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Waste disposal in late Iron Age and early Roman Silchester: a geochemical comparison of pits, post holes, ditches and wells in Insula IX.

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Abstract

Bulk chemical analysis was undertaken on samples taken from 143 negative features (wells, pits, post-holes, cess pits and ditches) across the area of excavation at Silchester Hampshire in order to help us understand the disposal of waste during late Iron Age and earliest Roman occupation. Results show that it is possible to split features into waste disposal which included animal/human waste and those which probably did not. It is also possible to identify post-holes based on organic matter content. This work forms part of the larger Town Life project run by the University of Reading.

Keywords: Iron Age, geochemistry, waste disposal

Introduction

Since 2002 a sampling strategy using bulk geochemical analysis (x-ray fluorescence) has been developed in the context of the Silchester Roman Town Life Project in Insula IX, where excavation by the Department of Archaeology at the University of Reading began in 1997 and was concluded in 2014. The aim of the strategy has been to enhance our knowledge of the changing use of space and of occupational behaviour within the area under investigation, some 3025m^2, which represents about one quarter of this entire block (*insula*) of the Roman town. Using XRF as the principal technique of investigation, research initially focused on the interior of one mid-Roman house (House 1) (Cook *et al*., 2005; 2011), then on the wider use of hearths across the excavated area (Cook *et al*., 2010) and, more recently, on the differential use of space of the timber-framed buildings occupying the area under excavation in the late 1st and early 2nd century AD (Period 2) (Cook *et al*., 2014).

As the excavation reached the earliest occupation layers, representing the initial settlement of the late Iron Age from *c*. 20BC (Period 0) and the earliest post-Roman conquest phase from the mid-40s to the last quarter of the 1st century AD (Period 1), a much greater density of pitting and well digging was found than in subsequent phases. It is generally assumed that the pits, even if originally dug in order to extract water or building materials such as gravel or clay, were eventually used to receive waste of all kinds. Even wells, once abandoned as a source of water, were used in a similar way. Typically such features contain quantities of discarded pottery, ceramic building material and animal bone as well as the macroscopic waste from metalworking. There are also the rarer, items of material culture like metalwork, including items such as coins and personal items. Programmes of environmental sampling use flotation to recover the carbonised remains of seeds and wood charcoal, while the residues from these processes produce finds not usually recovered in hand excavation such as small mammal and fish bone, mineralised seed and plant remains and the microscopic remains of metalworking. Waterlogged contexts producing well preserved seed and plant remains, as well as perishable materials such as leather, textiles and wood give an indication of the range of organic materials which do not normally survive.

The geochemistry of the soils reported here is designed to complement the comparative analysis of the contents of pits and wells based largely on the macroscopic finds of material culture and faunal remains and to investigate potential patterning that will shed light on variations in occupational behaviour across the excavated area. It will also help moderate initial interpretations made in the field, for example that certain pits were used for cess disposal. Underlying the approach is an assumption that the pits and wells will produce a distinctive geochemistry. In order to test this, the study has been broadened to include samples from ditches, gullies and post-holes. The latter, for example, are generally interpreted as such on the basis of their size, but the geochemistry may help to distinguish small pits actually used for waste disposal and holes dug to take the structural components of buildings.

Methods

Samples were taken from negative features across the excavation at Silchester Insula IX, these features were characterised during the excavation as pits (sixty four features), ditches/gullies (nineteen features) post-holes (sixty features) and wells (three features). The features were classified as follows:

Pits: features excavated for a variety of purposes such as storage and disposal of human and animal waste. Ditch/gully: features which have been used for drainage, either for roads or buildings, enclosures or defences.

Posthole: features used to hold posts, either for a fence or building.

Well: a feature used to draw drinking water for human and/or animal consumption.

The samples were allowed to dry, then dis-aggregated and passed through a 1 mm sieve. The number of sample analysed necessitated a technique that was both rapid and relatively low cost, in this case x-ray fluorescence was chosen. The samples were then ground and pressed into pellets with a KBr backing for analysis by X-ray fluorescence (XRF) using a Philips PW1480 XRF with Philips X40 analytical software. Analytical quality was determined by running multiple sub-samples and certified reference material was used to check the accuracy of analysis. Organic matter content of selected samples was determined using loss-on-ignition at 500^0C.

The bulk (the XRF anaylsis providing total element concentrations) geochemistry of the samples has then been compared both against each other and against background soil samples collected from outside the Roman town wall at Silchester, The aim of the work is to examine variability and elucidate any differences which may enhance the interpretation of individual features and, more generally, of occupational behaviours across the excavated area in the late Iron Age and earliest Roman period.

Results

In order to begin to understand the chemical fingerprints of each type of feature the average concentrations of both major and trace elements were first considered in relation to the mean background concentrations (Table 1a), these were then plotted to obtain an "average chemical fingerprint" for each feature type (Fig. 2). At first glance there are six elements which appear enriched within the samples from the anthropogenic features; these are copper, zinc, strontium, phosphorus, calcium and manganese.

Copper and zinc are found at highest concentrations in the cess and rubbish pit samples. The samples from these features contained greater amounts of organic matter (Table 1b) than the well samples but less than the post-hole samples. Unsurprisingly given its affinity for organic matter Cu has the largest correlation with organic matter content (0.46). The explanation for the high organic matter but lower copper concentration in the post holes may be due to the nature of the infilling and/or decay of the posts *in-situ*, particularly if the post was charred, examples of charred posts were found in the forum basilica excavations (Fulford and Timby 2000, 29). Pit 12462 was the only feature analysed that was interpreted during excavation as a cess pit. However the chemical signal from the samples analysed (Table1, Fig.2) demonstrates that this feature, whilst contained elevated P concentrations, is not markedly different from the chemical signature obtained from the pits. Cess and rubbish pits contain a variety of human and animal waste which is likely to be higher in Cu (Oonk *et al.,* 2009), whereas the material from the postholes is more likely to be packing for the post (rubble, soil) and soil infill into the void left by the decayed post. Zinc is also found in highest concentrations in the rubbish pits, in all probability for the same reason as Cu.

Strontium is also indicative of anthropogenic activity and has been shown to be associated with food preparation, animal penning and burning (Middleton, 2004). The highest concentrations of Sr were found in the cess and rubbish pit samples here.

Phosphorus is the most widely used anthropogenic indicator in archaeological sediments and it is a key element in living systems (Middleton 2004, Oonk 2009), phosphorus enrichment occurs most frequently as a result of disposing of excrement, waste and organic decay (Gauss et al., 2013). Phosphorus can enter the sediment and soil system by a variety of human processes (Schlezinger and Howes, 2000; Holliday and Gartner, 2007), and has been used as a general indicator of occupation intensity (Schlezinger and Howes, 2000; Wells et al., 2000; Marwick, 2005). It is not surprising, therefore that all the negative features sampled contain P concentrations well above our baseline (Table 1b), the highest concentrations of P are found in the pit samples with the cess pit samples second. This is as one would expect given the contents of the cess pit and the rubbish pits, both can be expected to have contained both animal and human excrement as well as ash from fires and plant remains both of which are sources of P (Middleton , 2004; Kanthilatha, Boyd & Chang, 2014).

Of the sampled features the wells contained the lowest levels of P, notably, of the samples analysed using loss on ignition as a method of determining organic matter, the wells had the lowest average organic matter content. In order to further investigate the distribution of P across the site and within the samples bubble plots were used to show varying concentrations (Fig. 3). Figure 3a shows the distribution of P concentrations in pits across the site, several pits stand out as having comparatively elevated P. These samples were from contexts 11970 and 11971, which were part of a cluster of Period 0 pits located towards the northern limit of excavation, while pits 12005 and 13539 were located close to the centre of the excavated area and were likely associated with early Roman activity. Feature 14322 was interpreted during excavation as a pit, yet was later recognised as post hole forming part of the northern wall of a substantial late Iron Age structure (Fig.1)

The samples from the ditches (Fig. 3) which run along the N-S street contain higher concentrations of P than the samples from ditches in the middle of the site, this is perhaps not surprising given that this road would have carried animal traffic and the ditches would have received run-off from the road. The bubble plot for the post-hole samples (Fig 3c) clearly shows that two samples contain far more P than the others. These samples belong to post holes 13717 which were associated with a possible later Iron Age structure and 12837 that truncated a construction trench associated with a further later Iron Age structure. (Fig 1)

Calcium has also long been regarded as a good indicator of human activities (Middleton and Price, 1996; Middleton, 2004; Oonk *et al.,* 2009b), and food production areas tend to contain elevated concentrations of phosphorus as well as calcium (Middleton, 2004). All the negative features sample contain high Ca concentrations with the pits and well samples having highest Ca and the ditch/gully samples lowest.

Managanese behaves in a similar way to Ca (Middleton, 2004) and is associated with plant remains. It is not surprising then that the cess pit and rubbish pit samples contain the most Mn, with the ditch/gully samples also containing similar Mn concentrations, perhaps indicative of vegetation washed or swept into the gullies.

Zirconium is depleted compared to background in all feature types but this is likely to be due to different weathering rates of the background soils and sampled features. Zirconium has no anthropogenic source and behaves in a conservative manner, thus as weatherable minerals are removed from the profile Zr appears enriched (Whitfield *et al.,* 2011).

Analysis of results

In order to further understand the differentiation between the different feature samples we employed a variety of statistical techniques. Principal component analysis (PCA) produced results which did not show much separation between the groups. An approach which considered individual variables one-at-a time was then chosen and box plots were produced (Fig. 4). A standard R boxplot function was used with outliers labelled as circles, the box shows the upper, median and lower quartile and the "whiskers" show the range of the (non-outlier) data. Therefore if the notches on two of the boxes do not overlap there is strong evidence for the medians of the distributions being different. In this way we can easily compare the different features.

Figure 4 shows the box plots for each type of feature, in this plot blue = well+cess, yellow = pits, green = postholes and red = ditches/gullies. This plot shows that pits have high P, Sr, Cu and Mn and wells are correspondingly low in these elements. It is difficult to separate the ditches and post-holes using this technique, the post-holes contain more Na Ti, and Zr than the ditches whilst the ditches are higher in P and Pb, perhaps a reflection of the waste matter present in ditches but not in post-holes.

Summary and conclusions

The different negative features sampled at Silchester, post-holes, pits, ditches/gullies and wells have been characterised according to their bulk chemistry in an attempt to understand whether it is possible to determine their function using chemistry alone. The results show that it is possible to split features into waste disposal which included animal/human waste and those which probably did not. It is also possible to identify post-holes based on organic matter content.

The samples analysed here are all taken from the earliest occupation associated with the beginning of urban life in Southern Britain. The timespan ranges from the origin of the late Iron Age *oppidium* at Calleva, c. 20BC, through the earliest phase of occupation after the Roman conquest of SE Britain in AD 43-44, to c.AD70, about 90 years. Although the results show higher concentrations of elements in some rubbish/cess pits, all the analysed samples across the whole excavated area show significantly above-background results for elements indicative of human and animal occupation. They do not show any concentrations of elements indicative of metalworking or any other specialised occupation, as for example identified in the later (Period 2) phase at Insula IX, late 1st century/early 2nd century AD (Cook et al., 2014).

On-site interpretations can be ambiguous and it is here that further investigation using techniques other than traditional archaeology can be of assistance. Features interpreted as post-holes for example are found to contain elevated organic matter and lower concentrations of phosphorus than pits and ditches.

Ditches that run along street fronts are higher in phosphorus than those away from main thoroughfares. This highlights the importance of across-site variation and of archaeological context, not all samples from each type of feature are the same but vary according to the use of space.

The well samples are noticeably lower in anthropogenic elements notably again P, but also in Cu, Mn and Sr.

While the statistical tests performed on the data did not produce a definitive separation of feature type, we were able to extract some differences in sample characteristics, particularly for ditches and pits (higher P in both these sample types) and post-holes with lower P and higher organic matter. It is perhaps a reflection of the multi-purpose use of pits, both household and animal/human waste that makes it hard to separate them from cess pits, and indeed even post holes may have been backfilled with general rubbish after use.

The samples analysed here are all from contexts stratified beneath those which were analysed and interpreted in Cook et al., (2014). An important question is whether there has been downward mobility of elements which may have influenced the results presented here. While this cannot be completely discounted, it is reassuring that the concentrations of elements individually and collectively are distinct. The samples taken from Period 2 (Cook et., 2014) are considerably higher in metallic elements associated with craft or industrial processes, this not evident in these earlier occupation levels.

At present there are no comparative data available from the earliest phases of other Late Iron Age and earliest Roman urban communities in Britain or elsewhere, but it is clearly desirable that this research be developed further to gain an insight into the characterisation and comparative analysis of early urban settlements.

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References

Bowen, H. C. & Wood, P. D. (1968) Experimental storage of corn underground and its implication for Iron age settlements. *Bulletin Institute of Archaeology,* 7, 1-4.

Cook S.R., Clarke, A.S., Fulford M.G. and Voss J.(2014) Characterising the use of urban space: a geochemical case study from Calleva Atrebatum (Silchester, Hampshire, UK) Insula IX during the late first/early second century AD. *J.Arch.Sci*. *50* 108-116

Fulford, M.G. and Timby, J., (2000) *Late Iron Age and Roman Silchester: Excavations on the Site of the Forum-Basilica, 1977, 1980-86,* Britannia Monograph 15, London

Gauss, R.K., B_atora, J.,Nowaczinski, E.,Rassmann,K., Schukraft,G. (2013) The Early Bronze Age settlement of Fidv_ar, Vr_able (Slovakia): reconstructing prehistoric settlement patterns using portable XR. Journal of Archaeological Science 40, 2942-2960.

Holliday, V.T., Gartner,W.G. (2007) Methods of soil P analysis in archaeology. Journal of Archaeological Science 34, 301-333.

Kanthilatha, N., Boyd, W. & Chang, N. (2014) Multi-element characterization of archaeological floors at the prehistoric archaeological sites at Ban Non Wat and Nong Hua Raet in Northeast Thailand. Quaternary International 08 1-13

Marwick, B. (2005) Element concentrations and magnetic susceptibility of anthrosols: indicators of prehistoric human occupation in the inland Pilbara, Western Australia. Journal of Archaeological Science 32, 1357-1368.

Nielsen N.H & Kristiansen S. M (2014) Identifying ancient manuring: traditional phosphate vs. multi-element analysis of archaeological soil. J.Arch.Sci 42 390-398

Nelum Kanthilatha, William Boyd & Nigel Chang (2014) Multi-element characterization of archaeological floors at the prehistoric archaeological sites at Ban Non Wat and Nong Hua Raet in Northeast Thailand. Quaternary International.
Middleton, W.D. (2004) Identifying chemical activity residues on prehistoric house floors: a methodology and rationale for multi-elemental characterization of a mild acid extract of anthropogenic sediments. Archaeometry 46, 47-65.

Middleton, W.D., Price, T.D. (1996) Identification of activity areas by multi-element characterization of sediments from modern and archaeological house floors using inductively coupled plasma-atomic emission spectroscopy. Journal of Archaeological Science 23, 673-687.

Oonk, S., Slomp, C.P., Huisman, J. (2009) Geochemistry as an aid in Archaeological prospection and site interpretation: current issues and research directions. Archaeological Prospection 16, 35-51.

Oonk, S., Slomp, C.P., Huisman, D.J., Vriend, S.P. (2009b) Effects of site lithology on geochemical signatures of human occupation in archaeological house plans in the Netherlands. Journal of Archaeological Science 36, 1215-1228.

Schlezinger, D.R., Howes, B.L. (2000) Organic phosphorus and elemental ratios as indicators of prehistoric human occupation. Journal of Archaeological Science 27, 479-492.

Smith D.N (20 13) Defining an indicator package to allow identification of 'cesspits' in the archaeological record. 40 (1), 526–543
Wells, E.C., Terry, R.E., Hardin, P.J., Parnell, J.J., Houston, S.D., Jackson, M.W. (2000) Chemical analysis of ancient anthrosols at Piedras Negras, Guatemala. Journal of Archaeological Science 27, 449-462.

Whitfield C, Watmore A & Aherne J (2011) Evaluation of elemental depletion weathering rate estimation methods on acid-sensitive soils of north-eastern Alberta, Canada. Geoderma 166 (1) 189-197

Figure headings:

Figure 1 Plan of excavation site at Silchester showing location of features sampled.

Figure 2 Elemental fingerprints for samples taken from negative features at Silchester compared to the average background sample. Concentrations in mg/kg dry weight.

Figure 3 Bubble diagram showing relative concentrations of phosphorus found in samples from pits, ditches and post-holes. Grid shown with eastings and northings.

Figure 4 Standard R boxplot function plots with outliers labelled as circles, the box shows the upper, median and lower quartile and the "whiskers" show the range of the (non-outlier) data. Blue = well+cess, yellow = pits, green = postholes and red = ditches/gullies