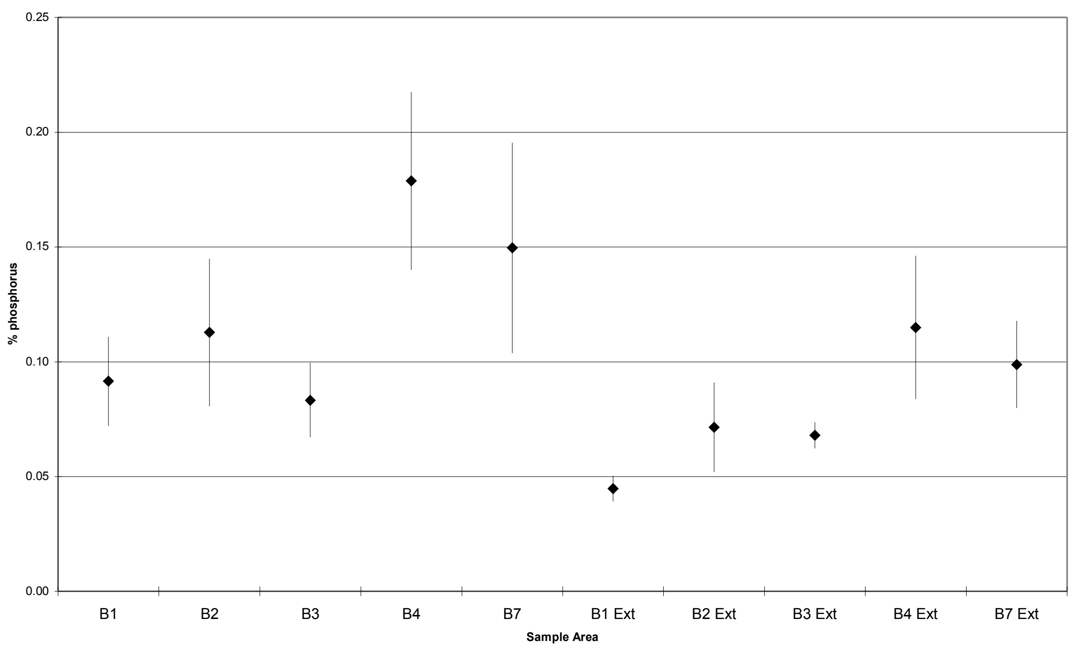

Figure 1. Plot of the mean and standard deviation for phosphorus for each sample area(B1, B2 etc.) and control set (B1 Ext, B2 Ext etc.).

Figure 3. Distribution plot of aluminium over the 5 areas.

Figure 4. Distribution plot of titanium over the 5 areas.

Figure 5. Distribution plot of iron over the 5 areas.

Figure 6. Distribution plot of silicon over the 5 areas.

Figure 7. Distribution plot of calcium over the 5 areas.

Figure 8. Distribution plot of phosphorus over the 5 areas.

Figure 9. Distribution plot of manganese over the 5 areas.

Figure 10. Distribution plot of sulphur over the 5 areas.

Figure 11. Distribution plot of potassium over the 5 areas.

Figure 12. Distribution plot of magnesium over the 5 areas.

Figure 13. Distribution plot of magnetic susceptibility over the 5 areas.

3 Appendix

3.1 Multi-Element Soil Analysis: the technique

Multi-element geochemical survey relies upon the assumption that changes occur within the soil chemistry of an area as a result of human intervention and that the function of various structures in and around archaeological sites is reflected in the elemental composition of the associated deposits. Thus, where as geophysical surveys can inform on the type of structures present on sites, geochemical analysis has the potential for more specific archaeological interpretations for the use of space in and around archaeological settlements.

The method utilises energy dispersive X-ray fluorescence (EDXRF) to provide a rapid quantitative multi-element analysis of soils from archaeological deposits/sites. The technique allows for the simultaneous accurate analysis of all the major and minor elements present within the sample thus providing a detailed characterisation of the soil. The elements under investigation are sodium (Na), magnesium (Mg), aluminium (Al), silicon (Si), phosphorus (P), sulphur (S), potassium (K), calcium (Ca), titanium (Ti), manganese (Mn) and iron (Fe) The group was chosen as it includes 11 of the 16 most abundant geological elements, five of which are soil macronutrients (Ca, Mg, K, P & S) and two micronutrients (Mn & Fe).

3.2 Analytical Method

3.2.1 Sample preparation

The samples are dried and sieved to collect the < 2mm fraction. This is ground to a fine powder and 0.5 grams of this are pressed into a 13mm diameter pellet ready for analysis.

3.2.2 Analysis

The analysis is undertaken using a Oxford Instruments ED2000 energy dispersive X-ray fluorescence spectrometer (EDXRF) employing a silver anode X-ray tube running at 10kV. All analyses are carried out under vacuum to allow detection of the low atomic number elements and the spectra are collected for a live time of 100 secs.

Simultaneous analysis is undertaken for the elements sodium (Na), magnesium (Mg), aluminium (Al), silicon (Si), sulphur (S), potassium (K), calcium (Ca), titanium (Ti), manganese (Mn) and iron (Fe)). The results being calibrated using an intensity based correction model (LaChance and Traill 1967; Lucas-Tooth and Price 1961; Lucas-Tooth and Pyne 1964) derived from the analysis of a suit of eight international soil standards.

The results as weight percent of element are then transferred to appropriate software for statistical analysis and mapping.

3.3 Presentation

The raw data for each element are mapped as separate two dimensional colour coded images using a scaling based on the rainbow sequence of colours. This offers a smooth transition from indigo and blue that represent low values, through yellow, to orange and red that represent the high values, and provides a very intuitive means of visually interpreting the data. This empirical observation also takes into account such factors as the topography of the area, the geology and, for example, the history of land use. When appropriate, interpolation of the raw data, using a spherical kriging model (Isaaks and Srivastava 1989), is undertaken to further aid visualisation and facilitate comparison between data sets.

Further interrogation of the data may be undertaken using Trend Surface analysis (Davis 1986). The data are separated into two components. The widespread or regional variations across the area, and the local deviations from this trend, thus producing a simulation of the broad features, which may be seen as background variation, and, through observation of the residuals, highlighting any local anomalies (Clogg and Ferrell 1993). The results are again presented as colour coded maps as above.

3.4 References

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4 Magnetic Susceptibility

4.1

Magnetic susceptibility is a measure of how magnetic a sample is. This can provide information on the minerals found in soils and sediments and hence the processes of their formation. Enhancement of magnetic susceptibility of soils can be attributed to heating or burning and to a lesser extent by fermentation caused by bacterial action on organic deposits and can therefore indicate anthropogenic activity.

4.2 Sample preparation

The samples are dried and sieved to collect the < 2mm fraction.

4.3 Analysis

The measurements were undertaken on a known weight (approximately 10 grams) of sample using a Bartington MS2B sensor. The resulting values were mass corrected to 10 grams to allow comparison of absolute mass-specific magnetic susceptibility.

4.4 Presentation

The magnetic susceptibility results were plotted as colour coded images as with the elemental data (Appendix section 1.3)