If, on the other hand, it is felt that the plan of the camp at Cow Close is sufficiently different to exclude it from the group of camps discussed by Maxwell, a Flavian date might still be possible if, for example, it belonged to a slightly later, possibly Agricolan, campaign. To go further at this stage would be to enter too far into the realms of speculation.

In his forthcoming review of the evidence, Professor Sheppard Frere proposes that the earliest of two timber forts at Bowes could have been established by Cerealis in the early 70s A.D., rather than by Agricola as has previously been thought.[14] Indeed, the Cow Close camp might even be seen as a construction camp associated with the building of the fort, though the relatively large distance between them might argue against this. In any case, a Flavian date would also fit in with the suggestion, made above, that the camp most likely pre-dates the branch road linking Bowes with Dere Street, which, if it is broadly contemporary with the route over Stainmore, must also be presumed to be late first-century in date.[15]

None of the arguments advanced here regarding the date of the camp at Cow Close is conclusive and together they constitute no more than a working hypothesis. Looking to the future, it is to be hoped that the eventual discovery of further camps between York and Carlisle will provide a more definitive context for the one now identified at Cow Close.

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Roman Diet and Trade: Evidence from Organic Residues on Pottery Sherds Recovered at the Roman Town of *Calleva Atrebatum* (Silchester, Hants.). L.-J. Marshall, S.R. Cook, M.J. Almond and M.G. Fulford write: One of the major goals of the study of ceramics in archaeology is the interpretation of vessel usage. This may be achieved in some cases from clues on the vessel itself, whether from specific design or patterns,[16] or from written sources in the form of inventories or catalogues. Furthermore the position of sooting as a result of heating may provide clues as to the type of heating that was used: placed in ashes or suspended over an open fire.[17] Occasionally macroscopic remains are found in complete vessels, e.g. an amphora containing olive stones,[18] which obviously provides the most accurate

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[14] Welfare 2001; Professor S.S. Frere, Yorkshire Archaeological Society monograph (forthcoming).

[15] Welfare and Swan 1995, 60.

[16] Orton *et al*. 1993.

[17] Hally 1983.

[18] Sealy and Tyers 1989.

identification of vessel usage. However, these finds are rare and in most cases only fragmentary evidence of pottery survives in the archaeological record.

The analysis of organic residues from pottery allows archaeologists the opportunity to determine the use of vessels in antiquity and hence affords an insight into both diet and trade.[19] Residues may constitute both plant and animal remains and are usually quantified using a combination of gas-chromatography (GC) and gas-chromatography mass-spectroscopy (GC-MS). Previous work has demonstrated that it is possible to distinguish between ruminant adipose, ruminant dairy and porcine fats, due to the way in which fatty acids are biosynthesised and routed in the ruminant animal.[20]

The aim of this work was to investigate the organic residues present in pottery samples obtained from ongoing excavations at Silchester. The excavations form part of the Insula IX 'Town Life' project under the direction of Professor Michael Fulford (www.silchester.rdg.ac.uk).

The majority of the seven Silchester pottery sherds analysed by GC-MS are fourth-century cooking vessels. They were selected for analysis in the first instance because of the presence of residues visible to the naked eye (calcium carbonate and, in the case of the amphora, a resin-like substance). Three body sherds derive from SE Dorset BB1 everted rim jars similar to Holbrook and Bidwell's type 20,[21] while three other body sherds derive from Alice Holt everted rim jars.[22] They derive from late and sub-Roman phases 3, 5 and 6, ranging in date from the fourth to the fifth–sixth century.[23] With one exception, from a very late pit, the contexts represent the latest stratified general layers in the proximity of Buildings 1 and 5 along the north–south street of the insula. The single amphora sherd is from a Gauloise flat-based amphora, probably of Laubenheimer's form 4.[24] It was found in the basal fills of a well in the north-west corner of the excavation area which was filled in in the second half of the second century. The similarity of the results obtained necessitates the description of only two sherds in full here. A list of all samples analysed is given in Table 1.

BLACK-BURNISHED WARE (BB1)

Sample 1321 is from a body sherd of a SE Dorset (BB1) cooking pot. This sherd was excavated from the fill of Pit 2634, cut into the remains of Building 1, from which the latest dateable finds are coins of the House of Theodosius, A.D. 388–402.[25] The cutting and filling of this pit represent some of the latest events recorded in this excavation and the date of deposition can be no earlier than the first half of the fifth century, but is more likely to belong to the second half of the fifth or the sixth century A.D.[26] The vessel form associated with this sherd is a common fourth-century type, but whether the vessel remained in use until the fifth–sixth century rather than having been used, broken and discarded in the fourth century, is impossible, at present, to say.

AMPHORA

Sample 3341 is from a base sherd of a flat-based amphora of Gauloise 4 form, which normally carried wine.[27] This sherd was excavated from the fill of Well 2234 in the north-west corner of the excavated area. The well was filled in the second half of the second century during the currency of this type of amphora.

ANALYTICAL METHODS

Organic residue analysis was carried out at the NERC facility which forms part of Professor Richard Evershed's research group at the University of Bristol in July 2004. Seven pottery sherds from Silchester

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[19] e.g. Copley *et al.* 2003; Evershed *et al.* 1990; 1994.
[20] Copley *et al.* 2003; Dudd and Evershed 1998.
[21] Holbrook and Bidwell 1991; see also Tyers 1996, fig. 227.
[22] See Tyers 1996, fig. 225, nos 9–11.
[23] Fulford *et al*. 2006.
[24] Tyers 1996, 94–6, fig. 66.
[25] The pottery assemblage is described in Timby 2006, 107–8.
[26] Fulford *et al*. 2006, 275–6.
[27] Tyers 1996, 94–6.

were subjected to extraction of residues and analysis of these residues by high-temperature gas chromatography. In two cases further analysis was performed by gas chromatography coupled with mass spectrometry. All the sherds were analysed for absorbed residues and five out of the seven sherds also showed visible surface residues of which some were removed and also analysed. Unfortunately all of the sherds taken to Bristol had been stored in plastic bags, this meant that unless a very high concentration of lipids was present within the pottery, peaks attributed to phthalate esters (from plastic) would dominate the chromatograms and make any other peaks difficult to detect. Furthermore, some of the sherds which had been supplied for the visit to the NERC facility were bases of pots which usually contain less absorbed organic residues than rim or neck sherds, depending on the use of the vessel.[28] This study should be considered as a preliminary survey designed to test the suitability of GC-MS analysis in this southern British (Roman urban) context and for method development. It is for this reason that the analysis of only one of the seven sherds taken to Bristol gave unequivocally positive results and is reported here (Sample 3341).

Further residue analysis was carried out at CEM Analytical Services (CEMAS) in August 2005. Residues from the seven pottery sherds from Silchester were extracted and analysed by GC-MS. Standard analytical procedure was followed as described by Copely *et al.* and Charters and Evershed.[29]

RESULTS AND DISCUSSION

Although seven samples were analysed for absorbed organic residues the similarity in the findings encourages only the discussion of two of the most interesting results, but all results are summarised in Table 1.

TABLE 1. SUMMARY OF RESULTS FROM ALL ANALYSED SILCHESTER POTSHERDS

Pottery sample	Compounds identified by GC-MS	Results summary
3341 (Base sherd from a Gauloise 4 vessel)	Retene, pimaric acid, methyl dehydroabietate, isopimaric acid, dehydroabietic acid, abietic acid, 7-oxo-dehydroabietic acid.	Heated, resinous pine wood. Probably used for waterproofing the vessel.
1321 (Body sherd from a BB1 cooking vessel)	TAGs (higher abundance of C50 and C52), DAGs and MAGs, C16:0 and C18:0 most dominant fatty acids identified. Bacterial markers (C15 and C17) present also. Long chain alkanes revealed.	Predominantly animal fat (probably ruminant adipose fat) derived. Some indication of leafy plants.
1989 (Body sherd from a BB1 vessel)	TAGs (higher abundance of C50 and C52) and DAGs, C16:0 and C18:0 most dominant fatty acids identified. Long chain alkanes and sitosterol also revealed.	Predominantly animal fat. Traces of plant waxes possibly indicating leafy plants were cooked in this vessel.
2676 (Body sherd from an Alice Holt cooking vessel)	Lower concentration of residues (when compared to I.S.) relative to other vessels. Long chain alkanes and sitosterol found and small amounts of C14:0, C15:0, C16:1, C16:0, C18:1 and C18:0 also present. Significant amount of contamination from plasticisers.	Predominantly plant wax derived. Possibly some animal fats also.
1355 (Body sherd from a BB1 vessel)	Substantial contamination by phthalate esters. Weak peaks attributed to MAGs identified. C14:0 and large amount of C18:0 found. Bacterial markers (C15 and C17) present also.	Animal fat derived.
2421 (Body sherd from an Alice Holt pot)	Only phthalate ester peaks identified.	No reportable results.
1945 (Body sherd from an Alice Holt pot)	Some MAGs identified as well as free fatty acids, dominated by C16:0 and C18:0. Long chain alkanes and sitosterol also found along with some contamination peaks.	Predominantly animal fat with some plant derived waxes.

TAG = triacylglyecrols; DAG = diacylglycerols; MAG = monoacylglycerols

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[28] Charters *et al.* 1993.

[29] Copley *et al.* 2003; Evershed *et al.* 1997.

Sample 3341

The residues in this vessel comprise a range of diterpenoid resin acids (FIG. 6; Table 2). These components are of the abietane and pimarane skeletal types, which are characteristic of conifer resins. Abietic acid is a more abundant constituent of conifer resin than pimaric acid,[30] as is shown by the size of each respective peak in FIG. 6. The chromatogram shows the presence of the diterpenoid acids: dehydroabietic acid, abietic acid, and possibly 7-oxo-dehydroabietic acid (markers for pine resin in aged materials),[31] as well as pimaric acid and iso-pimaric acid, all of which are indicative of the *pinaceae* family. The *pinaceae* family includes many genera of conifers such as cedars, firs, hemlocks, larches, pines and spruces. Methyl dehydroabietate has also been identified, which suggests that the resin was made by heating resinous wood,[32] as opposed to heating the resin alone. This is explained by the fact that methanol in the wood is released at high temperatures which reacts with diterpenic acids (i.e. dehydroabietic acid) to produce predominantly methyl dehydroabietate. Retene, which is a marker for pine pitch, is also present; retene is highly diagnostic of heating as when pine resin is heated to a high temperature to form a pitch.[33]

This is the first case of a pine pitch being discovered at Silchester and is one of a very small number attributable to the Roman period in Great Britain.[34] One important example involved the recovery of several samples of pitch-like material from a Gallo-Roman trading vessel from Guernsey.[35] The resin

TABLE 2. PEAK ASSIGNMENTS FOR THE FT-IR SPECTRUM OF POTSHERD 3341 COMPARED WITH PINE RESIN

Wavenumber / cm^{-1} (Potsherd 3341)	Wavenumber / cm^{-1} *Pinaceae* Pitch (Colombini *et al.* 2003)	Assignment
3402	3423.67	Water (OH Stretch)
2952		
2929	2929.42	*Pinaceae* Pitch (C-H Stretch)
2863	2869.06	*Pinaceae* Pitch (C-H Stretch)
1694	1711.22	*Pinaceae* Pitch (C=O Stretch)
1604	1604.95	*Pinaceae* Pitch (arC-C Stretch)
1458	1455.90	*Pinaceae* Pitch (CH_2 Scissoring, CH_3 Asymmetric Stretch)
1384	1383.48	*Pinaceae* Pitch (C-CH_3 Symmetric Stretch)
1240	1243.67	*Pinaceae* Pitch (δ(O-H))
1174		Ester (C-O Stretch)
1104		Kaolinite (Si-O Stretch)
1034		Kaolinite (Si-O-Si Stretcj)
908		Kaolinite (Al- -O-H In-plane Bend)
820	820.80	*Pinaceae* Pitch (arC-H Bend)
753	754.62	*Pinaceae* Pitch (arC-H Bend)
694	699.24	Kaolinite (Si-O-Al Stretch)
532		Kaolinite (Si-O-Al)
466		Kaolinite (Si-O Bend)
429		Kaolinite (Si-O Bend)

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[30] Robinson *et al.* 1987.
[31] Colombini *et al.* 2005.
[32] Robinson *et al.* 1987; Colombini *et al.* 2003; 2005; Serpico and White 2000.
[33] Colombini *et al.* 2005.
[34] Heron and Pollard 1987, 429–47
[35] Evershed 1993, 115–18.

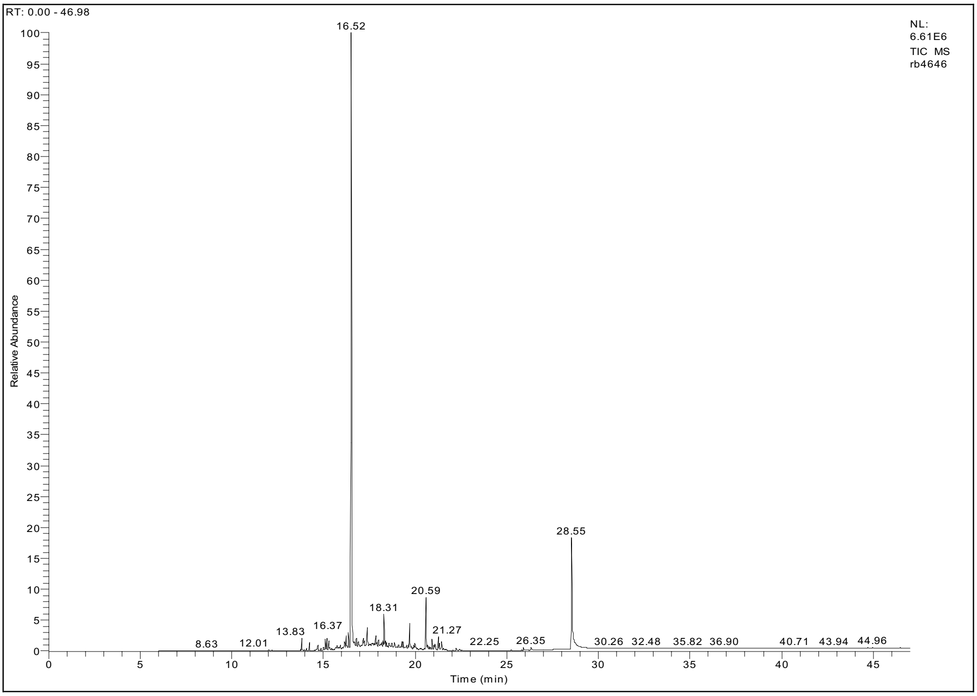

FIG. 6. GC-MS chromatogram of absorbed residue in Potsherd 3341.
(16.52 mins= phthalate ester, 18.31 mins= phthalate ester, 21.27 mins= dehydroabietic acid (TMS), 28.55 mins= n-34 alkane (I.S.)).

is likely to have been used as an adhesive or a protective hydrophobic coating as has been noted in the literature[36] and was produced by burning resinous pinewood. Pottery is known to have been used to transport pitch, e.g. excavation of an Etruscan vessel (*c.* 600 B.C.) led to the discovery of pitch in amphorae.[37] However, in our case the pine pitch was used to line the inside of the vessel before it was despatched from the south of France (from where Gauloise-type amphorae originate). The pinewood used to produce the hydrophobic pitch would therefore also have originated from the south of France.

Sample 1321

Analysis by GC-MS showed a wide distribution of compound classes in the sample and very little contamination by phthalate esters from plastic. The results of this analysis show that the potsherd contains a large amount of unsaturated free fatty acids, particularly C16:0 and C18:0, and a series of monoacylglycerols, diacylglycerols and triacylglycerols, all of which are indicative of degraded animal fats. The abundance of C50 and C52 TAGs together with the low amount of C42, C44 and C46 TAGs is not just indicative of animal fat, but more specifically it is characteristic of ruminant adipose fat.[38] A greater abundance of the lower TAGs and a larger distribution of all of the TAGs in general are characteristic of dairy fats;[39] this is not seen here.

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[36] See for example Colombini *et al.* 2003; Serpico and White 2000; Mills and White 1994; Pollard and Heron 1996, 239–70.

[37] Robinson *et al.* 1987.

[38] Dudd *et al.* 1999.

[39] Dudd *et al.* 1999; Regert *et al.* 2003.

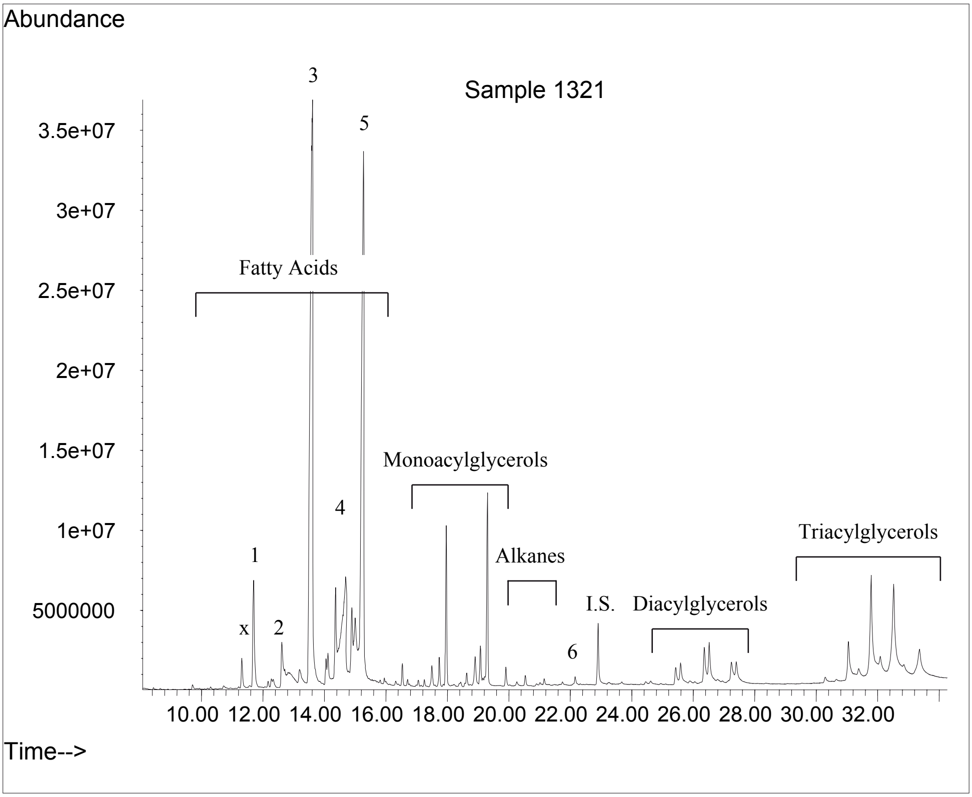

FIG. 7. GC-MS chromatogram of absorbed residue in Sample 1321.
(x = phthalate ester contamination, 1= C14:0 FA, 2= C15:0 FA, 3= C16:0 FA, 4= iso-C17:0, anteiso-C17:0, normal-C17:0, C18:1 FA, 5= C18:0, 6= Sitosterol)
N.B. Peak identities are: Cx:y, where Cx is the carbon number of the fatty acid and y is the degree of unsaturation.

Ruminant fat residues have higher concentrations of odd chain fatty acids than non-ruminant animals due to bacterial contribution from the rumen.[40] FIG. 7 shows that potsherd 1321 also displays a higher abundance of normal-C15:0 and normal-C17:0 (i.e. odd carbon numbered, straight-chained components) which also point towards ruminant origin of the lipid;[41] the presence of these normal (not iso or anteiso) fatty acids indicates the presence of ruminant adipose fat.[42]

A series of long-chain alkanes has also been identified in the chromatogram for this sample which, together with a peak attributed to sitosterol (labelled 6 in FIG. 7), suggests a plant origin. Sitosterol is a biomarker for higher plants and n-alkanes can derive from epicuticular plant waxes. Traces of long-chain n-alkanes (derived from epicuticular plant waxes) and sitosterol (found in plants) have also been identified suggesting that the vessel may have been used to process plants. The lack of primary alcohols and secondary ketones associated with plant fats in this vessel means a more precise identification of the species of plant(s) prepared in this pot is almost impossible to determine. This also raises the question of whether the meat and plants (possibly leafy vegetables) were deliberately cooked together in something resembling a stew or separately.

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[40] Dudd *et al.* 1999.
[41] Evershed *et al.* 2002.
[42] Dudd *et al.* 1998.

Ingrem has published the associated animal bones from the late and sub-Roman occupation of Insula IX.[43] The main source of meat through this period was cattle (57 per cent of identifiable remains), followed by sheep/goat (15 per cent) and pig (11 per cent). Bird accounts for 2 per cent. Although the bones of some wild mammals (e.g. red deer, roe deer and hare) have been documented, overall these contribute less than 1 per cent of the total assemblage. Thus the dominance of cattle supports the likelihood that the animal fat in this sherd is indeed ruminant adipose fat. Freshwater and marine fish were also recorded, but their variable survival makes it difficult to estimate their contribution to diet.[44] Organic residue analysis may prove to be of use in estimating this contribution. Marine animals are known to contain particularly high levels of isoprenoid compounds,[45] but as there is no evidence of such compounds in any of the sherds analysed, it can safely be assumed that marine animals were not processed in any of these vessels.

The associated plant remains from the late and sub-Roman contexts of Insula IX have been reported by Robinson *et al*.[46] A number of species that could have been eaten as leafy vegetables such as *Brassica* or *Sinapis* sp (cabbage, mustard, wild turnip, charlock, etc.) have been identified, as well as culinary herbs such as *Coriandrum sativum* (coriander) and *Anethum graveolens* (dill). No leafy vegetables have yet been identified by pollen analysis from Silchester samples.

The presence of intact TAGs after *c*. 1,600 years of burial suggests that the ceramic fabric and the burial environment of this particular pot (1321) provided a highly protective environment. Unsurprisingly the GC profile of this sample shows that extensive hydrolysis has taken place, shown by the presence of diacylglycerols, monoacylglycerols and ultimately free fatty acids. No mid-chain ketones have been identified in the distribution of animal fats, thereby indicating that the vessel has not been heated to temperatures above 300°C (or at least not heated directly over a flame).[47]

SUMMARY

Analysis of all of the potsherds has provided useful information on diet and the usage of pottery at Silchester. All but one of the six analysed sherds from cooking-pots contained evidence of animal fat residues, while four were also associated with plant waxes, which in one case were predominant. It is particularly valuable to have this evidence of use and incidence of use — albeit from a small sample — to complement the picture derived from the analysis of faunal and plant remains, where issues of preservation and representation make it difficult to infer the regularity with which meat, for example, formed part of the diet.

The chromatogram of the absorbed residues from Sample 3341, the base from a second-century amphora, showed large amounts of contamination by phthalate esters from the sample being stored in a plastic bag, an issue which will need to be addressed in future excavations. Experiments have shown that, depending on the use of a vessel, absorbed residues may be less likely to be detected in the base of a pot than around the middle or the rim of the vessel.[48] This therefore explains the low levels found in this sherd. In order to address specific archaeological questions, appropriate sampling and storage of the pottery is required by field and laboratory archaeologists.

Results from the surface (and absorbed) residues from this pot fragment indicate that the amphora was used either to prepare pine pitch, possibly for use as an adhesive, or that it was lined with pitch as ‘waterproofing’. Further work may incorporate an investigation into whether pollen might be trapped in the pitch. This might illuminate the area in France from which the pitch came.

Sample 1321 shows a distribution of compounds typical of the remaining Silchester potsherds analysed. The body sherd from a fourth-century BB1 cooking-pot contains absorbed residues indicative of animal fats and possibly some sort of leafy plants/vegetables. Intact TAGs, DAGs and MAGs show that the porous ceramic fabric of the pottery vessel acts as a protective environment. The distribution of TAGs

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[43] Ingrem 2006.

[44] Ingrem 2006, 183.

[45] Copley *et al.* 2004.

[46] Robinson *et al.* 2006.

[47] Dudd *et al.* 1999.

[48] Charters *et al.* 1993.

and the abundance of, in particular, the C50 and C52 TAGs, along with the high concentrations of C16:0 and C18:0 fatty acids, are characteristic of ruminant adipose fat.

This work has been carried out as a preliminary investigation into the use of vessels at Silchester and has shown some very promising results. The study is novel research as GC-MS analysis of this sort has not previously been carried out on potsherds from this site.

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A Publication Policy for Chedworth. Peter Salway writes: The death of Sir Ian Richmond in 1965 brought to an end the series of keyhole excavations he started in 1957 for the National Trust that was intended to elucidate the phases in the development of the Chedworth villa, to investigate the correctness of certain long-standing interpretations, and to inform the conservation of the visible remains. Prior to Richmond there had been hardly any archaeological activity on the site since the acquisition of the property in 1924 by the Trust after a notable public campaign — other than some early work by W. St Clair Baddeley, its principal mover[49] — or, for that matter, since the original discovery of the villa and the construction of the site museum in the 1860s. After Richmond there was another gap[50] till Dr Roger Goodburn commenced investigations linked to conservation in 1977 that lasted till the early 1990s, followed in 1994 by the appointment of Philip Bethell as property manager. The untimely death of Sir Ian left the Trust with the daunting problem that it had no detailed records of the work on which he based his interpretations and which it can be assumed he had every intention of writing up. Fortunately Goodburn's scholarly 1979 National Trust guidebook[51] preserves the essential structure of Richmond's overall interpretation and his conclusions on a number of important details. However, the general problem remained, further complicated by a number of subsequent difficulties. It was not till the award of a project-planning grant

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[49] 1925: stoke-hole, Room 25; 1935: infant burial outside Room 4, followed by Eve Rutter's excavation of Room 4 (latrine) itself in 1954 (Rutter 1957).

[50] Except for R. Shoesmith's 1977 evaluation in advance of the construction of the visitor reception building (Shoesmith 1978).

[51] Goodburn 1979.