Spatial analysis of intra-site surface collection data from the Trypillia mega-site of Nebelivka

Joseph Roe, Duncan Hale, Bisserka Gaydarska and John Chapman

Introduction

In this section, we present the results of an intra-site spatial analysis of one part of the Trypillia mega-site at Nebelivka, in order to assess the degree to which surface materials – primarily pottery and daub – matched the results of the non-destructive geophysical prospection of the same, 15-ha., part of the mega-site. This analysis will contribute to the debate on the meaning of artifacts retrieved from the ploughzone; the results suggest that gridded surface collection on mega-sites can contribute important information that may not necessarily be inferred from geophysical data alone.

Intra-site surface collection survey

As part of the 2009 field season, an intra-site gridded collection of surface material - the first on a Trypillia mega-site - was carried out over a 15 hectare area in the southwest corner of Nebelivka. A total of 138 30 x 30 m grid squares (12.5 ha) was surveyed, using the same grid as the geophysical survey of the same area (ADS LINK TO 4_7_2_IMAGES/ 4_7_2_1_COLLECTION_GRID). The collection was a timed pick-up of surface material, overwhelmingly burnt daub and potsherds, with thirty person-minutes allowed per square. 32 grid squares were not surveyed due to time constraints, and priority was given to those squares which included magnetic anomalies on the geophysical survey. Additionally, four squares have missing data for at least one class of find.

Site formation processes

The ultimate object of the survey is the spatial organisation of a settlement. However, there are several intervening site formation processes between this and the surface collection data which must be unpacked, assessed, and accounted for (Walker 1985). First, there are cultural processes (C-transforms) structuring the way artifacts are deposited in the ground. In the case of Trypillia mega-sites, these are dominated by house-burning; current thinking is that houses were burnt with more or less typical domestic assemblages *in situ*. The possibility that not all the structures at Nebelivka ended their use-life in this way would constitute a distinct C-transform, and this is something that will be looked for in the analysis. Secondly, there are the possible effects of natural post-depositional processes, or N-transforms, which may produce non-random spatial patterns that, even though not archaeologically interesting, may help to explain some of the patterning in the data (Taylor 2000). In the case of surface collection data, the two most prominent N-transforms are the dispersing and destructive effects of plough action and geomorphological processes which may variably affect the amount of archaeological material in the ploughzone. Finally, there are ground conditions at the time of survey that might variably affect pick-up rate during the survey – chiefly surface visibility.

Geophysical imagery is available to corroborate the surface collection data in terms of artifact dispersion by ploughing. There is no indication that mass movement of soils or sediments this has occurred within the survey area at Nebelivka. Although grid squares were coded for visibility on an ordinal scale of 1 (very poor) to 10 (excellent), the lack of quantitative data on with which to calibrate the visibility scores in terms of pick-up rate made it difficult to incorporate this information into the analysis.

Exploratory Data Analysis

Several approaches were taken to describing the dataset, with the primary aim of revealing spatial patterns. These included standard statistical descriptors as well as graphical plots. Basic numeric statistics were calculated using SOFA (sofastatistics.com) and Microsoft Excel 2007. Plots were prepared in Python using numpy (numpy.scipy.org) and matplotlib (matplotlib.sourceforge.net), and Inkscape (inkscape.org). The most important approach to visually displaying the spatial component of the dataset was contours plots of find density which, according to Blankholm (1991,78), represent the "most elegant way of displaying the general nature of a spatial distribution". To produce smooth contour plots and compensate for gaps, the gridded pick-up data was treated as point data-with each point placed at the centre of its grid square, then interpolated onto a grid of 1x1 m bins using matplotlib's implementation of natural neighbour interpolation (Sibson 1981). Contour plots often form the basis of algorithms that explicitly delineate clusters of finds (Blankholm 1991, pp. 61–90), but the continuous, high-density nature of the Nebelivka dataset makes it unsuitable for this type of analysis. Consequently, visual inspection of contour plots must be relied upon for identifying loose 'clusters' of high find density.

The second part of the analysis is concerned with the relationship between the surface collection data and magnetic anomalies in the geophysical survey carried out on the same area (ADS LINK TO 4_7_2_IMAGES/4_7_2_2_geophysical_plot_2009). The results of each survey are spatial datasets which provide an imperfect picture of the unexcavated archaeological remains beneath the surface of the site. The geophysical survey gives detailed information on the shape of subsurface magnetic features (ADS LINK TO 4_7_2_IMAGES/4_7_2_3_geophysical_plots_of_two_buildings), but does not include sufficient information about the nature of these features to distinguish with certainty man-made structures from geological anomalies and other non-archaeological noise. The surface collection data is complementary: the dispersal of material through ploughing means its spatial component has a much lower resolution, but there is more information on the nature of subsurface archaeological material.

The geophysical survey of the site is very clear and allows for the easy identification of man-made features against the background magnetic profile of the loessic sediments. There are three broad classes of features which are of interest: (1) three large rectangular burnt features (henceforth 'Assembly Houses') (ADS LINK TO 4_7_2_IMAGES/4_7_2_4_unburnt_house_anomalies). The largest of these anomalies is the so-called 'mega-structure (ADS LINK TO SECTION 3_1); (2) most commonly, smaller (approximately 14 x 8 m) burnt features, which are almost certainly houses; and clusters of houses in the Western corner of the survey area, some turned 90° from the typical orientation (collectively termed 'Cluster 3': ADS LINK TO 4_7_2_IMAGES/4_7_2_4_unburnt_house_anomalies). Within this class, a distinction can be drawn between the clear burnt structures and the more ambiguous features, mostly in the Eastern part of the survey area, which may represent smaller or less completely burnt houses; and (3). weaker 'shadows' interspersed across the survey area (ADS LINK TO 4_7_2_IMAGES/4_7_2_4_unburnt_house_anomalies), some attached to clear burnt houses as gardens, others perhaps representing unburnt houses.

A simple approach has been taken to codifying the geophysical data. The magnetic plot was first traced to produce a map of features and the presence or absence of features was recorded per grid square. No square contained more than one type of feature. When it came to the numerous small features, it was clear that recording the presence or absence of a feature missed a great deal information on the density within a square, so they were also counted. As each house is roughly the same size, this can be viewed as a rough proxy for both the proportional area of a square covered by a magnetic features and the likely volume of material under the surface.

Results

The find set from the surface collection survey is overwhelmingly dominated by burnt daub and Trypillia pottery. A total of 2,379 sherds and 6,204 fragments of daub was collected, weighing 18.14 kg and 128.33 kg respectively. A third of the daub (by number) collected was vitrified. This equates to a relatively modest find density across the entire site (ADS LINK TO 4_7_3_SPREADSHEETS/4_7_3_Tables_intra_site_gridded_collection), but the distribution of both daub and pottery per grid square is non-normal and strongly negatively skewed, with a few very large outliers (ADS LINK TO 4_7_2_IMAGES/4_7_2_5_daub_numbers-and-weights; ADS LINK TO 4_7_2_IMAGES/4_7_2_6_pottery_numbers_and_weights). Despite the large volume collected across the site, 29% of the grid squares surveyed yielded fewer than five sherds of pottery and 30% fewer than five fragments of daub. Conversely, 142 sherds and 384 fragments were collected in the most productive squares. The mean number of potsherds and daub fragments recovered per square was 17.5 and 45.6 respectively. This strongly suggests a markedly unequal distribution of both burnt daub and Trypillia pottery across the site, validating the expectation that there should be significant spatial patterning in these finds (ADS LINK TO 4_7_2_IMAGES/4_7_2_5_daub_numbers-and-weights; ADS LINK TO 4_7_2_IMAGES/4_7_2_6_pottery_numbers_and_weights; ADS LINK TO 4_7_2_IMAGES/4_7_2_7_box_plot_of_finds_densities).

Other classes of find were found in much smaller numbers, summarised below (ADS LINK TO 4_7_3_SPREADSHEETS/4_7_3_Tables_intra_site_gridded_collection). Only four ceramic sherds were identified as being non-Trypillia in origin, strongly suggesting that this part of the mega-site at least saw only single period occupation, and therefore greatly simplifying the analysis. Chipped stone, bone, and grindstone fragments were slightly more common but still very sparsely distributed across the site. In the latter two cases, this can be plausibly explained in terms of N-transforms: grindstones are much heavier and resistant to fragmentation by plough than burnt daub or pottery and are therefore much less likely to be represented on the surface even if they are common in excavated Trypillia houses, while animal bones, if deposited in rubbish pits, would generally lie outside the ploughzone. The small quantity of chipped stone may be more meaningful – i.e., reflecting the actual use of chipped stone tools. Certainly if there was knapping in this part of the mega-site, we would expect to see more concentrated scatters on the surface. Some Trypillia sites can produce large lithic assemblages, but more frequently in the Western part of their range and in earlier periods (Zbenovich 1996, 224). The provision of lithics to Cucuteni-Trypillia sites in general is not well understood (Chapman 2002); quite possibly at Nebelivka and other Eastern sites, flint and chert were relatively scarce imports that was not readily discarded, similar to copper. Other miscellaneous finds included a possible figurine and a conical fired clay counter. The general lack of identifiable ceramic artifacts can probably be attributed to plough action, which tends to both shatter and abrade ceramics and therefore destroy diagnostic features (Taylor 2000).

Spatial distribution of finds

Fragments of daub and potsherds were found at high density across the site, with clear spatial patterning (ADS LINK TO 4_7_2_IMAGES/4_7_2_7_box_plot_of_finds_densities). Three broad zones of high daub and pottery concentration (A, B and C) can be discerned across the survey area (ADS LINK TO 4_7_2_IMAGES/4_7_2_8_daub_density_by_number; to ADS LINK TO 4_7_2_IMAGES/4_7_2_15_interpolated_contour_plot_pottery_by_weight). Both daub and pottery are distributed in two North - South bands (Artifact Zones (AZ) A and B) running across the survey area (ADS LINK TO 4_7_2_IMAGES/4_7_2_16_interpretation_of_finds_clusters). Though not fully surveyed, the area between these two bands produced markedly less material. In the Western corner, the distinction is not as sharp, with a mostly continuous pottery distribution suggesting a third zone (AZ C) in that part of the site. This is more evident in the distribution of daub than pottery, and generally speaking pottery is more evenly distributed across the site. It may be that this is because ceramic sherds, typically bigger and heavier than fragments of daub, were moved further by plough action.

On the other hand, high density clusters of daub and pottery do tend to coincide – namely those centred around grid squares A3/4, G10, J13, K5/6 and N8. There is also a concentration of daub 17 around square N11 that is not at all matched by pottery. These might be grouped into a second set of zones (AZ a, AZ b and AZ c) (ADS LINK TO 4_7_2_IMAGES/4_7_2_16_interpretation_of_finds_clusters). AF a, on the South West edge of the survey area, is characterised by a high density of both pottery and daub. However, since this is spread along the edge of the field-where material scattered by ploughing would build up-and partially on a track-where surface visibility was much greater-the archaeological relevance is dubious. AZ b, in the Northern part of the Western band, has a very high concentration of burnt daub with a less marked area of high pottery density. Conversely, AZ c, in the Northern part of the eastern band has a very high concentration of pottery and a less dense, but still significant, scatter of daub. The ratio of unvitrified to vitrified daub appears to vary randomly across the site with no spatial patterning.

Given the small number of chipped stone, grindstone and bone fragments recovered and the fact that their position was only recorded by grid square (making it impossible to say whether isolated finds in adjacent squares constitute a scatter or are 60 m apart), there is little to be said about their spatial distribution. Grindstone was recovered in four locations, three of which fall in the zones of interest defined by high concentrations of pottery and burnt daub, as would be expected if these zones are a proxy for the presence of house remains under the surface. Bone fragments were mostly confined to the northern half of the survey area, but given the small number of finds it is not unlikely that this a spurious pattern. Chipped stone was found across the site with no apparent spatial patterning.

One interesting isolated find was a fragment of a Greek amphora handle in grid square B6, where there was also some indication on the surface of a ploughed-out mound. Scythian and Sarmatian groups on the Black Sea coast and Ukrainian forest-steppe had contact with the Aegean from the first millennium BCE and Greek artifacts were frequently deposited in their kurgans (Videiko 2008, pp. 207–11). The coincidence of these two observation (the amphora fragment and the possible ploughed-out mound) might therefore allow the tentative placing of a classical era kurgan in that part of the site. A piece of slag was recovered from grid square H9, perhaps suggesting metal production activity of unknown date in that locality.

Relationship of surface material with magnetic features

As the distribution of the find data was substantially non-normal, a Mann-Whitney U test was applied to assess whether there was a significant difference in find density between squares containing burnt features on the geophysics plot and those without. On average, squares containing burnt features produced significantly more daub than those without ($p < 0.001$). The difference between the amount of pottery recovered was less significant by weight ($p < 0.05$) than was the daub but still significant at the $p < 0.05$ level; the relationship was not significant in terms of the number of sherds. This agrees with the above suggestion that the distribution of daub fragments reflects the remains below the surface with higher fidelity than potsherds. Comparing different types of features, the greatest volume of pottery and daub was recovered from squares containing the smaller burnt features. The squares containing the large unidentified structures produced a below average amount of both pottery and daub.

Houses

The distribution of pottery and daub on the surface is best predicted by the numerous houses. There is a positive linear correlation between the number of the anomalies in a grid square and the amount of both daub and pottery collected from it, although the strength of the relationship is lessened by spatial autocorrelation (ADS LINK TO 4_7_2_IMAGES/4_7_2_17_mean_material_(daub&sherds)_by_type_of_anomaly_1 to ADS LINK TO 4_7_2_IMAGES/4_7_2_20_ mean_material_(daub&sherds)_by_number_of_small_anomalies; ADS LINK TO 4_7_3_SPREADSHEETS/4_7_3_Tables_intra-site_gridded_collection).

The ratio of vitrified to unvitrified daub can be taken as an overall proxy for the intensity of the fire which destroyed the structure. There was no significant difference between squares with clear burnt structures and those where the signal is more ambiguous, suggesting that the latter simply represent smaller structures rather than incompletely burnt ones ($p = 0.996$).

Assembly Houses

The three Assembly Houses were amongst the most interesting findings of the geophysics survey. Unfortunately, the surface collection data does not provide any positive evidence on their nature. None of the grid squares containing large features were distinguishable from surrounding squares on the basis of find densities of pottery or daub. In the latter case, this is not so surprising – though their interior space is large, the geophysics plot does not suggest that the large features have particularly massive walls, suggesting, rather, a visual similarity to a cluster of two or three houses. The lack of pottery is perhaps more suggestive. All other things being equal, it would be expected that a large interior space would be reflected in the deposition of a larger quantity of pottery. That there is not any increase in pottery density compared to the background level might therefore lead to the conclusion that the larger buildings did contain as much pottery as houses or that it was removed before they were burned.

Unburnt or weakly burnt houses

The indistinct 'shadows' on the geophysics plot proved the most difficult anomalies to codify satisfactorily, especially since they probably represent more than one class of feature. Ultimately, no significant relationship could be found between their presence or extent and the density of surface material in a grid square. It is suggested that, since they are generally adjacent to burnt houses which produce large amounts of surface finds, the 30 m x 30 m resolution of the surface collection survey is not sufficient to distinguish them from other types of magnetic anomaly.

Other finds
Most of the chipped stone and grindstone fragments were found in squares containing burnt features, while the opposite was true of bone. In all three cases, however, this difference was not statistically significant. Small sample size makes it difficult to reliably identify any patterns in these finds in relation to the geophysical data.

Discussion
The analysis of the gridded surface collection at Nebelivka demonstrates that a correlation between burnt remains, particularly those of houses, and surface material remains despite dispersion by ploughing. The question remains whether this correlation is strong enough to make surface collection a useful source of data for the site's spatial organisation over and above the information recovered from the geophysical investigation. One approach is the identification of fits between surface collection data and geophysical data, in comparison with mismatches.

We can identify only two good fits between geophysical anomalies and clusters of surface artifacts. The first concerns two of the Assembly Houses 1 and 2 which lie within or close to two daub clusters. However, this relationship does not recur with pottery clusters, which are located at some distance from the Assembly Houses. The absence of pottery clusters near these three important structures would suggest a possible function which differs from the Nebelivka houses, while the presence of nearby daub clusters suggests a similar building style and practice of destruction.

The second case concerns the absence of daub clusters in the open area separating the two house rows. This is partially supported by pottery data, which shows some discard in the Northern part of the open area. While indeed containing a few magnetic anomalies, the 'open area' does for the most part stand in marked contrast to the high-density building in House Rows 1 and 2. The possibility of a mixed farming function including grazing land and small fields is not contradicted by the spread of pottery in its Northern part, which may have been produced by manuring or general discard as people crossed the open area on their way to their fields.

The partial fits concern both of the House Rows, shown by geophysical evidence as two lines of houses interrupted by a single East – West-running open area, in which the mega-structure is located. There is a good fit between most of each House Row, not least at the Southern end of House Rows 1 and 2 (the East – West-running open area) and the end of Artifact Zones A and B. However, there are gaps in the Artifact Zones for the Northern part of House Row 1 and the middle part of House Row 2, defined as clearly for daub as for pottery. Why there is a mismatch between surface artifacts and only some of the clearly-defined house-sized anomalies remains unclear and merits further attention. The partial fit of Artifact Zone C and House Cluster 3 occurs only with daub numbers and is contradicted by daub and pottery weight as well as pottery numbers. One possible explanation was that the soil depth was greatest in this part of the site. This notion can be tested when the geophysical investigation is extended further to the West in a future season.

There are four areas of mismatch between surface artifacts and geophysical anomalies. The first three, concerning House Row 1, House Cluster 3 and the three Large Features, have already been mentioned. The fourth concerns the extension of Artifact Zones A and B to well beyond House Rows 1 and 2. This extension was noted for all finds for the area West of House Row 2, while the extension Eastwards of House Row 1 was prominent only in the pottery data. In the absence of further magnetic anomalies in these extension zones, we may interpret then as activity areas in which higher-than-usual ceramic discard was practised, perhaps relating to middening areas associated with houses. The location of magnetic anomalies interpreted as pits in the area West of House Row 2 suggests one possible source of this ceramic material.

We turn to the most interesting question raised by this analysis: does the surface artifact study provide information not already recovered through the geophysical investigation? To the extent that there were two examples of a good fit between surface finds and magnetic anomalies, confirmation has been provided of a pattern suggested by one or other data set rather than anything new. By contrast, while apparently unsatisfactory, the partial fits and mismatches between the two data sets are more productive in terms of yielding new information or posing fresh questions. Four questions in particular have been raised:

(1) How can we explain the variability in surface daub and pottery discard rates above magnetic anomalies interpreted as houses?
(2) Why is there so little artifact discard in House Cluster 3? Are the houses there in some significant way *different* from those in the House Rows?
(3) Why is there so little artifact discard associated with the Assembly Houses? Do these large structures differ significantly in function, associated social practices and such markedly little discard from those of the majority of domestic houses?
(4) To what extent can we recognise differences in social practices in the 'open area' between the House Rows on the basis of the presence or absence of discarded finds?

These questions will be built into the research design of future seasons at Nebelivka. Their discussion has shown conclusively that there is a major role for gridded surface collection to play in the investigation of complex settlements such as the Trypillia mega-sites.

Conclusion

Several broad hypotheses about the spatial organisation of the site have been suggested and found to be in agreement with the parallel geophysics survey. It appears very likely the structures on the mega-site are arranged in two concentric rows along the outer edge of the settlement with isolated clusters of buildings in the centre and between rows. Several less certain hypotheses have also been suggested: that chipped stone artifacts were not in wide use in the surveyed part of the mega-site, that there may be post-Trypillia metal-working activity and a post-Trypillia kurgan present at two locations, and that the smaller, more ambiguous small magnetic features are not partially burnt houses but likely just smaller ones.

Additionally, correlation of the surface collection data with the geophysics has helped clarify the effects of some post-depositional transforms and define what can and cannot be detected by surface survey. Neither geomorphology nor variable visibility in the survey area seems to have significantly affected the broad agreement between the surface collection data and the geophysics. It has been demonstrated that the surface distribution of burnt daub and, to a lesser extent, pottery, when surveyed at this resolution, yields a fairly reliable picture of the macro-scale organisation of the site. It is therefore useful in confirming the results of the geophysical survey and vice-versa. Areas of mismatch or partial agreement between the two datasets suggest avenues for further research.