8. Conclusions and Further Work

8.1 Conclusions

8.1.i The contents of RLWm ware vessels

The first aim of this project was to identify more accurately what commodities were being stored, used and traded in RLWm ware vessels. Some progress has been made in this area with four main types of residue being identified – beeswax, bitumen, resin from *Pinaceae spp*. and a fat or oil.

The fatty or oily residue is the most commonly identified and is present in sherds from all sites with only one exception. The original source of the fat or oil has remained frustratingly obscure although many of the characteristics of these residues, together with the main forms of the vessels, indicate a plant oil.

Beeswax residues are generally present in high abundances and their almost exclusive presence on the interior of closed vessels with very restricted openings does not support the use or storage of beeswax as a commodity in its own right. The most convincing explanation of its presence is as a post-firing treatment designed to reduce the porosity of the vessels.

Bitumen and *Pinaceae* resin were both found in only a small number of residues and in low abundances. It is tempting to conclude that these were both part of a mixture with an oily or fatty material but in a few instances they are the only

residues present. This does not rule out the use of these materials as part of a mixture as it is perfectly possible that any fatty residue may have degraded and left bitumen or resin biomarkers behind. Combining these results with those from a previous study (Steele, 2004; Knappett *et al*., 2005; Steele, 2007) confirms the findings from this project. The possible exception to this is that, during the previous study, two bitumen residues were analysed which were present in far greater abundance and without other residues – one from the interior and one from the exterior surface of two pilgrim flask body sherds. This indicates that bitumen could have been used as a post-firing treatment or decoration in its own right rather than as part of a mixture.

The use of other methods such as FT-IR and HPLC-MS-MS did not prove particularly helpful in the identification of residues. FT-IR proved not to be a good diagnostic technique when examining this type of archaeological residue. The use of HPLC-MS-MS to identify wine residues has been documented elsewhere (Guasch-Jané *et al*., 2004), but in this case no wine residues were detected in the 17 sherds examined. This does not prove that wine was never contained in RLWm ware vessels. However, given the abundance of other residues, the use of the vessels for wine seems unlikely.

It is probable, although not proved beyond question, that the main commodities present in RLWm ware vessels were oils mixed with other components including, in some cases, *Pinacea spp.* resin or bitumen. Castor oil was probably part of this mixture in at least some instances. There is no evidence

that all vessels contained the same commodity as resin and bitumen were identified in separate samples, never in the same sample.

The very few open shapes analysed for this study also raise the possibility that at least some RLWm ware vessels were traded in their own right and not simply for the contents. Residues on the interior surfaces of these vessels were interpreted as vessel use rather than transport or storage although the residues themselves appear identical in nature to those from the closed vessels.

8.1.ii Variation in contents of vessels

A second main aim of this project was to determine whether the contents of RLWm ware vessels were always the same or whether they varied with the vessel form or fabric, with time, or with the context or place of use. No conclusions can be drawn about the variation of contents over time due to the lack of securely dated samples. No statistically significant variation in the type of residues found could be determined with vessel fabric. However bitumen residues seem to occur more often in pilgrim flasks than might be expected from the number of pilgrim flasks present in the assemblage. However these apparent variations cannot be tested by statistical methods as there are too few examples.

The most obvious variation in residues is with the site where the vessels were used, relating particularly to the geographical location of the sites. All but one of the beeswax residues were found in sherds, RLWm ware and local, from

Boğazköy and Kuşakli – both Hittite sites in central Turkey. The only other beeswax residue was identified in a sherd from Kouklia on Cyprus reanalysed for this project. Bitumen was positively identified only in sherds from Cyprus, although a degraded fossil fuel like material was identified in two sherds from Kilise Tepe in Turkey. Similarly resin biomarkers were only identified in RLWm ware sherds from Cyprus. It is clear that something different was taking place at the sites in central Turkey possibly related to the use of similar shaped vessels in local fabrics. This may indicate local reuse of RLWm ware vessels or a case of catering for a specific market at the place where the vessels were filled. However it is impossible to distinguish between these options at present.

It is interesting to note that all the possible residues have been found at Cypriot sites, although beeswax has only been identified in one sherd. This is the situation that would be expected if the ceramic vessels and their contents originated on Cyprus. However more samples would need to be analysed from more areas of the eastern Mediterranean and from a wider range of sites on Cyprus to confirm this.

8.1.iii Database of stable isotope results for modern oils

The establishment of a database of GC-C-IRMS results for modern plant oils was also one of the objectives of this project. The foundation of a database was created which included seven different oils. While this is not a large sample, the close relationship of all but one of the oils is encouraging. However the presence of this main cluster of oils across the “mixing line” between

ruminant adipose fats and pig adipose fat may create a problem in interpreting the results of GC-C-IRMS data from sites where plant oils may be present with animal material. Comparison with $\Delta^{13}C$ may help to clarify the situation but may be equally undiagnostic as many of these values again lie in the lower range of non-ruminant adipose fats and the higher range for ruminant adipose fats.

8.1.iv Experiments with modern oils

The experiments with modern oils, although not part of the original aims and objectives of this study, did provide some interesting information. Even this limited study confirmed that it will be very difficult to detect many aromatic ingredients in archaeological perfumed oils using traditional GC-MS techniques. The only aromatic ingredients that could be detected, even in oils which smelt aromatic, were the resins and these have been identified in archaeological samples.

8.1.v Ceramic fabric

Although a reanalysis of data previously published on the elemental composition of RLWm ware fabric was not part of the original aims and objectives of the project, it proved to be a useful exercise. In particular it reinforced the conclusion that this fabric is remarkably consistent in its composition. Comparing this data with other published data on RLWm ware fabric composition (Schubert & Kozal, 2007) supported this conclusion. This in turn provides additional support for the theory that RLWm ware was all

manufactured at least in the same area, if not in the same town or even the same workshop, throughout the period of its manufacture.

8.2 Further work

8.2.i Organic residue analysis of the contents of RLWm ware

There is still a need for the definite identification of the precise commodities RLWm ware vessels contained. This will require further study of residues from these vessels, preferably of recently excavated, well stratified samples rather than sherds which have been stored for many years in museums. However, it would also be useful to identify and, if possible, sample any visible residues remaining in complete or nearly complete vessels from museums as these residues definitely represent the contents of the vessel and offer more material to work with than absorbed residues.

The use of techniques such as headspace analysis GC-MS, SIM GC-MS and HPLC-MS or HPLC-MS-MS may provide more information on the exact contents of RLWm ware vessels. HPLC could be particularly useful in looking for volatile compounds associated with aromatic mixtures which may be lost during extraction of residues for analysis by GC-MS. SIM GC-MS and HPLC-MS-MS could also be useful in identifying any non-volatile components released by aromatic materials into oils during steeping but which are present in very small abundances and so not generally visible in normal GC-MS analysis.

However, to apply these techniques successfully, a database of the compounds which might be present for analysis would be necessary and this would require more experimentation with modern materials. Further systematic experimentation on modern aromatic materials would be needed to establish such a database. HPLC-MS together with preparative TLC might also provide a useful tool for analysing this kind of residue but method development for unknown samples would be time consuming and might not provide any additional useful information.

Further work using GC-C-IRMS analysis of the fatty or oily residues could also provide a firmer identification of the exact nature of these residues, especially when used in conjunction with extended analysis of modern plant oils. The inconsistency of the GC-C-IRMS results obtained during this project is disappointing and brings into question the use of this method for the identification of fats and oils. Therefore the development of a preparation method which produces consistent results is of paramount importance. This should be rigorously tested during the analysis of archaeological samples by preparing and analysing standards of known isotopic signatures with each batch of unknown samples.

8.2.ii Variation in contents of RLWm ware vessels

Despite the analysis of 72 sherds (60 RLWm ware and 12 local wares) and two visible residues during this project and a further 40 sherds (39 RLWm ware and 1 local) and one visible residue during previous projects, there is a need for the

analysis of more examples of RLWm ware residues to establish any variation in the contents which would be statistically significant. Almost no samples have been analysed from Syria, Jordan and Israel, and only a handful of samples were available from Egypt. It is important that analysis of RLWm ware from these areas is carried out before drawing general conclusions about any variation in the commodities contained in these vessels. In addition, more examples from Hittite sites in Turkey, including local wares from similar shaped vessels and similar contexts, would enable clearer elucidation of any differences between RLWm ware found on Hittite sites and those from other areas of the eastern Mediterranean.

8.2.iii Stable isotopic identification of plant oils

The establishment of a small database of modern oil samples should only be considered a start in this area of analysis. The analysis of more samples of modern oils of plant origin, including many more varieties of plant oils and ensuring representation of both seed and fruit oils, is necessary to advance this area of research. In particular, it is important to determine how the stable isotopic signature of plant oils relates to that of animal fats and fish oils to avoid misinterpretation of data from sites where both plant and animal sources of fat were being exploited.

8.3 In Summary

This project has begun to identify the commodities transported or stored in RLWm ware vessels. The available evidence indicates that the contents of these vessels were usually a fat or oil, probably a plant oil, combined with other ingredients to give an aromatic or medicinal mixture which may have been used in a ritual context. These other ingredients included bitumen and *Pinaceae spp*. resin. It is also possible that bitumen was used as a post-firing treatment in some cases, possibly to seal the vessel fabric. The vessels found on Hittite sites in central Turkey, in the heartland of the Hittite empire, were often treated with beeswax in a similar way to local vessels found in the same contexts. Here the beeswax was probably a post-firing treatment designed to decrease the porosity of the fabric.

The project has not provided enough data to prove any links between different shapes of vessel and their contents, although pilgrim flasks may have contained the bituminous mixture. The most obvious variation in contents is with geographical area. If further research supports this variation it may be possible to draw more general conclusions about the origins of RLWm ware and its contents. It is still true that further research is needed on the residues found in RLWm ware vessels. This is particularly true if the origins of the ware and its place in the LBA eastern Mediterranean are to be securely established.