

Sutton Hoo - Leverhulme Trust Project

In-house analytical work: Introduction.

The analytical work carried out by J.Miles, the project's chemical research student, has followed two major directions. The initial experiments were designed to extract humic material from samples recovered during the 1986 field season. A series of samples from grave F235, the crouched burial on the north edge of Intervention 32, including wood, body, and grave fill material, has been investigated. It was decided to concentrate on this burial, because it was the only one so far excavated which is known to have no consolidant contamination. It seems that the consolidant spray (PVA emulsion) does not significantly affect the elemental composition of the samples, but it is not yet certain how it alters the results of any analysis of the organic material in the graves. It was felt better to examine a non-consolidated feature in order to compare the results with those from contaminated burials.

The underlying theory is that extraction of the humic material, followed by identification of the various fractions within that material, would give us a clear insight into the origin of the humic substances, ie. whether or not they are directly body-derived. It could also give us some idea of the nature of the bonding mechanism which fixes organic material at the site of burial of various organic artefacts.

The other major experiment has been an elemental analysis of all the samples from one of the graves, again F235. The purpose of this was to ascertain the spatial distribution of various elements within the grave, in order both to find distinct differences between the "body stain" material and the grave fill, and to examine the extent to which the burial has influenced the composition of the surrounding soil. The method chosen was Inductively-coupled Plasma Emission Spectrometry (ICP), a technique already used in a preliminary study undertaken on our behalf by Queen Mary College, London (see External Analyses).

It has taken some time to carry out this work, as the research student was required to learn a great deal of background theory before embarking on the practical side of the experiments, and we have also experienced difficulty in transferring the data from the ICP results into our own mainframe computer here in Birmingham. We are also still carrying out fuller statistical analysis of the results, another aspect which requires a considerable amount of time to master.

Also under way in the Dept. of Chemistry, is an initial organic analysis of the Sutton Hoo material, with amino acid and CHN analyses being currently done.

The details of the various experiments follow below.

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In-House analysis: Extraction of humic material from the body samples.

It was decided to extract the humic material from the body samples, in order to find out more about the origins, and the retention mechanism of the organic matter in the body silhouette. A standard soil chemistry procedure was used, and this is detailed below. So far only initial work to see how much humic material is there has been done. The next stage will be fractionation of the extractant.

Experimental procedure.

A: Extraction with Sodium pyrophosphate at pH 7.0.

- a) The soil is sieved through a 2mm sieve, to remove coarser particles.
- b) Sodium pyrophosphate, $\text{Na}_4\text{P}_2\text{O}_7$, is made up to a 1.0M aqueous solution.
- c) The pH of the solution is adjusted to neutrality (7.0) with HCl.
- d) 1g ($\pm 0.0005\text{g}$) is weighed out, and 10cm^3 of the $\text{Na}_4\text{P}_2\text{O}_7$ solution added, in a suitable vessel.
- e) The mixture is placed on a rotor, and shaken for 12 hours.
- f) The shaken mixture is centrifuged at 13,000 rpm for 3 minutes.
- g) 7.5cm^3 of the supernatant liquid is removed with a pipette, and set aside for use at D and E.
- h) 7.5cm^3 of pH 7.0 $\text{Na}_4\text{P}_2\text{O}_7$ solution is added to the centrifuge residue, and stages (e), (f) and (g) are repeated until the supernatant liquid is clear.

B: Extraction with sodium pyrophosphate at pH 10.0.

This procedure is carried out on the residue from (A), and is basically the same as (A), with the following changes;

At (c), the 1M $\text{Na}_4\text{P}_2\text{O}_7$ is not adjusted with HCl.

The extraction is carried out in a nitrogen atmosphere, and N_2 is bubbled through the $\text{Na}_4\text{P}_2\text{O}_7$ before extraction.

C: Extraction with sodium hydroxide.

This is carried out on the residue from (B). The basic procedure is the same as at B, but NaOH at pH 13.0 is used instead of $\text{Na}_4\text{P}_2\text{O}_7$, and as in (B), the adjustment with HCl is not made.

D: Isolation of humic acid.

- a) All portions of extractant from stage (g) of the above procedures are combined, and the pH adjusted to 1.0, and allowed to stand overnight.
- b) The resulting suspension is filtered through a Buchner funnel onto a pre-weighed filter paper.
- c) The filter paper is dried under vacuum in a dessicator for 24 hours, to a constant weight.

The % weight of the humic acid content can then be determined.

The average amount of humic acid recovered so far is;

For body samples - 2.50% by weight.
For fill samples - 0.67% by weight.

E: Extraction of fulvic acid.

- a) A suitable glass column is packed with 300cm³ of XAD-8 ion-exchange resin.
- b) This is washed through with 600cm³ of H₂O.
- c) The column is next washed through with 600cm³ of 1M HCl.
- d) The liquid remaining from the humic acid filtration is then put through the column.
- e) The column is then washed through with H₂O until the liquid coming out at the bottom is chloride free. (Test with AgNO₃ solution).
- f) The column is then back eluted with two column volumes of 1.0M NaOH.
- g) The eluted solution is passed through a cation exchange column, to remove the Na⁺ ions.
- h) Freezing and freeze drying of extractant leaves fulvic acid as residue.

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In-house analysis: ICP analysis of grave samples.

1. Methodology.

Inductively Coupled Plasma Emission Spectrometry was the method chosen for the analysis. It involves the dissolution of a known quantity of sample, followed by dilution to a fixed concentration in distilled water. The diluted sample is then introduced to the plasma flame, and the elemental composition measured by a polychromator, which measures both the wavelength and intensity of the emitted radiation. It is a method which has been largely developed for geological analyses, of rock and mineral samples.

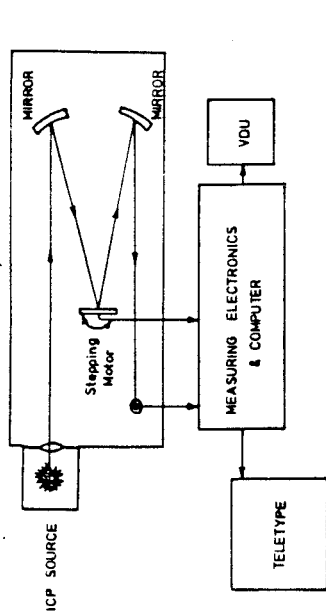
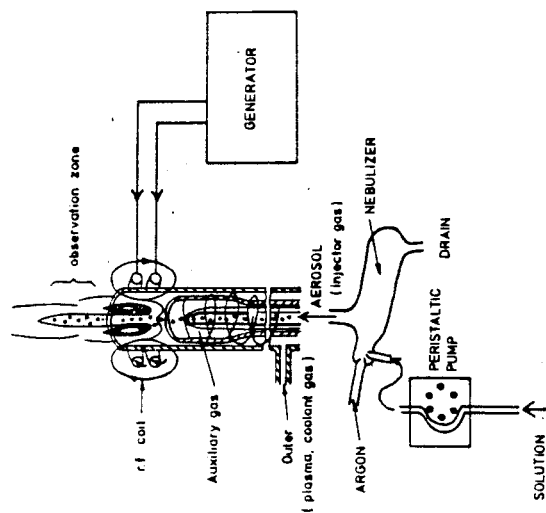
There are several preparation methods developed for specific materials requiring analysis. The one chosen for our purposes was a powerful hydrofluoric/perchloric acid digestion of the ground samples.

The heart of the technique is the ICP torch, which is a two (or more) turn coil carrying a high frequency current. When the current flows, a rapidly varying magnetic field is generated within the coil. Charged particles flowing through the magnetic field cut the force lines and ohmic heating results. The sample is introduced into the coil field as an aerosol, via an argon gas nebuliser, and 'ignited' with a Tesla spark, which ionises the aerosol particles. The plasma flame generated is so hot (6,000 - 10,000 °K) that no chemical bond can survive, and so 'atomization' of the analyte can be considered to be complete. The plasma is generated in the outer tube, and the sample is introduced to the relatively cooler centre of the flame. As a result, heating of the sample occurs from the 'outside inwards', thus minimising self-adsorption and self-reversal effects, and leading to calibration lines that are linear over four or five orders of magnitude. The extreme temperature of the flame generates strong emission lines which are detected by the spectrometer.

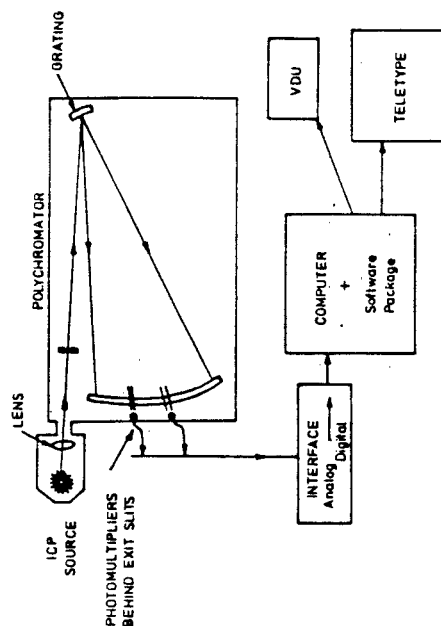
There are two major methods of operation of the spectrometer, a simultaneous and a sequential system. The sequential system uses a diffraction grating which can be rotated under computer control over an almost unrestricted range of spectral lines, and measurement by a series of monochromators, one for each wavelength. The simultaneous counting method uses a polychromator to measure several wavelengths and intensities at the same time. The latter method limits the number of elements analysed to about thirty, but enables much quicker throughput of samples.

It was decided to use ICP as the analytical method, for a variety of reasons. Radioactivation analysis, x-ray spectrometry, mass spectrometry, or absorption or fluorescence atomic spectroscopy were methods which could have been used in this experiment. They all have inherent strengths and weaknesses. Activation analysis involves the bombardment of a sample with a nuclear projectile, causing specific nuclear reactions which result in the radioactivation of the normally stable isotopes for most elements. Characteristics of the radiation are identified with specific elements, and the intensity of the radiation is dependent on the mass of element present.

ICP 'TORCH'



SEQUENTIAL SYSTEM



SIMULTANEOUS SYSTEM

INDUCTIVELY COUPLED PLASMA - EMISSION SPECTROMETER

About thirty elements can be studied, and high levels of precision can be achieved if the half-life of the isotope being studied is of favourable length. This technique has a rather slow rate of measurement, however.

X-ray spectrometry measures the x-ray spectra emitted by secondary excitation of the elements. It is a rapid analytical technique, but has a relatively low sensitivity.

Mass spectrometry relies on the separation of ions produced in the source region according to their mass. It is a fairly rapid and high precision technique, suitable for the analysis of solid samples.

The various types of atomic spectroscopy are more often used to analyse liquid samples. This is more useful, because an even distribution of elements is easier to achieve than in the solid state. By the addition of energy to an atom or ion, movement of electrons between quantum levels is induced, and the method works by measuring the radiation which is absorbed or emitted by this movement. ICP is a very useful version of the emission type of atomic/ionic spectroscopy, due to its rapidity, high precision for a large array of elements, and relative cheapness. We chose it because of these advantages.

2: Experimental procedure.

The problems associated with the sampling procedure are dealt with above, and the following is an account of the laboratory preparation of the samples. The problem to be most carefully guarded against in such analysis is contamination during the preparation. The greatest care was taken to minimise this risk.

The first stage of lab. preparation is the grinding of the samples to a flour-like consistency. This improves the efficiency of the dissolution by increasing the available surface area of the material, and enhances the homogeneity. The material is then digested in an hydrofluoric/perchloric acid mixture, to break down the bonds in the soil compounds. The HF/HClO_4 is then driven off by heating, and the samples redissolved in concentrated hydrochloric acid. After heating again, the sample is made up to a known concentration with distilled water.

2.1: Grinding.

a) Particles of size $> 2\text{mm}$ were removed manually from the air dried samples. It would have been more convenient to sieve the soil, but only copper sieves were available, and it was feared this could have caused contamination. The use of Teflon sieves is to be recommended. The Sutton Hoo samples were luckily very homogenous, so removal of larger particles was very easy, as they stood out from the consistent loose grain size of the sand.

b) Approximately 7g of sorted sample was placed in a Tema mill using a Teflon spatula. The grinding mill is made of steel, and could be a source of contamination. It was felt, however, that as any contamination would be a constant error, and taking into account the homogeneity of the samples,

it could be ignored in this instance. The mill was cleaned with acetone and medical wipes between samples.

c) The sample was ground for one minute (time dependent on composition of sample), and the resulting 'flour' removed to a clean, pre-labelled polythene bag.

2.2: Dissolution.

a) 0.1000g (± 0.0005 g) of air-dried, sorted and ground soil from each sample was weighed out into a numbered 10 cm³ Teflon beaker. The beakers were placed in heating trays in a preset order, so that irregularities in the efficiency of the heating plate could be allowed for.

b) 3 cm³ of HF/HClO₄ (1:2) mixture was added to each beaker using an automatic pipette, and the samples heated on the trays until all the HF had been driven off. (This has to be done inside a specially-built fume chamber, as HF is extremely corrosive to many materials, including glass, and so could not be used in the spectrometer. Great care must be taken in the handling of such reagents).

c) 1 cm³ of conc. HCl was added to each beaker using an automatic pipette, in order to redissolve the residue. The beakers were then three-quarters filled with distilled water, and heated for thirty minutes.

d) The solutions were made up to 10.20g (± 0.03 g) with distilled water, and stored in a clean sample tube. The tubes had previously been leached with distilled water for two weeks, to clean them. The stoppered tubes were then stored for two days.

e) Three standards were made up in a similar way to the dried and ground samples. The elemental compositions of the standards are given below.

Possible sources of error:

There were three unquantified sources of possible error encountered up to this point in the laboratory procedure.

i) Due to electrostatic forces in the ground soil, a portion of some of the weighed samples tended to stick to the sides of the Teflon beakers at stage (a) of the dissolution, and so avoided contact with the HF/HClO₄ mixture. Care must be taken that all the sample is in contact with the digesting fluid.

ii) A slight cloudiness was visible at the bottom of some samples after dissolution in conc. HCl, at stage (c) of the above process. This was thought to be due to undissolved organic matter, since the reliability of the preparation technique is well documented for other soil constituents. The proportion of undissolved material was very low, but this is nevertheless a source of error not easily countered. Elements may be differentially associated with the organic material in different regions of the grave, and although it seems unlikely that any such associations could survive the HF/HClO₄ treatment. It is a problem that should be tackled in any future work.

iii) On heating the sample after dissolution in conc. HCl, again at stage (c) above, differential volatilisation of chloride compounds can occur if the solution is allowed to boil. The problem mainly affects the concentration of chromic compounds (esp. CrCl_3). The treatment of the standards of known concentration in exactly the same way as the samples enables the scale of any such error to be quantified.

There are other known margins of error in the procedure, ie. the $\pm 0.5\%$ error in the weighing of the samples at the beginning, and end of the procedure, and the error in the volume measurement by automatic pipette. The various error margins can be quantified by comparison of the empirical compositions of the standard solutions, with their known composition. The highest observed percentage error for each element is taken as the outer limit of the experimental error.

Elemental compositions of the standard solutions:

Standard:	KC10	KC11	KC12
% by weight:			
Al_2O_3	17.40	16.51	11.60
Fe_2O_3	9.90	8.71	1.68
MgO	7.70	3.99	0.01
CaO	11.90	6.86	0.21
Na_2O	2.40	3.30	3.78
K_2O	0.20	2.15	4.78
TiO_2	0.84	1.10	0.13
P_2O_5	0.09	0.32	0.00
MnO	0.13	0.14	0.02
ppm:			
Ba	126	491	11
Ce	10	50	130
Co	45	27	<2
Cr	330	111	<10
Cu	170	108	2
La	4	24	65
Li	6	(380)	38
Nb	<5	12	26
Ni	104	280	<5
Sc	33	24	<1
Sr	360	370	8
V	220	210	<5
Y	13	28	120
Zn	60	119	90
Zr	38	145	420

2.3: Running the samples through the ICP spectrometer:

The instrument used comprised a Philips PV8490 ICP source unit, with a simultaneous detection system in operation. The detection system was set for the array of 24 elements noted in the composition of the standards (above), plus Molybdenum (Mo), which was not present in the standard.

Procedure:

a) For each individual sample, the inlet capillary was placed in the sample tube, (taking care to avoid any 'organic' sediment at the bottom). The analyte was then introduced into the plasma flame via a peristaltic pump, and allowed to 'burn' for 45 seconds before the emission spectra were automatically recorded. The detected signals were converted to % concentration by weight of oxide, or parts per million, depending on the element being studied. This raw data was stored on a micro-computer disc. The inlet capillary was flushed through with distilled water for 45 seconds between samples.

To compensate for fluctuations in the power source causing variations in the signal output, a sample of the KC11 standard was run after every 10 of the grave samples. The amount of 'drift' could thus be calculated, and the readings corrected by computer.

b) The three standards were run through the machine, and the errors in the preparation technique calculated from comparison of the results obtained, and the known compositions of the standards. The sample results were corrected for experimental error before analysis.

This work was carried out by J.Miles during 01/12/86 - 14/12/86, at the Geological Sciences Laboratory of the Royal Holloway and Bedford New College, (University of London), Egham, Surrey. The laboratory provided all equipment, and also the standard solutions. All corrections were made using computer programs already in use by the laboratory.

We would like to acknowledge with gratitude the assistance given by Dr. Nick Walsh and the staff of the Geological Sciences Lab. at Royal Holloway.

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Results of the ICP analysis.

1: Introduction and background.

The analysis was carried out on the basic assumption that the elemental composition of a buried artefact is different to that of the surrounding burial environment (ie. soil). On decomposition of the artefact, many of its components are liberated. These liberated elements may be differentially retained in the soil by adsorption onto clay particles, complexation with humic substances, etc.; or they may be leached out of the burial horizon, or used by soil biota in biological processes. The elements which remain in situ may be present in a quite different ratio to that found in the original artefact. Study of the elemental composition of the artefact-affected soil can only fully elucidate these processes in conjunction with other types of analysis, but even so the elemental composition might indicate the nature of the buried artefact, allowing for example the development of element-specific dyes for use in the field.

The elemental composition of the grave fill can act as an important indication of the movement of of the soil material occurring since disturbance and burial of the artefact(s). Because the soil system is not uniform the contours of the elemental composition may not be uniform, for example they may follow the contours of different horizons within the soil profile, which need not be horizontal. In order to study the changes in the soil brought about by burial of an artefact, it is essential to identify samples which come from the same 'contour of composition'. For example, where the soil horizons are dipping, a horizontal sampling transect could show up differences which could be wrongly attributed to an artefact. The 3-D recording of the samples should make it possible to correct for this, by comparing elemental composition with height.

The difficulty associated with sampling a soil of archaeological significance originates from a conflict of interests between the archaeologist and the soil scientist. The former attempts to sample soil features by careful judgement so as to ascertain the layout and contents of the grave, whereas the soil scientist tries to sample systematically in order to avoid bias, and ensure consideration of the total population. The implements and methods used by the archaeologist may lead to considerable chemical contamination of the samples, and bias in the overall sample; the systematic sampling scheme of the soil chemist (which is ideally not influenced by visible variations in the soil), may lead to loss of valuable archaeological information. In reconciling the two approaches, information will inevitably be lost. For example, at Sutton Hoo, it would have been better to have assigned at least one grave solely to sampling for chemical analysis. This was not possible, however, due to the archaeological demands placed on the limited evidence from the graves.

2.0: The burial.

The grave analysed was F235, and appeared on the surface as a sub-rectangle approx. 1.40m x 0.90m. on excavation, it turned out to be c. 0.70m deep, with vertical sides and a flat bottom. It contained the remains

of a wooden coffin, F236, and an inhumation, F240. The extant coffin remains were discovered overlying the body.

The artefact identified as a coffin was observed as a black staining in the much lighter sandy soil of the grave fill. It first appeared as mottled grey smudges, becoming darker and more charcoal-like towards what had been the centre of the wood. The remains were frequently penetrated by small rootlets, although there was no evidence of larger root systems in the area. The dark stain was excavated to reveal a narrow linear shape, with parallel sides, interpreted as a plank. Traces of other pieces of planking could be seen at the ends of the grave, and the general shape of the wooden remains appeared to be a rectangle slightly smaller than the dimensions of the grave cut.

The body was revealed after removal of the wood traces, and could be clearly seen to be a crouched inhumation, with all limbs traceable. The remains again appeared as staining in the sand, but with a dark brown rather than a black colour, and again with much penetration by rootlets (which in fact helped to preserve the body shape). No bone traces apart from tiny fragments could be discerned. There was also no trace of other organic artefacts such as shroud or clothing, nor any inorganic grave goods.

2.1: Sampling.

In analysing for trace elements, great care must be taken to avoid contamination during sampling. The steel tools used in the excavations at Sutton Hoo could have been a source of contamination, but it was felt that contact with the tools was minimal, and so any contamination ought to be negligible. The use of Teflon sampling tools could be a way of avoiding such worries over contamination.

Improvements to the sampling scheme:

Too few samples were taken to provide a reliable cross-section of the grave. It would require at least five sample points along each axis (ie. five sample 'columns', instead of the maximum of three employed in practice), to allow a reasonable profile to be drawn.

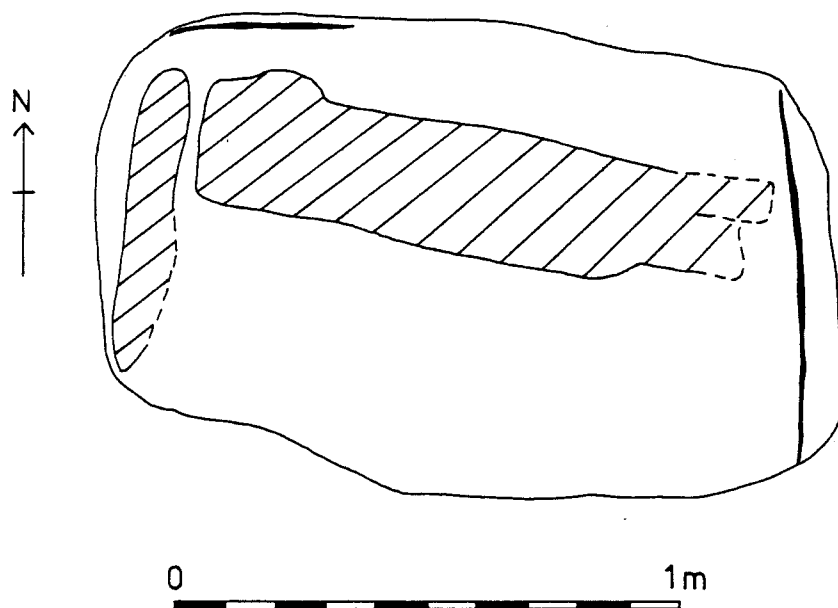
At least thirty samples need to be taken from each feature, to allow a reliable statistical analysis to be carried out. In this study, the practical difficulties encountered in sampling the coffin remains to ensure separation from the body stain, meant that too few wood samples were recovered.

Having said this, it does not invalidate the results obtained so far, but allows a more careful assessment of their reliability.

3.0: Interpretation of results.

The samples analysed consisted of 131 grave fill samples, 28 body samples, and 6 wood samples from the grave. Also analysed were 84 samples from the four columns in Intervention 43 (described above). These totals do not include 3 fill samples and 4 wood samples for which the computer adjusted

a) LOCATION OF WOOD REMAINS F 236



b) LOCATION OF BODY F 240

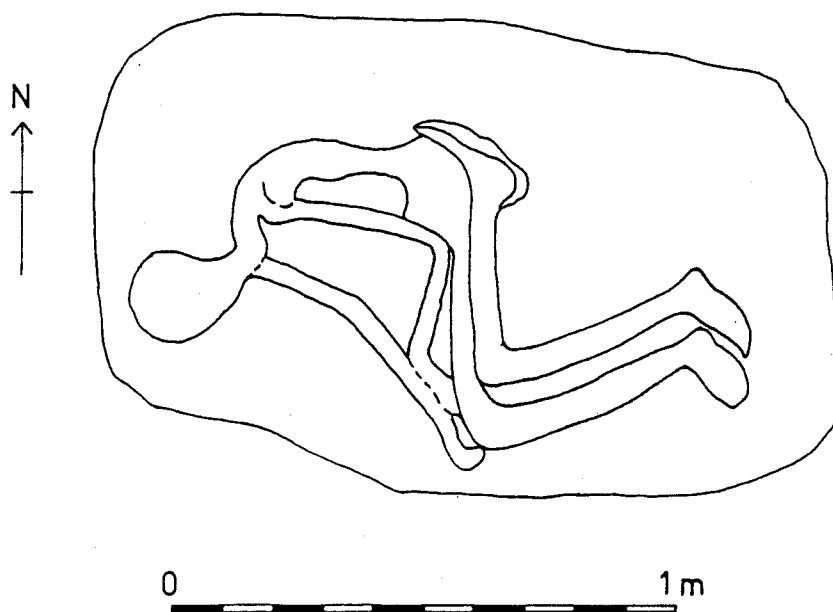


FIG. 4

results have clearly been wrongly calculated (eg. negative concentrations of elements appear). the results were received as tables showing the content of the following elements as % by weight of oxide: Aluminium (Al), Iron (Fe), Magnesium (Mg), Calcium (Ca), Sodium (Na), Potassium (K), and Manganese (Mn); and as parts per million: Barium (Ba), Cerium (Ce), Cobalt (Co), Chromium (Cr), Copper (Cu), Lanthanum (La), Lithium (Li), Molybdenum (Mo), Niobium (Nb), Nickel (Ni), Scandium (Sc), Strontium (Sr), Vanadium (V), Yttrium (Y), Zinc (Zn), and Zirconium (Zr).

It must be noted that this is essentially a trace element analysis, and does not include any organic material, or the bulk of the sand which is composed of silicates.

We are still in the process of interpreting the results of this analysis, and so far have concentrated on the grave fill and body samples. Our first interpretation has been a graphical one, generating bar charts with the aid of an automatic computer program. The purpose of this is obviously to see if any clear separation of the two populations can be picked out visually. Although many emerging trends may be represented graphically, a more conclusive representation is achieved using statistical analysis.

Errors have been calculated from empirical measurements and used to plot variations in elemental content. These errors are non-systematic, ie. the observed composition may be either higher or lower than the actual composition. The non-systematic error can be calculated statistically using the observed compositions. The statistically calculated errors are more reliable, if extraneous values are absent, because errors in methodology which cannot be predicted may also be accounted for. Comparison with the graphical representation allows extraneous values to be omitted. Thus both graphical and statistical analyses merit attention.

The statistical analysis should have the following objectives;

- i) assess the reliability of the results;
- ii) outline any relationships between variations in elemental composition and location of sample within the same population;
- iii) outline any relationships between variations in elemental composition and the presence of grave artefacts;
- iv) Outline any relationships between variations in elemental composition with respect to that of other elements.

Point i) appears to be shown by the statistical analyses, ie. the results can be shown to be reliable, by the relatively normal distributions exhibited for the elemental concentrations when plotted.

ii): Simple graphical analysis of plots of the sample 'columns' reveal a clear homogeneity in the grave fill samples which it was felt would not be made any more clear through statistical analysis.

iii): The results of significance tests for each element, which give the probability of the concentrations within the two populations being distinguishable, are given in the table below.

Ordered table of tests of significance:

Element:	Probability that the two populations have the same elemental compositions:	
<hr/>		
Aluminium - Al	0.0000	Group 1.
Cerium - Ce	0.0000	
Cobalt - Co	0.0000	
Lanthanum - La	0.0000	
Molybdenum- Mo	0.0000	
Phosphorous-P	0.0000	
Potassium - K	0.0000	
Scandium - Sc	0.0000	
Titanium - Ti	0.0000	
Yttrium - Y	0.0000	
<hr/>		
Calcium - Ca	0.0003	Group 2.
Sodium - Na	0.0006	
Copper - Cu	0.0012	
Chromium - Cr	0.0014	
Barium - Ba	0.0140	
Magnesium - Mg	0.0210	
Strontium - Sr	0.0260	
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Niobium - Nb	0.0630	Group 3.
Zinc - Zn	0.1200	
Vanadium - V	0.1500	
Nickel - Ni	0.4000	
Iron - Fe	0.5800	
Zirconium - Zr	0.6900	
<hr/>		
Lithium - Li	0.9700	Group 4.
Manganese - Mn	0.9800	

The elements in Group 1 show the clearest distinction between the two populations, and would therefore be the most useful indicators of the nature of a sample of uncertain origin. Group 2 has probability values within the 5% cut-off margin (0.0500), and so should also be reliable as distinguishing elements. Those in Group 3 represent overlapping of the two populations, but the analysis of more body samples might produce a more conclusive result for these elements. Group 4 elements are those for which the concentrations are indistinguishable between the two populations.

Of the clearly diagnostic elements, Aluminium is present in the largest absolute quantities, and so would probably be the best element to produce a diagnostic indicator for. However, more must be found out about the bonding mechanisms of the various elements, for example an element present in smaller concentrations than Al may be easier to extract and bond with whatever indicator is used.

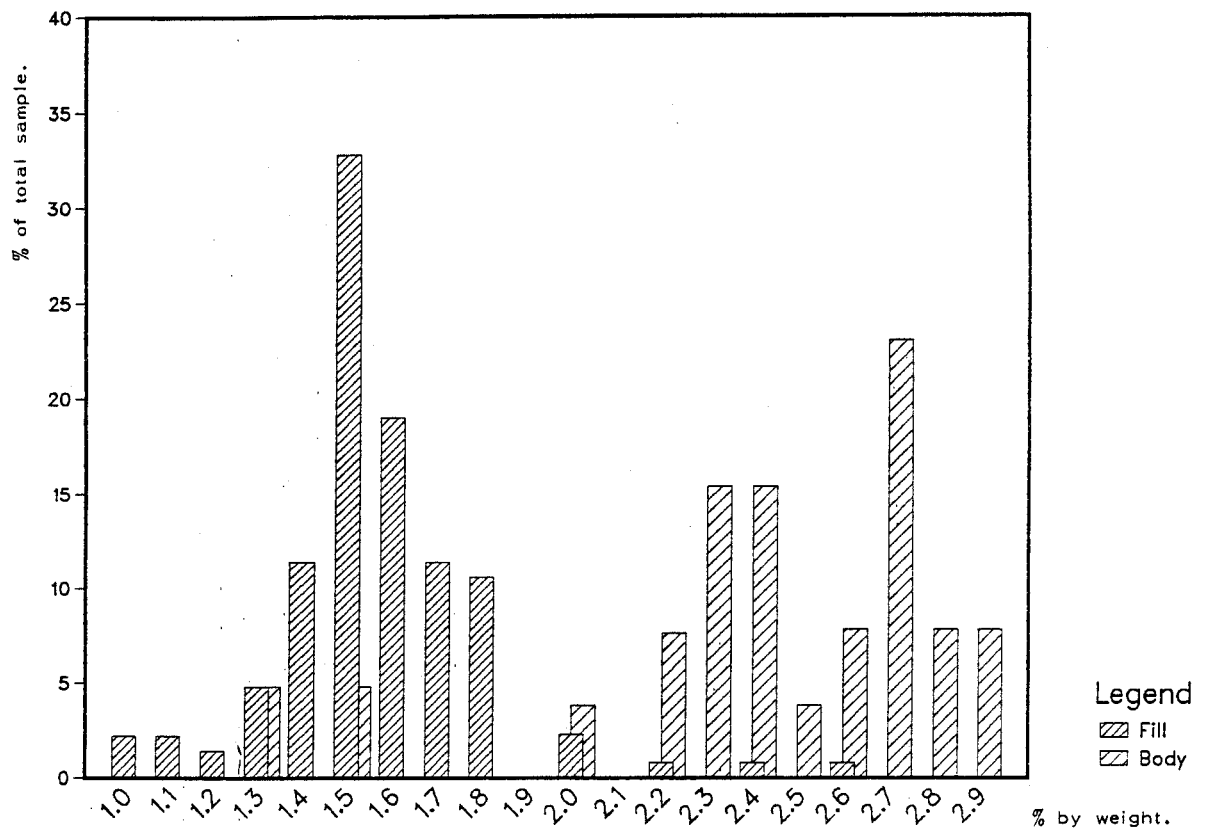
Point (iv) above, the relationship between the variations in elemental composition with respect to those of other elements, is currently being studied through the use of Stepwise Discriminant Analysis. This will show whether the concentration of any particular element is dependent on that of any other(s).

There follow a number of tables and figures, illustrating the elemental contents of the two sample populations graphically, and showing some of the statistical results.

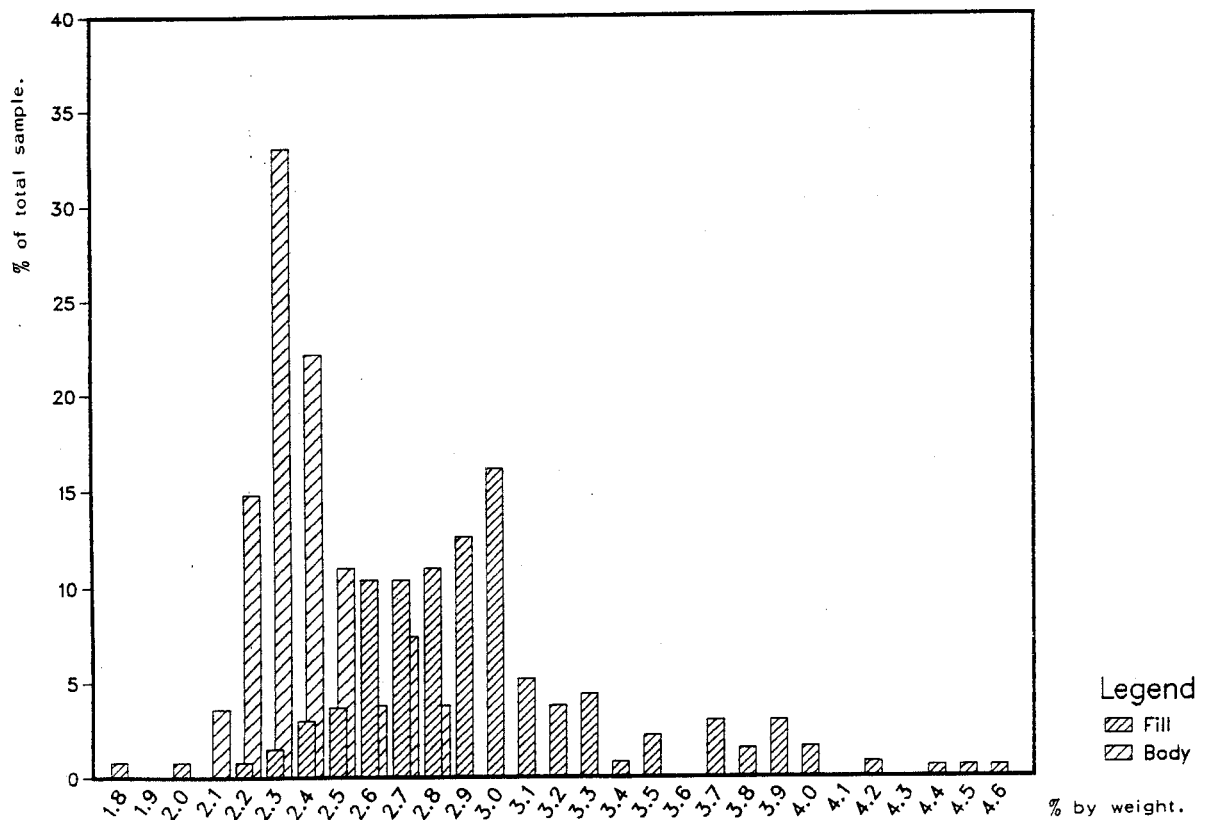
Philip Bethell and Joanne Miles,
University of Birmingham.

5th March 1987.

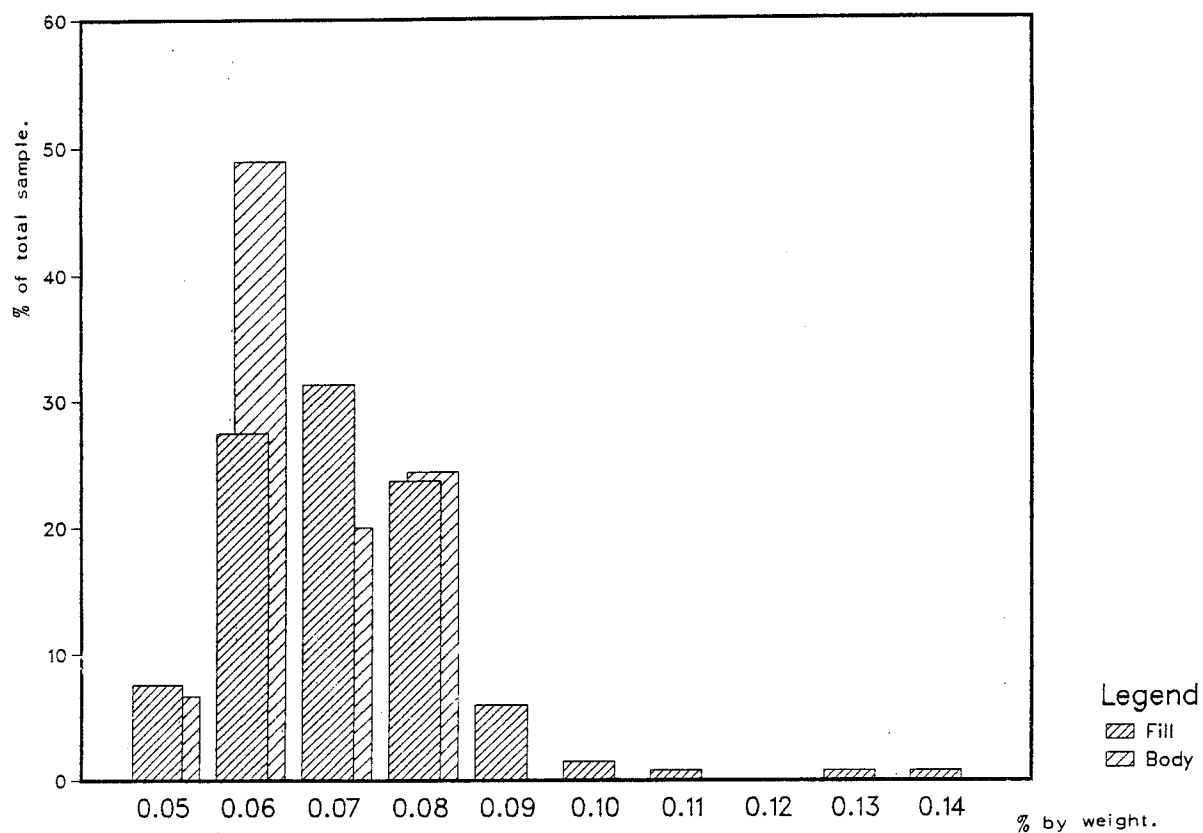
Sutton Hoo Body Analysis — Aluminium Content



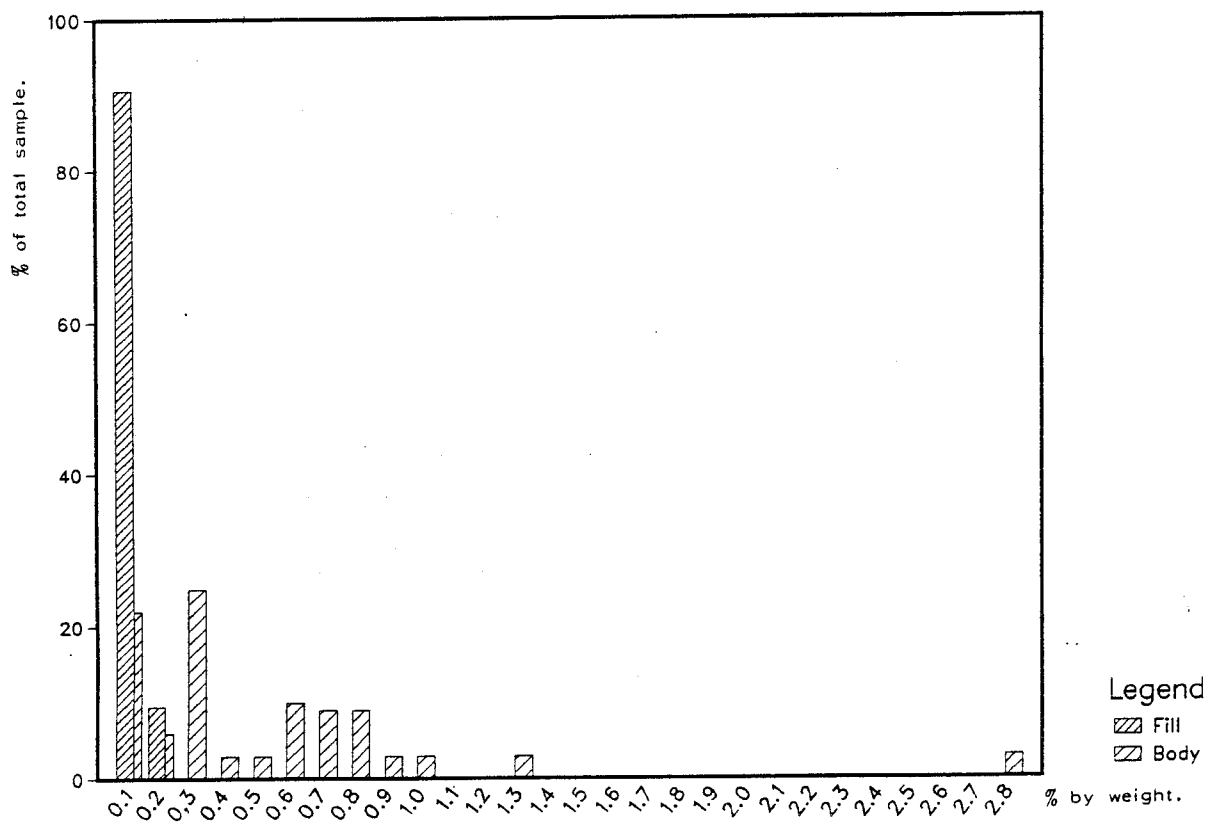
Sutton Hoo Body Analysis — Iron Content



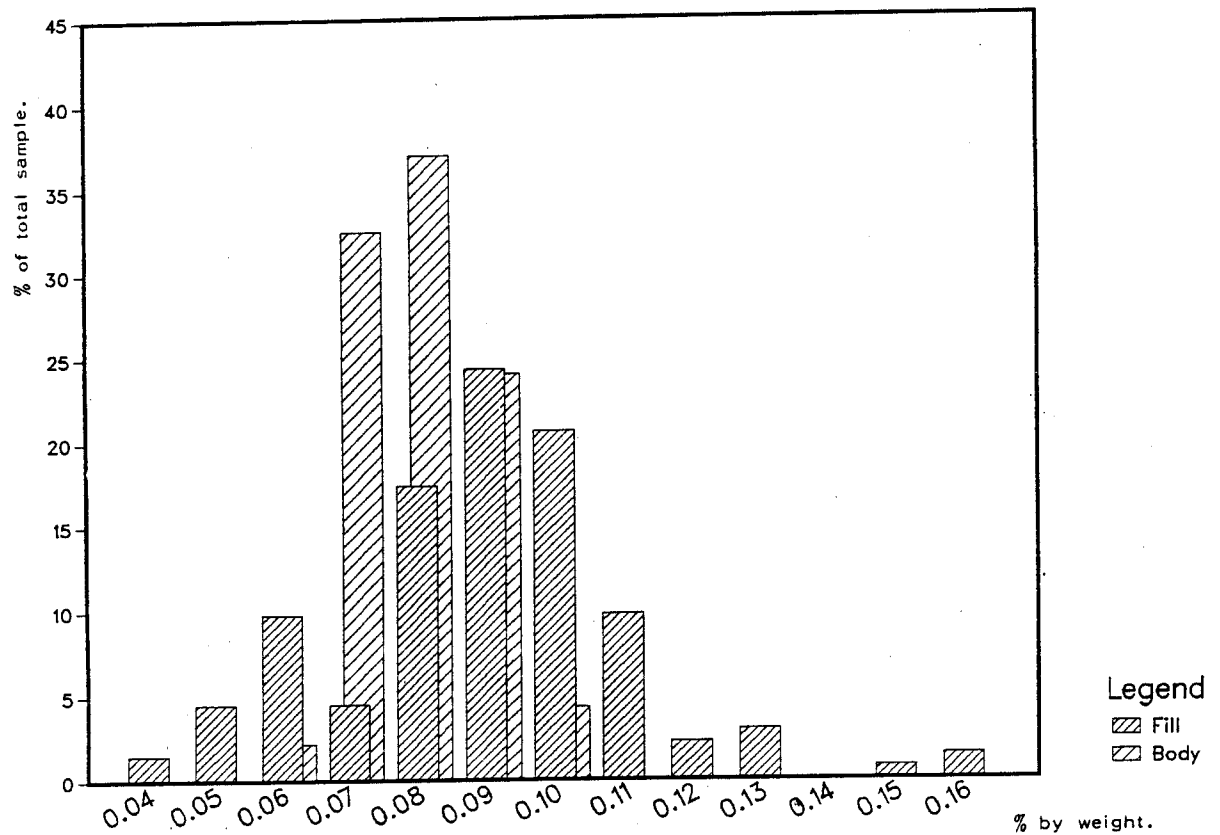
Sutton Hoo Body Analysis – Magnesium Content



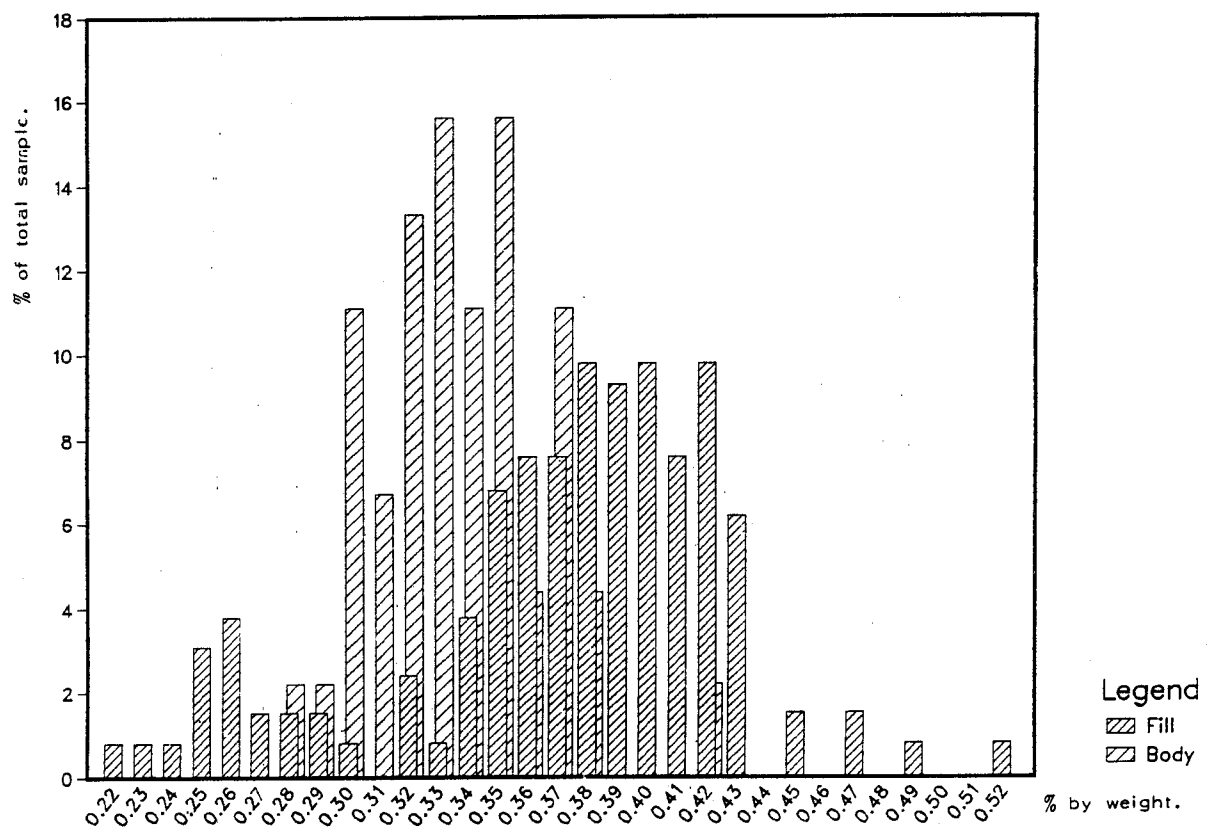
Sutton Hoo Body Analysis – Calcium Content



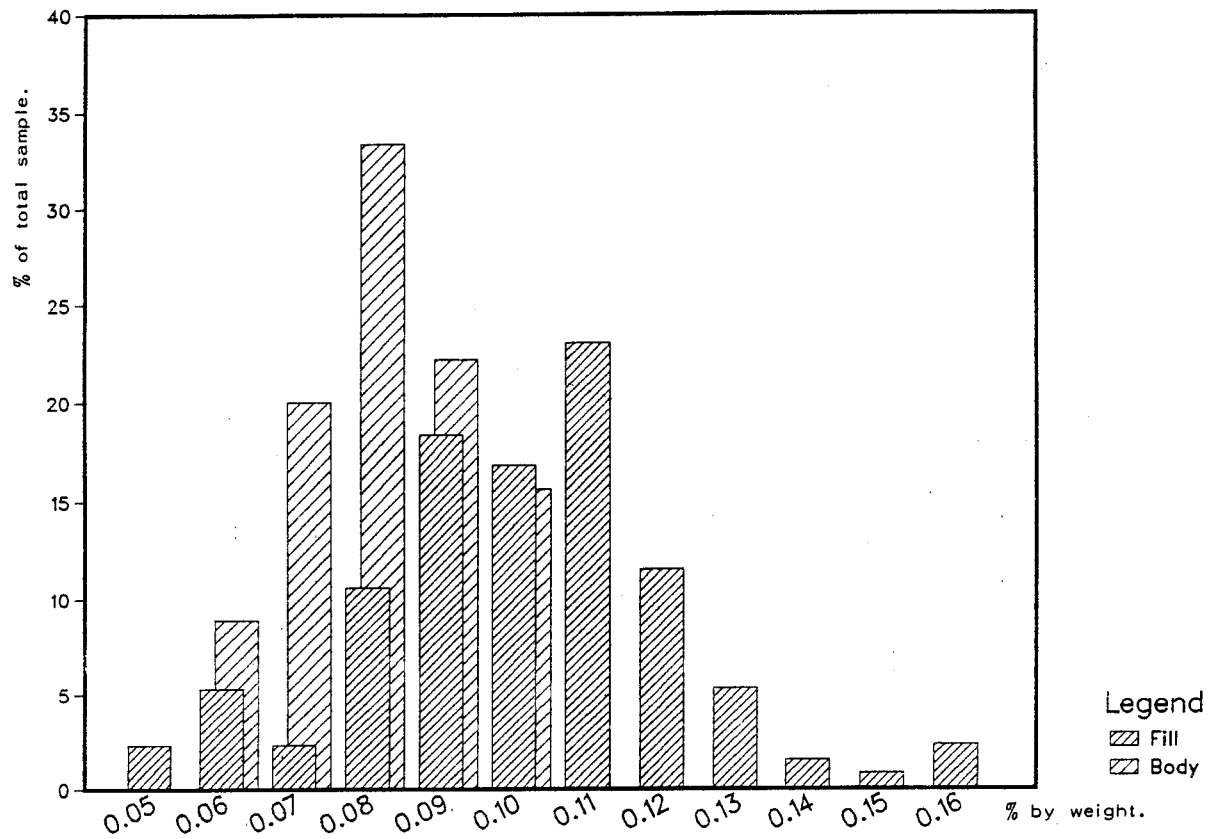
Sutton Hoo Body Analysis – Sodium Content



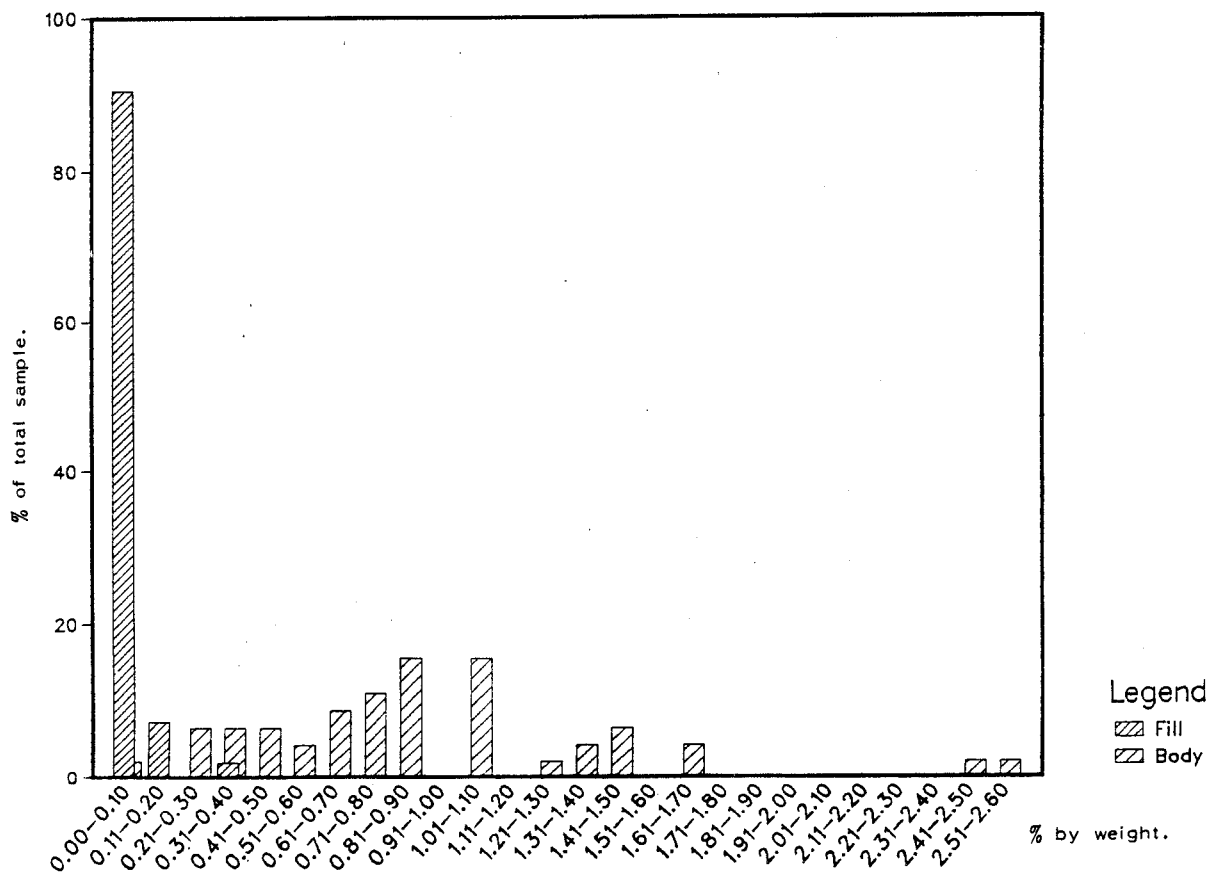
Sutton Hoo Body Analysis – Potassium Content



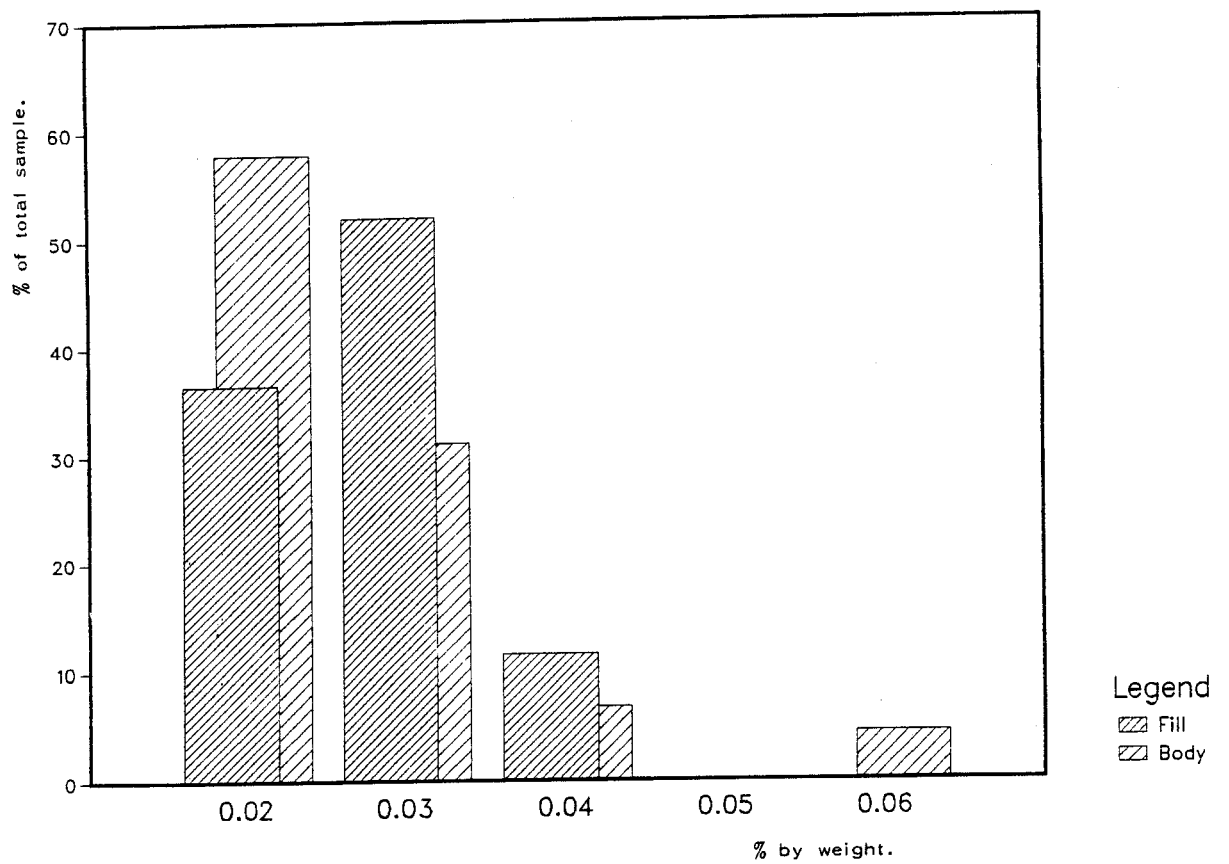
Sutton Hoo Body Analysis – Titanium Content



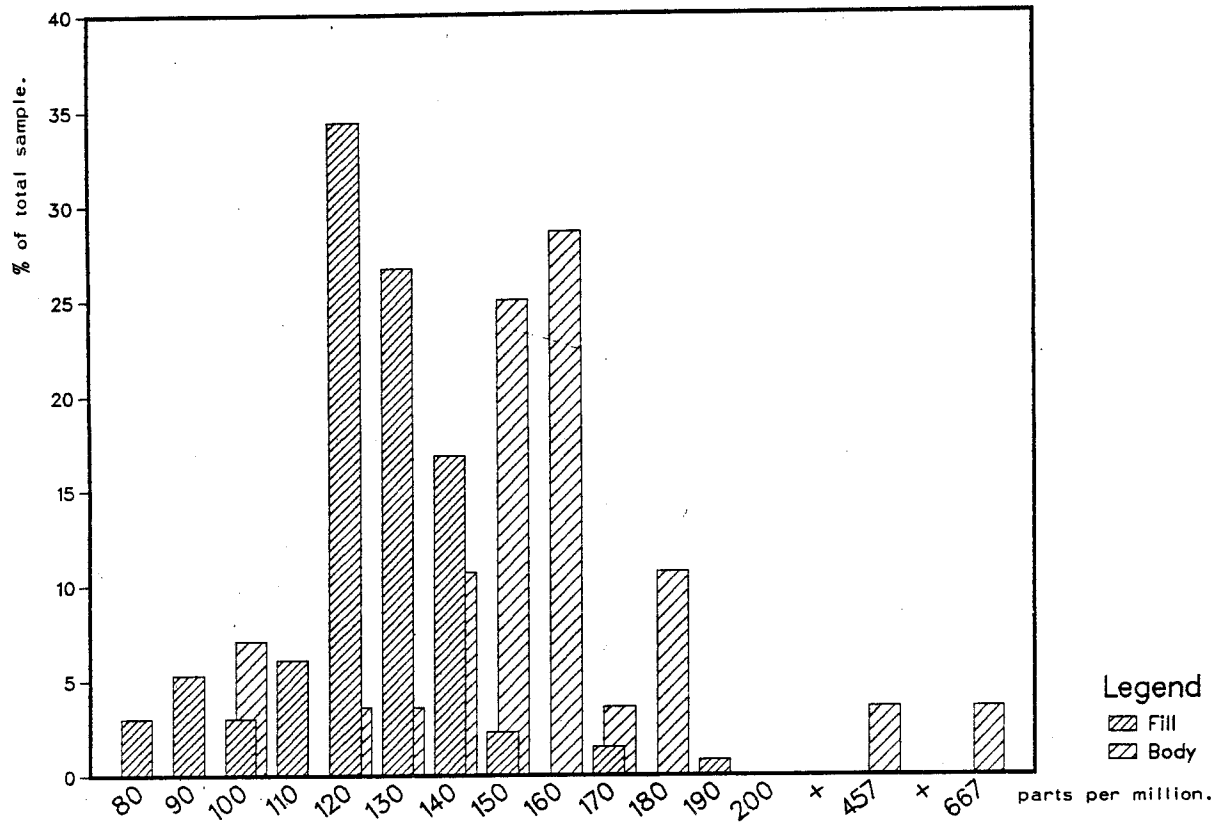
Sutton Hoo Body Analysis – Phosphorous Content



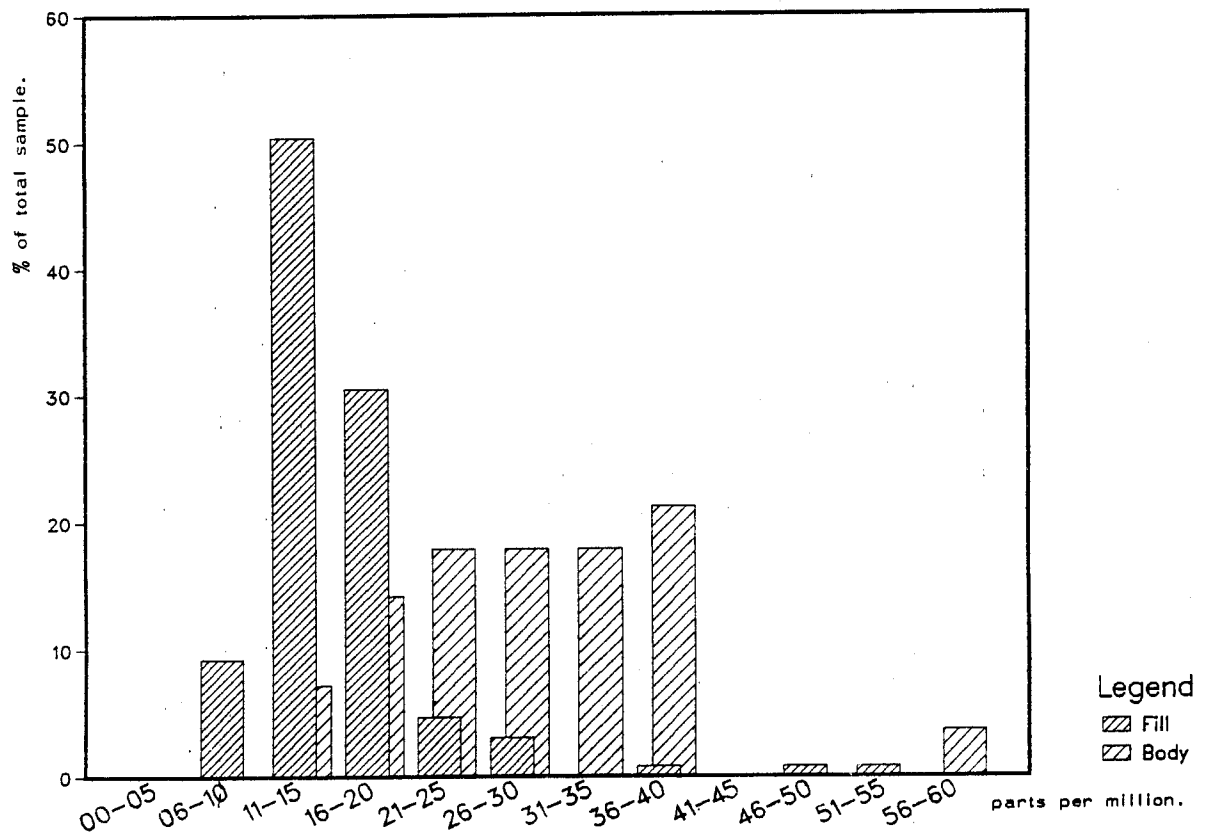
Sutton Hoo Body Analysis — Manganese Content



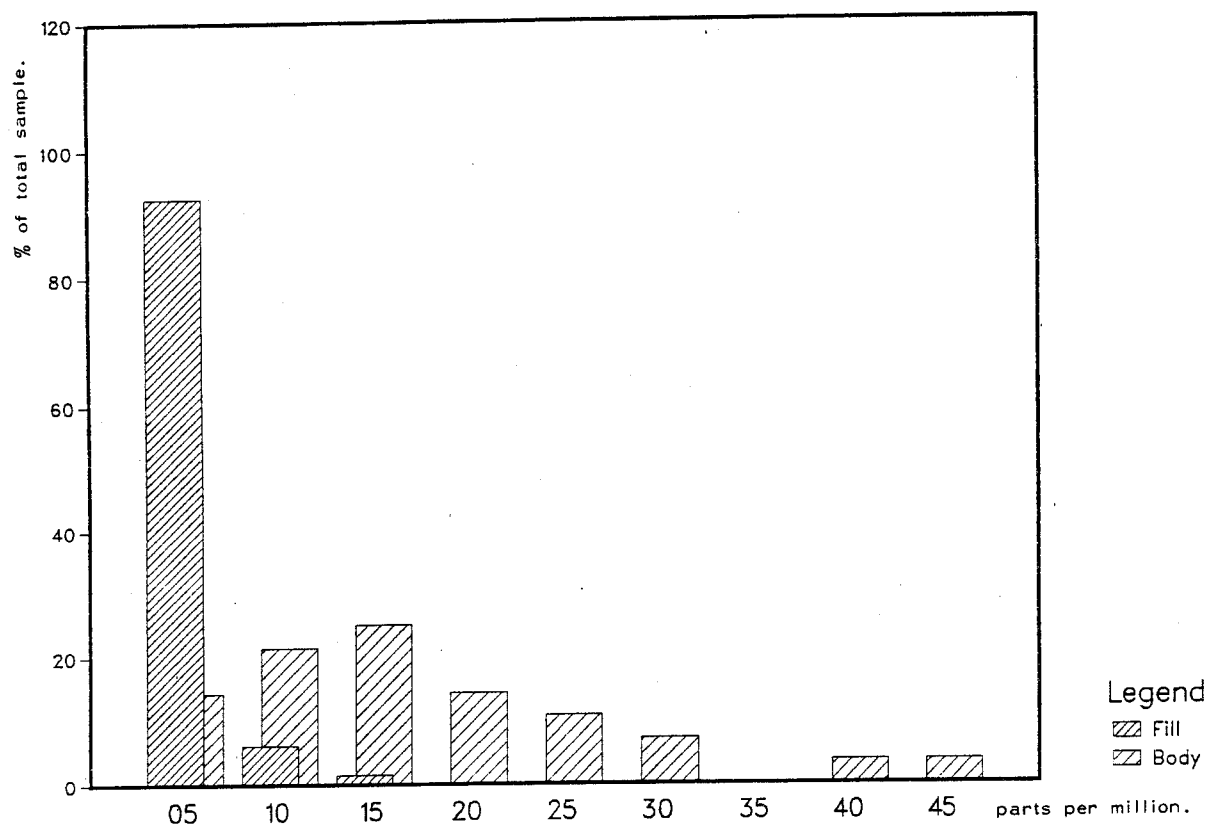
Sutton Hoo Body Analysis – Barium Content



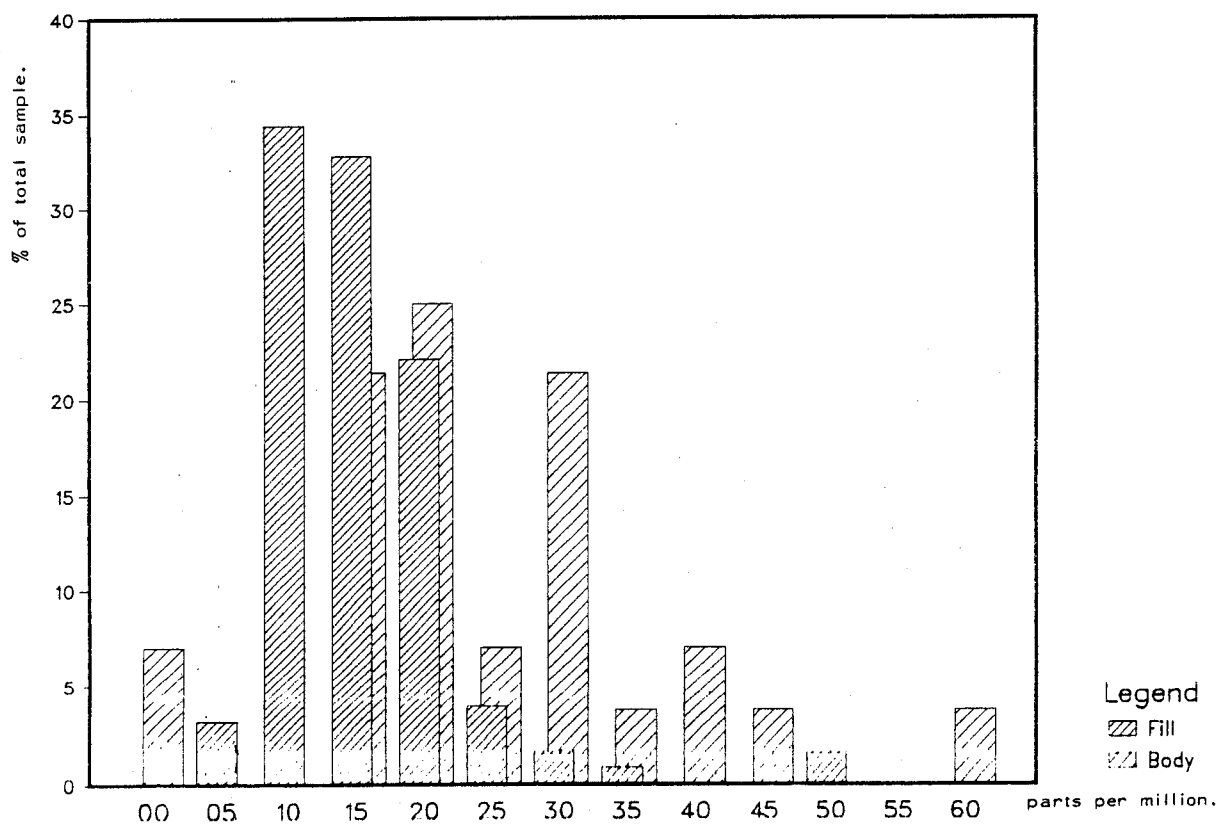
Sutton Hoo Body Analysis – Cerium Content



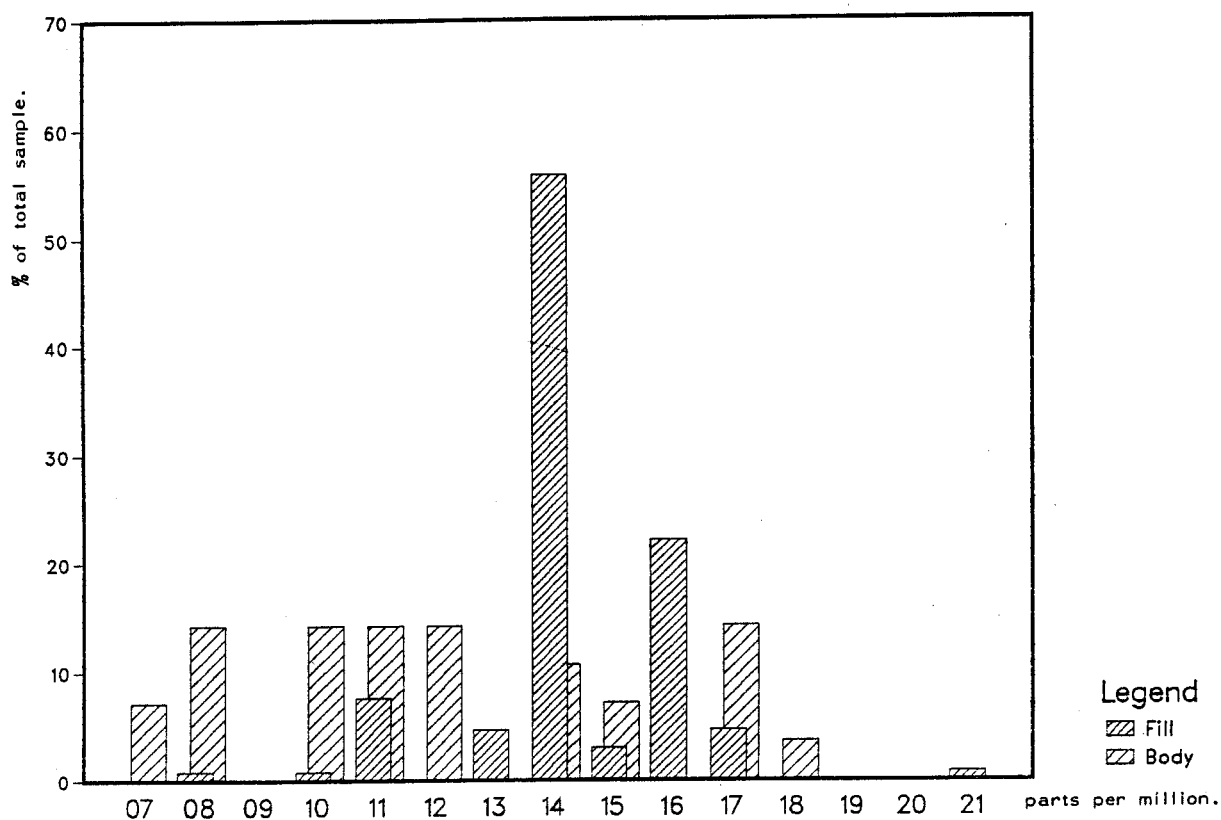
Sutton Hoo Body Analysis – Cobalt Content



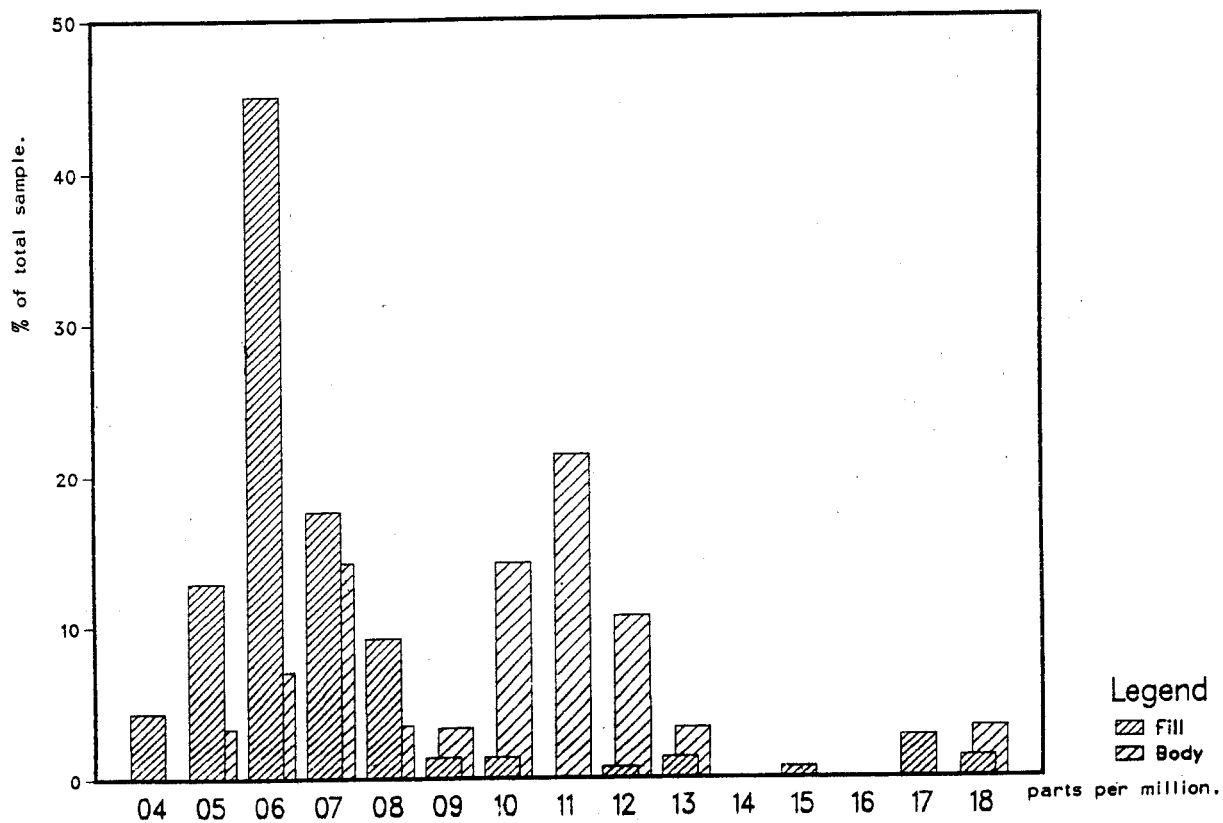
Sutton Hoo Body Analysis – Chromium Content



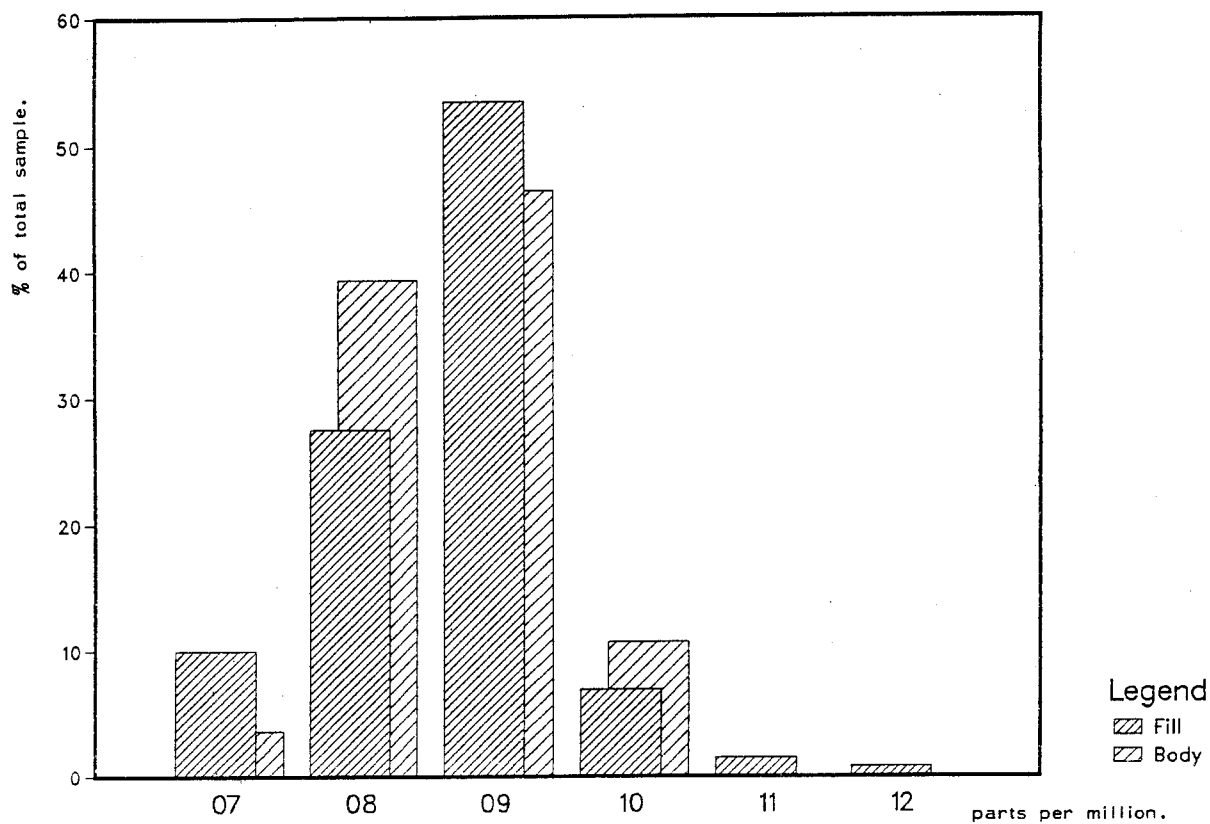
Sutton Hoo Body Analysis – Copper Content



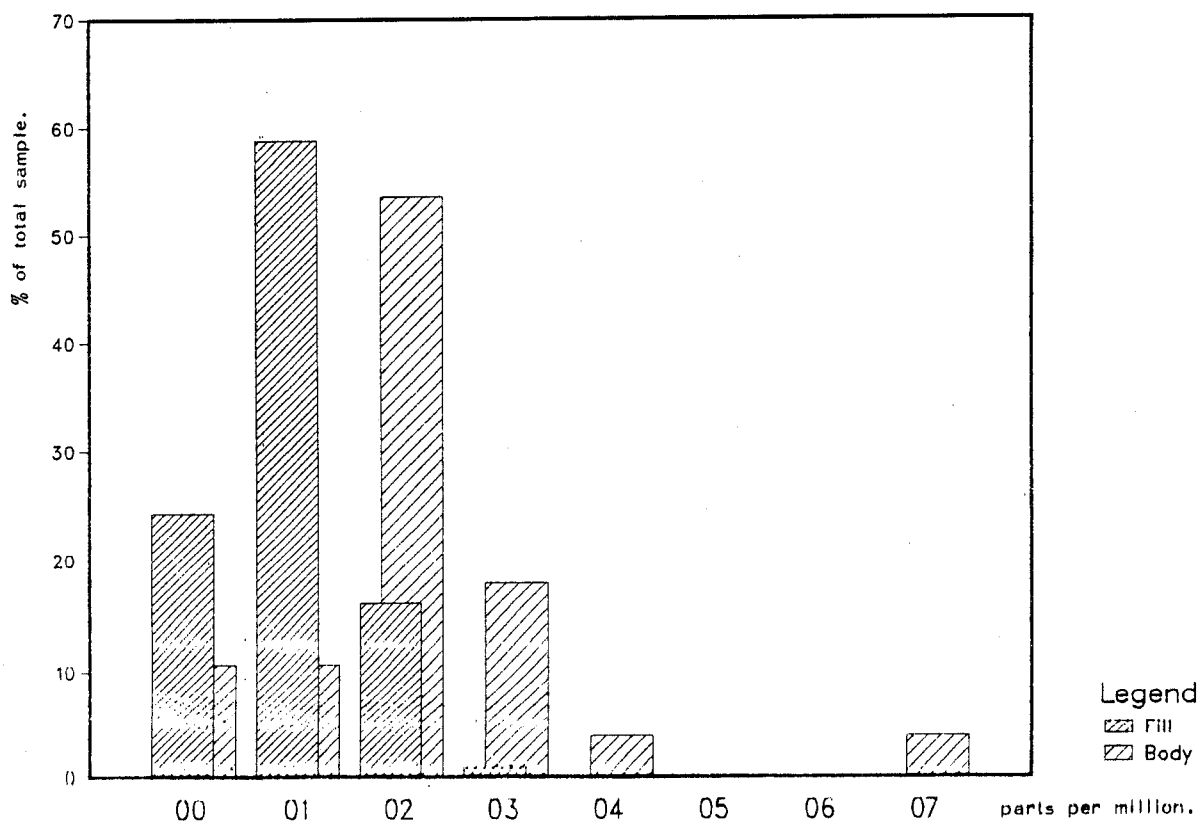
Sutton Hoo Body Analysis – Lanthanum Content



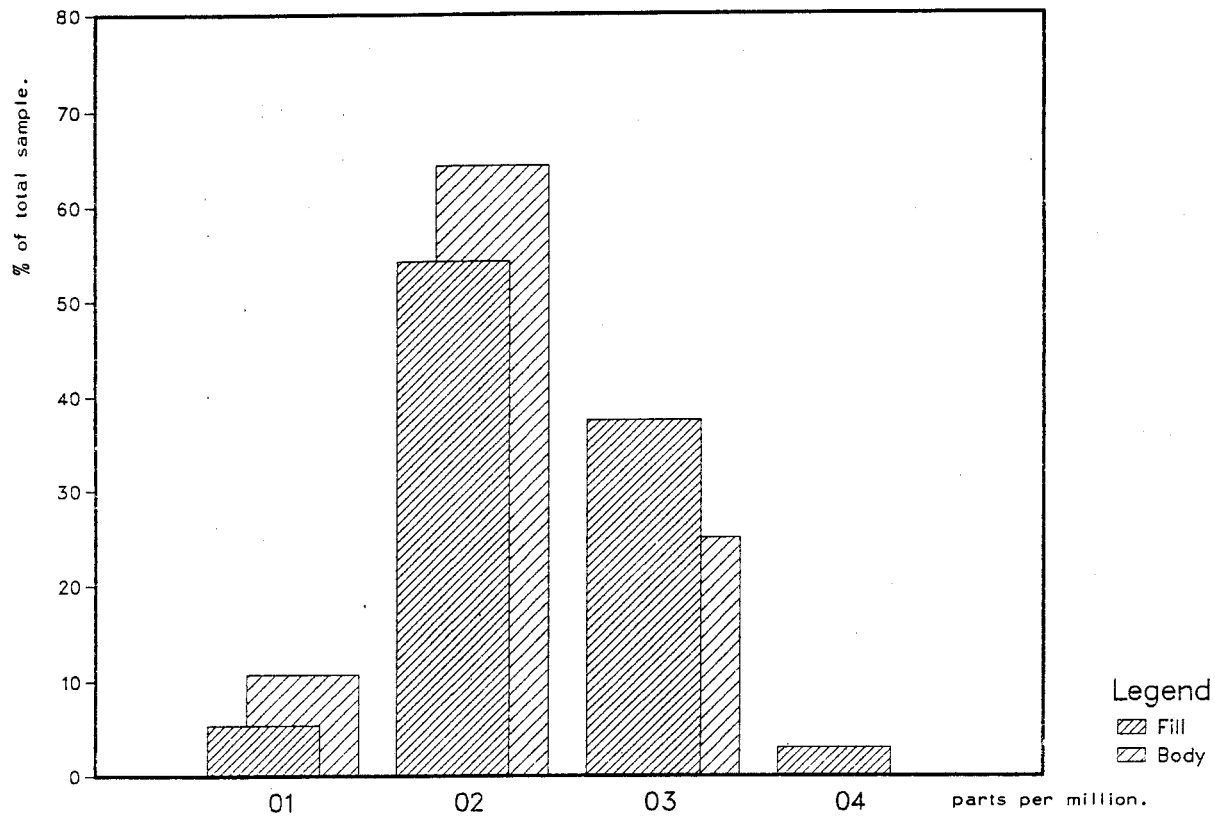
Sutton Hoo Body Analysis – Lithium Content



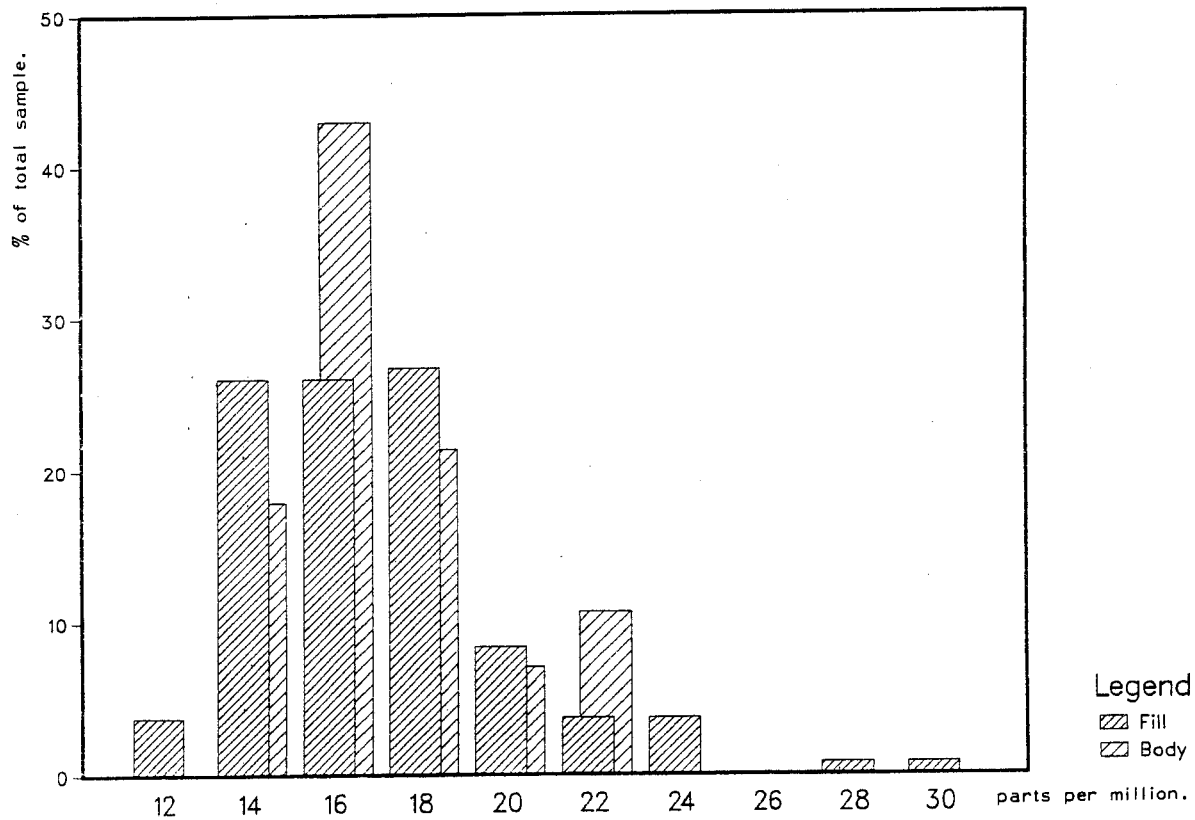
Sutton Hoo Body Analysis – Molybdenum Content



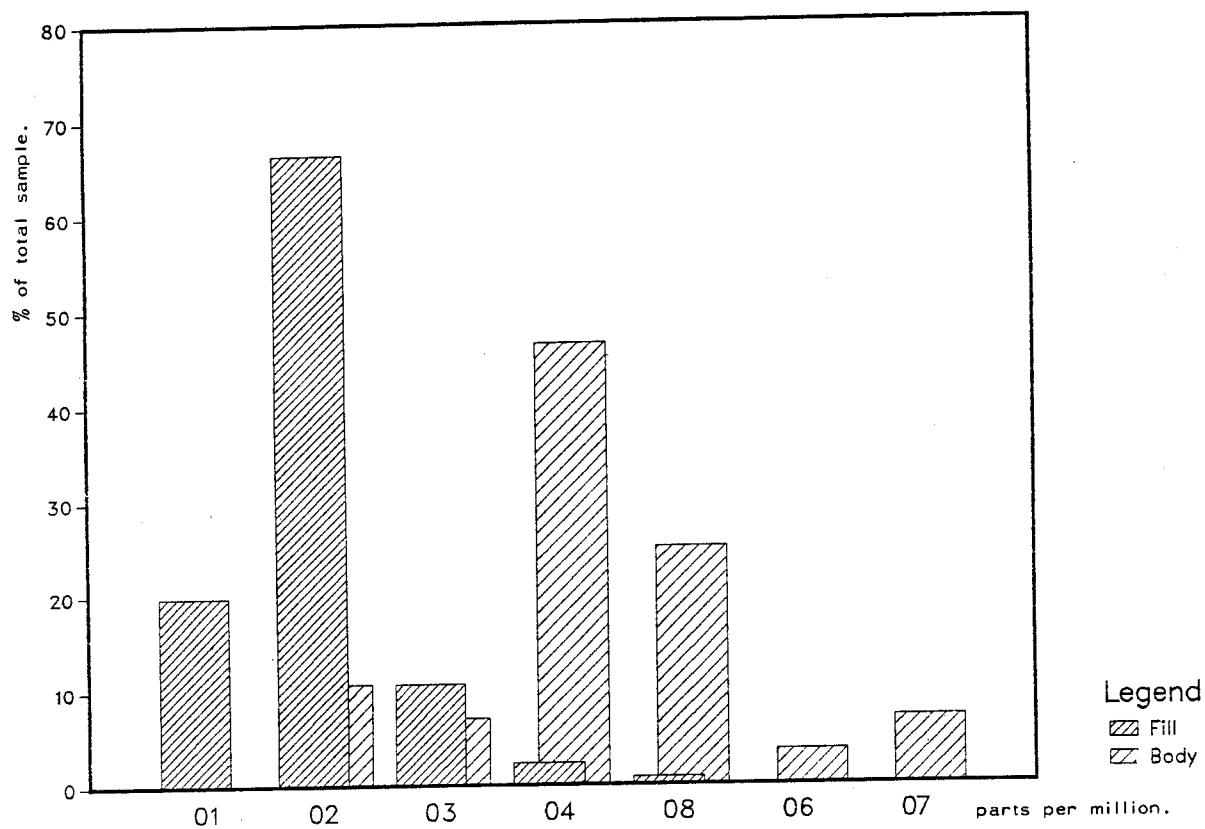
Sutton Hoo Body Analysis – Niobium Content



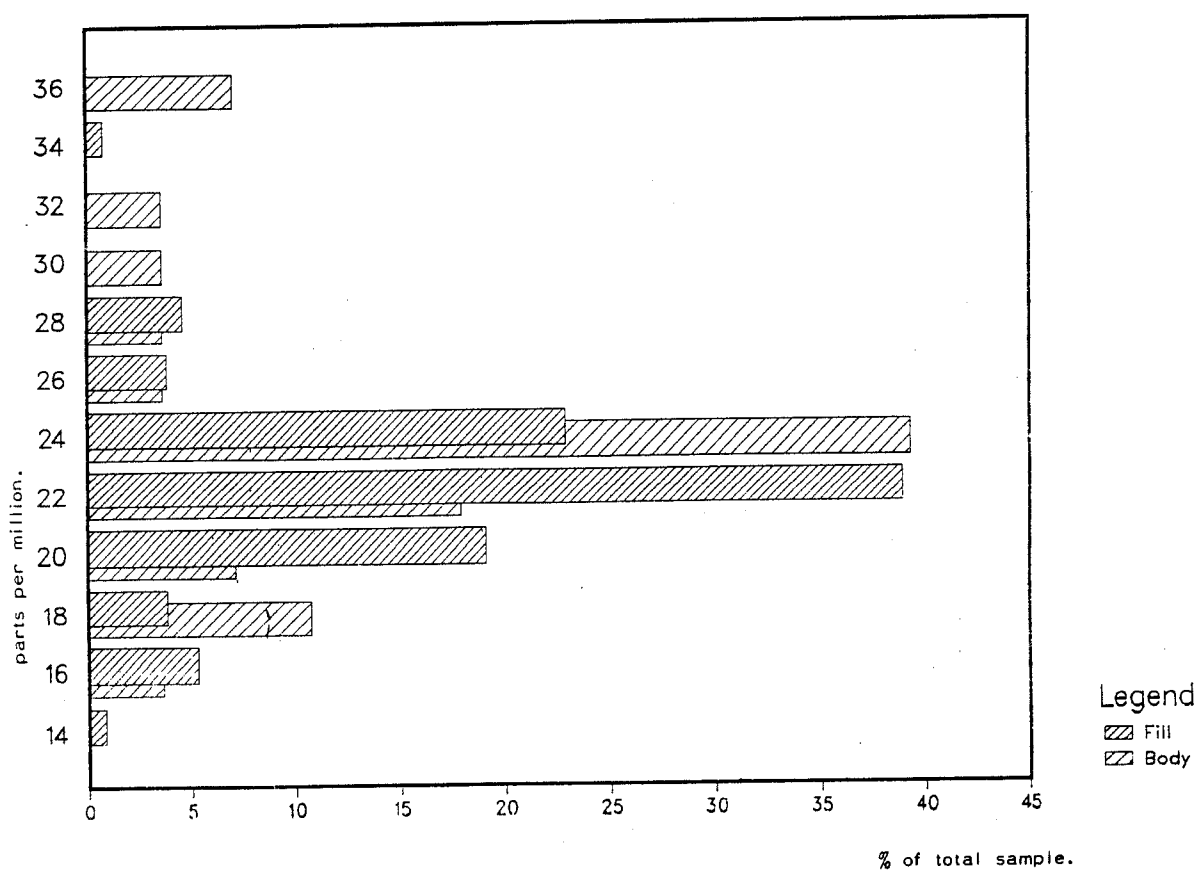
Sutton Hoo Body Analysis – Nickel Content



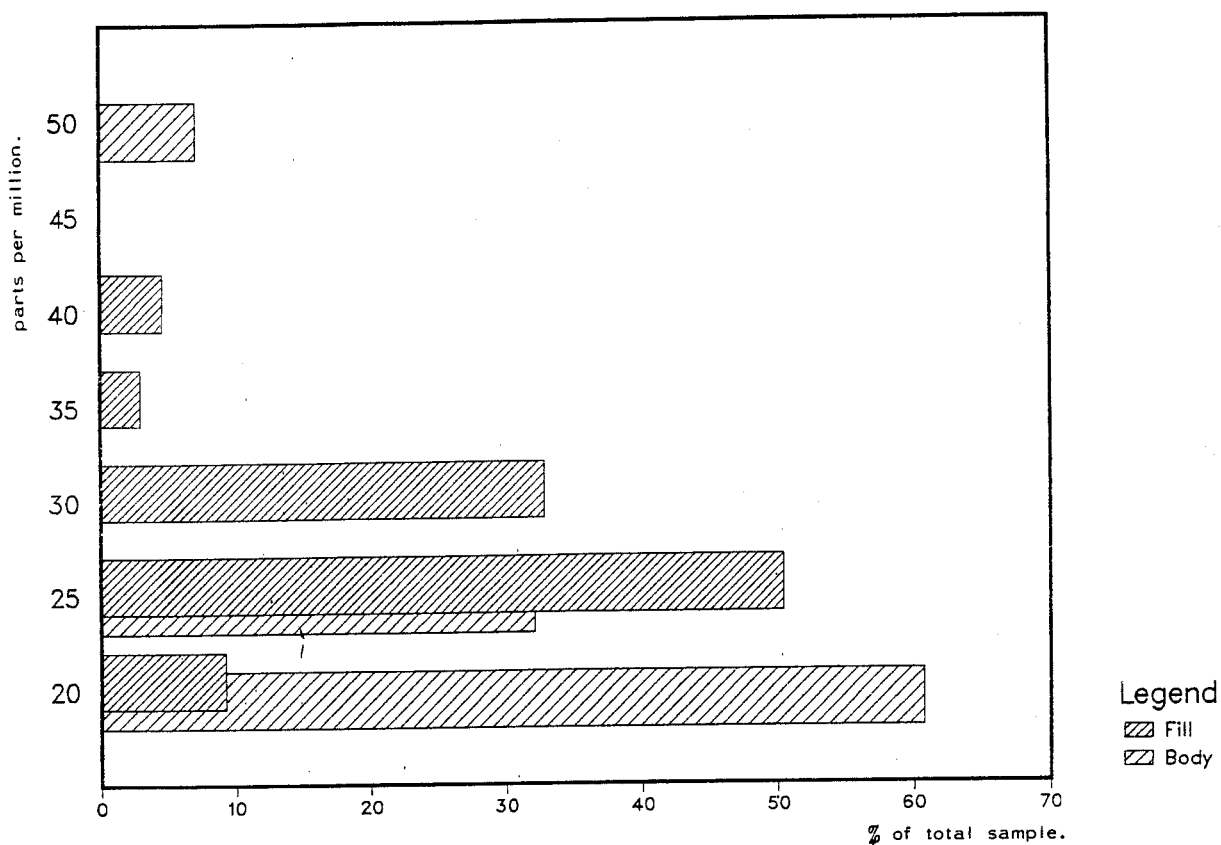
Sutton Hoo Body Analysis – Scandium Content



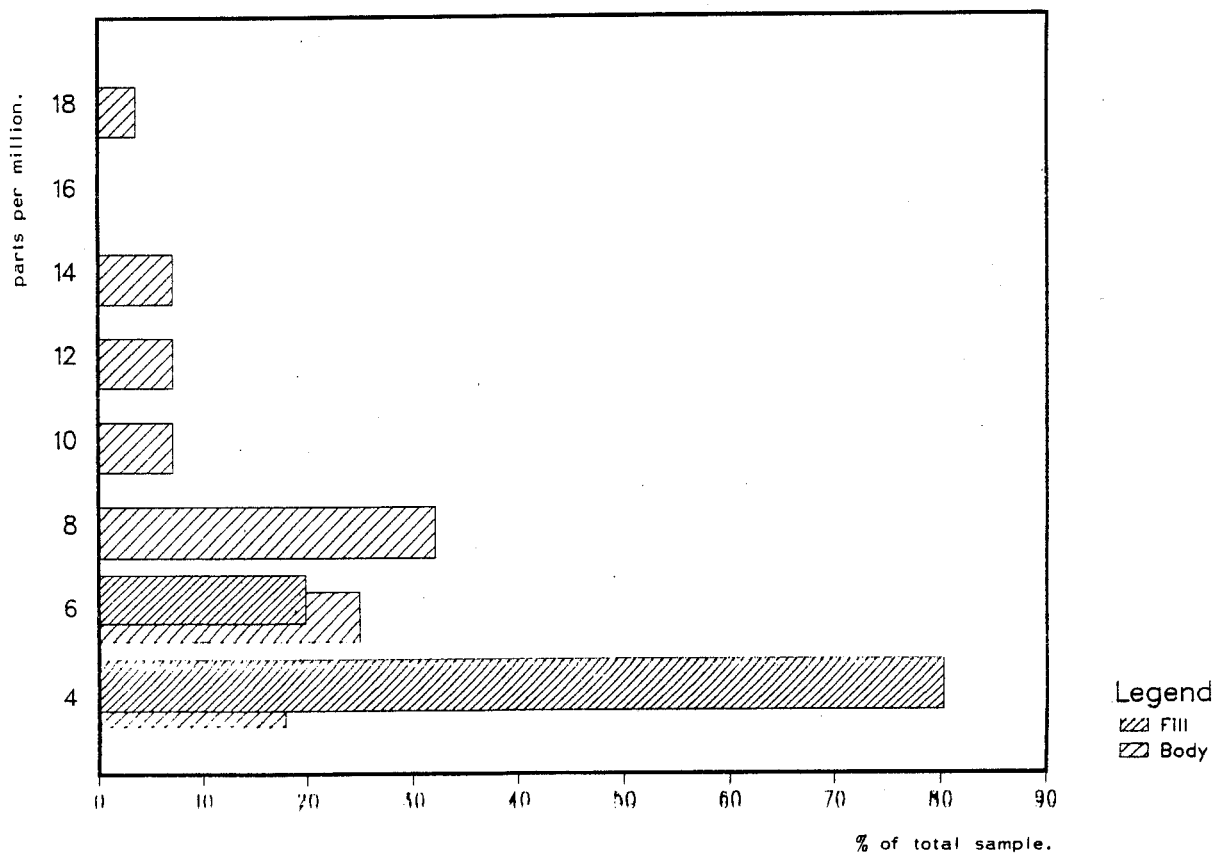
Sutton Hoo Body Analysis – Strontium Content



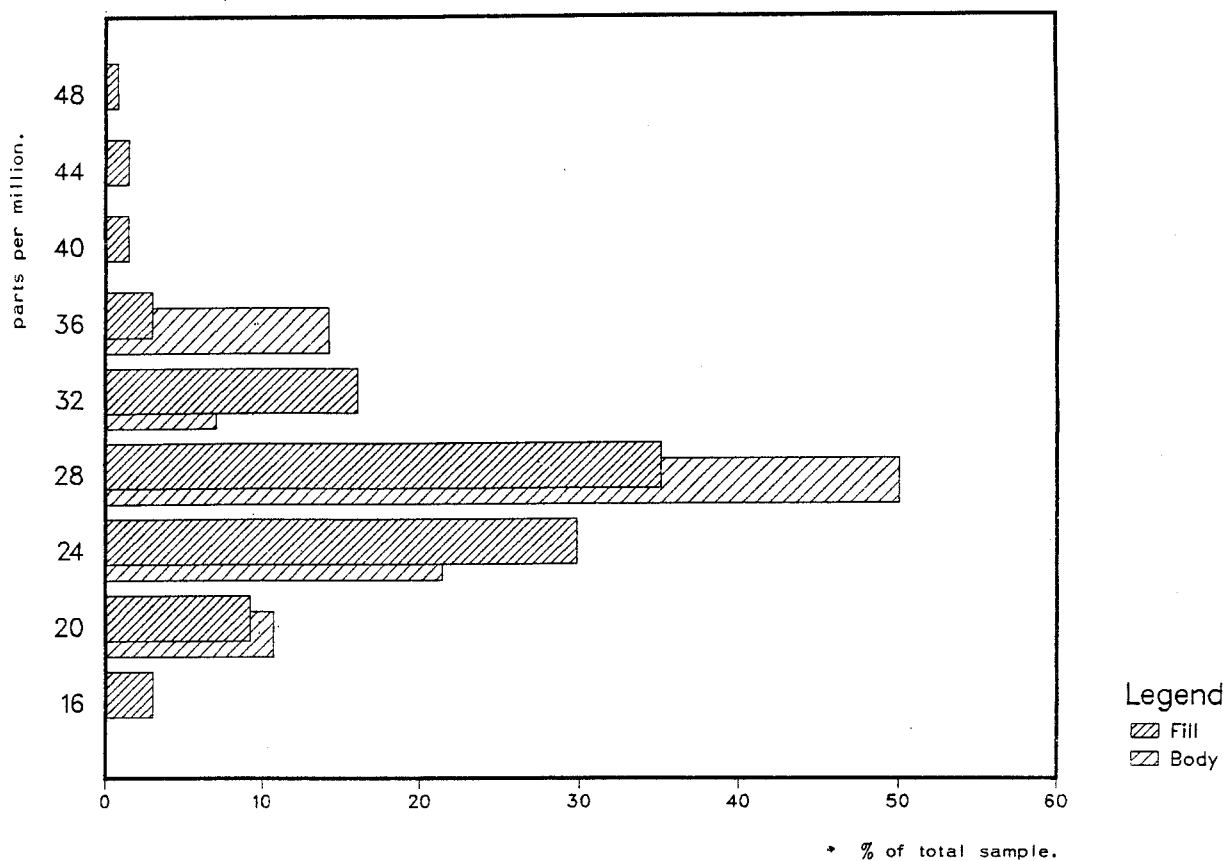
Sutton Hoo Body Analysis – Vanadium Content



Sutton Hoo Body Analysis – Yttrium Contents



Sutton Hoo Body Analysis – Zirconium Content



Sutton Hoo Body Analysis – Zinc Content

