Does it Matter How We Collect Samples?

– A case study on sampling strategies, soil chemistry and soil physics at a settlement site, 1750- 300 BC, Tanum 1821:1

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1.1 Introduction

The purpose of this article is to examine how a premeditated strategy for recording and sampling creates a basis for intra-site studies as well as landscape studies. A case study of the archaeological excavations of the site Tanum 1821 is described; this is a site largely consisting of cooking pits and hearths. Work carried out within the project *Skärvstenar och härdar* [Cracked Stones and Hearths] conducted at Bohuslän Museum (Algotsson och Swedberg 1999) constitutes a background to the excavation strategy. Experiences from this project have been deepened through the results and interpretations of archaeological excavations conducted during the beginning of the twenty-first century. Previous to the case study, a strategy for collecting samples was developed together with the Environmental Archaeology Laboratory (MAL) at Umeå University.

Tanum 1821 was situated on the southern side of a small stream, see figure 1. The ground consisted of sandy podsol, which was covered with forest before the excavation. A moraine formation was situated in the northernmost part of the surface. During the excavation, 57 features were uncovered, mostly comprising hearths, cooking pits and concentrations of cracked stones. The cultural layer together with several small concentrations of cracked stones was particularly interesting; these were probably the remains of some kind of a building. Most of the features were discovered in the western part of the surface, close to the cultural layer (Swedberg 2014).

Figure 1: View of the eastern parts of the site, Tanum 1821. In the bottom left-hand corner, the remaining parts of features A26 and A27 can be seen.

One of the purposes of the method used at the archaeological excavation was to test if it was possible to sort cooking pits into categories, based on other criteria than morphology. Categories distinguished in the field were based on the volume of cracked stones, along with the degree of fragmentation of the stones and their relationship with nearby features. Results from analysis of lipids and analysis of the chemical properties of the soil were then added to this information. The outcome was the definition of three categories.

Category 1: Single cooking pits of varying sizes. Slight degree of fragmentation of cracked stones (see figure 3).
Category 2: Cooking pits with an adjacent hearth. Relatively high degree of fragmentation of cracked stones (see figure 4).
Category 3: Cooking pits containing, or situated adjacent to, concentrations of cracked stones (layers of cracked stones).

The level of ambition and the amount of resources possible to spend on the project were the grounds for focusing on category 1 and 2 for analysis. In some cases, the analysed parameters were possible to associate with differences in function. Occurrences of cereals in features dated to certain periods but not others indicate a variation of functions over time. Cereals were dated to two phases, approximately 1730 B.C. and 820 B.C. An intermediate phase was represented by cooking pits without cereals, category 2, dated to approximately 990 B.C. The type of pits and the results of analysis imply that these were used for small-scale cooking of food. A functional analysis of the pits also indicates that activities were carried out at certain parts of the site. However, since the pits seem to be of varying date, this is most likely a random pattern. The importance of cooking pits belonging to category 3 was downgraded in the budget and only one of these, or to be accurate, one of the concentrations of cracked stones was dated. The result of the dating was a median value of 1420 B.C, which is not contemporary with any of the other phases of the site.

Few finds were recovered from the site, in total 72 items were listed; mainly pottery and worked flint. Most of the worked flint consisted of debitage and flakes; some of the flakes were bifacial. All tools, sickle, dagger and arrowhead, were manufactured in bifacial technique; all had been exposed to fire. They were recovered from the surface where the earliest dates have been noted; this was thus near one of the cooking pits, feature A64, which had been used for processing grain.

Maybe the main function of the site was similar over time even though the production varied. There are no clear signs of houses. The only traces of any building appear to be associated with the production in cooking pit A58. Probably all the activities that we have been able to identify at the site were temporary and were carried out on the activity areas of the site, most likely placed in a peripheral situation in relation to the settlement.

1.2 Methodological background

The work of recording and investigating the function of cooking pits was carried out as a separate project at Bohuslän Museum during the second half of the 1990s. A method for how to record the archaeological data of cooking pits was developed within this project (Algotsson and Swedberg 1997). An excavation of a cooking pit was conducted at the rock-carving museum at Vitlycke (Algotsson and Swedberg, 2002). Further, a series of experiments with cooking pits was carried out in collaboration with an upper secondary school in Strömstad during the years 1997-1998; the reports from the experiments were written as school projects. The results were summarised for a conference at Bohuslän Museum (Algotsson and Swedberg 1999). Parts of the funding of the project were used to support recording and sampling at other archaeological excavations, for example, the sites of Forshälla 342 and Svarteborg 589.

A strategy for recording was developed within the project, in which one half of the cooking pit was excavated according to single context methodology. Apart from the usual description of layers and construction details, the cracked stones were weighed, or the volume of them was measured. Cracked stones were sorted according to size and classified into small or large stones. A few experiments showed that stones fired in situ cracked into larger parts, larger than 10 centimetres. Stones that were moved after they were heated broke into smaller parts; after repeated use, they were usually only a few centimetres in size. Thus, seven centimetres was chosen as a dividing line between the categories; or in other words, stones were sorted into groups depending on whether they were heated in situ or moved after heating. The volume of cracked stones was measured in ten-litre buckets. After this was recorded, the section through the feature was extended in order to cover an area outside the actual feature. Thereafter the feature was photographed or drawn; finally, samples were collected. The extended section made it possible to collect samples outside the feature itself, which is particularly important for analysis of lipids and chemical properties of the soil. In particular, analysis of lipids was applied at the previously mentioned excavation of the cooking pit site at Forshälla 342 (Isaksson 1998, Langsted 2000 and 2005).

During the following decade, several cooking pit sites were excavated in Bohuslän. Marianne Lönn (2007) made a compilation of these sites. She concentrates on excavations related to construction work on the road E6 though Bohuslän, which encompasses most of the excavated cooking pit sites in the county. The compilation makes it clear that cooking pits occur both individually and gathered in groups, but also arranged in fairly distinct spatial patterns. Occurrences are systematised in the study, their location in the landscape and periods when they occurred are examined. Finally, ways of studying cooking pits and the aspects that should be especially considered are discussed. Cooking pits occur in a few particular sections of the landscape such as; under cliffs, which might be high and vertical; adjacent to or with a view over water, which might be the sea, rivers or streams. Many of the excavated cooking pits are dated to late Bronze Age – early Iron Age. As regards interpretations, ideas concerning the function of cooking pits have ranged from structures intended as saunas for religious or profane purposes or other ritual functions (often near water), to places for plain cooking. Other purposes that have been discussed include preserving food, boiling train oil and other proto-industrial activities. The idea that they were meeting and resting places for shepherds in a system of pasture husbandry has also been considered. Finally, Lönn emphasises the significance of applying several different kinds of analysis in order to understand their function. Within environmental archaeology, this is a well-tried method, a multiproxy approach.

When the specification for the archaeological excavation for Tanum 1821was drawn up, background information about cooking pits was compiled. A spontaneous reaction to this was the observation that cooking pits that are not found in distinct settlement contexts are often interpreted as expressions of ritual activity. Moreover, a review of a number of excavated sites containing cooking pits in Tanum showed that there was a clear correlation between the amount of performed analyses and interpretations determining them as having functional or ritual purposes, see fig 2. There may be other reasons for this grouping; the context of the cooking pits provides information about functional or maybe ritual purposes. The two cooking pits at Tanum 1209 were encountered together with a hearth, several remaining pockets of a cultural layer and the so called granary, a pit containing 350 000 grains of corn. Samples for macrofossil analysis were collected in one of the cooking pits, resulting in the discovery of cereal. Wood species was determined and dated in the other cooking pit. These cooking pits were understood to have functional purposes in the context of a settlement site (Gerdin & Munkenberg 2005). Within the same project, but at another site, Tanum 1229, four features were identified as ovens/cooking pits. Two of these contained considerable amounts of burnt clay, leading to the conclusion that they must have been ovens. Two of the features were dated and wood species were determined, one was also sampled for macrofossils. Among the macrofossils in the latter, grain was discovered. These features were also interpreted as having functional purposes in a settlement context (Gerdin & Munkenberg 2005). Tanum 1830 was seen to contain 8 cooking pits, 8 hearth pits and 21 hearths, although the categorisation was uncertain in several cases. Further features included post holes and the possible remains of a building. Four of the cooking pits and four hearths were sampled to determine wood species and dating. Macrofossil samples were collected in the fill of two postholes; one of these contained a fragment of grain. The features of the site, including hearths, postholes and traces of a building, were interpreted as part of a ritual context in regard to their appearance and their placing in the landscape (Petersson et al. 2009). At the excavation of Tanum 1835, 33 cooking pits, 18 postholes, cultural layers and settlement pits were uncovered. At this excavation, samples were collected for determination of wood species and dating only, irrespective of the type of feature. It should be noted that the archaeologists excavating the site would have preferred to send a greater number samples for analysis, but the County Administrative Board decided on a lower level of ambition. The section in the report on interpretations discusses functional and ritual purposes. A centrally placed posthole is considered in terms of a totem pole and the identified building is understood to be included in the rituals performed on the site. In view of the position in the landscape and the placing of the cooking pits, the site is believed to be a cult site (Petersson 2009). Tanum 1848 was a site adjacent to marshland, comprising 18 cooking pits, 9 hearths, 4 pits and a layer of packed cracked stones. Several of the cooking pits were sampled to determine wood species, dating and macrofossils. In the macrofossil analysis, only charcoal and one shell of a hazelnut were found. The author of the report identifies a functional difference between the cooking pits of the site, although considering the packed layer of cracked stones to evoke the idea of ritual purposes (Nieminen 2008). Finally, we have Tanum 1857, where three cooking pits, two hearths and eight postholes were recorded. The author of this report bases the conclusions on a landscape analysis, considering the most likely interpretation of the site to be that it was a place for rituals (Petersson 2006).

A usual statement in reports is that 'ordinary macrofossil analysis provides quite a meagre result' (Petersson 2009). Lönn discusses this commonly occurring idea as well, pointing it out as incorrect and adding that this misconception leads to a lack of sampling of cooking pits (Lönn 2007). Based on the background mentioned above, a sampling strategy was established, encompassing analyses of wood species, C^{14}, macrofossils, soil properties and lipids. This was to be applied at the excavation according to the method described below.

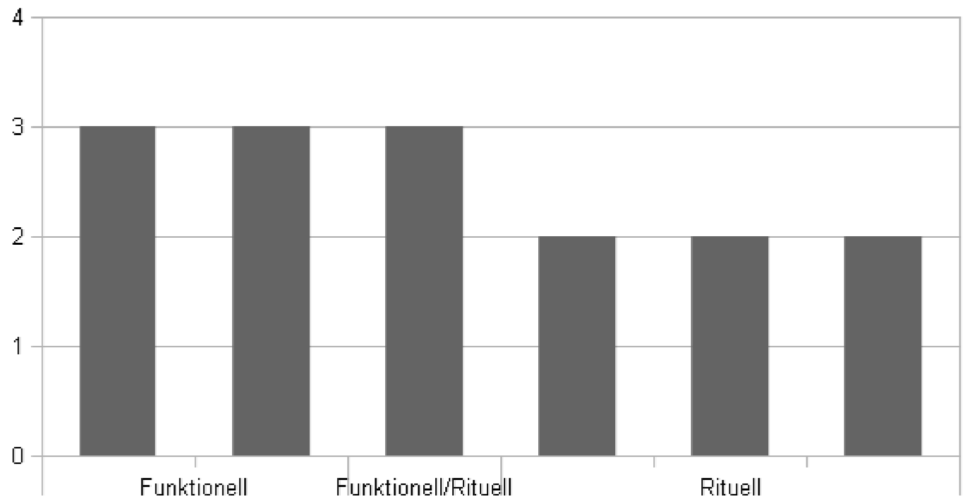

Figure 2. Chart showing the number of performed analyses and the main interpretation, based on the archaeological excavations of Tanum 1209, 1229, 1830, 1835, 1848, and 1857.

The outcome of the various methods of analysis, for instance those discussed in this article, are highly dependent on the material that is analysed; in other words, what it is we sample, but most importantly, where we choose to collect our samples. If the context of the sample is not considered properly, this limits the prospects of interpreting the results of the analysis, no matter which method that is discussed. The main point is that the collected sample reflects the event we want to study. There is no absolute 1:1 correlation between what we regard as a physical feature and the activity that once took place. Consequently, the results we get are not necessarily relevant for the matter we have chosen to study. Furthermore, it might be difficult to determine with certainty the meaning of a quantitative outcome or to understand any variability in measurements, or even to make any meaningful interpretations. A contextual understanding of what it is we are sampling is thus extremely important, particularly when archaeological phenomena are of a complex nature. Perhaps we cannot, or should not, reduce the composition of the archaeological feature into components, or as we might think, the main component.

1.3 Theoretical background

Environmental archaeological analyses are associated with physical material and are still largely dependent on collection of samples. The quality of the analyses is affected by a multitude of factors. Some of these factors, such as sampling, are formed by premises defined through questions and plans included in research. Sampling is necessary since it would be impossible to study all the soil and sediment on a site, considering the sheer volume of material this would involve. Furthermore, human activity varies both spatially and chronologically and is thus no static and immobile occurrence (Engelmark & Linderholm 2008, O'Connor & Evans 2005).

However, other factors do not fit so easily into research questions. Taphonomy and formation of soil are continuous natural processes that must be taken into account when collecting samples, since they might affect the results of the analysis, or might partly explain them. Taphonomy is the study of accumulation and preservation processes of organic remains from plants, animals or humans in soil and sediments (Goldberg & Macphail 2006, Linderholm 2010). The rate of decomposition varies between different materials and is affected by prevailing preservation conditions. Consequently, taphonomy is a significant part of preservation processes affecting a good deal of the archaeological material. If this factor is regarded, the risk of collecting non-representative material and of misinterpreting the data is reduced. Formation processes of the soil have an impact on taphonomy, and so do factors that influence the progress of the formation of soil. These factors include climate, topography, organisms, basic material and time. Air temperature, precipitation as well as quantity and quality of organic debris are some of the occurrences involved in these factors and which are vital for the formation of soil. Human activity also makes an impact on the formation of soil. This is particularly noticeable in studies of, for example manured fields, when human impact is prominent in relation to effects of natural processes in the formation of soil (Eriksson 2011, Linderholm 2010).

Sampling is a factor that researchers are able to design themselves; the purpose and questions framed for the project should govern the sampling scheme and the amount of samples collected (Holliday 2004). Sampling strategies should be adjusted to the studied occurrence; an archaeological feature may need different treatment than, for example, a surface. Moreover, sampling strategies may vary according to the type of feature. Soil and sediment are sometimes the most common material on an archaeological site. Unfortunately, sophisticated strategies for sampling this material are few within archaeology (Wells 2010). Decisions about how samples are collected and the amount of material gathered will influence the data.

Sampling of larger surfaces can be carried out in various ways; samples are often collected from a specific horizon in the soil, usually the illuvial horizon. Test points for collecting samples may be distributed in different ways over the surface; the common procedure is that they are evenly distributed. However, quite often the spacing of samples may be more frequent around certain points of interest, for instance, archaeological features. Within archaeology, studies of this type often rely on systematic sampling methods (Wells 2010), usually mesh or grid sampling (c.f. Entwistle et al. 2000, Marshall 2001).

Bulk testing is commonly applied to features, particularly layers interspersed with soot and charcoal. Generally, sediments thought to represent activities or functions connected with the feature are of interest. These usually consist of greasy layers containing charcoal and soot or are sometimes red in colour. This means that the analytical response of a feature only reflects one or several subjectively chosen predefined layers, irrespective of the method of analysis. There might usually be a manifold of purposes in collecting bulk samples from features. Macrofossil analysis, also enabling determination of wood species, is a commonly applied method. In addition, several chemical and physical properties might be analysed and identified in the same sample.

2. Case study

2.1 Material

A total of 393 samples were analysed at the archaeological excavation of Tanum 1821:1. This study deals with a selection of these. The studied samples originate from a survey of the entire surface uncovered during the excavation, along with samples from a selection of features. Before the archaeological excavation of Tanum 1821, a sampling strategy was planned together with the Environmental Archaeology Laboratory (MAL). This involved conducting a surface survey, after the surface was stripped of turf, targeting archaeological features. Four samples were collected on each side of the feature, about a metre away from the feature in the direction of the cardinal points of the compass. These series of samples were complemented with another four samples collected a further three to five metres away from each feature, this time at a compass point 45° from the cardinal point. If the distance between features was greater than ten metres, additional samples were collected from these surfaces. During the fieldwork, this sampling strategy was modified. On the eastern side, where features were comparatively sparsely spaced, the strategy was generally followed. However, on the western side, an improvised sampling strategy for the surface survey was followed, since the features were placed closer together and it was not possible to fit samples into every direction. On the north-western side, sampling was made much more difficult because of a moraine formation situated to the north of the features. A further limitation to collecting samples was that parts of the surface were covered with dumped soil, obstructing the sampling of some areas.

A grid of test points was prepared for each feature, covering the feature itself and its surrounding context. Series of samples were collected at each point where it was possible, these ranged from the surface down to the bottom subsoil. Bulk samples were collected in selected layers of features to analyse macrofossils, determine wood species and for radiocarbon dating. Lipids were analysed in a selection of these bulk samples. Recording was carried out according to the documentation strategy formulated within the project, discussed in the introduction.

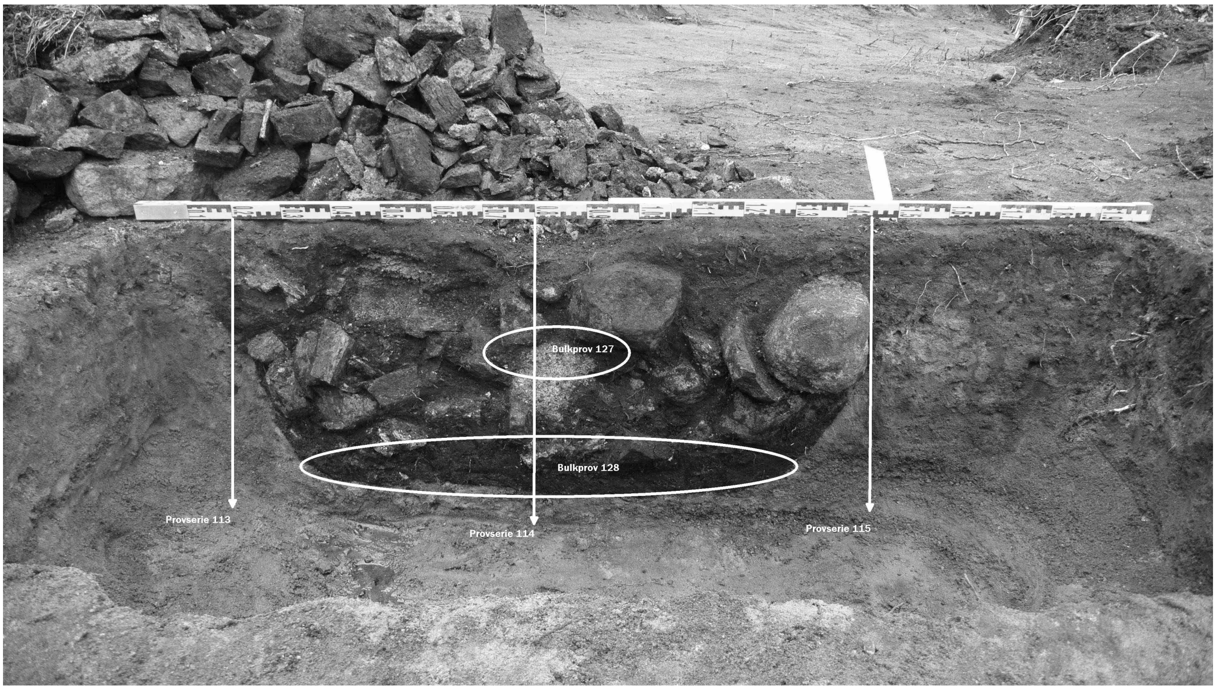

Figure 3. Picture showing the principles of serial sampling to identify chemical properties of soil and for collecting bulk samples.

Initially, analysis of the stripped surface encompassed five parameters (Jerand 2012), but this study mainly focuses on magnetic susceptibility and the content of phosphates in collected soil samples (see section on method below). Among features determined as category 2 (figure 4), a selection was made in order to examine whether features classified in this way respond to the analysed parameters in a similar way.

Four features were included in category 2. These were two cooking pits, features 4 and 51a, and two hearths, features 3 and 51b. In the field, an uncertainty arose as to feature 26 and 27, a hearth and a cooking pit, and whether they should belong to this category; further analysis of these thus became of interest. Feature 1, which was a hearth in an apparently undisturbed area, was chosen for comparison as a reference example. Feature 46 was a type that would be termed a hearth by some archaeologists, others would call it a hearth-pit and others again would say that it was a cooking pit. This feature was therefore included in the study to see if a closer analysis of chemical properties might clarify the classification and interpretation of the feature. Eight features were included in this study all in all. For the purpose of evaluating the method, the selection is of less importance, even if there is a point in including features assumed to have different functions in order to be able to exclude any sources of error connected with specific functions. For a full account of analysis data, see MAL rapport nr.

2014-006 (Linderholm & Jerand 2014) or Jerand (2012) for the archaeobotanical material. Swedberg (2014) has presented a preliminary interpretation of the data in the first stage of the report.

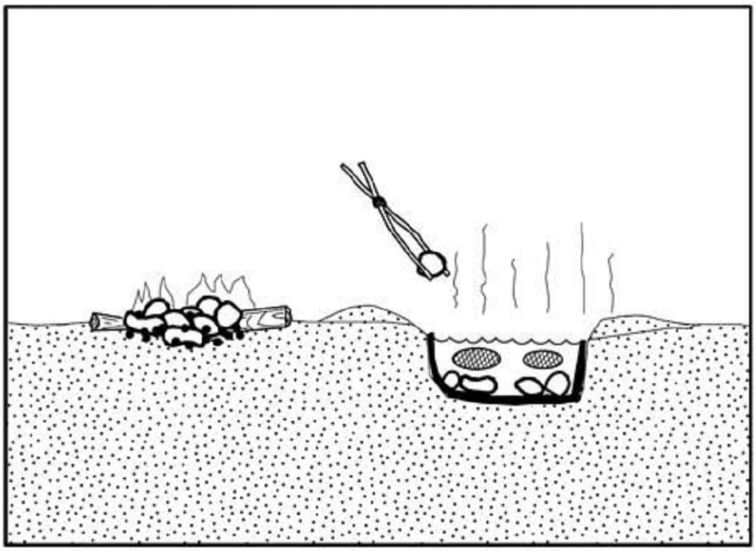

Figure 4. Possible interpretation of cooking pits category 2. The principle is that stones were heated at the side of the pit, after which the hot stones were placed in the pit irrespective of whether the cooking pit contained water or if fluid from the food was used for cooking. Illustration from Alston V. Thoms 2008.

2.2 Method

Besides a surface survey, two strategies for collecting samples in features were employed at the archaeological excavation of the site Tanum 1821:1.

1. Bulk samples for analysing chemical and physical properties of the soil, collected in selected layers of features. Using this strategy, a layer is regarded as a separately defined context. The size of the sample was suited for macrofossil analysis, generally the amount was 2 litres. In order to be able to perform further testing of bulk samples, a representative sub-sampling was undertaken for additional analysis of chemical and physical properties of the soil.
2. In grid sampling, samples are collected at test points with a distance of 10-20 centimetres from each other, vertically and horizontally over the entire section of a feature. Only the chemical and physical properties of the soil are sampled; the size of the sample is suited for this purpose with a volume of 0.5-1 decilitres. This strategy

treats sediments and layers as a continual event, enabling us to view the section as a surface (see figure 3).

These strategies were applied to two types of features: hearths and cooking pits. From these features, 12 bulk samples and 72 grid samples were collected and analysed; the latter were analysed with consideration to two parameters relating to chemical and physical properties of the soil.

- Phosphate analysis, **cit-P** (phosphate degrees P°) according to Arrhenius and the citric acid method of the Environmental Archaeology Laboratory (Arrhenius, 1934; Engelmark & Linderholm, 1996). The connection between accumulation of phosphates and human settlement is well known to archaeologists. The focus of this method of analysis is mainly inorganic phosphates, the source is thus decomposed bone material, general waste, etc.
- Magnetic susceptibility, MS (SI) using a Bartington MS2 susceptibility system with a MS2B sensor in accordance with Thomson & Oldfield (1986) (data is defined in mass specific susceptibility $X_{lf}10^{-8}m^3kg^{-1}$). In principle, the analysis illuminates the qualitative characteristics of the sample. MS provides information about geology and formation of soil. However, there is a strong link between high magnetic susceptibility and human activity through fire/sources of heat, metal working or through impact on the soil due to ploughing or digging ditches (Linderholm 2010).

To facilitate and simplify the presentation of data, photographs of sections through features (figure 9 and 11) have been rectified in relation to vertically oriented test points; the distance between the points represents a horizontal axis and depth from ground level acts as a vertical axis. No previously recorded reference points are obtainable, which means that the scale and position of each photograph may have a greater margin of error than optimal conditions would provide. The margin of error is estimated as not exceeding a centimetre or more, which is considered sufficiently precise for the purpose. To simplify matters in descriptions and discussions, left and right will be referred to in photographs showing test points. When necessary, figures 6 and 9 can be used for orientation on a horizontal level; the excavated squares show which direction the photograph was taken from.

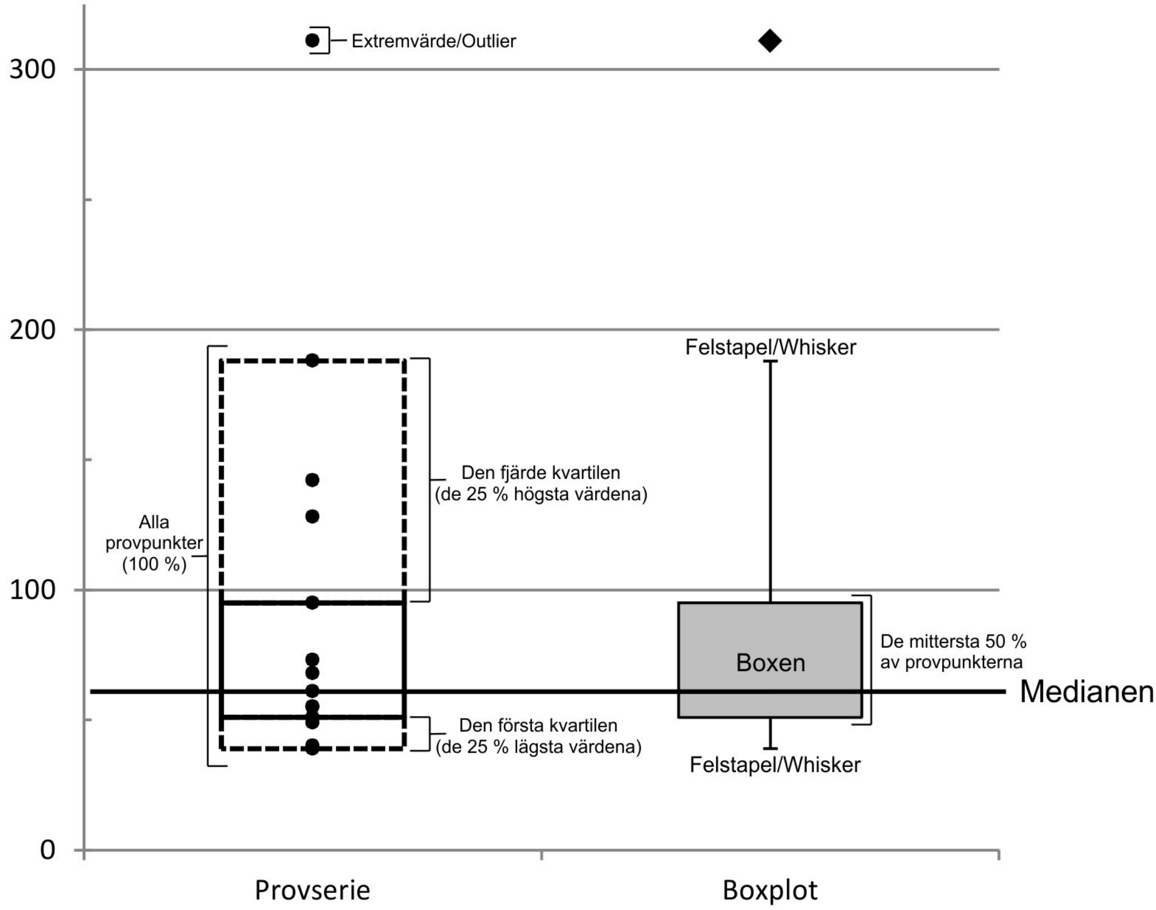

Figure 5. Example of how a box plot is constructed; the test series to the left and the box to the right are based on the same data.

Besides photographs of sections, box plots are used to present and visualise the distribution of data from the features. Box plots are used to clarify comparisons between features containing small amounts of data. Data is presented in quartiles, in other words quarters. In this case, the boxes show the second and third quartiles; this represents data from 50 % of the test points in each feature. Whiskers represent the minimum and maximum measurements. This means that the first quartile (25% of the data with the lowest values) and the fourth quartile (25% of the data with the highest values) are shown between the end of the box and end of the whiskers. A small box or short whiskers means that the results from samples in that quartile are concentrated around the same values, see figure 5.

3. Results

For the sake of clarifying matters, the data below is presented in sections treating the different parameters of the analysis. This is not the best disposition in regard to interpretation, since these methods should be combined in order to extract the most information from the material. Nevertheless, this division has been chosen to simplify the visualisation and presentation of data in the form of text and figures. It should be added that when the samples were collected, the features A51a and A51b were thought to be one feature A51. The division into two sub-features was determined at a later stage; sampling was thus not adapted to this decision.

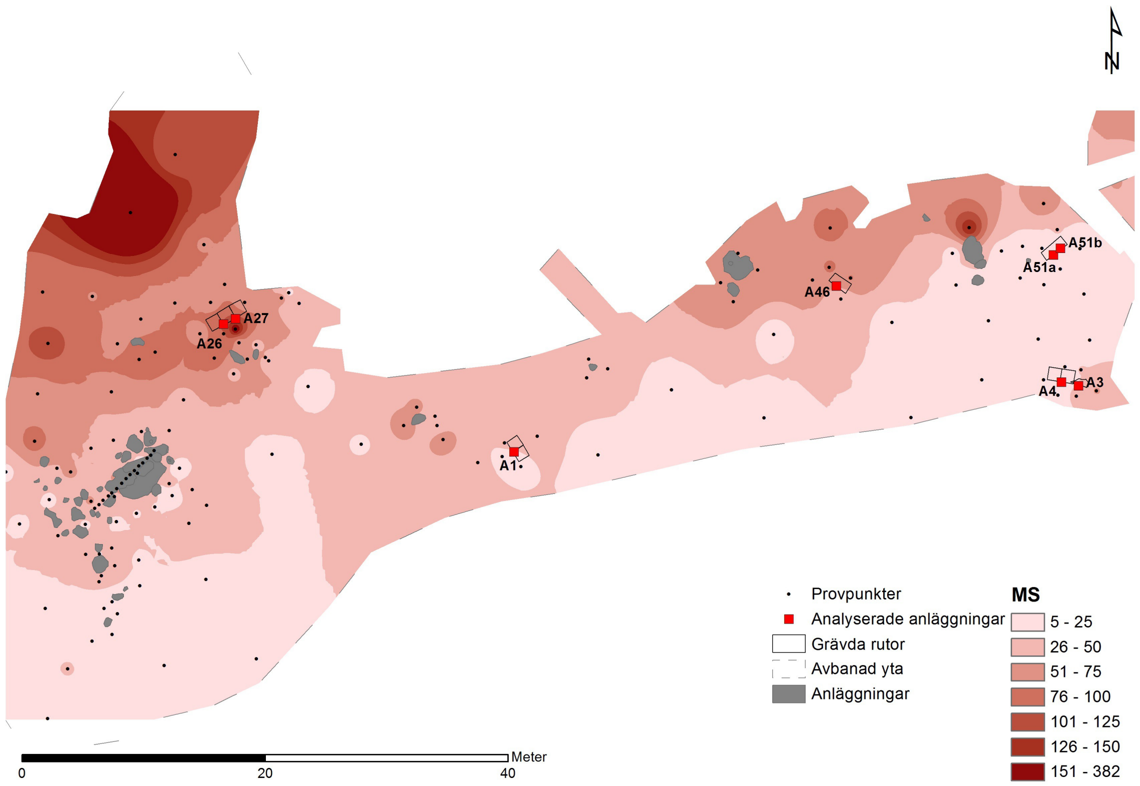

Figure 6. Interpolation of measured magnetic susceptibility (MS) based on surface survey samples distributed over the examined area.

A1 can be seen in figure 6; it is located in the central parts of the excavated surface in a somewhat isolated position and with a relatively low background magnetic susceptibility. **A3** and **A4** are situated in the eastern corner of the surface, where the background MS is within the same range as it is for A1. In the southern parts of the excavated surface, the ground was much wetter, which was particularly noticeable outside the stripped surface where trees and vegetation were still growing. This is reflected in the magnetic susceptibility, which is generally lower in the southern parts. **A26** and **A27** were situated in the north-western parts; a further 6-12 metres beyond these features, the previously mentioned rocky moraine was uncovered. The background MS was slightly higher because of this, although a distinct increase close to the features associated with activities carried out nearby is noticeable. **A46** was located a short distance to the north-east of the centre of the surface. There were more features in this part of the surface and the background MS is somewhat higher here than in general. The features **A51a** and **A51b** are situated on the easternmost side of the excavated surface, 10-20 metres to the north of **A3** and **A4**. The background MS is similar to that of A3 and A4, which is quite low. Just to the west, there is a cluster of features, mainly consisting of hearths, where slightly higher MS can be observed.

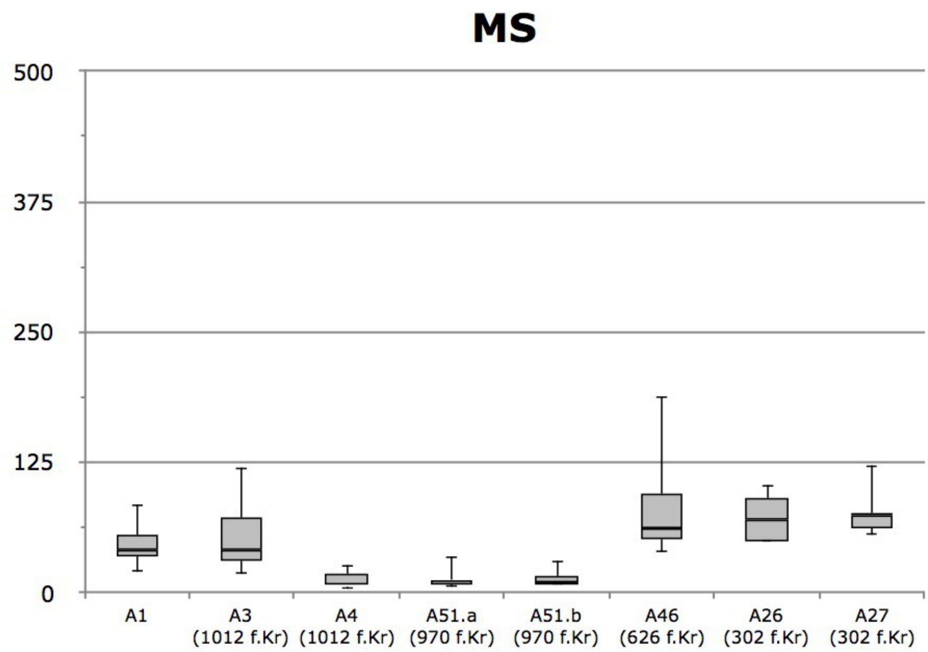

Figure 7. Box plot showing magnetic susceptibility; the boxes contain data from the test series of each feature.

Variations in magnetic susceptibility of the analysed features are shown in the box plot (figure 7). Measured MS in **A1** is concentrated to around 40-50, the lower values are gathered within a shorter range. A difference in MS can be noted between **A3** and **A4**. As a whole, values are gathered within the same range in A4, which is much lower, since the third quartile is on the same level as the minimum measurement for A3. This means that 75% of the MS in A4 is lower than the lowest values in A3. In the cases of **A26** and **A27**, a box plot is not the optimal way of presenting the data, because the number of observations is too low, particularly in A26. In part, this is the result of insufficient sampling, especially in these two features. In turn, this depends on lack of time; these were the two last features to be sampled, on the last day of the excavation. What is possible to say is that there are generally higher measurements of MS in A27 and that the values are gathered in the upper half of the box. **A46** displays data that are much more concentrated to the lower half, while there is a greater variation in the higher values. An outlier with a measurement of up to 300 can be noted. MS for A51a and A51b is comparatively similar. A51a had a measurement of 226, which came from a sample collected immediately adjacent to the packed stones of the feature. This probably means that the sample contains a larger amount of permeable rock constituting a geological contribution to such an increase in susceptibility.

In figure 8, it can be seen that **A1** displays generally higher signals in the left hand side of the feature even if an increase is possible to see in a test point near the outer limit to the right. In the case of **A3** and **A4**, the difference in MS might be even more distinct than is visible in the box plot, since signals in A3 are much higher than in A4. When it comes to **A26** and **A27**, MS signals are similar for those of A3 and A4, while the feature with fewer stones, A26, has higher levels of MS, similar to A3. The section of **A46** shows that the highest MS signals are recorded in the centre of the feature. In the figure, we also see an outlier in **A51a**, at the lowest point of the right hand corner of the section. An increase is noticeable around the packed stones of both features **A51b** and A51a. As in the box plot, the figure displays a comparatively similar view of the MS of the features.

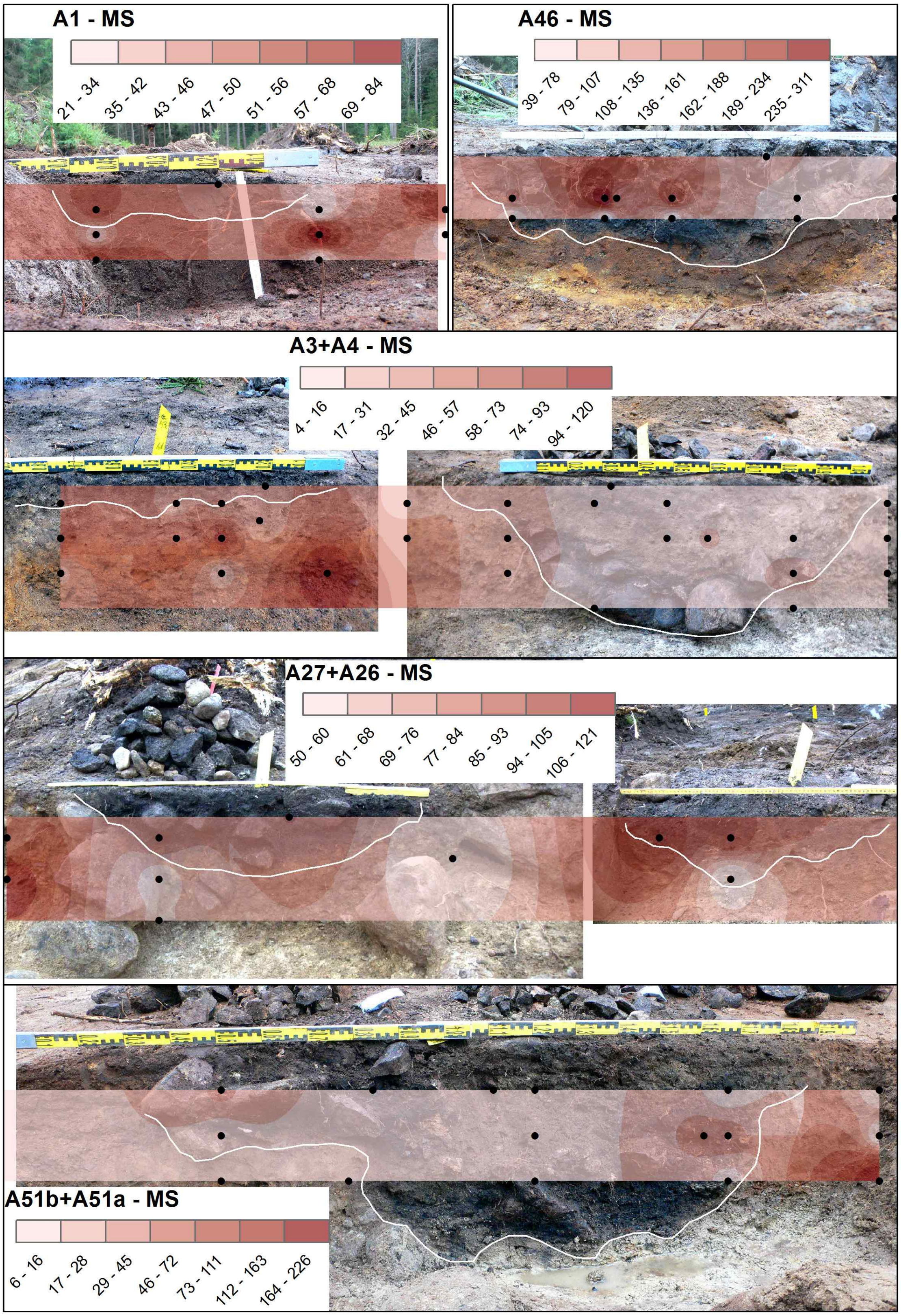

Figure 8. Interpolation of measurements of magnetic susceptibility. The black dots show the estimated placing of test points and the white lines show the approximate outer limit of the features.

Phosphate analysis (cit-P)

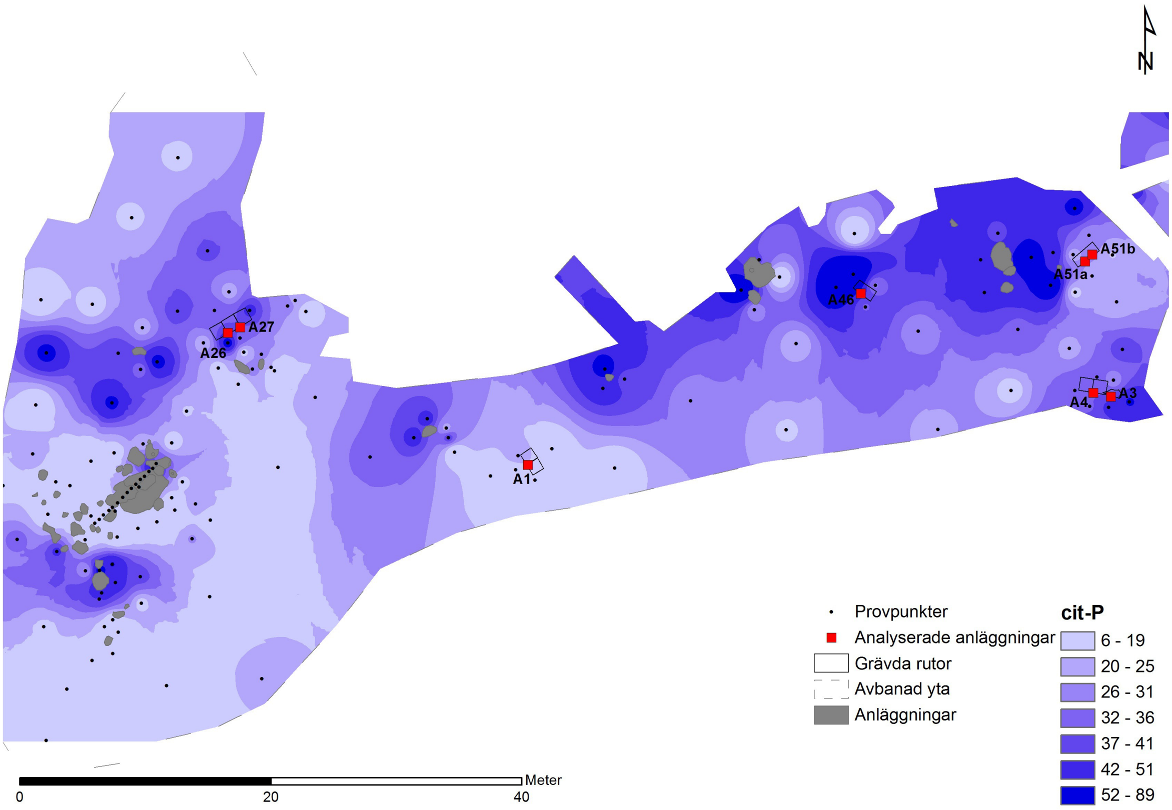

Figure 9. Interpolation of cit-P measurements, based on a surface survey of the studied area.

The background level of cit-P, as well as MS, is relatively low in the area surrounding **A1**. In comparison, the surface surrounding **A3** and **A4** is situated in the middle of the spectrum, having somewhat higher signals near A3 in the south-east. Higher signals were seen around A26 and A27 too, which corresponds with the MS of this surface. Around A46 there are several indications of high signals for cit-P, particularly immediately to the north-west of the feature. A51a and A51b are located in an area with comparatively low levels, although it is possible to distinguish much higher signals to the west.

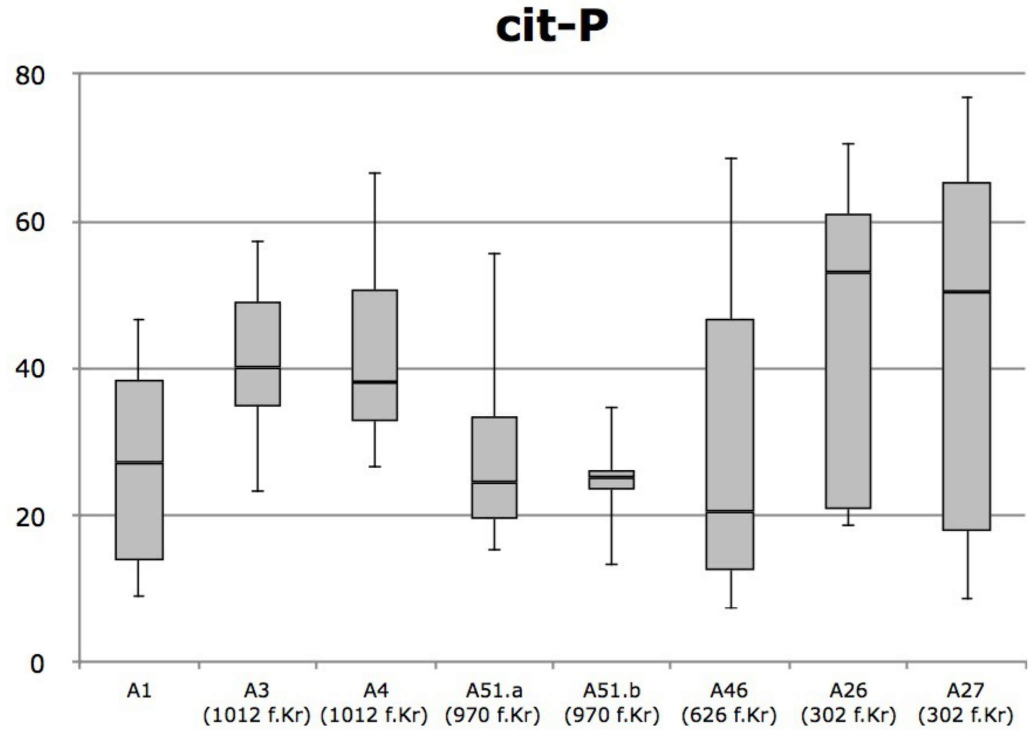

Figure 10. Box plot showing cit-P, each box shows the test series for the corresponding feature.

Variations in cit-P in analysed features are presented in the figure above (figure 10). The measurements of **A1** are slightly dispersed with a median around 27. **A3** and **A4** have a similar distribution, even though A4 generally displays a greater number of high signals. Measurements for **A26** and **A27** resemble those of A3 and A4, although they are slightly more varied. The highest levels are higher in A27 than in A26. A46 displays the same tendencies in cit-P as in MS; the lower half is considerably more concentrated. Regarding A51a and A51b, we see that the levels of A51b are much more concentrated, although in the lower half, they are consistently much lower.

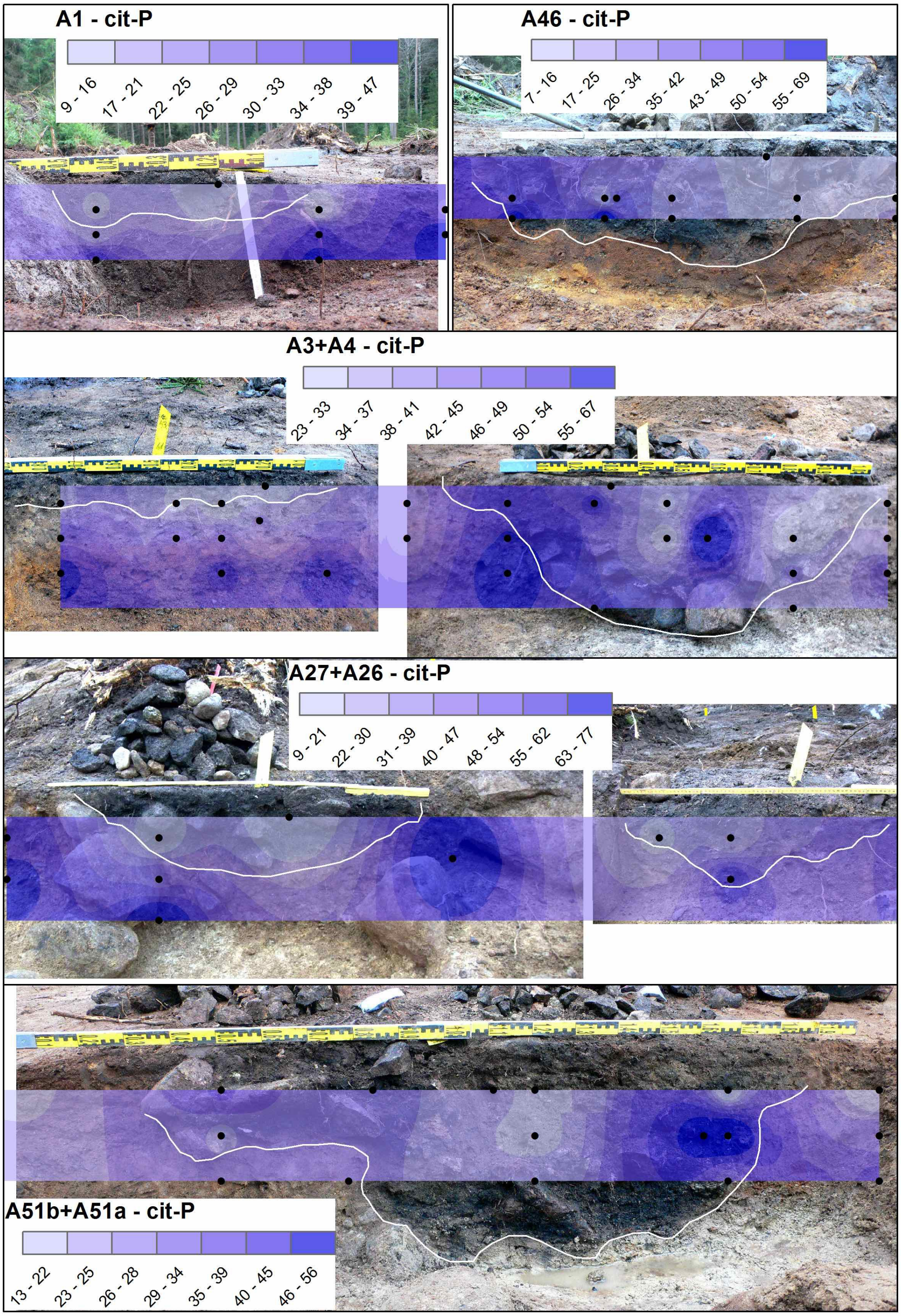

Figure 11. Interpolation of measurements in phosphate analysis. The black circles mark the estimated location of test points and the white lines are the approximate outer limit of the features.

In the figure, we can clearly see that the higher signals in **A1** are consistently found in the lower parts of the feature. The highest measurements are concentrated to the right hand side of the feature. In **A3** and **A4**, there is a general increase deeper down in the features. In A4, high signals occur in the centrally placed layer of packed stones and in the left hand side of the feature. In **A26** and **A27**, conditions are similar to A3 and A4. A27 and A4 display higher values than the features A26 and A3 that contain few stones. These signals also occur slightly deeper down in the feature. In the figure, we can see in **A46** a clear difference in cit-P between the left hand side and the right hand side of the feature, with high measurements to the left and low to the right. In A51b, we see slightly higher signals in the upper part of the layer of packed stones, while in A51a, a considerably stronger signal can be observed in the right hand layer of packed stones.

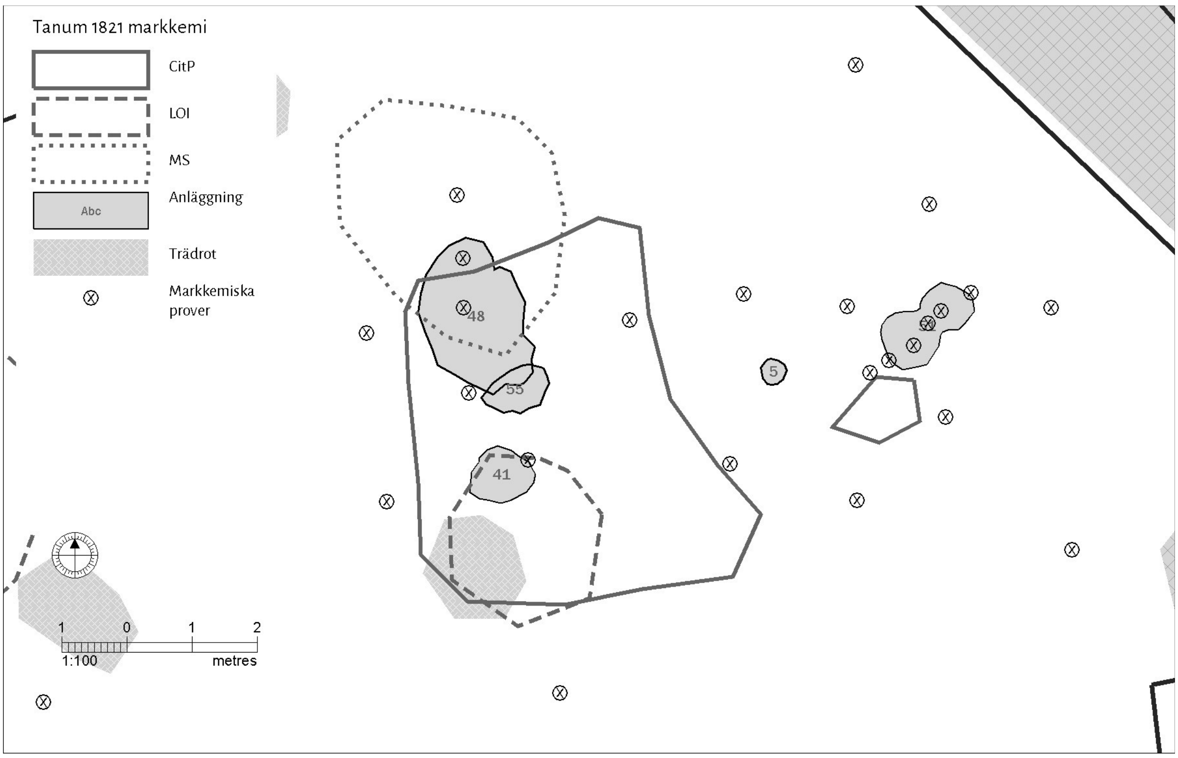

Figure 12. A schematic interpretation of the results from analysis of the surface surrounding the features 41, 48, 51 and 55. The continuous line shows an increase in phosphates indicating activities connected with preparation of food. Dots mark an increase in magnetic susceptibility. This increase is probably the result of activities in which fire and heat were used. The area delineated with dashes indicates a greater amount of organic content, associated with activities carried out in and around the cooking pit; parts of the (organic) material that was processed in the pit was deposited here. Illustration in Swedberg (2014).

The focus of this study is to benefit from a purposeful sampling strategy providing means to determine the function and to categorise separate features. Figure 12 helps to illustrate this; the different categories of features are related to the activity areas surrounding the features. The illustration is a schematic interpretation of the results of the analysis based on the two parameters, cit-P and MS, with the addition of organic content; it is based on an interpretation discussed by Swedberg (2014). The results connected with feature 51, which we have made a closer study of here, can be said to be common to all category 2 features in this case. They generate little or no traces of activity in the surroundings of the feature; even inside the feature, the response of the analysed parameters is often comparatively low. However, around all the category 2 features, there is a limited area with accumulation of phosphates. Lipid analysis conducted on this category of features indicates that they may have been used for preparation of animal products, which is not contradicted by these results (Isaksson 2013). An interpretation of this might be that the features were used for cooking, intended for direct consumption and not for surplus production. A considerably larger area of phosphate concentrations occurs around the features 41, 48 and 55. These features can also be linked to an area with an increase of organic content, which does not occur together with any category 2 feature. It is possible that there has been an accumulative effect due to intense use of the surfaces surrounding these features, but it is more likely that there was a difference in the actual activities. One interpretation is that the features were used for some form of large-scale preparation of surplus production.

3. Discussion

The purposes of archaeological excavations may vary but collecting information is always an element that is included. The information we arrive at constitutes the basis for interpretations, enabling progress in research. One of the aims of the excavation of Tanum 1821:1 was to study the function of hearths and cooking pits. These are complex features, sometimes neglected because they are considered comparatively sparse in content and difficult to interpret (Lindfors et al. 2008; Lönn 2007). If samples are collected, specific layers are generally selected because they are considered to have certain properties favourable for the chosen methods of analysis. From the perspective of soil chemistry/physics, it is interesting to reflect whether these selected layers are representative for the function of the feature and the activities that were carried out. A feature might moreover be subject to internal sedimentary variation, which might be overlooked if the sampling is selective, oriented only towards specific layers. Features associated with heat make a greater impact on their surroundings than many other types of features. Layers considered favourable for certain types of analysis do not necessarily fully reflect the nature of the chemical and physical properties of the soil. In the case of analysis of chemical and physical properties of the soil, the results are likely to be misleading, since these kinds of features consist of more than one layer. Thus, the analysis is hardly representative if the entire context is not regarded.

The results from the excavation are undoubtedly interesting. Extracting and visualising data from a further dimension shows the variation between the features more clearly. This has made it possible to distinguish patterns. Measurements from the reference feature A1, which is interpreted as a hearth, are similar to general measurements from hearths, and it is consequently distinct from cooking pits. Like other single hearths, it has had little impact on its surroundings. Another feature that was considered difficult to determine in the field was A46, it could be interpreted as either a hearth or a cooking pit. Analysis shows that it is not possible to classify it in terms of these rough categories. Properties of the soil are similar to those of hearths, although there is a greater impact on the surrounding area. Category 2 features, A3 and A4 as well as A26 and A27, display particularly interesting results. Features that were smaller and contained fewer stones, A3 and A26, had higher MS but lower signals for cit-P. Opposite results were seen in A4 and A27 with more substantial layers of packed stones and thick layers mixed with soot and charcoal. Similar tendencies can be discerned in A51, even if these are slight. In the right hand side, A51a, there is a distinct increase in cit-P (see figure 10 and 11); in figure 7, it is possible to distinguish somewhat increased MS in A51b. In the bottom right hand corner of figure 8, an outlier can be seen; obviously, this will affect the interpolation of MS data, causing an increase in the values of the surrounding area. If the outlier is excluded, an increase would still occur on the right hand side of A51a, but it would be much less distinct. Therefore, the picture is somewhat clearer in the boxplot (figure 7), where the outlier is marked as a dot. The median value for A51b is 7.5, while it is 11 in A51b. The difference in the MS of A51a and A51b is thus not as marked as the difference between A3 and A4, and in some degree between A26 and A27.

Consequently, there are similarities in chemical/physical properties of the soil within each type of feature, but responses occur in certain samples collected outside the colouring of the soil that we often consider to define a feature. Is this due to natural circumstances, for instance, a reflection of the background environment, is it the result of bioturbation (disturbance in the ground by living organisms), or is it a sign that a feature makes an impact even on its immediate surroundings? In this material, tendencies indicate the latter; the degree of impact of a feature on the surrounding material is exceedingly likely to depend on the function. Is it reasonable to assume that several hearths with the same function generate the same chemical/physical response in an analysis of the soil? To support such an assumption, it would be necessary to study a larger material applying a uniform sampling strategy.

Ideally, a uniform sampling strategy should have been applied to all features. Most importantly, the number of collected samples should be the same, to provide comparable data. In this case, a decision was taken in the field concerning the selection of suitable features for grid sampling of sections. Among other things, this was based on available resources and the position and characteristics of the features. This method is time-consuming, needing more resources; the result is that the cost is balanced against the level of ambition. However, if a well-suited plan is constructed and carried through in an organised manner, the accomplishment of the procedure presented here need not necessarily be more costly than for instance a surface survey. This would of course depend on the range of the study and the number of features.

The procedure presented here is not necessarily the most optimal, but at least it constitutes the basis for a strategy enabling collection of a larger amount of data than many other more commonly applied methods do. Nor is it a finalised recipe, stating black on white how to collect samples or how not to. In many cases, these methods are applied only as a tool for prospecting, certainly with far-reaching empirical success. This study is an example of application in cases of features at an archaeological excavation generating a considerable amount of information about the chemical and physical composition of features, making it possible to deepen the discussion about their function. Moreover, this procedure shows that it can provide decisive support to interpretations of the uses of a surface. As mentioned in the beginning of this article, sites with cooking pits are often interpreted without investigation into their basic function. If this is clarified, discussions about function and possible links between function and rituals can be substantiated in a better way. This procedure should be possible to apply even with a limited level of ambition; with a higher level of ambition, the number of analysed features and the intensity of a surface survey might be increased. The methodological procedure presented in this article illustrates that cooking pits, commonly classed as a comparatively anonymous type of feature, could provide significant information about their function, as well as their role in the settlement, if a well-planned strategy is applied.

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