

## Table of Contents

<b>1.</b>	<b>Introduction</b>	<b>1</b>
1.1	Red Lustrous Wheelmade Ware	1
1.2	The aims of the study	3
1.3	The objectives of the study	3
1.3.i	Identification of the contents of RLWm ware vessels	3
1.3.ii	Variation in the contents of vessels	5
1.3.iii	The structure of the thesis	5
<b>2.</b>	<b>Red Lustrous Wheelmade Ware – the background</b>	<b>7</b>
2.1	Research up to 1993	7
2.2	Research since 1993	15
2.3	The pottery	19
2.3.i	Distribution	19
2.3.ii	Form	23
2.3.iii	Fabric	26
2.3.iv	Technology	29
2.3.v	Pot marks	33
2.3.vi	Contents and function	34
<b>3.</b>	<b>Red Lustrous Wheelmade Ware – part of the Late Bronze Age emporium in the eastern Mediterranean</b>	<b>40</b>
3.1	Historical background	40
3.2	Trade	50
3.3	Red Lustrous Wheelmade Ware – part of the LBA emporium	56
<b>4.</b>	<b>Archaeological material</b>	<b>58</b>
4.1	Sherd material	58
4.1.i	Cyprus	59
4.1.i.a	Arpera	60
4.1.i.b	Dhenia	63

4.1.i.c	Enkomi	65
4.1.i.d	Hala Sultan Tekke	68
4.1.i.e	Kalavassos	72
4.1.i.f	Kazaphani	77
4.1.i.g	Koulia	81
4.1.i.h	Myrtou-Pigadhes	84
4.1.ii	Turkey	86
4.1.ii.a	Boğazköy	87
4.1.ii.b	Kilise Tepe	91
4.1.ii.c	Kuşakli	96
4.1.iii	Syria	98
4.1.iii.a	Tell Tweini	99
4.1.iv	Egypt	100
4.1.iv.a	Saqqara	101
4.2	Visible residues	103
4.2.i	Cyprus	103
4.2.ii	Egypt	104
4.2.ii.a	Royal Ontario Museum sample	104
4.2.ii.b	Saqqara residue	106
<b>5.</b>	<b>Methods</b>	<b>112</b>
5.1	Residue analysis	112
5.1.i	Background	112
5.1.i.a	Survival of residues	112
5.1.i.b	Analytical techniques	114
5.1.i.c	The use of biomarkers for identification of residues	122
5.1.ii	Contamination	123
5.1.iii	GC and GC-MS analysis	124
5.1.iii.a	Sample preparation	124
5.1.iii.b	Chromatographic methods	129
5.1.iii.c	Gas Chromatography-Mass Spectrometry	130
5.1.iii.d	Quantification and errors	132
5.1.iv	HPLC-MS-MS analysis	133
5.1.iv.a	Sample preparation	133
5.1.iv.b	HPLC-MS-MS analysis	133

5.1.v	Compound specific stable isotope analysis	135
5.1.v.a	Sample preparation	135
5.1.v.b	GC-C-IRMS analysis	138
5.1.vi	Fourier Transform Infra-Red spectroscopy	139
5.2	Pottery analysis	139
5.2.i	Re-examination of thin sections	143
5.2.ii	Neutron Activation Analysis data manipulation	143
5.2.iii	Laser Ablation Inductively Coupled Plasma-Mass Spectrometry	144
5.2.iii.a	Sample preparation	145
5.2.iii.b	LA-ICP-MS analysis	145
5.3	Estimation of vessel volumes	146
<b>6.</b>	<b>Analysis of modern oils and experimental perfumes</b>	<b>151</b>
6.1	GC-C-IRMS analysis of modern oils and waxes	151
6.1.i	Modern oils	151
6.1.i	Modern waxes	159
6.2	Experimental perfumed oils	161
<b>7.</b>	<b>Results and discussion</b>	<b>172</b>
7.1	Ceramic residues	172
7.1.i	The nature of the absorbed ceramic residues	172
7.1.i.a	Beeswax	173
7.1.i.b	Bitumin	191
7.1.i.c	Fats or Oils	202
7.1.i.d	Resins	229
7.1.i.e	Contamination	235
7.1.i.f	HPLC-MS-MS analysis of absorbed residues	251
7.1.ii	The nature of the visible residues	252
7.1.ii.a	HPLC-MS-MS analysis of a visible residue	265
7.1.ii.b	FTIR analysis of a visible residue	266
7.1.iii	Compound specific stable isotope analysis of the residues	268
7.1.iv	A summary of the results by site	277
7.1.iv.a	Cypriot sites	277
7.1.iv.b	Turkish sites	288

7.1.iv.c	Syrian sites	296
7.1.iv.d	Egyptian material	297
7.1.v	Discussion of the ceramic residues	300
7.1.v.a	The nature of the residues	300
7.1.v.b	Variation in the residues	306
7.2	Results of experiments with modern oils	317
7.2.i	GC-C-IRMS of modern oils and waxes	317
7.2.i.a	Plant oils	317
7.2.i.b	Modern beeswax	321
7.2.ii	GC-MS analysis of experimental perfumed oils	324
7.3	Ceramic fabrics	330
7.3.i	Re-examination of the Neutron Activation Analysis data	330
7.3.ii	LA-ICP-MS analysis of some ceramic samples	336
7.3.iii	Re-examination of ceramic thin sections	339
7.3.iv	Comparison of results with those from a previous study	342
7.4	Vessel volume calculations	346
7.4.i	Spindle bottles	346
7.4.ii	Pilgrim flasks	347
7.4.iii	Arm-shaped vessels	348
7.4.iv	Discussion	348
<b>8.</b>	<b>Conclusions and further work</b>	<b>349</b>
8.1	Conclusions	349
8.1.i	The contents of RLWm Ware vessels	349
8.1.ii	Variation in the contents of vessels	351
8.1.iii	Database of stable isotope results for modern oils	352
8.1.iv	Experiments with modern oils	353
8.1.v	Ceramic fabric	353
8.2	Further work	354
8.2.i	Organic residue analysis of the contents of RLWm Ware	354
8.2.ii	Variation in Contents of RLWm Ware vessels	355
8.2.iii	Stable Isotope Identification of Plant Oils	356
8.3	In Summary	357

<b>Appendices</b>	358
Appendix 1: Dating in the Late Bronze Age Eastern Mediterranean	358
Appendix 2: Estimating the Quantity of Pottery Excavated From Sites	368
Appendix 3: Results of GC-C-IRMS Analysis of Archaeological Samples and Modern Oils and Waxes in Tabulated Form	370
Appendix 4: Summary of results of sherd residue analyses in tabular form	372

<b>Bibliography</b>	377
---------------------	-----

### **Contents of Data Disc**

FT-IR data	
Raw data files	
Absorption spectrum for Saqqara residue in Word format	
GC data – raw data files	
Blanks	
Methylated blanks	
Modern material	
Beeswax	
Modern oils	
Sherd analyses	
Arpera	
Boğazköy	
Dhenia	
Enkomi	
Hala Sultan Tekke	
Kalavasos	
Kazaphani	
Kouklia	
Kuşakli	
Myrtou- <i>Pigahdes</i>	
Tell Tweini	
Visible residues	
Medelhavsmuseet residue	
Royal Ontario Museum residue	
Saqqara residue	
GC-MS data – raw data files	
Blanks	
Beeswax	
Castor bean extract	
Modern oils	
Perfumed oils	
Sherd analyses	

Arpera  
Boğazköy  
Dhenia  
Enkomi  
Hala Sultan Tekke  
Kalavassos  
Kazaphani  
Kilise Tepe  
Kouklia  
Kuşakli  
Myrtou-*Pigahdes*

Visible residues

Medelhavsmuseet residue  
Royal Ontario Museum residue  
Saqqara residue

GC-C-IRMS data – excel spreadsheets

Archaeological samples  
Modern oils and waxes

Photographs

Arpera sherds  
Boğazköy sherds  
Dhenia sherd  
Enkomi sherds  
Hala Sultan Teke sherds  
Kalavassos sherds  
Kazaphani sherds  
Kilise Tepe sherds  
Kouklia sherds  
Kuşakli sherds  
Myrtou-*Pighades* sherd  
Saqqara residue  
Tell Tweini sherd  
Exeter pilgrim flask  
Exeter spindle bottle