Analysis of sherd samples from Cheviot Quarry, Northumberland, for organic residues by gas chromatography-mass spectrometry, bulk stable isotopes and compound specific-combustion isotope ratio-mass spectrometry.

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Introduction

Molecular and isotopic analyses have been undertaken on a total of 54 ceramic sherds and selected associated soils. The sherds are from Cheviot Quarry, Northumberland (UK) and have been dated by typology and radiocarbon to the early, mid and late Neolithic (Carinated Bowls, Impressed Wares and Grooved Wares), Late Neolithic/Early Bronze Age (Beaker) and Late Bronze Age (Flat-rimmed Ware).

Molecular analysis has been used to examine lipids present in visible organic residues (where present) and ceramic absorbed lipids from the interior and exterior surfaces of each sherd, in order to determine vessel use and function. Isotopic analysis of both the bulk visible residues and compound specific analysis of the $C_{16:0}$ and $C_{18:0}$ fatty acids has been used to distinguish ruminant dairy and ruminant/non-ruminant adipose fats.

Methods

Sample preparation

Where present, scrapings of any adhering visible residues were taken from the surfaces of the sherds. Sub-samples of the ceramic (between 0.1 and 0.3 g) were also removed to a depth of 2mm from both the exterior and interior surfaces of each sherd with a *Dremmel* electric drill fitted with a tungsten abrasive bit. The interior/exterior was determined by the sherd curvature.

Preparation for Gas chromatography-mass spectrometry (GC-MS)

These samples were extracted with three aliquots of ~3 ml DCM:MeOH (dichloromethane:methanol 2:1, v/v), with ultrasonication for 5 min. The solvent extract was transferred to a clean glass vial. The solvent was removed under a stream of nitrogen. Excess BSTFA (N, O- bis(trimethylsilyl)trifluoroacetamide) with 1% TMCS (trimethylchlorosilane) (*Pierce*) was added to derivatise the sample. An additional drop of DCM was added to ensure thorough mixing of sample and reagent, and the sample was left overnight. Excess derivatising agent was removed under a stream of nitrogen. The samples were diluted in DCM for analysis by GC-MS. A modern pot (previously solvent extracted) was also analysed using the same method as the samples.

Preparation for Gas chromatography-combustion isotope ratio-mass spectrometry (GC-CIR-MS). Method adapted from Dudd et al. (1999) and Mottram et al. (1999).

Selected sherd powders (from the interior surfaces) and visible residues were solvent extracted as described above. The solvent was removed under a stream of nitrogen. The lipid extracts were then saponified by heating with 4 ml 5% aqueous methanolic NaOH (5% NaOH in 95:5 methanol:deionised water v/v) for 2 hours at 70°*C* in closed vials. Once cooled, the samples were acidified using approximately 20 drops concentrated HCl (checking the samples are acidic). The solvent soluble portion was the extracted with 3x 2ml hexane, again evaporating to dryness with gentle heat and a stream of nitrogen.

The saponified lipid extracts were then methylated using 2ml boron trifluoride (BF_3) methanol complex per sample and heated in a closed vial at 70 °*C* for 1 hour. The resultant fatty acid methyl esters (FAMES) were extracted using 3x 2ml hexane and evaporated to dryness. 2ml of DCM was added to each sample and either allowed to stand or shaken gently to dissolve the FAMES. A 400 μl sub-sample was transferred to a clean vial and evaporate to dryness for analysis by GC. The remainder of the sample was transferred to a clean vial, evaporated to dryness and stored in freezer prior to GC-CIR-MS analysis.

Instrumental

Gas chromatography-mass spectrometry (GC-MS)

Analysis was carried out by combined gas chromatography-mass spectrometry (GC-MS) using a *Hewlett Packard* 5890 series II GC connected to a 5972 series mass selective detector. The splitless injector and interface were maintained at 300°C and 340°C respectively. Helium was the carrier gas at constant inlet pressure. The temperature of the oven was programmed from 50°C (2 min.) to 340°C (10 min.) at 10°C/min. The GC was fitted with a 15m X 0.25mm, 0.1µm OV1 phase fused silica column (*MEGA*). The column was directly inserted into the ion source where electron impact (EI) spectra were obtained at 70 eV with full scan from *m/z* 50 to 700.

Bulk stable isotopes $\delta^{13}C$ *and* $\delta^{15}N$ *(IR-MS)*

Pressed tin capsules (5 x 9 mm) were used, into which approximately 1 mg amounts of samples were weighed. Samples were flash combusted in a column containing Cr_2O_3 and silvered cobalt (I) oxide held at a temperature of 1020°C and the resultant gases reduced in a column of elemental copper at 680°C then passed through a water trap of magnesium perchlorate before being separated by the GC column prior to introduction to the MS (Europa 20/20).

Gas chromatography-combustion isotope ratio-mass spectrometry (GC-CIR-MS) of the major fatty acids ($C_{16:0}$ *and* $C_{18:0}$*).*

Analysis was carried out by Dr. Andy Stott of the Centre for Ecology & Hydrology, Lancaster, UK. Originally 20 samples were selected for GC-IR-MS, however after sample preparation and confirmation of correct derivatisation by GC it was found that only fourteen of these samples contained sufficient $C_{16:0}$ and $C_{18:0}$ for analysis. Samples were determined in duplicate. The error on the fatty acid methyl ester standard which were analysed 'in batch' was better than 0.2 per mil for both $C_{16:0}$ and $C_{18:0}$.

As the fatty acids are derivatised with an extra carbon we needed to take account of this (the results are presented as corrected values). The $\delta^{13}C$ value of the methyl group carbon was determined as -44.67 ‰. Values for archaeological samples are corrected using the formula: $C_{16:0}$ = (16 chain length FA + 1 extra from methyl group) x (measured $\delta^{13}C$ value of compound by GC-CIR-MS) - ($\delta^{13}C$ of BF_3) divided by number of original C atoms in fatty acid chain (ie 17 x (Deriv fame value) - (-44.67) / 16 For the C18 = 19 x deriv fame value - (-44.67) / 18)

Results and Discussion

Molecular results: Gas chromatography-mass spectrometry (GC-MS)

a)

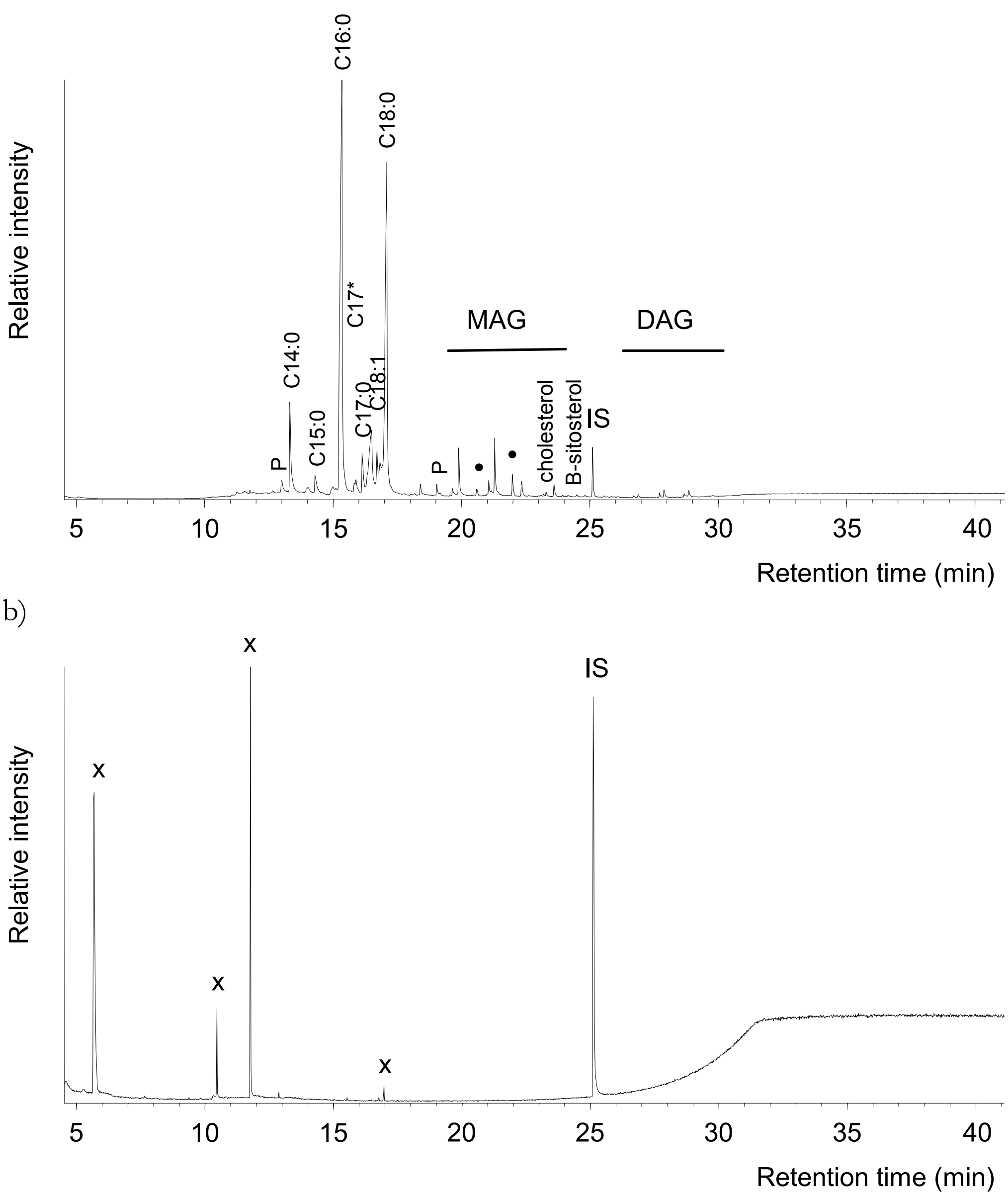

Figure 1. Examples of mass chromatograms of the BSTFA derivatised solvent extracts from a) absorbed lipid from the internal surface and b) the absorbed lipid from the external surface of sherd MAP204, Mid-Neolithic Impressed Ware. IS = internal standard, x = analytical artifact.

Typical examples of the GC-MS results are shown in Figure 1. Due to the large number of samples the molecular data is summarised in Table 1 which includes the sherd type and interpretation of the recovered lipids. A detailed table is shown in Appendix 1 which lists the molecules extracted from each sample.

The solvent extracts from selected soil samples (data in Appendix 1) yielded a range of fatty acids, *n*-alkanes and alcohols. However, the distribution was dissimilar to those of the sherd samples and therefore contamination from the burial matrix can be excluded. In addition, the modern pot which was used to examine contamination during sample preparation and analysis yielded only trace levels of fatty acids. These are ubiquitous compounds and despite the precautions used to avoid contamination their presence at such low abundances is not unexpected. Almost all the samples yield a number of compounds called phthalate plasticisers (labelled as P, Figure 1), these are modern synthetic compounds and are associated with leaching from plastics. In addition, a number of known analytical artefacts (labelled as x) were identified. All these components do not represent significant contamination and do not interfere with the interpretation of the extracts from the samples.

Overall a wide range of lipids were extracted from the archaeological sherds and the general preservation of the organic residues was very good, although there was evidence of degradation of some lipids. For the interpretation of vessel use, the presence of mono-, di- and triacylglycerols was used to indicate the presence of an oil/fat. When these biomarkers were not present, but significant abundances of fatty acids were recovered from the vessel, this was interpreted as containing a degraded oil/fat. Based on a degraded fatty acid or acylglycerol distribution, it is not possible to identify the source any further (i.e. to distinguish animal fat from plant oil). However, the sterol cholesterol was used to identify the presence of an animal input and the absence of squalene was used to confirm that cholesterol had not been introduced as contamination due to recent handling. Phytosterols were used to indicate the input of plant materials. Molecular evidence that the vessel was used for heating was based on the presence and distribution pattern of odd numbered ketones, which are known to be derived from the heating of oils in ceramic vessels to temperatures in excess of 300°C (Evershed *et al.* 1995; Raven *et al.* 1997). Beeswax was tentatively identified from the presence and distribution of *n*-alkanes, long chain alcohols and wax esters (e.g. Heron *et al.* 1994; Evershed *et al.* 1997; Regert *et al.* 2001). Levoglucosan was extracted from one sample this molecule is a marker for burning biomass, in particular cellulose (Simoneit 2002). This could originate from the fuel used for heating, or from the burial matrix which for some samples is known to contain burnt remains.

141 archaeological samples were analysed by GC-MS for this study (including soils, visible residues, exterior and interior ceramic absorbed). Of these, 58 (41%) yielded no lipid, 30 contained a degraded oil/fat (with an additional 18 possibly containing degraded oil/fat (a total of 37%)), 22 (16%) had molecular evidence that the vessel was used for heating, 10 had biomarkers indicating the fat was an animal source, 2 contained an animal/plant mixture and 2 possibly contained beeswax. When the same data is examined 'per sherd' the majority of the lipids are extracted from the interior 2mm of each vessel. Where lipids are extracted from the interior 2mm only (and not from the exterior), contamination from the burial environment as a source of the lipids can be excluded and the lipids can be considered to represent the content of the vessel. In addition to the interior surface, lipids were also extracted from the exterior surface – this can either be attributed to overspill from the vessel or to migration of the vessel contents through the ceramic.

Sample Code	Context number (ref to Context register)	Pot Type	Date (uncal. C years BP)	Interpretation of molecular evidence
932	009 – not on Context Register	Grooved Ware	Late Neolithic	**No lipid**
949	009 – not on Context Register	Grooved Ware	Late Neolithic	**No lipid**
935	009 – not on Context Register	Grooved Ware	Late Neolithic	**No lipid**
933	009 – not on Context Register	Grooved Ware	Late Neolithic	**Possible degraded oil/fat absorbed into the interior surface**
919	009 – not on Context Register	Grooved Ware	Late Neolithic	**Possible degraded oil/fat absorbed into both interior and exterior surfaces**
424	009 – not on Context	Grooved Ware	Late Neolithic	**No lipid, fossil fuel contamination**

	Register			
16811	168	Grooved Ware	4177 ±33BP	**Possible degraded oil/fat absorbed into the interior surface**
16816	168	Grooved Ware	4177 ±33BP	**Possible degraded oil/fat absorbed into the interior surface**
1338	133	Grooved Ware	4152 ±31BP	**No lipid, fossil fuel contamination**
1635	163	Grooved Ware	Late Neolithic	**No lipid**
13313	133	Grooved Ware	4152 ±31BP	**No lipid**
52173	52	Carinated Bowl	Early Neolithic	**Lipids absorbed into the interior surface indicate the vessel was used for heating oil/fat, the exterior surface also yields possible degraded oil/fat**
5125	51	Carinated Bowl	4348 ±34BP	**Possible degraded oil/fat absorbed into both the interior and exterior surfaces**
52127	52	Carinated Bowl	4348 ±34BP	**Possible degraded oil/fat absorbed into the interior surface**
13321	133	Grooved Ware	4152 ±31BP	**No lipid**
31149	31	Carinated Bowl	Early Neolithic	**Possible degraded oil/fat absorbed into the interior surface**
5134	51	Carinated Bowl	4348 ±34BP	**Lipids absorbed into the interior surface indicate the vessel was used for heating Milk**
4913	49	Carinated Bowl	Early Neolithic	**Possible degraded oil/fat absorbed into the interior surface**
31140	31	Carinated Bowl	Early Neolithic	**Animal fat from interior visible residue, but no ceramic absorbed lipids**
52177	52	Carinated Bowl	Early Neolithic	**Possible degraded oil/fat absorbed into the interior surface, animal fat absorbed into the exterior surface**
MQ219	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	**Possible degraded oil/fat from the interior visible residue, but no ceramic absorbed lipids**
306/406	306	Flat-rimmed Ware	Late Bronze Age	**Lipids absorbed into the interior surface indicate the vessel was used for heating Milk. Lipids from the visible residue on the exterior surface indicate that the vessel was used for heating oil/fat**
52123	52	Carinated Bowl	Early Neolithic	**Cow Milk/Adipose identified in the interior visible residue. Interior absorbed lipid indicates vessel used for heating oil/fat**
51/65	51	Carinated Bowl	4348 ±34BP	**Degraded Milk in the interior visible residue. Possible degraded oil/fat absorbed into the interior ceramic whilst the lipid absorbed into the exterior indicates the vessel was used for heating oil/fat**
F204	Pit feature – not on Context Register	Impressed Ware	Mid-Neolithic	**No lipid**
F219	Pit Feature – not on Context Register	Impressed Ware	Mid-Neolithic	**Possible degraded oil/fat from the interior visible residue. The interior absorbed residue indicates that the vessel was used for heating**

				oil/fat and possible mixture with Beeswax.
MMRB /4sav	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	**Degraded fat/oil from the interior visible residue and absorbed into the interior and exterior surfaces**
DVORY	483	Flat-rimmed Ware	2693 ±30 BP	**Visible residue and lipids absorbed into the interior surface of the ceramic indicate the vessel used for heating an oil/fat. Fossil fuel contamination of the exterior surface**
224434	224	Carinated Bowl	Early Neolithic	**No lipid**
224201	224	Carinated Bowl	Early Neolithic	**No lipid**
224222	224	Carinated Bowl	Early Neolithic	**Lipids absorbed into the interior surface indicate the presence of degraded Milk and that the vessel was used for heating Milk**
314421	314	Flat-rimmed Ware	Late Bronze Age	**Degraded oil/fat absorbed into the interior and exterior surfaces**
477368	477	Flat-rimmed Ware	Late Bronze Age	**No lipid**
482373 /0	482	Flat-rimmed Ware	Late Bronze Age	**Lipids from the interior visible residue and absorbed into the interior and exterior surfaces indicate the vessel was used for heating an oil/fat**
482369	482	Flat-rimmed Ware	Late Bronze Age	**Degraded oil/fat from the interior visible residue and from both exterior and interior absorbed surfaces. The lipid from the interior surface also indicates a degraded animal fat and that the vessel was used for heating oil/fat**
483382	483	Flat-rimmed Ware	2693 ±30 BP	**No lipid**
485389	485	Flat-rimmed Ware	Late Bronze Age	**Degraded oil/fat lipids extracted from interior and exterior visible residues and absorbed from both surfaces. Interior visible, interior and exterior ceramic absorbed indicate that the vessel was used for heating oil/fat. Possible beeswax absorbed into the exterior surface**
340367	340	Flat-rimmed Ware	Late Bronze Age	**Animal fat identified in the interior visible residue. Lipids absorbed into the interior surface indicate that the vessel was used for heating oil/fat**
340319	340	Flat-rimmed Ware	Late Bronze Age	**The visible residue from the interior surface indicates that the vessel was used for heating an animal fat. An oil/fat absorbed into the interior surface was also heated. A fat/oil is absorbed into the exterior surface**
340257	340	Flat-rimmed Ware	Late Bronze Age	**Degraded fat/oil absorbed into both interior and exterior surfaces. Possible beeswax in the visible residue on the interior**
340269	340	Flat-rimmed Ware	Late Bronze Age	**No lipid**
483388	483	Flat-rimmed Ware	Late Bronze Age	**Interior of vessel used for heating oil/fat. Degraded oil/fat absorbed into exterior surface**
348289	348	Flat-rimmed Ware	Late Bronze Age	**No lipid-**

306413	306	Flat-rimmed Ware	Late Bronze Age	**Lipids absorbed into the interior ceramic indicate that the vessel was used for heating Cow Milk/Adipose**
352248	352	Flat-rimmed Ware	Late Bronze Age	**Interior of vessel used for heating oil/fat**
459V	?	?		**Degraded fat/oil from the interior visible residue, no ceramic absorbed lipids**
F13317	133	Grooved Ware	Late Neolithic	**No lipid**
F13318	133	Grooved Ware	Late Neolithic	**Degraded animal fat extracted from the interior visible and absorbed fractions. Degraded fat/oil absorbed into the exterior surface. Burnt cellulose (wood/higher plants) from the interior visible residue**
F219		Beaker	Late Neolithic/Early Bronze Age	**Possible degraded fat/oil from the interior visible residue, degraded animal fat identified absorbed into the interior surface of the ceramic**
F3128	52	Carinated Bowl	Early Neolithic	**Degraded fat/oil absorbed into the interior surface with animal fat absorbed into the exterior surface**
F5110	51	Carinated Bowl	Early Neolithic	**Possible degraded oil/fat absorbed into both interior and exterior surfaces**
MAP1	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	**Degraded Milk from the interior visible residue, identified as degraded fat/oil in the ceramic absorbed fraction. Lipids identified as degraded animal fat from the exterior absorbed fraction**
MAP204	Pit Feature – not on Context Register	Impressed Ware	Mid-Neolithic	**Animal fat/plant mixture absorbed into interior surface**
MAP2204	Pit Feature – not on Context Register	Impressed Ware	Mid-Neolithic	**Animal fat/plant mixture absorbed into the exterior surface, with a degraded oil/fat identified from the exterior visible residue**

Table 1. Sherd code, contexts, type, date and interpretation of recovered lipids.

Isotopic results: *Bulk stable isotopes (IR-MS) and gas chromatography-combustion isotope ratio-mass spectrometry (GC-CIR-MS)*

Detailed tables shown in Appendices 2 and 3 includes the bulk $\delta^{13}C$ and $\delta^{15}N$ values for visible residues and compound specific $\delta^{13}C$ for the $C_{16:0}$ and $C_{18:0}$ fatty acids.

For bulk stable isotope analysis 20 visible residues were selected for their potential to contain preserved organic material (Appendix 2). Bulk analysis determines the combined isotopic value of the sample which may itself be very heterogeneous in its composition, for example containing a mixture of lipid, carbohydrate and protein, each component having its own isotopic signature. All these samples were visible residues adhering to the surfaces of the sherds and many were also selected for radiocarbon dating. For these samples the recovered carbon varied between 2 and 44%, indicating that the majority of the visible residues were not organic material and that they were highly heterogeneous. In addition, the yields of nitrogen were all less than 5%, making the $\delta^{15}N$ values unreliable and therefore they are not interpreted any further. The low nitrogen yields do however exclude the presence of protein in these samples. The bulk $\delta^{13}C$ values ranged from -30.6 to -26.1‰ with an average of -27.5‰. This is typical of a terrestrial C3 environment, and although only a crude measure, can be use to exclude a marine input which would be expected to have more positive values.

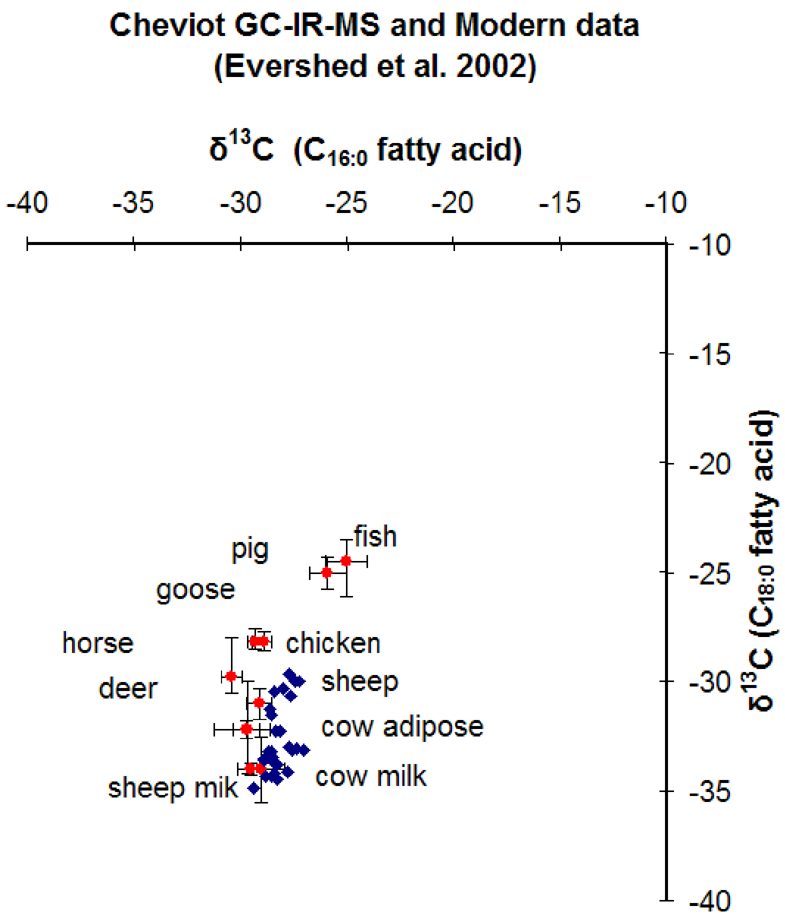

Figure 2. Plot of compound specific □ ^{13}C *(‰) for the* $C_{16:0}$ *and* $C_{18:0}$ *fatty acids. Blue points (including duplicate values) are data from archaeological samples. The error on the fatty acid methyl ester standard run 'in batch' was better than 0.2 per mil for both the* $C_{16:0}$ *and* $C_{18:0}$. *Red points are data derived from Evershed et al. (2002) the error bars here represent the range of values for these modern samples. This modern data has previously been corrected for the extra carbon due to derivatisation and for the modern burning of fossil fuels.*

Fourteen samples containing sufficient $C_{16:0}$ and $C_{18:0}$ fatty acids for analysis were selected for compound specific analysis (Figure 2). Previous work has shown that when the characteristic lipid distributions have been lost by degradation it is still possible to assign sources based on the carbon isotopic values of the principle fatty acids. This is due to differences in the biosynthesis and routings of these components and has been used to distinguish ruminant dairy, ruminant adipose and porcine adipose fats amongst others (e.g. Dudd *et al.* 1999; Mottram *et al.* 1999; Evershed *et al.* 2002; Copley *et al.* 2005a; Copley *et al.* 2005b). Corrections for derivatisation and the modern burning of fossil fuels have previously been applied (Evershed *et al.* 2002) and therefore makes the two data sets directly comparable. Figure 2 shows it is easily possible to exclude sources such as pig, fish, goose, deer, chicken etc (although the number of data points for these modern samples are limited and therefore the true natural variability is not known).

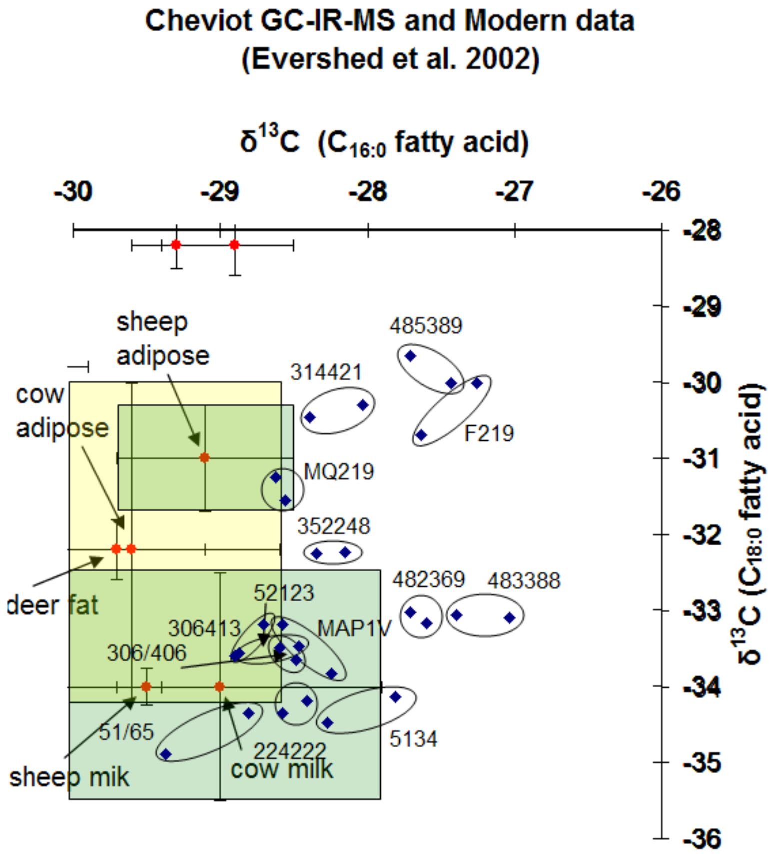

Figure 3. Detailed plot of compound specific □ *^{13}C (‰) for the $C_{16:0}$ and $C_{18:0}$ fatty acids. Ellipses enclose the duplicate samples.*

Figure 3 shows a more detailed plot of the same data as in Figure 2. Five samples; 51/65 (Carinated bowl, 4348 BP), MAP1V (Beaker, Late Neolithic/Early Bronze Age), 224222 (Carinated bowl, Early Neolithic), and the mean value of samples 5134 (Carinated bowl, 4348 BP) and 306/406 (Flat-rimmed ware, Late Bonze Age), all plot within the area defined by modern cows milk. Two samples; 306413 (Flat-rimmed ware, Late Bronze Age), 52123 (Carinated bowl, Early Neolithic) are within the overlapping isotopic values of cows milk and cow adipose fat. Sample MQ219 (Beaker, Late Neolithic/Early Bronze Age) is just within the overlapping areas of modern sheep and cow adipose fat.

The remaining six samples (482369 (Flat-rimmed ware, Late Bronze Age), 483388 (Flat-rimmed ware, Late Bronze Age), 352248 (Flat-rimmed ware, Late Bronze Age), 314421 (Flat-rimmed ware, Late Bronze Age), F219 (Impressed ware, Mid-Neolithic) and 485389 (Flat-rimmed ware, Late Bronze Age)) are not within the boundary values of the modern reference samples. Of these, samples 352248, 314421, F219 and 485389 could be on the theoretical bovine and porcine mixing line, or could represent different isotopic values due to a different animal dietary regime in antiquity as compared to the modern day samples (Evershed *et al.* 2002).

Due to the relatively small number of samples and the selection of samples for analysis based on the presence of sufficient $C_{16:0}$ and $C_{18:0}$ fatty acids it is not possible to identify any clear patterns of vessel use relating to either date or pot type (Figure 3 and Table 1). It is however apparent that dairying was present in all periods from the Early Neolithic to the Late Bronze Age. Previous studies of dairying as evidenced by lipid residues from a large number of sherds from a range of sites in Southern Britain (Copley *et al.* 2005a and b) report the extensive use of ruminant dairy fats (5 to 41% of sherds) during the British Bronze Age and approximately 25% during the British Neolithic. Copley *et al.* (2005a) report during the Neolithic there was little intra-site variation. An examination of vessel use with type found that Beakers were less likely to contain lipids, and although Carinated bowls from one site yielded more dairy products than adipose fats, overall no association was found with lipid content and vessel type (Grooved ware, Peterborough ware, Beakers). These reported findings contrasts with a previous study by Dudd *et al.*

(1999) who observed that Grooved wares were more likely to be associated with porcine fats whilst Peterborough ware was associated with ruminant fats.

The possible assignment of beeswax to three sherds 340257, 485389 (both Flat-rimmed Ware, Late Bronze Age) and F219 (Impressed Ware, Mid-Neolithic) is intriguing, especially as all three contained degraded fat/oil in addition to the beeswax. Although the addition of honey is a possibility, the usual assumption is that the beeswax was used as a waterproofing/sealing agent. The use as a sealant is possible for two of the vessels as it was recovered from the interior surfaces, however from sample 485389 the beeswax was extracted from the exterior surface. Low numbers of sherds containing beeswax have also been reported by Copley *et al.* (2005b and b) who examined a large number of British Bronze Age and Neolithic vessels, those authors also report the mixing of animal and plant products with the beeswax and they argue that that beeswax was not commonly used with vessels associated with cooking or processing of foodstuffs.

Plant products were positively identified in only two sherds MAP204 and MAP2204 (both Mid-Neolithic Impressed Ware). Both these vessels also had evidence for animal fats. Similar mixing and the pattern of low numbers of sherds with plant biomarkers was observed by Copley *et al.* (2005b).

Conclusions

Molecular analysis of fifty four ceramic sherds from the site of Cheviot Quarry, Northumberland, ranging in date from the Early Neolithic to the Late Bronze Age revealed that 41% contained no lipid, 37% contained a degraded oil/fat and 16% had molecular evidence that the vessel was used for heating. In addition, a small number of sherds contained an animal or plant lipid input, beeswax and there was evidence for burnt cellulose. The majority of lipids were extracted from the interior 2mm of each vessel, indicating recovery of the original vessel contents.

Bulk stable isotope analysis of 20 visible residues indicated that these samples were highly heterogeneous. The yields of nitrogen were all less than 5%, excluding the presence of protein in these samples. The carbon isotope values are typical of a terrestrial C3 environment, and can be use to exclude a marine input (e.g. marine fish).

Fourteen samples containing sufficient $C_{16:0}$ and $C_{18:0}$ fatty acids were selected for compound specific analysis. Of these, five samples all plot within the area defined by modern cows milk. Two samples are within the overlapping isotopic values of cows milk and cow adipose fat. One is just within the overlapping areas of modern sheep and cow adipose fat. The remaining six samples are not within the boundary values of the modern reference samples and could represent mixing of ruminant and non-ruminant fats.

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Appendix 1: Molecular results: Gas chromatography-mass spectrometry (GC-MS)

Sample Code	Context number (ref to Context register)	Pot Type	Date (uncalibrated carbon years BP)	Notes	Sample	Fatty acids	Ketones	Alcohols	Sterols	n-alkanes	Triacylglycerols	Wax esters	Interpretation
932	009 – not on Context Register	Grooved Ware	Late Neolithic		Interior 2mm	trace C16:0 and C18:0 (FAMES)							**no lipid**
					Exterior 2mm	low C16:0 and C18:0							**no lipid**
949	009 – not on Context Register	Grooved Ware	Late Neolithic		Interior 2mm								**no lipid**
					Exterior 2mm								**no lipid**
935	009 – not on Context Register	Grooved Ware	Late Neolithic		Interior 2mm								**no lipid**
					Exterior 2mm	low C12:0, C16:0 and C18:0		C18 and 26		trace even/odd			**no lipid**
933	009 – not on Context Register	Grooved Ware	Late Neolithic	rim	Interior 2mm	C16:0 and C18:0 (FAMES)							**Possible degraded oil/fat**
					Exterior 2mm								**no lipid**
919	009 – not on Context Register	Grooved Ware	Late Neolithic		Interior 2mm	C14:0, C16:0, C18:0 and C20:0 (FAMES). C18:1							**Possible degraded oil/fat**
					Exterior 2mm	C12:0 to C20:0, C16:0 and C18:0 dominant . Low C15:0 C17:0 and C17:0 branched. Low C18:1							**Possible degraded oil/fat**
424	009 – not on Context Register	Grooved Ware	Late Neolithic		Interior 2mm								**no lipid**
					Exterior 2mm Visible					trace C14 to 24, pristane and phytane. No hopanes			**Fossil fuel contamination no lipid**
16811	168	Grooved Ware	4177 ±33BP		Interior 2mm	C10:0 to C18:0, C16:0 and C18:0 dominant . Low							**Possible degraded oil/fat**

						C15:0 and C17:0 branched. Low C16:1 and C18:1			
					Exterior 2mm				no lipid
16816	168	Grooved Ware	4177 ±33BP		Interior 2mm	C10:0 to C18:0, C16:0 dominant . Low C15 and C15 branched.			**Possible degraded oil/fat**
					Exterior 2mm				**no lipid**
					Visible				**no lipid**
1338	133	Grooved Ware	4152 ±31BP	rim	Interior 2mm			trace n-alkanes, hopanes	**Fossil fuel contamination**
					Exterior 2mm				**no lipid**
1635	163	Grooved Ware	Late Neolithic		Interior 2mm				**no lipid**
					Exterior 2mm				**no lipid**
13313	133	Grooved Ware	4152 ±31BP		Interior 2mm				**no lipid**
					Exterior 2mm				**no lipid**
52173	52	Carinated Bowl	Early Neolithic	rim	Interior 2mm	high C16:0 and C18:0	C31 and 33	n-alkanes C30, 21 and 33? odd/even distribution	**Vessel used for heating oil/fat**
					Exterior 2mm	C12:0 to C20:0, C16:0 and C18:0 dominant . Low C15:0 and C17:0 branched. Low C18:1			**Possible degraded oil/fat**
5125	51	Carinated Bowl	4348 ±34BP		Interior 2mm	C12:0 to C18:0, C16:0 and C18:0 dominant . C15:0 and C17:0			**Possible degraded oil/fat**
					Exterior 2mm	C10:0 to C18:0. C16:0 and C18:0 dominant. C13:0, C15:0 and C17:0. C15:0 and			**Possible degraded oil/fat**

						C17:0 brtanched. C16:1 and C18:1						
52127	52	Carinated Bowl	4348 ±34BP		Interior 2mm	C8:0 to C18:0. C16:0 and C18:0 dominant. C9:0, C11:0, C13:0, C15:0. C15 branched. C18:1						**Possible degraded oil/fat**
					Exterior 2mm							**no lipid**
13321	133	Grooved Ware	4152 ±31BP		Interior 2mm					trace n-alkanes		**no lipid**
					Exterior 2mm							**no lipid**
31149	31	Carinated Bowl	Early Neolithic		Interior 2mm	C14:0 to C18:0. C16:0 and C18:0 dominant. C17:0. C17 branched	C29 to C35. C31 and 33 dominant. Odd over even dominance					**Possible degraded oil/fat**
					Exterior 2mm							**no lipid**
5134	51	Carinated Bowl	4348 ±34BP		Interior 2mm	High C10:0 to C23:0. C16:0 and C18:0 dominant. C15:0, C17:0, C21:0 and C23:0. C15 and C17 branched	C31, 33 and 35				Monoacylglycerols C14, 16 and 18. Diacylglycerols C26, 28, 30, 32, 34 and 36. Triacylglycerols C46, 48, 50 and 52	**Vessel used for heating oil/fat**
					Exterior 2mm	low C18:0 (FAME)				trace		**no lipid**
4913	49	Carinated Bowl	Early Neolithic	Grimston, crust	Interior 2mm	C14:0 to C18:0. C16:0 dominant. C16:1, C15:0 and C17:0		low C18				**Possible degraded oil/fat**
					Exterior 2mm	low C16:1 and C16:0		low C18				**no lipid**
					Visible							**no lipid**
31140	31	Carinated Bowl	Early Neolithic	crust	Interior 2mm							**no lipid**
					Exterior 2mm							**no lipid**
					Visible	Low C16:0 and C18:0			cholesterol, cholesta-3,5-dien-7-one and other sterols		Triacylglycerols C42, 44, 46, 48, 50 and 52	**animal**

52177	52	Carinated Bowl	Early Neolithic	rim	Interior 2mm	low C16:0 and C18:0 (FAME)				**Possible degraded oil/fat**
					Exterior 2mm	C10:0 to C20:0. C16:0 and C18:0 dominant . Low C15:0 and C17:0. Low C16:1 and C18:1		cholesta-3,5-diene		**animal**
MQ219	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age		Interior 2mm	low C16:0 and C18:0				**no lipid**
					Exterior 2mm					**no lipid**
					Visible	C16:0, C18:0 and C18:1				**Possible degraded oil/fat**
306/406	306	Flat-rimmed Ware	Late Bronze Age		Interior 2mm	High C16:0 to C20:0. C18:0 dominant. C17:0 and C17 branched	C31, 33 and 35		Diacylglycerols C32 and 34. Triacylglycerols C44, 46, 48, 50 and 52	**Vessel used for heating oil/fat**
					Exterior 2mm	trace C16:0 and C18:0				**no lipid**
					Visible residue from Exterior	C14:0 to C18:0. C18:0 dominant. C15:0 and C17:0.	C31 and 33		Diacylglycerols C30, 32, 34 and 36. Triacylglycerols C44, 46, 48, 50 and 52	**Vessel used for heating oil/fat**
52123	52	Carinated Bowl	Early Neolithic		Interior 2mm	C12:0 to C20:0. C16:0 and C18:0 dominant. C13:0, C15:0 and C17:0. C17 branched.	C31, 33 and 35		Triacylglycerols C44, 46, 48, 50 and 52	**Vessel used for heating oil/fat**
					Exterior 2mm	low C9:0, C16:0 and C18:0			Triacylglycerol C48	**no lipid**
					Visible				Triacylglycerol C48 and 50	**Oil/fat**
51/65	51	Carinated Bowl	4348 ±34BP		Interior 2mm	C12:0 to C24:0. C16:0 and C18:0 dominant. C13:0, C15:0, C17:0, C19:0, C21:0 and C23:0. C15 and C17 branched.				**Possible degraded oil/fat**

					Exterior 2mm	trace C16:0 and C18:0	C31 and 33				Diacylglycerols C30, 32, 34 and 36. Triacylglycerols C40, 42, 46, 48, 50 and 52		**Vessel used for heating oil/fat**
					Visible	high C14:0 to C18:0. C16:0 and C18:0 dominant. C17:0 and C17 branched					Diacylglycerols C28, 30, 32, 34 and 36.		**Degraded oil/fat**
F204	Pit feature – not on Context Register	Impressed Ware	Mid-Neolithic		Interior 2mm	trace C16:0 and C18:0							**no lipid**
					Exterior 2mm								**no lipid**
					Visible								**no lipid**
F219	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age		Interior 2mm	C14:0 to C20:0. C16:0 and C18:0 dominant. C15 and C17	C33 and 35	C26 and 28			Monoacylglycerols C16 and 18. Diacylglycerols C32 to 36. Triacylglycerols C46 to 52.	Wax exters C42, 43, 44 and 45	**Beeswax? Degraded fat/oil. Vessel used for heating oil/fat**
					Exterior 2mm	low C16:0 and C18:0							**no lipid**
					Visible	trace C16:0 and C18:0							**Possible degraded oil/fat**
MMRB/4sav	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age		Interior 2mm	High C14:0 to C20:0. C16:0 and C18:0 dominant. FAMES also present					Diacylglycerols C30, 32, 34 and 36. Triacylglycerols C42, 44, 46, 48, 50, 52 and 54		**Degraded fat/oil**
					Exterior 2mm	C9:0 to C18:0. C16:0 and C18:0 dominant.					Diacylglycerols C30, 32, 34 and 36. Triacylglycerols C46, 48 and 50		**Degraded fat/oil**
					Visible	C14:0 to C18:0. C16:0 and C18:0 dominant.C15:0 and C17:0. C17 branched					Monoacylglycerols C14, 16 and 18. Diacylglycerols C30, 32 and 34		**Degraded fat/oil**
DVORY	483	Flat-rimmed Ware	2693 ±30 BP		Interior 2mm	C16:0, C17:0 and C18:0	C31, 32, 33, 34 and 35				Diacylglycerols C34 and 36		**Degraded fat/oil. Vessel used for heating oil/fat**
					Exterior 2mm	trace C16:0				fossil fuel type n-alkane distribution			**Fossil fuel contamination**

					Visible	C16:0 and C18:0	C31, 33 and 35		**Vessel used for heating oil/fat**
224434	224	Carinated Bowl	Early Neolithic		Interior 2mm				**no lipid**
					Exterior 2mm				**no lipid**
224201	224	Carinated Bowl	Early Neolithic		Interior 2mm				**no lipid**
					Exterior 2mm				**no lipid**
					Visible (exterior)				**no lipid**
224222	224	Carinated Bowl	Early Neolithic	rim	Interior 2mm	C14:0 to C20:0. C16:0 and C18:0 dominant.	C31 and 33	Diacylglycerols C30, 32, 34 and 36. Triacylglycerols C40, 42, 44, 46, 48 and 52	**Degraded fat/oil. Vessel used for heating oil/fat**
					Exterior 2mm	low C16:0 and C18:0			**no lipid**
					Visible (exterior)				**no lipid**
314421	314	Flat-rimmed Ware	Late Bronze Age		Interior 2mm	C16:0 and C18:0		Monoacylglycerols C16 and 18. Diacylglycerols C32, 34 and 36. Triacylglycerols C48, 50 and 52	**Degraded fat/oil**
					Exterior 2mm	C16:0 and C18:0		Monoacylglycerols C14, 16 and 18. Diacylglycerols C30, 32, 34 and 36. Triacylglycerols C46, 48, 50 and 52	**Degraded fat/oil**
477368	477	Flat-rimmed Ware	Late Bronze Age		Interior 2mm				**no lipid**
					Exterior 2mm				**no lipid**
					Visible				**no lipid**
482373/0	482	Flat-rimmed Ware	Late Bronze Age		Interior 2mm	C16:0 and C18:0	high abundance C27 to C45. C31, 33 and 35 dominant. Even numbers also present		**Vessel used for heating oil/fat**
					Exterior 2mm		low C29, 31, 33 and 35		**Vessel used for heating oil/fat**

					Visible/Soil attached	Low C12:0 to C18:0	C31, 33 and 35	C22, 26, 28, 30					**Vessel used for heating oil/fat**
482369	482	Flat-rimmed Ware	Late Bronze Age		Interior 2mm	C9:0 to C18:0. C16:0 and C18:0 dominant.					Monoacylglycerols C14, 16 and 18. Diacylglycerols C28, 30, 32, 34 and 36. Triacylglycerols C42, 44, 46, 48, 50, 52 and 54		**Degraded fat/oil**
					Exterior 2mm	Low C16:0 and C18:0	C31, 33 and 35		cholesterol		Monoacylglycerols C14, 16 and 18. Diacylglycerols C30, 32, 34 and 36. Triacylglycerols C46, 48 and 50		**Degraded fat, animal. Vessel used for heating oil/fat**
					Visible	C9:0 to C20:0. C16:0 and C18:0 dominant.					Diacylglycerols C28, 30, 32, 34 and 36. Triacylglycerols C42, 44, 46, 48, 50 and 52		**Degraded fat/oil**
483382	483	Flat-rimmed Ware	2693 ±30 BP		Interior 2mm								**no lipid**
					Exterior 2mm	trace C16:0 and C18:0							**no lipid**
485389	485	Flat-rimmed Ware	Late Bronze Age		Interior 2mm	C14:0 to C24:0. C16:0 and C18:0 dominant. C17:0	High abundance C27 to 43. C31 and C33 dominant. Odd over even dominant				Triacylglycerols C44, 46, 48, 50 and 52		**Fat/oil. Vessel used for heating oil/fat**
					Exterior 2mm	C16:0 to C20:0. C18:0 dominant. C15:0	C31, 33 and 35. Also C32 and C34				Triacylglycerols C46, 48, 50 and 52	Wax esters C37, 39, 42, 43 and 44	**Beeswax? Fat/oil. Vessel used for heating oil/fat**
					Visible (interior)	low C12:0, 16:0, 18:0, 22:0 and C24:0	C31, 33 and 35		cholesterol, cholesta-3,5-dien-7-one, cholest-4-en-3-one, 4,6-cholestadien-3-one and other sterols		Diacylglycerols C32 and 34. Triacylglycerols C46, 48, 50 and 52		**Degraded fat/oil. Vessel used for heating oil/fat**
					Visible (exterior)	trace C16:0 and C18:0							**Possible degraded oil/fat**

340367	340	Flat-rimmed Ware	Late Bronze Age	Interior 2mm	C16:0 and C18:0	High abundance C31, 33 and 35. C33 and C33 dominant. C32 and C34 low				Triacylglycerols C48, 50 and 52		**Fat/oil. Vessel used for heating oil/fat**
				Exterior 2mm								**no lipid**
				Visible	low C16:0 and C18:0			trace cholesterol				**animal**
340319	340	Flat-rimmed Ware	Late Bronze Age	Interior 2mm	C9:0 to C20:0. C16:0 and C18:0 dominant. C17:0	C 31, 32, 33, 34, 35. Odd over even dominance						**Vessel used for heating oil/fat**
				Exterior 2mm						Triacylglycerols C48 and T50		**Fat/oil**
				Visible	low C16:0 and C18:0	low C33 and 35		cholesterol, cholest-3,5-dien-7-one		Triacylglycerols C48, 50 and 52		**animal fat. Vessel used for heating oil/fat**
340257	340	Flat-rimmed Ware	Late Bronze Age	Interior 2mm	trace C16:0 and C18:0					Diacylglycerols C32 and 34		**Degraded fat/oil**
				Exterior 2mm	trace C16:0 and C18:0					Monoacylglycerols C14, 16 and 18. Diacylglycerols C31, 32 and 34. Triacylglycerols C44, 46, 48 and 50		**Degraded fat/oil**
				Visible	low C16:0 and C18:0		C22, 24, 26 and 28		C30, 31 and 33		Wax esters C42 and 44	**Beeswax?**
340269	340	Flat-rimmed Ware	Late Bronze Age	Interior 2mm	trace C16:0 and C18:0							**no lipid**
				Exterior 2mm								**no lipid**
483388	483	Flat-rimmed Ware	Late Bronze Age	Interior 2mm	C10:0 to C26:0. C16:0 and C18:0 dominant. C15:0 and C17:0. C15 and C17 branched. C18:1	C29, 31, 33 and 35				Monoacylglycerols C14, 16 and 18. Diacylglycerols C28, 30, 32, 34 and 36. Triacylglycerols C40, 42, 44, 46, 48, 50 and 52		**Degraded fat/oil. Vessel used for heating oil/fat**
				Exterior 2mm	Low C8:0 to C18:0.					Monoacylglycerols C14, 16 and 18. Diacylglycerols C28, 30, 32, 34 and 36. Triacylglycerols C44, 46, 48, 50 and 52		**Degraded fat/oil**

348289	348	Flat-rimmed Ware	Late Bronze Age	Interior 2mm						**no lipid**
				Exterior 2mm			trace C26 and 28			**no lipid**
306413	306	Flat-rimmed Ware	Late Bronze Age	Interior 2mm	High C14:0 to C24:0. C16:0 and C18:0 dominant. C15:0 and C17:0. C15 and C17 branched	C 31, 33 and 35			Triacylglycerols C44, 46, 48, 50, 52 and 54	**Fat/oil. Vessel used for heating oil/fat**
				Exterior 2mm						**no lipid**
352248	352	Flat-rimmed Ware	Late Bronze Age	Interior 2mm	C10:0 to C20:0, C16:0 and C18:0 dominant .	C31, 33 and 35			Diacylglycerols C30, 32, 34, 36 and 38. Triacylglycerols C44, 46, 48, 50, 52 and 54	**Degraded fat/oil. Vessel used for heating oil/fat**
				Exterior 2mm						**no lipid**
459V	?	?		Visible	C14:0 to C18:0. C16:0 and C18:0 dominant. C17:0				Monoacylglycerols C14, 16 and 18. Diacylglycerols C28, 30, 32, 34 and 36. Triaclyglycerols C44, 46, 48 and 50	**Degraded fat/oil**
F13317	133	Grooved Ware	Late Neolithic	Exterior 2mm	Trace C16:0 and C18:0					**no lipid**
				Interior 2mm	Trace C16:0					**no lipid**
F13318	133	Grooved Ware	Late Neolithic	Exterior 2mm	C14:0 to C20:0. C16:0 and C18:0 dominant. C18:1					**Degraded fat/oil**
				Interior 2mm	C14:0 to C26:0. C16:0 and C18:0 dominant. C17 and C18:1			cholesterol	Monoacylglycerols and Diacylglycerols	**Degraded fat/oil, animal**
				Visible	C12:0 to C20:0. C16:0 and C18:0 dominant. C15:0 and C17:0. C17 branched. C18:1			cholesterol	Monoacylglycerols	**Degraded fat/oil, animal, levoglucosan**
F219		Beaker	Late Neolithic/Early Bronze Age	Exterior 2mm						**no lipid**

				Interior 2mm	C12:0 to C24:0. C16:0 and C18:0 dominant. C13:0, C15:0, C17:0, C23:0. C17 branched. C16:1 and C18:1.	cholesterol		**Degraded fat/oil, animal**
				Visible	C14:0 to C18:0. C16:0 and C18:0 dominant			**Possible degraded fat/oil**
F3128	52	Carinated Bowl	Early Neolithic	Exterior 2mm	C14:0 to C20:0. C16:0 and C18:0 dominant. C15 and C15 branched. C18:1	cholesterol	Monoacylglycerols	**animal**
				Interior 2mm	C12:0 to C24:0. C16:0 and C18:0 dominant. C15, C17, C19, C21, C23. C17 branched. C18:1		Monoacylglycerols and Diacylglycerols	**Degraded fat/oil**
F5110	51	Carinated Bowl	Early Neolithic	Exterior 2mm	C12:0 to C18:0. C16:0 and C18:0 dominant. C15:0, C17:0. C17 branched. C18:1		Monoacylglycerols and Diacylglycerols	**Degraded fat/oil**
				Interior 2mm	C10:0 to C18:0. C16:0 and C18:0 dominant. C13, C15 and C17. C15 and C17 branched. C18:1		Diacylglycerols	**Degraded fat/oil**
MAP1	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	Exterior 2mm	C12:0 to C18:0. C16:0 and C18:0 dominant, C15 and C17, C17 branched. C18:1	cholesterol	Monoacylglycerols and Diacylglycerols	**Degraded fat/oil, animal**
				Interior 2mm	C12:0 to C18:0. C16:0 and C18:0 dominant, C15		Monoacylglycerols and Diacylglycerols	**Degraded fat/oil**

					and C17. C18:1					
				Visible	C14:0 to C18:0. C16:0 and C18:0 dominant. C15:0 C17:0. C17 branched. C18:1				Monoacylglycerols and Diacylglycerols	**Degraded fat/oil**
MAP204	Pit Feature – not on Context Register	Impressed Ware	Mid-Neolithic	Exterior 2mm						**no lipid**
				Interior 2mm	C14:0 to C18:0. C16:0 and C18:0 dominant. C15:0 and C17:0. C17 branched. C18:1		cholesterol, B-sitosterol		Monoacylglycerols and Diacylglycerols	**animal/plant mixture**
MAP2204	Pit Feature – not on Context Register	Impressed Ware	Mid-Neolithic	Visible Exterior	C12:0 to C18:0. C16:0 and C18:0 dominant. C17:0					**Degraded fat/oil**
				Exterior 2mm	C14:0 to C22:0. C16:0 and C18:0 dominant. C15:0 an C17:0. C18:1		cholesterol, B-sitosterol		Monoacylglycerols	**animal/plant mixture**
				Interior 2mm	low C16:0 and C18:0. C18:1					**no lipid**
Soil	Wood 05	2168		Soil	C12:0			low n-alkanes C27, 29 and 31, odd/even distribution		
Soil	Wood 05	051		Soil				low n-alkanes C27, 29 and 31, odd/even distribution		
Soil	Wood 05	224		Soil	C9, C10, C11, C12	C18				
Soil	Wood 05	2133		Soil	C12:0		low n-alkanes			
Soil	Wood 05	031		Soil	trace C12:0 and C16:0	C18 and 26				
Soil	Wood 05	340		Soil	C9, C10, C12 and C16:0		trace triterpenoids	C27 to 33, odd over even distribution		
Modern Pot				Method	trace C16:0 and					**No**

	control	C18:0	**contamination**

Appendix 2 Isotopic results: Bulk stable isotopes (IR-MS)

Sample Code	Context number (ref to Context register)	Pot Type	Date (uncalibrated carbon years BP)	δ13C ‰	% C	δ15N ‰	% N
424	009 – not on Context Register	Grooved Ware	Late Neolithic	-28.1	23	7.8	2
16816	168	Grooved Ware	4177 ±33BP	-27.1	2		0
4913	49	Carinated Bowl	Early Neolithic	-27.4	33	6.7	3
31140	31	Carinated Bowl	Early Neolithic	-27.9	44	5.5	5
306/406	306	Flat-rimmed Ware	Late Bronze Age	-29.5	7	6.4	0
51/65	51	Carinated Bowl	4348 ±34BP	-30.6	9	7.4	0
F204	Pit feature – not on Context Register	Impressed Ware	Mid-Neolithic	-28.1	14	6.7	1
F219	Pit Feature – not on Context Register	Impressed Ware	Mid-Neolithic	-27.8	32	6.3	2
MMRB/4sav	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	-29.4	9	3.3	1
DVORY	483	Flat-rimmed Ware	2693 ±30 BP	-26.9	17	8.3	2
224201	224	Carinated Bowl	Early Neolithic	-26.6	4		0
224222	224	Carinated Bowl	Early Neolithic	-27.1	3		0
477368	477	Flat-rimmed Ware	Late Bronze Age	-27.1	4		0
482373/0	482	Flat-rimmed Ware	Late Bronze Age	-26.5	3		0
482369	482	Flat-rimmed Ware	Late Bronze Age	-26.2	19	6.8	2
485389	485	Flat-rimmed Ware	Late Bronze Age	-27.9	16	7.4	1
485389	485	Flat-rimmed Ware	Late Bronze Age	-27.1	39	10.7	3
340367	340	Flat-rimmed Ware	Late Bronze Age	-26.6	34	8.8	3
340319	340	Flat-rimmed Ware	Late Bronze Age	-26.1	30	7.8	3
340257	340	Flat-rimmed Ware	Late Bronze Age	-26.8	6	5.1	0

Appendix 3 Isotopic results: Gas chromatography-combustion isotope ratio-mass spectrometry (GC-CIR-MS)

Sample Code	Context number (ref to Context register)	Pot Type	Date (uncalibrated carbon years BP)	Sample	$\delta^{13}C$ ‰ Hexadecanoic acid ($C_{16:0}$)	$\delta^{13}C$ ‰ Octadecanoic acid ($C_{18:0}$)
51/65	51	Carinated Bowl	4348 ±34BP	Visible residue	-28.81	-34.35
51/65	51	Carinated Bowl	4348 ±34BP	Visible residue	-29.37	-34.89
MAP1	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	Visible residue	-28.57	-33.20
MAP1	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	Visible residue	-28.24	-33.83
MQ219	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	Visible residue	-28.56	-31.56
MQ219	Pit Feature – not on Context Register	Beaker	Late Neolithic/Early Bronze Age	Visible residue	-28.63	-31.25
482369	482	Flat-rimmed Ware	Late Bronze Age	Visible residue	-27.71	-33.03
482369	482	Flat-rimmed Ware	Late Bronze Age	Visible residue	-27.60	-33.16
306/406	306	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-28.49	-33.66
306/406	306	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-28.59	-33.49
5134	51	Carinated Bowl	4348 ±34BP	Interior ceramic absorbed	-27.81	-34.15
5134	51	Carinated Bowl	4348 ±34BP	Interior ceramic absorbed	-28.28	-34.47
52123	52	Carinated Bowl	Early Neolithic	Interior ceramic absorbed	-28.87	-33.57
52123	52	Carinated Bowl	Early Neolithic	Interior ceramic absorbed	-28.47	-33.48
224222	224	Carinated Bowl	Early Neolithic	Interior ceramic absorbed	-28.41	-34.19
224222	224	Carinated Bowl	Early Neolithic	Interior ceramic absorbed	-28.57	-34.35
F219	Pit Feature – not on Context Register	Impressed Ware	Mid-Neolithic	Interior ceramic absorbed	-27.64	-30.69
F219	Pit Feature – not on Context Register	Impressed Ware	Mid-Neolithic	Interior ceramic absorbed	-27.26	-30.02
314421	314	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-28.03	-30.30
314421	314	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-28.39	-30.46
485389	485	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-27.71	-29.66
485389	485	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-27.44	-30.03
483388	483	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-27.03	-33.10

483388	483	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-27.39	-33.06
306413	306	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-28.90	-33.61
306413	306	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-28.71	-33.20
352248	352	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-28.35	-32.26
352248	352	Flat-rimmed Ware	Late Bronze Age	Interior ceramic absorbed	-28.15	-32.25