SUTTON HOO RESEARCH TRUST

LEVERHULME TRUST PROJECT

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Report to the Leverhulme Trustees. 5th March 1987.

Introduction

Our last communication directed to you contained a summary report of the initial progress to that date (June 1986). We are now able to supply a much fuller set of information, most importantly containing results from the first series of chemical analyses undertaken on material from the Sutton Hoo burials. We are happy to say that very interesting progress has been made, and that our work has become of increasing interest to other workers in the field. Indeed, one of the key factors in our progress has been the advice and practical assistance given by other academics/institutions, for which due acknowledgement is given.

The project remains under the overall direction of the Sutton Hoo Research Project director, Martin Carver (now Professor). The day to day work has been carried out by the archaeological researcher Philip Bethell, happily now assisted by Miss Joanne Miles. Miss Miles has been appointed as a research student in the Department of Chemistry at Birmingham University, under the supervision of Dr. M.B.H. Hayes, the director of the Soil Chemistry lab., who has been associated with the project from its inception. Miss Miles began her work here in August of last year, and has already contributed a great deal to the project.

The broad pattern of work has consisted of the field season at Sutton Hoo, during August and September 1986, followed by processing of the samples taken. The main laboratory work since then has comprised the extraction of humic material from the body samples, and the elemental analysis (25-element array) of all the samples from one of the graves excavated in the summer. The results from this are currently being subjected to statistical analysis, but significant patterns of elemental concentration within the result spread can already be discerned.

Other work has involved field sampling of comparative sites, notably Brandon, Suffolk; Hacheston, Suffolk; and Snape, Suffolk. Several other sites have been visited in order to arrange future sampling. Contact has been made with other interested parties, and samples have or are being sent for analysis to the British Museum; Queen Mary College, London; Oxford Radiocarbon Accelerator Unit; Manchester University; and Cardiff University. We have also attended several conferences: PHB to Leeds (15/02/86 - 'Death, Decay and Reconstruction'); Liverpool (08/11/86 - Anglo-Saxon Cemeteries); Sheffield (21-23/11/86 - Weekend skill-school on human osteology). JUM to Hamburg (13-20/08/86 - International Soil Science Congress); and Ghent (25-29/08/86 - International Humic Studies Society Conference). We have also spent time visiting other labs, etc. for discussion, and have of course continued with our background research. PHB has also co-written a paper on soil phosphate analysis, for an Oxford University symposium volume.

The first full year of the project has thus been a very busy one, which has seen the important step of putting the theory into practice, with the first series of analyses. The details of this work follow below.

Sutton Hoo - Leverhulme Trust Project

Field Sampling at Sutton Hoo, 1986 Season.

The 1986 season was the first field season in which the Leverhulme Trust Project had an active involvement on site at Sutton Hoo. PHB had responsibility for the sampling of any inhumations excavated, in order to provide material for subsequent laboratory analysis. The main aim of the sampling programme was to produce a relevant body of material from which comparisons between the natural soil, grave fill, and any organic remains, human or otherwise, could be made, and from which the decay trajectories of the organic remains could be examined. This required a thorough sampling programme throughout the burials, with special care taken to locate the samples accurately.

It was apparent that there was an immediate point of conflict between the requirements of the analytical programme and the archaeological record. The normal procedure of archaeological recording requires the maximisation of possible information concerning the position, arrangement and associations of any bodies present. This involves the physical separation of the various components, for example to reveal as much of the body as possible, by removing the fill from around it. In the case of Sutton Hoo, it may well also involve chemical additions to the material, in the form of consolidants. The ideal sampling strategy for chemical analysis would, however, treat the whole grave - fill and body (and any other organic remains, eg. coffin) - as one entity, and seek to create a 3-D chemical picture of the burial, with all the samples equally spaced, and of equal size, and so on. Clearly this would not necessarily provide the archaeological information sought, which still relies primarily on visual assessment of the remains. Only a minute analysis of a grave could approach the level of detail recoverable by standard excavation procedures. It was thus necessary to compromise at the outset, and the sampling procedure was designed to give a fairly even distribution of samples within the grave. In practice, a controlled distribution of samples was possible until an organic object such as coffin or body was encountered. The shape of the object then dictated to some extent the pattern of subsequent sampling. The compromise was such that if the distribution of samples was not completely even, at least the origin of all samples was known (ie. whether they were body, fill, etc.). This was very important for the first set of analyses, in order to characterise the chemical 'signature' of each identifiable type of deposit.

The initial distribution of samples was as shown in the diagram (fig.1a), and the pattern was repeated every 5 cm downwards. This would ideally have provided a set of seven columns of samples running from the top through the bottom of the grave. Due to the reasons outlined above, the exposure of the body to reveal the best possible tableau made it very difficult to continue the sample pattern. In fact the body levels show a larger number of samples, as all the organic decay material was hopefully recovered, but with a distribution that reflects the position of the body, and not the arbitrary positions of the sampling columns. This means that any interpretation of the elemental content of the samples would reflect a more general picture of the elemental distribution than a more strictly

controlled sampling programme. The pattern of sampling suggested for future work is shown in fig.1b.

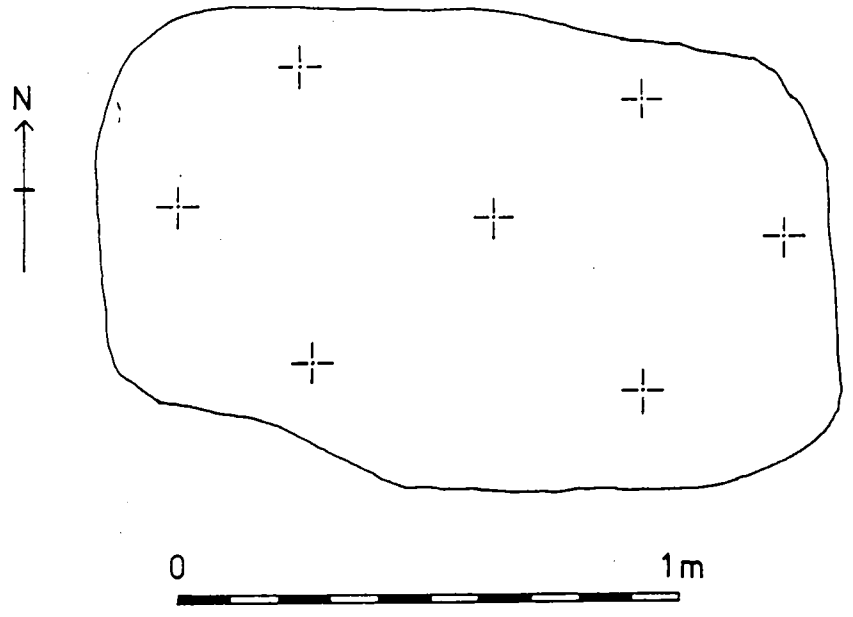
The samples were taken with a clean stainless steel spatula, and placed in a clean minigrip bag with write-on panels. The sample size varied, because more of the body material was recovered proportionate to the fill. The average size was c. 50g. While taking the column samples, care was taken not to dig too deep, so as to merge with the sample below, but rather a larger horizontal area around the point of sampling was removed. This enabled clear vertical differentiation between samples from the same column. Location of the samples was facilitated by use of the site hand-held computers, which were programmed to provide accurate 3-D positional plots from a given theodolite reading, effectively recreating the functions of an EDM. Initial points were carefully fixed, and subsequent points measured from them. The body sample points were generally very accurately fixed, as part of the archaeological recording procedure.

After being taken, the samples went into the finds recording process. It must be said here that they ought to have been air-dried almost immediately, to prevent any post-excavation microbial action taking place, and altering the organic content. However, this proved rather difficult in practice, as there was no room to do this. It remains to be seen whether any samples have been contaminated in this way. They were taken back to Birmingham at the end of the season, and most were immediately deep frozen. There has been a steady programme of drying out and bottling of the samples for long term storage. In future, we would hope to have a drying cabinet on site, and insist that all samples are air dried as soon as possible. Air drying was recommended by Dr. Hayes at Birmingham, as it did not fundamentally alter the conditions under which the samples existed normally, for example waterlogged samples should be kept wet, and so on.

In all, three graves and one suspected grave were sampled, the feature nos. being F226, F227, F231, and F235. Samples were also taken from many of the features in Intervention 39, along with comparative material from the natural around them. It is hoped to be able to analyse these for any differences between the average feature fill and the natural, in order to look into the possibility of chemically mapping the pre-excavation surface. A number of samples from the natural soil around the graves was also taken, and a series of columns from the topsoil through to the natural was recovered (Intervention 43).

Sampling procedures carried out on other sites, such as Brandon and Hacheston, were dictated very much by the prevailing conditions and the time available, and were not as thorough as those carried out at Sutton Hoo.

a) INITIAL SAMPLING PATTERN



b) SUGGESTED SAMPLING PATTERN

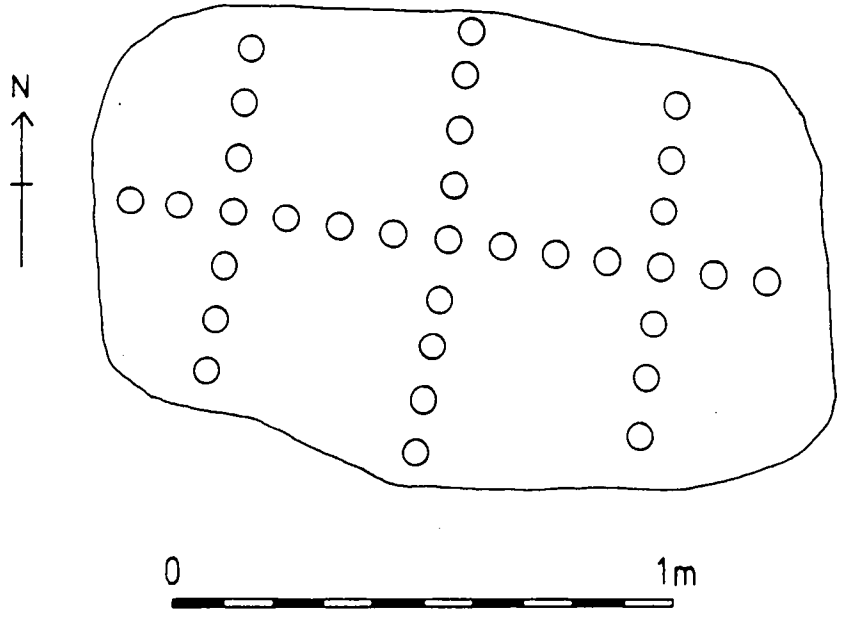


FIG. 1

Sutton Hoo - Leverhulme Trust Project

Sampling programme: comparative material.

Hacheston, Suffolk. Suffolk county unit SMR code HCH 013.

The site was visited during the Sutton Hoo season, on 11/08/86. PHB did the sampling, and was conducted to the site by John Newman of the Suffolk Unit, to whom acknowledgement must be given. It is one of a number of sites in the immediate area, around Hacheston and Wickham Market, yielding material from several periods.

HCH 013 was a small area on top of a sandy knoll, which was being removed by sand quarrying. As such it was a rapid rescue excavation, and the detail of recording was correspondingly poorer than one would have liked. The conditions were very sandy, beneath grass cover. I am not certain whether the area had been under the plough or not, but it was certainly adjacent to a ploughed field.

The sampling was conducted on a burial identified as pagan Anglo-Saxon, consisting of a deep grave within a ring ditch (presumably originally under a small barrow). The grave was approx. 2m N-S x 1m E-W, and had already been partially excavated, the N. end having been removed to leave a vertical section (N-facing) across the centre of the grave. Samples were taken as a column down the face of this section, and the southern end of the grave was then excavated, and samples taken from the coffin stain and horizontally along the bottom of the grave. There were no visible signs of an actual inhumation - not even a stain remained to show the shape or position of the body. Site grid refs. and spot heights were not recorded, but the sketch plan shows the relative positions of the samples. The site was situated approximately on the 20m AOD contour.

The most noticeable feature of the burial was the lack of visual evidence of an actual inhumation, although there were very clear traces of a coffin, including a large area of the flat bottom. There were no traces of grave goods. Chemical examination of the samples should be very interesting, in furnishing proof that this grave contained an inhumation.

List of samples: Hacheston, Suffolk. HCH 013. 11/08/86. PHB.

Sample no.	Distance below top of grave.	Comments.
01	0.00 m.	top of grave fill.
02	0.15 m.	grave fill.
03	0.30 m.	grave fill.
04	0.45 m.	grave fill.
05	0.60 m.	grave fill.
06	0.75 m.	grave fill.
07	0.90 m.	grave fill.
08	1.05 m.	grave fill.
09	1.20 m.	grave fill.
10	1.35 m.	bottom of feature.
11	1.50 m.	natural below grave/column base.
12	1.35 m.	bottom of feature, E. side.
13	1.35 m.	bottom of feature, W. side.
14	0.75 m.	natural in side of feature, W.side.
15	0.75 m.	natural in side of feature, E.side.
16	1.20 m.	
17	1.20 m.	
18	1.30 m.	
19	1.30 m.	
20	1.30 m.	
21	1.32 m.	coffin stain.
22	1.35 m.	coffin stain.
23	1.35 m.	inside coffin.
24	1.35 m.	inside coffin.
25	1.35 m.	inside coffin.
26	1.35 m.	coffin stain.
27	1.40 m.	base of coffin (horizontal stain).
28	1.40 m.	base of coffin (horizontal stain).
29	1.40 m.	base of coffin (horizontal stain)
30	1.40 m.	"control" outside coffin.
31	1.45 m.	natural below coffin.
32	1.45 m.	natural below coffin.

Total of 32 samples, stored at BUFAU as of 18/02/87.

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Sampling programme: comparative material.

Brandon, Suffolk. Suffolk County Unit SMR code BRD 018.

The site at Brandon, in northern Suffolk, was visited on 3rd December 1986, by PHB and SMC. Assistance was greatly appreciated from the Suffolk county unit, specifically from Bob Carr and Andrew Tester, who gave permission for the sampling to be carried out.

Brandon is a large complex site, mainly Middle Saxon, and containing settlement, cemetery, riverside and industrial components in the archaeological record. The conditions are extremely sandy, as at Sutton Hoo, but not apparently as acidic. The site does not appear to have been ploughed, so the archaeology, though very shallowly buried, remains undisturbed. The skeletal preservation was much better than at Sutton Hoo, with the bulk of the skeleton being recognisable, and very little visible evidence of soil staining around the body. A clear dark coffin stain was visible along the N. edge of the grave examined. The bones were, however, rather fragile and difficult to lift without breaking. The sampling was done on an inhumation revealed immediately to the S. of a timber building identified as a church, at the southern limit of the current excavation. This in fact lay on the northern edge of a cemetery already largely excavated.

The burial sampled was that of an adult in extended position, oriented E-W, lying approximately in the site grid position 94800/52500 - 95000/52500. The head lay to the W., and sampling was carried out in the region of the legs, pelvis, and upper thorax, from context no. 8007.

The burial, and several others being excavated, were very near to the surface of the field, being on average 0.5m below the modern ground surface. Samples were taken at the E. end of the grave, above, below, and around the left (?ie. southernmost) tibia; in the pelvic region, and above the upper thorax. Much of the grave fill had been removed so it was difficult to get a continuous column from the top of the grave to the bone. The sample locations are detailed below.

A series of samples was also taken at a point c.10m to the E., from the edge of the excavation, in order to sample the complete profile. 17 samples were taken at 0.05m intervals, from the top of the turf down to the sandy natural.

List of samples: BRD 018 (Brandon, Suffolk) 03/12/86.

Sample No.	Grid (site)	Ht. (AOD)	Position/comments.
01	95010/52517	4.48	E. end of grave.
02	95010/52517	4.43	E. end of grave.
03	95010/52517	4.38	E. end of grave.
04	94998/52511	4.39	Above bone (tibia).
05	94998/52511	4.34	Directly above/on lwr. part tibia.
06	94990/52516	4.33	N. of tibia.
07	94996/52505	4.33	S. of tibia.
08	94970/52512 -	4.34	Actual bone - tibia.
to	95000/52511		
09	94995/52511	4.32	Around tibia and fibula.
10	94995/52511	4.30	Below fibula.
11	94783/52500	4.52	Above upper thorax.
12			
13	94995/52521	4.33	N. of tibia.
14	94995/52511	4.27	Boundary of fill and natural.
15	94995/52511	4.22	Natural below bone.
16			
17			
18	94990/52546	4.40	Natural on N. side of grave.

Soil column:

A 01 c.	96000/52500	5.01	Top of 'garden' soil = turf line.
A 02	96000/52500	4.96	
A 03	96000/52500	4.91	
A 04	96000/52500	4.86	
A 05	96000/52500	4.81	
A 06	96000/52500	4.76	
A 07	96000/52500	4.71	
A 08	96000/52500	4.66	
A 09	96000/52500	4.61	
A 10	96000/52500	4.56	
A 11	96000/52500	4.51	
A 12	96000/52500	4.46	
A 13	96000/52500	4.41	
A 14	96000/52500	4.36	
A 15	96000/52500	4.31	
A 16	96000/52500	4.26	
A 17	96000/52500	4.21	Into sandy natural.

Total 35 samples, stored in BUFAU 18/02/87.

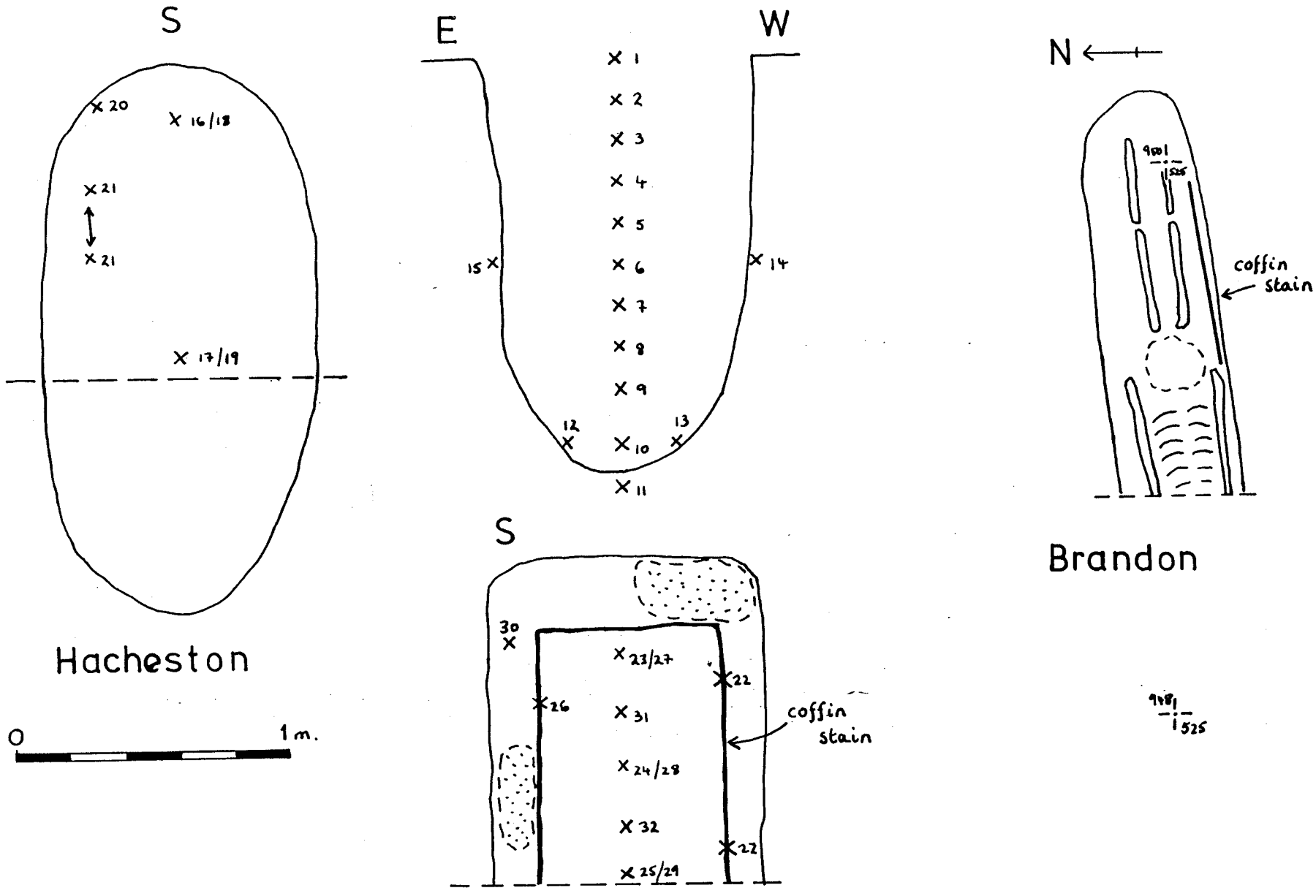

FIG 2: POSITION OF SAMPLES - HACHESTON & BRANDON

Sutton Hoo: Leverhulme Trust Project.

Field Experiments 1 - 3 (FXP1-3): Archive Report.

Phosphate enhancement spray experiment, August 1986.

The experiment was based on the phosphate spot test described in Eidt, 1973. This involves the use of two reagents added dropwise to a small soil sample on a filter paper, the presence of phosphates being indicated by the formation of a blue phospho-molybdic complex. It was decided to transfer the reaction directly to the ground surface, with greatly increased quantities of reagents, in order to see if any areas of phosphate enhancement would be revealed, ie. phosphate rich features would hopefully stand out as patches of deeper blue colouration against the natural background.

The field procedure was as follows, recorded in field notes by PHB.

Reagent A was prepared on the evening preceding the experiment (6th August), by PHB assisted by Carol Williams. The work was carried out in the site office premises, where a small sink and draining board area was available (normally used for photographic work). Reagent A consisted of 290 ml of 10N HCl, made up to 2.5l with distilled water, and having 95g of ammonium molybdate dissolved in it. The container used was a 2.5l capacity Killaspray (Model no. 4036 Courier 4). Reagent B was mixed on the morning of the experiment, and consisted of 12.5g of ascorbic acid dissolved in 2.5l of distilled water, in an identical container to that used above.

As regards the ease of preparation, the following points were noted. The ammonium molybdate and ascorbic acid were brought to the site in pre-weighed portions, in labelled glass bottles, so their preparation presented no problem on site. The hydrochloric acid was in 2.5l Winchesters, at a concentration of 10N or 36% w.w. In retrospect this should not have been used. Although safety gloves and goggles were worn, the fumes proved to be extremely irritant, and simple nervousness at handling a potentially dangerous chemical was also a factor. In future, the use of much more dilute acid would be recommended, bearing in mind that this would increase the volume of material to be transported and stored. As a further point, extreme accuracy of measuring the acid was not necessary, as the large volume of reagent used gave some leeway regarding concentration.

In general, the preparation of the reagents was not difficult to carry out, and the limited facilities available were adequate. Assistance was required with the handling of the concentrated acid, but one person could comfortably manage the procedure if dilute acid was used. For safety reasons, however, such work should not be carried out by totally inexperienced people, nor in the absence of a source of running water. Great care should also be taken in the storage and disposal of any chemical reagents. Excess of distilled water should be provided, as it was needed in large quantities for washing the equipment, prior to use. Safety goggles, gloves and lab. coat should be worn.

Equipment used:

1 x 1000ml graduated glass measuring cylinder.
1 x 100ml graduated polypropylene measuring cylinder.
2 x 2500ml polypropylene beakers.
1 x 15cm glass funnel.
1 x glass stirring rod.
2 x 2500ml capacity Killasprays (No. 4306 Courier 4).
Safety gloves (heavy duty rubber).
Safety goggles.

Reagents:

10N Hydrochloric acid (HCl).
AR Ammonium molybdate ($(NH_4)_6Mo_7O_{24}.4H_2O$)
AR Ascorbic acid ($C_6H_8O_6$).
Distilled water.

LTPFXP1: The on-site experiment. 7th August 1986.

The application of the reagents to the excavation surface was carried out on the morning of 7th August 1986, before the normal working day commenced, in order to minimise any risk of wind-borne contamination to the staff. Present were PHB, MOHC, AC, and NMcB. The area chosen for the experiment was within the stripped and trowelled area of Intervention 32, around F225, F226, F227, and F228. These features were visible after normal trowelling and cleaning, and after spraying with ordinary water, and appeared to have outlines typical of other features which had been found to be inhumations. Thus a phosphate enhancement could be expected if these were inhumations, and thus they ought to show up as blue against the natural sand, when sprayed.

Reagent A was sprayed over the area around these features, as evenly as possible. Reagent B was applied 30 seconds later, again with care to get as even a spread of the reagent as could be acheived. Two people were required for this, both wearing overalls and rubber gloves. A problem was encountered early on, as one of the Killasprays had a faulty seal, and so could not produce as much pressure as the other one. It was attempted to compensate for this during the spraying.

At first, it appeared as if the area had simply been sprayed with ordinary water, the only sign of anything happening was the appearance of a strong blue colouration around the nails fixing the context labels to the ground. Gradually, a blueish/greenish tinge could be discerned, particularly in the feature furthest to the west (F226), which we felt was enhanced by the reaction, and showed the strongest greenish tinge. The others were not so marked, but at the peak of the colouration intensity, c.10 - 15 minutes after the spraying, a clearly green colour was visible over the whole sprayed area. (After c. 10 minutes, the area was sprayed with plain water, which appeared to enhance the colour. MOHC suggested that future attempts should begin with a thorough wetting of the surface).

Four hours after spraying, the outlines of the graves were still clearly visible, and carried a strong greenish tinge. At 5 p.m., (9.5 hours after application), the stains were still strongly visible, even after rain showers in the afternoon. On gentle trowelling, it was found that the staining reaction affected only the very surface of the soil, ie. <1mm of the feature fill. Because of this, it was very easy to trowel away. The stains remained visible throughout the next day (8th), but were fading. The colouration greatly facilitated the planning of the features.

The experiment was not an unqualified success, but was quite encouraging. A small patch of the anti-glider ditch and adjacent soil in Int. 39 was also sprayed, but with no visible effect.

LTPFXP2 9th August 1986.

This experiment was a direct repeat of FXP1, using the same preparation techniques, and spraying over the same area. It was hoped to make this second run a more controlled version of the first, with more careful timing of the colour changes, and so on.

The area of the features already sprayed was fine trowelled to reveal the natural colours once more. This was followed by a fine spray with ordinary water, which was observed to enhance the outline of the features, and also the fine detail of their surface, such as tip lines etc. This began to dry out after only a few minutes, and a second spray with water was carried out before the reagents were applied.

On spraying with the two chemicals, as before with a 30 second gap between the two applications, a greenish-blue tinge appeared almost immediately, but was somewhat patchy over the whole sprayed area, and did not bring out the outline of the features. After two hours, the whole sprayed area was a dark bluish colour, without any distinction between the features and the surrounding soil. The area was sprayed again with water, but this did not aid the differentiation.

This version of the experiment was clearly a failure, the reason apparently being contamination of Reagent A inside the Killaspray. The cause appeared to be a section of metal pipe incorporated in the spraying tube, which was observed to carry blue stains inside it. This indicated that the blue stain was a result of complexing with some constituent of the pipe metal before it even reached the ground. Whether this had affected the results of FXP1, was not certain, but it was felt that on balance the contamination had only become noticeable during the second run.

LTPFXP3 12th August 1986.

It was decided to conduct essentially the same experiment over a larger area, to see if any features not visible after trowelling might be revealed. The Reagent A contamination problem was hopefully circumvented by using a different type of Killaspray, the smaller 1.25l capacity No. 4075 Polyspray 2. This model does not have the flexible pipe attachment of the other, and so the reagent does not come into contact with any metal parts. The area sprayed was Lane 3D in Intervention 39, measuring 8m x 4m., before any features were excavated. As before, the reagents were applied at a 30 second interval, (after water spraying), but it was difficult to get an even quantity of each reagent on any one spot, because of the difference in size between the two Killasprays, and hence differences in pressure, etc.

After 10 - 15 minutes, green-blue streaks began to appear - the streaky effect probably being caused by the uneven spraying - over the whole area. One suspected grave was apparently darker than before spraying, and BN reported that F24 was clearer than it had been. Along the N. edge of the lane, an apparently barren patch carried an ovoid green-blue stain, which was felt might indicate a previously undetected feature. After 1 hour, the W. end of the lane was sprayed again with water, and a 1 - 2m strip in the centre was resprayed with the reagents. The stain in this strip became a much darker blue, and covered most of the ground. It did not appear to enhance any features. In general, there was very little clear differentiation over the whole lane.

A series of samples was taken over the whole of 39/Lane 3D, on a 0.5m grid, with the intention of carrying out a laboratory phosphate analysis over the same area as the spray experiment, for comparative purposes.

Discussion

It was felt at the time that the phosphate enhancement spray experiments were a little disappointing, and that the results did not really tell us anything. However, following the excavation of the features sprayed in FXP1 and 2, and Lane 39/3D (FXP3), some positive aspects have been revealed. F226 did not contain any visible human remains, although F227 turned out to be a double burial. F228 was not excavated. The lane in Int. 39 contained no graves, and in fact most of the features excavated were rather amorphous, and interpreted as natural features. It thus seemed that the spraying enhanced the anthropogenic features, while the negative enhancement shown by Lane 39/3D was in fact a positive reflection of the nature of the archaeology present. It must be borne in mind that this was by nature a trial experiment, but the indications are that it could be very useful in feature detection. The analysis of F235/236/240 shows a phosphate enhancement at the level of the body, compared to the rest of the grave fill, but whether backfilled features have an increased phosphate content vis-a-vis the natural sand, is not yet certain. The phosphate analysis of the samples from Lane 39/3D has not yet been carried out (as at 17/02/87).

What the experiment did show, however, is that it is comparatively easy to carry out such spray experiments in a field situation. The reagents can be prepared off-site, or failing that, only limited facilities are required for on-site preparation. Providing full safety precautions are taken, such experiments could be undertaken by anyone with common sense and a basic knowledge of handling chemicals. The cost of the experiment was not very great either, the most expensive items being the Killasprays.

Conclusion

The experiment can be regarded as a qualified success, in that the results from two areas of differing feature type and arrangement were different, the area of apparently positive enhancement being found to contain at least one grave, the area showing negative enhancement apparently devoid of anthropogenic features. At the very least, the use of such reagents simply to stain the surface of known features, in order to delimit them in such poor digging conditions as Sutton Hoo, would be useful. The blue stains were observed to last for some considerable time (at least 48 hours), and to only penetrate the upper 1mm of soil. The normal drying rate (under the prevailing conditions) for water-sprayed enhancement is minutes, rather than hours.

In general the experiments were a useful step towards the wider use of chemical enhancement techniques on archaeological sites.

Ref: Eidt,R.C. 1973: A rapid chemical field test for archaeological site surveying. American Antiquity 38, 206-211.

Sutton Hoo - Leverhulme Trust Project

External analysis: British Museum.

The British Museum has of course been involved with the site of Sutton Hoo since its original excavation. Although no longer directly responsible for the excavation, the Museum has been assisting the current project with technical and scientific back-up. Their first involvement with material from the recent excavations was an attempt to date a bone sample from one of the burials. The bone was found to contain what seemed at first to be unidentifiable organic matter. After consultation with the Oxford Radiocarbon Accelerator Unit, it was discovered that these were amino acids probably derived from the original bone.

The most recent work undertaken by the Museum for the Sutton Hoo project, is the development of a suitable consolidant for use on the site. This would enable (hopefully) excavation of otherwise unrecoverable fine details of organic artefacts, such as ships, burials, and so on.

This work is currently being done, and no final results are available at the time of writing.

External analysis: Oxford Radiocarbon Accelerator Unit.

As mentioned above, the Oxford Unit was involved with the original extraction of organic residues from the bone, an important step in its own right, as it shows that organic material does survive under the Sutton Hoo conditions. Whether the case of bone is a special one, in that organic material not part of an integrated organo-mineral complex such as bone does not survive, we have yet to determine fully.

The particular bone sample submitted to the Accelerator Unit yielded 65 mg of amino acids from 200 mg of bone. This was reported to be a "high collagen yield", and "very satisfactory", (Dr. J.Gowlett, pers.comm.). The C-14 date given by the bone sample was AD 750 ± 70 years, (OxA - 819). This indicated, along with another date from the Harwell lab., of AD 620 ± 90 (HAR-6800), that the flat-grave burials were roughly contemporary with the ship burial, and could certainly be assigned to the early medieval period. This was simply confirmation that we should be looking at comparative material from sites of roughly that period, in order to eliminate the time factor in the monitoring of the diagenetic processes affecting the burials.

The Accelerator Unit will become more involved in the work of the Leverhulme project in the near future. It is hoped to send a quantity of extracted humic material from body silhouette samples for analysis. Most usefully, this material will be dated, thereby giving us an indication of whether it is contemporary with the burial (ie. the bones). This will tell us whether the body "stain" is formed of material directly derived from the inhumation, or from subsequent build up of biota decay products over a longer period. This work will be carried out as part of one of the Oxford lab.'s own research programmes, by Dr. Ian Law.

External analysis: Manchester University.

We have submitted a section of pelvic bone from one of the Intervention XX graves to Neil Garland, a post-graduate researcher in the Department of Rheumatology at Manchester University. His particular field is histology, a biological discipline whose usefulness to archaeology is being widely studied. The techniques largely involve the examination of bone thin sections, with the use of various dyes and light sources to investigate the microscopic variations in the bone tissue. By comparison with known examples, it can be seen how the bone ultrastructure has been affected by the conditions of burial, and it may be possible to deduce such information as relative length of burial, age at death, and sexing within the cemetery. One of the techniques under investigation currently in the archaeo-histological world is the counting of osteons in specific bone locations, as a means of determining age at death.

We are still awaiting results from Mr. Garland, but are looking forward with great interest to viewing his findings.

External analysis: University College Cardiff.

The most recent involvement with an external body that we have undertaken has been with Dr. Mark Pollard of the Dept. of Chemistry at UCC. Dr. Pollard teaches partly within the Dept. of Archaeology, and is supervising a number of students working on archaeologically-related chemical studies. One such is an experiment to examine the organic residues from an inhumation from a very sandy burial site at Atlantic Trading Estate, Barri, South Glamorgan, of early medieval date. It is hoped to be able to extract cholesterols from "body stain" material recovered from directly beneath the bones, using chromatographic methods. The UCC students have also carried out thermogravimetric analysis on a transect of samples across the body area. The purpose of this is to examine the gross organic content of the soil by monitoring the weight loss during heating to high temperatures. The data should indicate the distance to which the decaying organic "fallout" from the body affects the surrounding soil. We have submitted a number of body samples from Sutton Hoo, in order to have similar analyses carried out on our own material. The results will provide a useful comparison with material from a similar burial environment, but where skeletal preservation is quite different to that at Sutton Hoo.

We have also been in contact with the Glamorgan-Gwent Archaeological Trust, who are responsible for the excavations at Atlantic Trading Estate, with a view to taking our own samples from one of the inhumations.

Sutton Hoo - Leverhulme Trust Project

External analysis: Queen Mary College, University of London.

During the course of the project, much help and advice has been received from Dr. Alan Hart of the Dept. of Chemistry, Queen Mary College, London. To assist partly with his own researches, and partly with ours, a number of samples were submitted to QMC for various analyses.

The samples submitted were:

Intervention:	Finds no.	Contxt.	Description.
20	1985	1049	Body matrix, including bone.
20	1994	1049	Body matrix, including bone.
20	2021	1067	Body matrix/soil.
20	2026	1067	body matrix/soil.

These samples had been dried and stored for some time in boxes in BUFAU, and part of the reason for submission was to see if the storage had affected them adversely, eg. by microbial action.

Dr. Hart carried out the following analyses:

'Magic angle' NMR probe of the C-13 spectrum of one of the bone samples.
Conventional solution NMR of the hydrolysed amino acids.
ICP spectrometry of the samples, and comparison with fresh bone.

These analyses were originally part of the research programme of a post-graduate student under Dr. Hart, who unfortunately has abandoned his studies before completion. Hence the results from these experiments are as yet incomplete, and what results there were have not been followed up. However, some useful and valid conclusions can be drawn from the work done so far.

Analytical results from samples submitted to QMC.

As yet, no results are available for the conventional solution NMR of the hydroloysed amino acids.

The magic angle spin NMR results were not particularly clear, as the spectrum studied, that for C-13, was rather weak. However, the spectrum did seem to show a distinct chemical modification over the spectrum from fresh (bovine) bone. Further work is required to increase the carbon density, by compression of the porous material, in order to get stronger spectra. This is an area of study that would be worth investigating further, in order to understand more about the trajectory of change of specific components of the bone, during the taphonomic processes operating on it.

The ICP results were far more revealing. It must be borne in mind that the number of samples analysed do not provide a statistically viable range, for quantitative purposes. However, as an introduction to using this technique for bone and soil analyses, the results provide some very useful qualitative pointers towards the sort of trends to be expected in a wider scale sample series. One of the reasons for running these samples was to get some immediate idea of the effect, if any, of the Vinamul consolidant spray on the elemental/trace elemental content of the material from the burials, and as mentioned above, to see if the older samples had been affected by their storage. (The details of the experimental procedure are given elsewhere. The work was carried out at Royal Holloway and Bedford New College, Egham, Surrey, on the same machine as our later analyses)

The trends discussed here refer to the table of results below. Bovine bone was used for the fresh bone comparison, due to the difficulties encountered in obtaining fresh human bone. No statistical treatment of these figures has been undertaken, the observations are simply empirical.

Referring to Table 1 below, it is apparent that the unaltered grave fill, as represented by the first four samples, is very homogeneous, with an extremely regular elemental make-up. The iron/aluminium ratio is between 3 and 4:1, and there are minimal contents of calcium and phosphorous (phosphate), which are the main constituents of the mineral phase of bone. The actual bone samples are clearly characterised by massive peaks at the calcium and phosphorous readings, with relatively low percentages of other elements. The trace-element content is also distinctive, with enhanced amounts of copper, niobium, strontium and zinc, and very clear dearths of material represented in the other samples. The proportions of elements in the fresh bovine bone and the archaeological specimens are quite different, although the peaks are in the same places. It is not certain whether this is a result of intrinsic differences in the bones of two different species, or whether it reflects the diagenetic effects on the buried bone. The real interest lies in the group of soil samples between the grave fill and the bone columns, clearly different from the background provided by the fill.

The points that this set of samples have in common, by comparison with the grave fill levels, are:
a) some alteration in the iron/aluminium ratio, in some cases a clear enhancement of aluminium, and generally lower iron levels;
b) a clear enhancement in the levels of calcium and phosphorous;
c) a general increase in the contents of the following trace elements; barium, cerium, cobalt, chromium, lanthanum(?), strontium.

Discussion.

The critical diagnostic elements for differentiating the 'body stain' samples from the grave fill appear to be calcium and phosphorous. The enhancement of these elements over the background level must be derived from the body tissues, almost cetainly from the bone itself. This is clear for all five central samples in Table 1 (E,J,K,F,B). However, the two samples with the lowest calcium and phosphorous readings, J and K, show far less obvious variations in the concentrations of the trace elements. In fact the trace element contents alone would not differentiate them from the grave fill samples. Neither of these samples was recognisable as 'body

stain', but their elemental content clearly distinguishes them from the other visually similar grave fill samples. It is provisionally possible to suggest that the calcium and phosphorous contents of samples of unknown origin could be used to determine whether or not they were derived from a decayed burial, and that the presence of enhanced quantities of these two elements would be sufficient evidence of a burial where no visible traces remained (at least under the conditions prevailing at Sutton Hoo).

The three soil samples with more marked calcium and phosphorous contents, must be assumed to be closer to the centre of decay, and thus more affected by the decay products. Samples E, F, and B all have enhanced levels of calcium and phosphorous, but they also have an increased level of aluminium, and a relatively lower concentration of iron, (the aluminium/iron ratio is altered). The mechanism of this alteration is uncertain, but the conclusion is that the presence of the body decay products fixes aluminium as a replacement for iron. In other conditions, at Mucking, Essex, (Keeley et al. 1977), a strong manganese (Mn) enhancement was observed in the body silhouette, over the background level. It was inferred that the manganese was drawn in from the surrounding soil. There are unfortunately not enough properly located samples in this series to determine whether that is the case with the aluminium enhancement observed here, but it seems likely that some interchange with the surrounding soil has taken place. Incidentally, a comparable manganese enhancement is not apparent here - it has been suggested that the enhancement of one element rather than another is a pH dependent phenomenon.

The three clear body samples show the highest values of several of the trace elements, including a number not present in the bone. The inference is either that the enhancement comes from an interaction with the surrounding soil, as mentioned above, or that the 'extra' trace elements are derived from the soft tissues of the body rather than the bones. The presence of all the enhanced trace elements in the grave fill soil suggests that the increased quantities are derived from the soil - one might expect a different range of elements to be present in each set of samples, if the sources of those elements were different. Another possibility is that the trace elements are derived from material added to the topsoil (ie. fertilisers, rain), and that during the leaching process, those elements are differentially adsorbed by the in situ body decay products.

One final note from the table of figures is that the pH readings from this set of samples are much higher than those previously taken at Sutton Hoo, (Dimbleby 1975), which were considerably more acidic (as low as 3.80). This may also be an effect of chemical additions to the topsoil.

The question of contamination derived from the use of consolidant sprays on the site must also be considered. The consolidant used is Vinamul, a water borne PVA emulsion. This is clearly an organic hydrocarbon, the basic elements of which cannot be measured by this method, as all organic material is destroyed during the digestion process. So the only real danger as regards the ICP analysis, is possible contamination by trace elements in the consolidant. The two clearly consolidated samples, E and J, do not show any trace element pattern distinctive from the other samples. They instead show a trace element distribution pattern related to their proximity to the burial, and do not appear anomalous in any other way - ie.

J is closely related to K, and E clearly belongs with F and B. The two possible exceptions to this are the chromium and nickel contents of sample E; but as this is not reflected in the contents of those elements in J, it does not seem likely that they are consolidant derived.

Conclusions.

The main conclusion to be drawn from what must still be regarded as a very inadequate sample is that there are chemical differences between the areas affected by the decay products of the buried bodies, and the grave fills. It can be further noted that certain elements are diagnostic of this chemical difference, and as such provide criteria for chemical separation of body/non-body samples where visual differentiation is not possible. It also appears that the use of Vinamul consolidant on the grave material does not affect the elemental or trace elemental concentrations in that material, although it may affect the organic content.

References:

Dimbleby,G.W. 1975 The environment, in Bruce-Mitford,R.L.S. (ed) The Sutton Hoo Ship Burial Volume I. British Museum, London.

Hudson,G.E. and Evans,J. 1977. Trace Element Contents of Human Bones in Various States of Preservation. Journal of Archaeological Science 4, 19-24.

QMC: ICP spectrometry results, July 1986. Table 1.

Major Elements % ↓ / Sample →	A	C	G	H	E	J	K	F	B	D	I	L	M
Al (Aluminium)	0,51	0,74	0,58	0,54	1,33	0,28	0,42	0,92	2,52	0,21	0,29	0,06	0,00
Fe (Iron)	1,96	2,05	2,20	2,90	1,49	1,05	1,91	1,72	1,08	0,06	0,36	0,05	0,00
Mg (Magnesium)	0,05	0,06	0,05	0,37	0,06	0,04	0,06	0,06	0,06	0,16	0,18	0,57	0,10
Ca (Calcium)	0,33	0,72	0,42	0,06	2,57	1,71	2,54	4,70	3,78	44,59	45,01	36,42	0,10
Na (Sodium)	0,06	0,13	0,08	0,03	0,08	0,08	0,08	0,17	0,18	0,43	0,46	0,76	0,00
K (Potassium)	0,04	0,04	0,03	0,01	0,06	0,04	0,03	0,04	0,03	0,01	0,00	0,04	0,00
Ti (Titanium)	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,04	0,04	0,01	0,00
P (Phosphorous)	0,13	0,40	0,17	0,18	1,91	1,01	1,53	2,94	2,63	29,73	30,32	18,87	0,00
Mn (Manganese)	0,02	0,02	0,02	0,02	0,03	0,02	0,03	0,04	0,02	0,00	0,02	0,00	0,00
Trace Elements ppm. ↓													
Ba (Barium)	20	36	20	23	144	37	59	95	116	74	29	29	3
Ce (Cerium)	10	13	7	4	48	2	6	28	53	-	-	-	-
Co (Cobalt)	5	9	5	6	24	8	10	31	19	-	-	-	-
Cr (Chromium)	6	7	7	17	152	19	20	28	30	-	-	-	7
Cu (Copper)	12	11	9	9	14	11	14	18	16	45	37	36	4
La (Lanthanum)	6	7	4	4	14	3	5	11	21	-	-	-	-
Li (Lithium)	2	2	1	1	3	1	2	4	4	9	8	2	-
Mo (Molybdenum)	3	3	4	3	4	4	4	4	2	-	-	-	3
Nb (Niobium)	2	2	2	2	4	2	2	5	7	28	28	3	-
Ni (Nickel)	20	16	15	22	83	11	15	17	16	-	-	-	4
Sc (Scandium)	1	1	1	1	3	-	1	2	6	1	1	1	-
Sr (Strontium)	17	25	18	18	42	27	40	48	93	212	228	74	6
V (Vanadium)	16	16	17	21	12	8	13	17	8	8	10	4	-
Y (Yttrium)	4	4	3	3	8	1	2	7	15	2	2	1	-
Zn (Zinc)	60	57	38	45	72	52	67	120	71	353	325	97	15
Zr (Zirconium)	-	1	-	-	1	-	-	1	3	2	5	1	-
pH (H_2O)			6,65		6,80				6,60				

Sample Key:

A = Find 2026, light soil concretion; flesh stain?
B = Find 2026, dark soil concretion; body matrix.
C = Find 2026, light soil; grave fill.
D = Find 1985, bone.
E = Find 1985, flat concretion; consolidant contamination.
F = Find 1985, soil; grave fill.
G = Find 2021, soil concretion; grave fill?
H = Find 2021, soil; grave fill.
I = Find 1994, bone.
J = Find 1994, flat concretion; consolidant contamination.
K = Find 1994, soil; grave fill.
L = Fresh bovine bone.
M = Blank.

Samples consisted of 0,25g of finely ground material.