Products of social distinction: organic residue analysis of specialized products in Bronze Age Cyprus

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PRODUCTS OF SOCIAL DISTINCTION:
ORGANIC RESIDUE ANALYSIS OF SPECIALIZED PRODUCTS
IN BRONZE AGE CYPRUS

by

Zuzana Chovanec

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Organic Residue Analysis of Specialized Products
in Bronze Age Cyprus

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Zuzana Chovanec

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Abstract

In this study, I examine the emergence of social complexity during the Prehistoric Bronze Age (c. 2400-1750 B.C.) on the Eastern Mediterranean island of Cyprus through a systematic program of organic residue analysis. I define a model based on the theoretical concept of the feast in conjunction with a product-centered approach that aims to identity a range of prestigious products, including perfumes, medicines, and psychoactive substances, that have been preserved in ceramic containers using Gas Chromatography-Mass Spectrometry (GC/MS).

The basis of the model is that feasting, in all its forms, serves as an arena in which various social, economic, political and ideological strategies are negotiated by various parties within a community. These strategies of social distinction simultaneously foster a sense of communal solidarity, while creating occasions on which opportunistic individuals may exert, gain, and consolidate their power, resulting in the emergence of a stratified, urban-oriented society, as in the case of Protohistoric Bronze Age Cyprus (c. 1750-1050 B.C.). It is during the formative, Prehistoric Bronze Age, that the relationships that lead to these social changes would have been negotiated in various communal events, in which increasingly elaborate drinking and serving sets were utilized in the consumption of a range of prestigious substances as a way to signal and legitimate claims of social distinction. From a product-centered perspective, I argue that the identity of the products that are being consumed and displayed in these events is as important to such strategies as the elaborate objects from which they are consumed.

To examine these relationships, I analyzed a total of 12 pottery samples from three curated collections and 98 pottery samples from five stratified archaeological sites that span the Cypriot Bronze Age. All three categories of prestigious products were identified, which documents a rich repertoire of specialized organic products being produced from locally available aromatic plants and being consumed, displayed and shared in increasingly elaborate and socially significant ways.
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TABLE OF CONTENTS

Abstract iii
Acknowledgements iv
List of Tables x
List of Figures xi
List of Appendices xv

I. Introduction 1
   A. Issues in Investigating Psychoactive Substances 2
      1. Fermented Beverages 4
      2. The Opium Poppy 6
   B. Medicines 8
   C. Perfumes and Cosmetics 10
   D. An Approach to Examining Prestigious Products in Prehistoric Contexts 12

II. Feasting and the Emergence of Social Complexity 18
   A. Introduction 18
   B. The Feasting Model 18
      1. A Review of Strategies of Social Distinction 19
      2. The Role of Prestigious Products in Feasting Practices 22
      3. Characteristics and Types of Feasts 24
   C. A Product-Focused Approach to Emergent Complexity 27

III. The Prehistoric Bronze on Cyprus: A Case For Emerging Complexity 29
   A. Background 29
   B. Cyprus in the Bronze Age 30
   C. Emerging Complexity Through Feasting: A View from Early Cyprus 33
      1. Aceramic Neolithic 33
      2. Ceramic Neolithic 35
      3. Chalcolithic 37
   D. Feasting and Emergent Complexity on Cyprus in Later Prehistory 41
   E. A Product-Centered Perspective to Feasting as Model for Investigating Social Complexity in Cyprus during the Prehistoric Bronze Age 47

IV. Methodology 49
   A. Introduction to Residue Analysis in Archaeology 49
   B. Discussion of Analytical Techniques 52
      1. Separation Techniques 53
         a. Gas Chromatography 53
         b. Mass Spectrometry and Gas Chromatography/Mass Spectrometry 55
         c. Mass Spectra Interpretation 56
   C. Approaches in the Analysis of Archaeological Residues 57
      1. The Analysis of Lipids 58
      2. The Analysis of Alkaloids 60
      3. The Analysis of Essential Oils 61
   D. The Taphonomy of Residues and Experimental Archaeology 62
   E. Methods Utilized 68
      1. Taphonomic Studies 68
         a. Opium 68
            1. Additional Experimental Work with Opium Residues 73
         2. Collection of Reference Sample Data 76
            a. Botanical Plants from the Island of Cyprus 76
               a.1. Additional Extraction and Analytical Procedures 77
b. Botanical Plants of Unknown Sources 78

3. Archaeological Samples 79
   a. Samples from Stratified Bronze Age Sites 79
   b. Samples from Museum Collections and Other Samples 79
   c. Methods of Analysis 80

V. Data Analysis and Interpretation: The Stratified Samples 81
   A. Episkopi Bamboula 81
      1. Site Background 81
      2. Samples 82
      3. Methodology 83
      4. Summary of Results 83
      5. Analytical Data and Discussion 86
         a. 74 EB02 VII Lot 2 053 (Base Ring I Shoulder) 86
         b. 75 EB04 XII J28 W 2 060 (Base Ring I Closed Body with Handle) 90
         c. 76 EB02 VIII T6 2AE 107 (Base Ring I Juglet Body Fragment Near Base) 92
         d. 77 EB02 VIII T6 2AE 107 (Base Ring I Neck Fragment) 95
         e. 78 EB02 VII 2 062 (Base Ring I Ring Base) 97
         f. 79 EB02 VIII T6 2E 065 (Base Ring I Fragment) 99
         g. 80 EB02 VIII T6 2E 065 (Base Ring I body fragment with relief decoration) 99
         h. 81 EB04 XII I28W 4 077 (Base Ring I Body Fragment near Base) 100

   B. Alambra Mouttes 105
      1. Site Background 105
      2. Samples 107
      3. Methodology 108
      4. Summary of Results 108
      5. Analytical Data and Discussion 111
         a. F3/P15 (RPA Juglet with Round Spout – Room 8) 111
         b. F82/P95 (RPB Juglet with Round Spout, Undecorated – Room 8) 113
         c. F84/P33 (RPB Juglet with Round Spout, Undecorated – Room 8) 113
         d. F86/P3 (RPB Juglet with Round Spout, Undecorated – Room 13) 114
         e. F87/P69 (RPB Juglet with Round Spout Undecorated – Room 8) 114
         f. F92/P4 (RPB Juglet with Round Spout, Decorated – Room 13) 117
         g. F98/P64 (RPB Juglet with Round Spout, Decorated – Room 8) 118
         h. F103/P35 (RPB Juglet with Cutaway Spout, Undecorated – Room 8) 119
         i. F106/P42 (RPB Juglet with cutaway spout, undecorated mini – Room 13) 119
         j. F118/P36 (RPB Juglet with Indeterminate Spout – Room 8) 120
         k. F119/P39 (RPB Juglet with Indeterminate Spout – Room 8) 121
         l. F120/P68 (RPB Juglet with Indeterminate Spout – Room 8) 122
         m. F391/P11 (WP/PW Juglet with Round Spout – Room 8) 122

   C. Marki Alonia 124
      1. Site Background 124
      2. Samples 125
      3. Methodology 126
      4. Summary of Results 126
5. Analytical Data and Discussion
   a. P15122 (BP Small Closed Vessel – Compound 15) 127
   b. P15370 (RP Large Closed Pithos – Compound 13) 128
   c. P15381 (RP Small Closed Juglet with Cutaway Spout – Compound 15) 128
   d. P15656 (RP Pyxis – Compound 9) 129
   e. P16098 (Small miniature vessel – Compound 9) 132
   f. (Small closed vessel with cutaway spout – Space 7) 133
   g. P16254 (RP Small Closed Amphora with Round Spout – Space 7) 136
   h. P16854 (RP Small Closed Gourd Juglet – Compound 9) 136

D. Sotira Kamínoudhía
   1. Site Background 137
   2. Samples 138
   3. Methodology 139
   4. Summary of Results 140
   5. Analytical Data and Discussion 142
       a. Area B, Unit 13.10, Lot 71, Red Polished Mottled Bowl 142
       b. Area B, Unit 13.24 Lot 79, Red Polished sherd from bowl with flat base 148
       c. Area B, Unit 12b, FN 157, Coarse ware tray 152
       d. Area A, Unit 27, P185, Storage jar) 155
       e. Tomb 4, P27, Brown Polished bottle 156
       f. Area A, Unit 44, P169, Drab Polished Blue Core juglet sherd 158
       g. Tomb 19, P105, Brown Polished bottle 159
       h. Area A, Unit 5, P74, Red Polished Black-topped bottle 163
       i. Area A, Unit 18, Lot 14, FN 2, P148, Drab Polished juglet 167
       j. Tomb 4, P29, Brown Polished Bottle 173
       k. Area B, Unit 13.34, Lot 77, 1, Red Polished bowl sherd 176
       l. Area A, Unit 7, G17C, 3, Brown Polished bottle 177

E. Politiko Troullia
   1. Site Background 180
   2. Samples 181
   3. Methodology 184
   4. Summary of Results 185
   5. Analytical Data and Discussion 189
       a. W.006.78.42, Small spout of Red Polished vessel 189
       b. S.011.42.8, Neck/shoulder of Red Polished jug 192
       c. V.010.64.32, Flared spout of Red Polished vessel 193
       d. Q.004.39.6, Red Polished spout 195
       e. T.008.49.2, Neck of Red Polished juglet 195
       f. X.013.74.368, Spout/neck of Red Polished vessel 198
       g. W.006.78.29, Red Polished Spout 198
       h. Q.009.49.49, Red Polished bowl spout 199
       i. S.011.76.110, High spout of Large Red Polished bowl 202
       j. Q.009.49.30, Red Polished bottle 202
       k. T.007.44.49, Body of Red Polished closed vessel 202
       l. Z.0.18.1, Red Polished spout fragment 204
       m. U.002.13.1, Small Red Polished spout 204
       n. W.006.139.80, Red Polished Closed Body 210
       o. W.012.120.68, Red Polished Spout 214
       p. W.012.120.69, Flared Red Polished spout 218
       q. W.012.120.70, Base of Red Polished juglet 219
       r. W.012.120.111.2, Footed base of Red Polished vessel 222
       s. V.010.53.12, Body of Black Polished juglet 224
t. S.001.6.12, Red Polished closed vessel sherds
u. D.010.72.1.3, Body of White Painted vessel
v. G.003.16.1.4, Small Red Polished cup
w. A.005.46.7, White Painted Jug Neck
x. D.010.64.2, Neck of small White Painted vessel
y. D.010.67.1, White Painted Small Closed Body
z. U.006.17.1, Black-topped bowl
aa. P.004.36.1, White Painted bowl with high handle
bb. U.006.30.1, Red Polished cup
c. U.006.30.2, Red Polished bowl
dd. P.004.54.4, Body of close Red Polished vessel
e. D.030.48.5, White Painted Small Bowl with Handle
ff. P.004.40.1.7, Small Black-topped bowl
gg. P.004.41.2, Base of Red Polished IV Jug
hh. W.018.190.1, Red Slip/Black Slip bowl
ii. P.004.23.1, Red Polished Closed Vessel Base
jj. O.008.77.1, White Painted closed vessel
kk. O.007.77.2, White Painted base
ll. O.009.85.1, Black Polished animal shaped vessel
mm. P.003.87.1, Red Polished amphoriskos
nn. O.009.98.1, Red Polished Juglet Neck
oo. U.034.232.1, Red Polished Spout
pp. U.010.173, Red Polished Black-Topped Bowl Fragments
qq. Z.033.93.1, Red Polished Bowl Base
rr. O.011.103.47, Cooking Pot Body
ss. R.007.63.2, Storage Vessel Base
tt. R.007.62.2, Black Polished Bowl Body
uu. R.007.76.3.2, Red Polished Bowl Body
vv. R.007.76.3.3, Red Polished Bowl Body
ww. R.014.61.3, Cooking Pot with a Button Base
xx. R.015.101.3, Red Polished Bowl Body
yy. R.015.101.31 Red Polished Incised Bowl
zz. R.022.108.6, Black Polished Decorated Juglet Base
aaa. S.011.76.231.2, Red Polished Coarse Ware Basin
bbb. W.011.108.83, Red Polished Footed Closed Body
ccc. X.010.9.78, Red Polished Juglet Body
ddd. Y.024.156.4, Red Polished Juglet Base
eee. Y.024.156.1, Storage vessel body fragment with attrition
fff. Y.024.156.2, Storage vessel body fragment with carbon residue
ggg. Y.024.156.3, Storage vessel base fragment

VI. Data Analysis and Interpretation: The Museum Samples
   A. Background
   B. Samples
   C. Methodology
   D. Summary of Results
   E. Analytical Data
      1. Belcher Collection
         a. BC 5, Red Polished Gourd Juglet
         b. BC11, Black Polished Flask
         c. BC18, White Painted III-IV Stringhole Juglet
         d. BC20, White Painted V Trough Spouted Juglet
         e. BC64, Base Ring II Sherd
         f. 160.EAI.12, Base Ring II Sherd
2. Barlow Collection
   a. 130.DK.5, Base Ring II sherd
   b. 151.DK.1, Base Ring II Juglet Sherd
3. Semitic Museum
   a. 1995.10.543, Base Ring I Sherd
   b. 1995.10.1329a, Base Ring I Sherd
   c. 1995.10.1331a, White Painted Sherd
   d. 1995.10.1332, Base Ring I Juglet

VII. Summations, Observations and Problems
   A. Observations and Conclusions By Sample Set
      1. Stratified Samples
         a. Episkopi *Bamboula*
         b. Alambra *Mouttes*
         c. Marki *Alonia*
         d. Sotira *Kaminoudhia*
         e. Politiko *Troulia*
      2. Museum Samples
   B. Observations and Conclusions from a Product-Centered Perspective
   C. General Methodological and Interpretative Issues
   D. Implications for Feasting as a Model for Complexity in Bronze Age Cyprus

VIII. Conclusions
   A. Summary and General Conclusions
   B. Future Directions

References Cited
### List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table II.A</td>
<td>Comparison of Characteristics of Feasts</td>
<td>25</td>
</tr>
<tr>
<td>Table III.A.1</td>
<td>Chronological Scheme for Early Cyprus</td>
<td>32</td>
</tr>
<tr>
<td>Table III.A.2</td>
<td>Traditional and Revised Chronological Scheme for Bronze Age Cyprus</td>
<td>32</td>
</tr>
<tr>
<td>Table IV.A</td>
<td>Molecular ions targeted in SIM scan of opium alkaloids</td>
<td>72</td>
</tr>
<tr>
<td>Table V.A.1</td>
<td>Provenience information for samples from Episkopi Bamboola</td>
<td>83</td>
</tr>
<tr>
<td>Table V.A.2</td>
<td>Chemical constituents identified in Episkopi Bamboola</td>
<td>86</td>
</tr>
<tr>
<td>Table V.A.3</td>
<td>Chemical constituents identified in Episkopi Bamboola</td>
<td>91</td>
</tr>
<tr>
<td>Table V.A.4</td>
<td>Chemical constituents identified in Episkopi Bamboola</td>
<td>93</td>
</tr>
<tr>
<td>Table V.A.5</td>
<td>Chemical constituents identified in Episkopi Bamboola</td>
<td>96</td>
</tr>
<tr>
<td>Table V.A.6</td>
<td>Chemical constituents identified in Episkopi Bamboola</td>
<td>98</td>
</tr>
<tr>
<td>Table V.A.7</td>
<td>Chemical constituents identified in Episkopi Bamboola</td>
<td>100</td>
</tr>
<tr>
<td>Table V.A.8</td>
<td>Chemical constituents identified in Episkopi Bamboola</td>
<td>103</td>
</tr>
<tr>
<td>Table V.B.1</td>
<td>Provenience information for samples from Alambra Mouttes</td>
<td>107</td>
</tr>
<tr>
<td>Table V.B.2</td>
<td>Chemical constituents identified in Alambra Mouttes F2/P15</td>
<td>112</td>
</tr>
<tr>
<td>Table V.B.3</td>
<td>Chemical constituents identified in Alambra Mouttes F87/P69</td>
<td>115</td>
</tr>
<tr>
<td>Table V.B.4</td>
<td>Chemical constituents identified in Alambra Mouttes F98/P64</td>
<td>118</td>
</tr>
<tr>
<td>Table V.B.5</td>
<td>Chemical constituents identified in Alambra Mouttes F118/P36</td>
<td>120</td>
</tr>
<tr>
<td>Table V.B.6</td>
<td>Chemical constituents identified in Alambra Mouttes F119/P3</td>
<td>121</td>
</tr>
<tr>
<td>Table V.B.7</td>
<td>Chemical constituents identified in Alambra Mouttes F391/P11</td>
<td>123</td>
</tr>
<tr>
<td>Table V.C.1</td>
<td>Provenience information for samples from Marki Alonia</td>
<td>125</td>
</tr>
<tr>
<td>Table V.C.2</td>
<td>Chemical constituents identified in Marki Alonia P15381</td>
<td>129</td>
</tr>
<tr>
<td>Table V.C.3</td>
<td>Chemical constituents identified in Marki Alonia P15656</td>
<td>131</td>
</tr>
<tr>
<td>Table V.C.4</td>
<td>Chemical constituents identified in Marki Alonia P16098</td>
<td>133</td>
</tr>
<tr>
<td>Table V.C.5</td>
<td>Chemical constituents identified in Marki P16171</td>
<td>134</td>
</tr>
<tr>
<td>Table V.D.1</td>
<td>Provenience information for samples from Sotira Kaminoudhia</td>
<td>139</td>
</tr>
<tr>
<td>Table V.D.2</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 1</td>
<td>145</td>
</tr>
<tr>
<td>Table V.D.3</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 2</td>
<td>151</td>
</tr>
<tr>
<td>Table V.D.4</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 3</td>
<td>154</td>
</tr>
<tr>
<td>Table V.D.5</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 5</td>
<td>157</td>
</tr>
<tr>
<td>Table V.D.6</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 7</td>
<td>162</td>
</tr>
<tr>
<td>Table V.D.7</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 8</td>
<td>166</td>
</tr>
<tr>
<td>Table V.D.8</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 9</td>
<td>170</td>
</tr>
<tr>
<td>Table V.D.9</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 10</td>
<td>175</td>
</tr>
<tr>
<td>Table V.D.10</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 11</td>
<td>177</td>
</tr>
<tr>
<td>Table V.D.11</td>
<td>Chemical constituents identified in Sotira Kaminoudhia 12</td>
<td>178</td>
</tr>
<tr>
<td>Table V.E.1</td>
<td>Provenience information for samples from Politiko Troullia</td>
<td>182</td>
</tr>
<tr>
<td>Table V.E.2</td>
<td>Chemical constituents identified in Politiko Troullia 1</td>
<td>189</td>
</tr>
<tr>
<td>Table V.E.3</td>
<td>Chemical constituents identified in Politiko Troullia 2</td>
<td>193</td>
</tr>
<tr>
<td>Table V.E.4</td>
<td>Chemical constituents identified in Politiko Troullia 3</td>
<td>194</td>
</tr>
<tr>
<td>Table V.E.5</td>
<td>Chemical constituents identified in Politiko Troullia 5</td>
<td>196</td>
</tr>
<tr>
<td>Table V.E.6</td>
<td>Chemical constituents identified in Politiko Troullia 8</td>
<td>200</td>
</tr>
<tr>
<td>Table V.E.7</td>
<td>Chemical constituents identified in Politiko Troullia 11</td>
<td>203</td>
</tr>
<tr>
<td>Table V.E.8</td>
<td>Chemical constituents identified in Politiko Troullia 14</td>
<td>207</td>
</tr>
<tr>
<td>Table V.E.9</td>
<td>Chemical constituents identified in Politiko Troullia 15</td>
<td>213</td>
</tr>
<tr>
<td>Table V.E.10</td>
<td>Chemical constituents identified in Politiko Troullia 18</td>
<td>216</td>
</tr>
<tr>
<td>Table V.E.11</td>
<td>Chemical constituents identified in Politiko Troullia 19</td>
<td>218</td>
</tr>
<tr>
<td>Table V.E.12</td>
<td>Chemical constituents identified in Politiko Troullia 20</td>
<td>221</td>
</tr>
<tr>
<td>Table V.E.13</td>
<td>Chemical constituents identified in Politiko Troullia 21</td>
<td>223</td>
</tr>
<tr>
<td>Table V.E.14</td>
<td>Chemical constituents identified in Politiko Troullia 22</td>
<td>225</td>
</tr>
<tr>
<td>Table V.E.15</td>
<td>Chemical constituents identified in Politiko Troullia 25</td>
<td>226</td>
</tr>
<tr>
<td>Table V.E.16</td>
<td>Chemical constituents identified in Politiko Troullia 28</td>
<td>228</td>
</tr>
<tr>
<td>Table V.E.17</td>
<td>Chemical constituents identified in Politiko Troullia 30</td>
<td>230</td>
</tr>
<tr>
<td>Table V.E.18</td>
<td>Chemical constituents identified in Politiko Troullia 32</td>
<td>234</td>
</tr>
<tr>
<td>Table V.E.19</td>
<td>Chemical constituents identified in Politiko Troullia 34</td>
<td>237</td>
</tr>
</tbody>
</table>
Table V.E.20 Chemical constituents identified in Politiko Troullia 37
Table V.E.21 Chemical constituents identified in Politiko Troullia 39-41
Table V.E.22 Chemical constituents identified in Politiko Troullia 42
Table V.E.23 Chemical constituents identified in Politiko Troullia 44
Table V.E.24 Chemical constituents identified in Politiko Troullia 49
Table V.E.25 Chemical constituents identified in Politiko Troullia 51
Table V.E.26 Chemical constituents identified in Politiko Troullia 54
Table V.E.27 Chemical constituents identified in Politiko Troullia 57
Table V.E.28 Chemical constituents identified in Politiko Troullia 61
Table V.E.29 Chemical constituents identified in Politiko Troullia 63
Table V.E.30 Chemical constituents identified in Politiko Troullia 64
Table V.E.31 Chemical constituents identified in Politiko Troullia 67
Table V.E.32 Chemical constituents identified in Politiko Troullia 68
Table V.E.33 Chemical constituents identified in Politiko Troullia 69
Table V.E.34 Chemical constituents identified in Politiko Troullia 70
Table V.E.35 Chemical constituents identified in Politiko Troullia 71
Table VI.1 Provenience information for samples from Museum Collections
Table VI.2 Chemical constituents identified in BC5
Table VI.3 Chemical constituents identified in BC11
Table VI.4 Chemical constituents identified in BC18
Table VI.5 Chemical constituents identified in BC64
Table VI.6 Chemical constituents identified in 160.EAI.12
Table VI.7 Chemical constituents identified in 130.DK.5
Table VI.8 Chemical constituents identified in 151.DK.1
Table VI.9 Chemical constituents identified in 1995.10.1331a

List of Figures
Figure V.A.1 74 EB02 VII Lot 2 053 (Base Ring I Shoulder) 85
Figure V.A.2 EB 74 Sonication-Lipid Total Ion Current 87
Figure V.A.3 EB 74 Lipid-Lipid Total Ion Current 89
Figure V.A.4 EB 74 Alkaloid-Alkaloid Total Ion Current 89
Figure V.A.5 75 EB04 XII J28 W 2 060 (Base Ring I Closed Body with Handle) 90
Figure V.A.6 EB 75 Sonication-Lipid Total Ion Current 91
Figure V.A.7 EB 75 Lipid-Lipid Total Ion Current 92
Figure V.A.8 76 EB02 VIII T6 2AE 107 (Base Ring I Juglet Body Fragment Near Base) 92
Figure V.A.9 EB 76 Alkaloid-Alkaloid Total Ion Current 94
Figure V.A.10 EB 76 Alkaloid-Lipid Total Ion Current 94
Figure V.A.11 EB 76 Sonication-Lipid Total Ion Current 94
Figure V.A.12 EB 77 EB02 VIII T6 2AE 107 (Base Ring I Neck Fragment) 95
Figure V.A.13 EB 77 Alkaloid-Lipid Total Ion Current 96
Figure V.A.14 78 EB02 VII 2 062 (Base Ring I Ring Base) 97
Figure V.A.15 EB 78 Alkaloid-Lipid Total Ion Current 99
Figure V.A.16 79 EB02 VIII T6 2E 065 (Base Ring I Fragment) 99
Figure V.A.17 80 EB02 VIII T6 2E 065 (Base Ring I body fragment with relief decoration) 99
Figure V.A.18 EB 80 Alkaloid-Lipid Total Ion Current 100
Figure V.A.19 81 EB04 XII I28W 4 077 (Base Ring I Body Fragment near Base) 100
Figure V.A.20 EB 81 Sonication-Lipid Total Ion Current 103
Figure V.A.21 EB 81 Alkaloid-Lipid Total Ion Current 104
Figure V.A.22 EB 81 Alkaloid-Alkaloid Total Ion Current 104
Figure V.B.1 F3/P15 (RPA Juglet with Round Spout – Room 8) 110
Figure V.B.2 F3/P15Alkaloid-Alkaloid Total Ion Current 112
Figure V.B.3 F3/P15Alkaloid-Lipid Total Ion Current 112
Figure V.B.4 F62/P95 (RPB Juglet with Round Spout, Undecorated – Room 8) 113
Figure V.B.5 F84/P33 (RPB Juglet with Round Spout, Undecorated – Room 8) 113
Figure V.B.6 F86/P3 Juglet (RBP Juglet with Round Spout, Undecorated – Room 13) 114
Figure V.E.104 PT73 Y.024.156.1 (Storage vessel body fragment with attrition) 272
Figure V.E.105 PT73 Y.024.156.2 (Storage vessel body fragment with carbon residue) 272
Figure V.E.106 PT73 Y.024.156.3 (Storage vessel base fragment) 273
Figure VI.1. BC 5, Red Polished Gourd Juglet 278
Figure VI.2 BC5 Lipid-Lipid Total Ion Current 278
Figure VI.3 BC11, Black Polished Flask 279
Figure VI.4 BC11 Alkaloid-Alkaloid Total Ion Current 280
Figure VI.5 BC18, White Painted III-IV Stringhole Juglet 280
Figure VI.6 BC11 Lipid-Lipid Total Ion Current 281
Figure VI.7. BC20, White Painted V Trough Spouted Juglet 282
Figure VI.8 BC64 Alkaloid-Alkaloid Total Ion Current 283
Figure VI.9 160.EAI.12, Base Ring II Sherd 283
Figure VI.10 160.EAI.12 Lipid-Lipid Total Ion Current 284
Figure VI.11 130.DK.5 Lipid-Lipid Total Ion Current 285
Figure VI.12 151.DK.1 Alkaloid-Alkaloid Total Ion Current 286
Figure VI.13 1995.10.543, Base Ring I Sherd 287
Figure VI.14 1995.10.1329a, Base Ring I Sherd 287
Figure VI.15 1995.10.1331a, White Painted Sherd 287
Figure VI.16 1995.10.1331a Alkaloid-Alkaloid Total Ion Current 288
Figure VI.17 1995.10.1332, Base Ring I Juglet 288

List of Appendices
Mass spectra data files will be made available on the Harvard Dataverse Network, http://dvn.iq.harvard.edu/dvn/).

Appendix 1: Analytical Reports for References Samples
Appendix 2: Analytical Reports for Archaeological Samples
I. **INTRODUCTION**

The goal of this project is to examine the use of prestigious products during the Bronze Age (c. 2400-1100 B.C.) on the Eastern Mediterranean island of Cyprus by analyzing residues that may have preserved inside ceramic containers. Over the last three decades, archaeologists have increasingly emphasized the advantages of incorporating analytical techniques into their research (Evershed 2000:204-7; Pollard and Heron 2008:9-11; Loy 1993:44). The main benefit of such techniques, organic residue analysis in particular, is that research questions may be addressed that are minimally approachable using traditional archaeological methods. One such area concerns the range of specialized products that were used by ancient peoples, the ways in which they were prepared and consumed, and the social importance attributed to them. Knowledge of such substances is generally outside of the purview of typical archaeological means, particularly in prehistoric contexts at significant time depths.

The designation of “prestigious product” applies to the following categories of substances:

1) preparations of psychoactive substances, or substances that produce “changes in thought, perception, and mood… without causing major disturbances to the automatic central nervous system” (Furst 1990:xiii). These may include mind-altering hallucinogens (e.g., belladonna), inebriants (e.g., alcohol), or stimulants (e.g., ephedra) (Hofmann in Schultes 1990:4-5; Ott 1993; Rudgley 1993).

2) substances that improve health, such as medicines or herbal infusions. This category may be somewhat less clear cut in that some psychoactive substances are known to have medicinal benefits as do various herbs (Balick 1996:58; McGovern et al. 2009:7361; Riviera et al. 2006:18-9).

3) products that may be cosmetic or hygienic in nature. These may include perfumes, scented oils, ointments and salves that would have been applied to the hair and skin (Colombini et al. 2009:1489; El-Shimy 2003:46-9; Green 2011:4-5, 19-23, 3262; Halioua and Ziskind 2005:87).
It is acknowledged that a division between “food” and “drug” plants or products is fundamentally arbitrary and associated with modern concerns with illicit and non-illicit substances and that such classifications tend not to be static (Sherratt 1995:1-2; Ott 1993:20-9; Poston and Haddock 2000; Ripinsky-Naxon 1993:22-3; Sullivan and Hagen 2002:389-9). As such, there is considerable overlap in the proposed categories.

Recent research trends have emphasized the socioeconomics of intoxication and consumption as it relates to the social histories of particular products. This product-focused perspective is exemplified by seminal works on sugar (Mintz 1985), tobacco (Rafferty and Mann 2004; Wilbert 1997, 1990, 1987), opium (Merlin 2003, 1984; Merrillees 2003[1962]), olive oil (Hadjisavvas 2009, 1992), cacao (Edgar 2010; Henderson et al. 2007) and various works on alcohol (Arthur 2003; Dietler 2006; McGovern 2009; McGovern et al. 2004; Michel et al. 1993). The focus on alcohol is particularly significant in discussions of social complexity in Mediterranean and Near Eastern societies (Hamilakis 1999; Joffe 1998). Although these substances certainly played a significant role in the region, the use of alcohol in the form of grape wines and grain beers is often assumed a priori rather than qualitatively demonstrated (Sherratt 1987:376; Steel 2004a:113, 2004b:282, 2002:107). The increasing utilization of scientific techniques for the analysis of ancient residues of vessels from archaeological contexts has, in some cases, demonstrated the inequity of such assumptions (Beck et al. 2004; Childe 1930; Guerra-Doce 2006).

Thus, the incorporation of such techniques makes the investigation of the range of specialized products that were used by ancient peoples more definitive and approachable, than with traditional archaeological methods alone.

I.A. Issues in Investigating Psychoactive Substances

This is particularly true for the investigation of psychoactive substances because the majority of information about their use comes from historical documents, pictorial representations of their use or the plants from which they derive, and most frequently from ethnographic studies of non-western societies in the recent past. For these reasons, the archaeological investigation
into the use of psychoactive substances has largely centered on New World societies. In comparison to the New World, European and Mediterranean archaeology has been somewhat conservative in the range of psychoactive plants investigated. When Old World intoxicants are investigated, the major focus is on the use of fermented beverages, especially in the Mediterranean basin where the production and consumption of alcohol is well-documented.

In the 1960s, the anthropologist Wesson La Barre and ethnobotanist Richard Schultes suggested that a far greater number of such substances were utilized in the New World in comparison with its Old World counterparts. Explanations for this proposed lack of Old World psychoactive substances centered on greater botanical diversity in the Western Hemisphere, the development of agriculture in the Eastern Hemisphere, and the retention of a hunter-gatherer lifestyle in the Americas for millennia (Cauvin 2002; La Barre 1990:270-2, 1971, 1970; Ripinsky-Naxon 1989; Schultes 1990[1960], 1987, 1969; Simmons 2007). Schultes (1987, 1990[1960]) further suggested that the deep-rooted relationship that Amerindian groups maintained with psychoactive plants was the result of an intimate knowledge of botanical diversity through extensive experimentation, but also that this knowledge was intimately tied to the shamanic religion and cosmology (La Barre 1990:270-2; McClennon 1997; Merlin 2003:296, 1984:100-5, 204-9; Schultes 1967 in La Barre 1970:73-8).

Since that time, it has been acknowledged that whatever disparity may exist in the range of psychoactive substances, to some degree, may be attributed to the breadth of anthropological and ethnobotanical research (Merlin 2003:295-6). In the 1960s and 1970s, for instance, there was a great surge in interest in the documentation of indigenous ethnobotanical knowledge in the non-Western world, which certainly introduced a geographic bias to the topic (Ott 1993:23-58). In another sense, credence must be given to Schultes and La Barre's observation that the development of agriculture fundamentally changed the way in which humans related to the plant world and the range of plants which were deemed important (Cauvin 2002; Simmons 2007). As such, it is acknowledged that comparable types of psychoactive substances may have been utilized in Old World societies at greater time depths, making their investigation somewhat more difficult than in other parts of the world, where such practices continue(d) in the recent past.

I.A.1. Fermented Beverages

While there may be a breadth of information about the use of alcohol, tracking its history is not without its challenges. Investigating a substance that is consumed throughout the globe, has long and complicated history of human use and for which there are various lines of evidence is rather difficult. For this reason, researchers working in the Mediterranean frequently turn to ancient texts, such as the Classical Greek writings, which have numerous references to alcohol, as well as other types of psychoactive substances. However, in some cases in which the identity of the substance is unclear, it was assumed that substance in question was in fact alcohol (Fericgla 1996; McGovern 2009, 2004, 2003; Ott 1993:156).

One case in which the intoxicating substance is not explicitly named comes from the Odyssey in which Circe, a woman who has been described as a shamaness or sorceress, ushered her guests into a hall, where she “prepared for them a mixture of cheese, barley-meal and yellow honey flavoured with Pramnian wine. But into this dish she introduced a powerful drug to make them lose all memory of their native land” (Seltman 1957:43). The source of the drug however is not identified (Totelin 2009:92). Elsewhere the name of a drug is mentioned but is not translatable, such as the euphoric nepenthe that Helen of Troy added to a special wine, which served to alleviate the sorrow of mourners (Ott 1993:156; Ruck in Wasson et al. 1978:15-6). Another example from Greek mythology in which a sleep-inducing drug is associated with the quelling of sorrow is the kykeon given to the goddess Demeter when she mourned the loss of her daughter, Persephone (Ruck 2008:12-15; Merlin 1984:204-5; Ott 1993:141-2; Webster 2000).
In some cases, varieties of presumably alcoholic beverages are distinguished, such as the strong drink that the Hebrews referred to as shekar, which was differentiated from yayin and tirosh, which were wines of different strengths (Ott 1993:143). In addition to references to alcoholic beverages, the Old Testament mentions rosh and la’ana numerous times, terms which generally refer to bitter or poisonous plants. Suggested botanical sources for these bitter plants include the opium poppy (Papaver somniferum), white wormwood (Artemisia herba-alba), poison hemlock (Conium maculatum), and the thorn-apple (Datura inoxia) (Amor 2006:43-4; Ayalon 2006:7; Kapoor 1995:7; Merrillees 2003[1962]:2-3; Zohary 1982:185-6). While the diversity of wines is well-documented, the use of the bitter plants seems less clear.

In the case of the sacred Egyptian drink, shedeh, chemical analysis of the contents of a vessel inscribed with the name of the drink indicated the presence of an alcoholic drink made of red grapes (Guash-Jané 2006:99-100). According to Halioua and Ziskind (2005:93-4), shedeh was one of six types of wine that was known in the Old Kingdom, alongside red, white and black wines. It also served an important role in the preservation of the internal organs during mummification: following removal, the organs were “immersed in a sweet, strong liquid infused with aromatics and resin, known as shedeh, a highly alcoholic brew” (Halioua and Ziskind 2005:50). Corroboration of textual evidence with analytical work is not always possible because the identity of the plant or substance named is unknown (Halioua and Ziskind 2005:88). An example of this from ancient Egypt centers around references to the ibw plant in the Ebers Papyrus, a medical text that dates to 1536 B.C. The plant (a tree) is said to originate in Upper Egypt and is said to be sacred to Horus. A botanical species could not be determined, however, because the word is not translatable (Carpenter et al. 1995:3; Budge in Carpenter et al. 1998:181). Merlin (2003, 1984) detailed similar issues in his attempts to associate botanical representations in the archaeological record to specific plant species, such as the opium poppy, which is addressed below.

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1 Rubric No. 282, Column 50, Line 13
Elsewhere, it may be a matter of generalization, such as in case of the cult of Dionysus, who the god of the vine and of wine (Dietler 2006:241; McGovern 2003:240-50; Ott 1993:156). There is extensive documentation of Dionysus’ female devotees having “periodic bouts of…frenzy” due to what was assumed to be drunkenness (Seltman 1957:101). But Carl Ruck (2008:14-5) has highlighted that the vine that was so venerated by Dionysus may not have simply been the grape vine. He points specifically to the symbol of the “thyrsos”, “a fennel stalk stuffed with ivy leaves”, which was also revered by Dionysus (Ruck 2008:16). Ruck (2008:16) further suggests that the ivy leaves may have had psychoactive properties. While the commonly held association between the god and wine is certainly accurate, there is also ample suggestive evidence that “ancient wine… did not contain alcohol as its sole inebriant but was ordinarily a variable infusion of herbal toxins in a vinous liquid” (Ruck 2008:14-16).

During the 1960s and 70s, when this area of research was garnering increasing interest – scholars like Alfred Hoffman, Jonathan Ott and R. Gordon Wasson categorized the effects of psychoactive plants from a botanical, chemical, and cognitive perspective. In doing so, they distinguished between the experience and behaviors associated with the consumption of hallucinogens, which function to alter experience, the perception of reality, time, space and consciousness itself, as opposed to psychotropic substance which “act normally only to calm or to stimulate” (Schultes 1990:4). The review of such observations in the context of ancient Mediterranean texts suggests that in some cases, an intoxication other than alcohol inebriation may be indicated (Ott 1993:156-7).

I.A.2 The Opium Poppy

One exception to the focus on alcohol is the opium poppy, Papaver somniferum L. Merlin (2003, 1984), Kapoor (1995), Bernáth et al. (1998), Collard (2011) and others have detailed the long and varied relationship that humans have maintain with this plant. While the poppy was used for a diverse range of purposes, the most significant reason is for the medicinal and psychoactive properties that the more than forty alkaloids produce (Hesse 1981:3-4; Kapoor 1995:162; Merlin 1984:91). Alkaloids are relatively small organic molecules that occur frequently in plants and are

Archaeological evidence for the narcotic use of opium purportedly came from the Eastern Mediterranean island of Cyprus during the Protohistoric Bronze Age (c. 1700-1400 B.C.E.). Robert S. Merrillees (2003[1962]:2-3; 2003[1979]:123-4) proposed that a particular vessel form, the Base Ring juglet, was utilized in the storage and transport opium from Cyprus to destinations throughout the Eastern Mediterranean. The juglets have a distinctive form and frequently exhibit distinctive decorations. It is from this perspective that Merrillees (1992:47-50) proposed that, in connection with the high quality of the ware and its wide distribution, the form of the juglet was consistent with the dimensions of an inverted poppy capsule and the decoration with the incision method used to extract its opium (Åström 1972:137, 173-4; Bisset et al. 1994:104; Koschel 1996:159; Merlin 2003, 1984).

There have been attempts at chemical analysis of the contents of these vessels. The first consisted of a colorimetric analysis of a sandy residue from a Base Ring juglet excavated from an Egyptian tomb in the early 20th century (Schiaparelli, Muzio in Bisset et al. 1996:100), but as discussed by Bisset et al., the observed the reactions were consistent with but not limited to morphine or other compounds restricted to opium. Similarly, Belgiorno (2004) claims that a large Red Polished bowl encrusted with a hard, white material once held a substance that contained opium. However, she provides little information on the analytical techniques used and still has yet to formally publish any analytical data. John Evans (in Merrillees 1989:185-6) reported finding opium and olive oil in a Base Ring sherd from the London University Institute of Archaeology and opium and an unidentifiable degenerate oil in a Base Ring sherd from the Rockefeller Collection in Jerusalem. Despite his description of the analytical techniques utilized, Evans’ results are

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2 A detailed review of the analytical work investigating the possible use of opium in the Eastern Mediterranean during the Bronze Age is presented in Chovanec et al.’s article, “Opium for the Masses: An Experimental Archaeological Approach in Determining the Antiquity of the Opium Poppy”, in the Journal of Ethnoarchaeology.
questionable primarily due to the lack of any analytical data. Koschel (1996:159-60) highlights that the chemical identifications were made on the basis of fats and oils, not of alkaloids. Thus, it is unclear what criteria were employed for determining the presence of opium.

The original contents of two sealed Base Ring juglets from the British Museum were analyzed with the preliminary results that may suggest papaverine (Rebecca Stacey, email corresp., Apr 14, 2008; David Collard, email corresp., Oct. 19, 2008). However, to date Koschel's article, which details the identification of five opium alkaloids in a Base Ring I juglet from the Martin-von-Wagner Museum at the University of Würzburg in Germany, is the only published study that explicitly demonstrates the presence of opium in a Base Ring juglet. Moreover, a consistent problem in the opium question is that the majority of the vessels analyzed are museum specimens that lack provenience, making larger considerations of social use untenable. Most recently, Collard (email correspondence, Oct. 19, 2008) has rightly attempted to address this by collecting samples in situ from excavations in Cyprus, but with no results.³

I.B. Medicines

The evidence for medicines and perfumes in the archaeological record comes almost entirely from ancient literary sources and these are primarily Egyptian medical papyri and the writings of Classical Greek and Roman physicians and historians, such as Pliny the Elder, Herodotus, Dioscorides, Galen, and Hippocrates. However, in terms of ancient medical knowledge, two key acknowledgments must be made. First, what we today view as the practical and rational aspects of modern Western medicine did not originate with the Classical Greek philosophical tradition; rather, it was via Greek and other travelers to pharaonic Egypt that the great breadth of a medical tradition that precedes Hippocrates by some two millennia was transmitted to the rest of the ancient world (Halioua and Ziskind 2005:2-4, 179, 189; Smith 1930:xiii). For example, Arnott (2002:43-4) emphasizes the fact that despite great advances in other areas, in medicine the Hittites "had not much advanced beyond magic and simple

³ It should be noted that in Collard's 2011 doctoral thesis, he makes little specific mention to his analytical work.
remedies" that were based almost entirely on analogy, rather than practical knowledge. This is related to the second key acknowledgment that medicine in the ancient world is inseparable from religion, as the natural and supernatural forces that cause of human suffering, and magic, as the formalized means available to humans to manipulate those forces for the patient’s benefit. This applies equally to the magic-based analogical medicine of the Hittites as it does to the detailed Egyptian papyri that diagnose, prognosticate, and prescribe (Budge 1928:1-4, 9-12; Halioua and Ziskind 2005:27-8).

Much of what is known about ancient Egyptian medicine and practice derives from some ten papyri, though there are also references in various epigraphic inscriptions, ostraca and artistic depictions from Egypt and indirectly in the writing of Greek and Roman travelers and biblical accounts. The papyri themselves, which are more often than not copies of more ancient texts, tend to focus on symptoms, using a spoken formula which include verbal incantations, a description of symptoms, a prognosis, and a recipe for a medicine that would be taken for four days (Halioua and Ziskind 2005:27-30, 189). For example, the Ebers Papyrus, which is the longest manuscript and dates to the reign of Amenhotep I (New Kingdom, 1525-1504 B.C.), is “mainly a treatise on pharmacology and therapeutics” and dealing with the diseases affecting women, the skin, the upper respiratory, gastrointestinal, urinary, and circulatory systems (Bryan 1930; Halioua and Ziskind 2005:189, 205-8). The example below is from a section of the Ebers Papyrus that has been suggested to pertain to diabetes (Carpenter et al. 1998:3-6):

“If you examine someone sick (in) the center of his being (and) is/ his body shrunk with disease at/ its limit; if you examine him not (and) you do find/ disease in (his) body except for the surface of the ribs/ of which the members (are) like a pill you should then recite (a spell)/ (against) disease this in your house; you should (also) then prepare for him/ ingredients for (treating) it: blood stone of Elephantine,/ ground; red grain; carob; cook in/ oil (and) honey; (it) should be eaten by him over/ mornings four for the suppression/ of his thirst (and) for curing his mortal illness”.4

4 Rubric No. 197, Column 39, Line 7
But as with references to intoxicating substances, there are cases in which plants or other ingredients are unknown, such as the sacred *ibw* tree from Upper Egypt. The name for the tree is not translatable and therefore its botanical identity unknown (Budge in Carpenter et al. 1998:18; Halioua and Ziskind 2005:31, 168). It may also be noted that the efficacy of many treatments may be questionable by modern standards. A number of these are salves for the eye that may include, amongst other ingredients, saffron, zinc oxide, lycium, cooper scales, castoreum, and “poppy-tears” (poppy juice). The final ingredient shows up time and time again in primary Egyptian texts and indirect references in Greek documents are poppy-tears, which suggests that the opium poppy played an important role in pain management (Celsus 6.6; Halioua and Ziskind 2005:31,39, 83). Overall, the investigation of ancient medicine is difficult without of written documentation. In its absence, only cautious inferences can be drawn using historical or cultural analogy, botanical remains in discrete contexts, or chemical data indicating the presence of plants with medicinal benefits.

I.C. Perfumes and Cosmetics

Perfumed oils and unguents, on the other hand, played a significant role in daily life from personal hygiene to participating in banquets that honored the gods. In Classical Greece, in lieu of bathing with water, perfumed oils were applied to the skin and scraped off, along with any dirt, using a scraper called a strigil. While bathing with water was common in both ancient Greek and ancient Roman society, this method of cleansing the body was often used in situations when bathing with water was not available or practical. For instance, athletes would apply and scrape a perfumed oil, and dirt with it, after exercising (Perseus Encyclopedia; Pl. St. 1.3). In prehistoric Cyprus, Swiny (1989, 1981) highlights that settlements would have normally been situated near springs or other natural sources of fresh water. However, this does not necessarily mean that water would have been plentiful. As such, it is reasonable to suggest that this kind of waterless bathing using various perfumed oils likely would have been the preferred technique for special occasions in Bronze Age Cypriot society.

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5 Rubric No. 282, Column 50, Line 13
In pharaonic Egypt, solid perfume cones made of animal fat and scented oils were customarily worn on the head during banquets. This is illustrated not only in representations of attendees, but also different aspects of the production process (Shelmederine 1985:16, 128). In addition to their ritual use in banquets, to venerate statues of deities, and in mummification, ancient Egyptians also utilized perfumed substances in secular life for hygienic and cosmetic purposes “when baths were scarce and soap nonexistent” (Brun 2000:277; Halioua and Ziskind 2005:47-52; Matthews 1973:1-4; Shelmederine 1985:123-4, 126-8). This included the application of perfumed oils to skin and hair, fumigating living spaces, as well as the preparation of cosmetics (Bryan 1930:164; Halberstein 2005:686-7; Halioua and Ziskind 2005:87; Plin. Nat. 12.40).

Perhaps the most famous cosmetic was kohl, a black powder made of antimony to paint eyelids, and likely would have been used in conjunction with other preparations that had both cosmetic and medicinal applications (Halioua and Ziskind 2005:134; Matthews 1973:2). The Ancient Greeks are also documented to have offered gifts of perfumed oil to the gods and included them in burials and also treated their clothes with them (Shelmederine 1985:123-9).

In terms of production procedures, administrative tablets from Mycenaean Pylos document the main method for the extraction of floral essences. It involves enfleurage, which Matthews (1973:46) defines as: “an absorption process whereby flowers were spread on greased plates, the flowers being frequently removed so that more and more perfume could be absorbed by the grease or fat”. The greased plates would have been a modern innovation, which, in its ancient formulation, consisted of one of two techniques. The similar form involved steeping flowers in cold olive, almond, or sesame oil. The second involves maceration (or hot steeping), utilizing two critical steps. The first, stypsis, prepared the oil by adding a series of astringents that “…did not scent the oil, but made it more receptive to stronger fragrances…” (Shelmederine 1985:13). This would have been particularly necessary for olive oil, which Theophrastus (de Odor, 55 in Shelmederine 1985:14) highlights does not hold scents well. The second step involved the repeated steeping, straining, and addition of aromatics (usually coriander, sage, or rose) (Brun 6)

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6 In one particularly instance, four linked wood vessels are labeled, indicating their contents as: 1) “excellent kohl”, 2) a medicinal remedy for the eyes that “opens vision”, 3) cease bleeding, and 4) to repel insects (Halioua and Ziskind 2005:134).
Steps of the manufacture process are illustrated in various wall paintings which show, among other things, men stirring the contents of large basins resting on ovens and hot boxes that provided indirect heat, the extraction of floral essences using the torsion press method, which involves the twisting a sack above a large storage jar, as well as the importation of various aromatic ingredients, such as the carrying of incense and myrrh trees in ceramic pots (Brun 2000:278; Halioua and Ziskind 2005:16).

A series of Assyrian tablets from the palace at Mari document a further variation on the process, which included successive rounds of heating, steeping, and setting overnight, adding a different set of ingredients at each stage. (Brun 2000:278; Shelmederine 1985:15). The production process could take up to two weeks with the end-products being used as luxuries consumed primarily by members of royalty or for ritual purposes in the temples (Brun 2000:278). Similar contexts of use are documented at Pylos, as well as by the Hebrews during the rabbinic period (Brun 2000:279-81; Green 2011; Shelmederine 1985:123-4, 130).

I.D. An Approach to Examining Prestigious Products in Prehistoric Contexts

Based on the above information, there appears to be a significant body of knowledge about the production and use of prestigious products in the Eastern Mediterranean region in historic times. Much of this insight derives from the range of textual sources discussed above, but we know much less about the range of products being produced and consumed prior to advent of writing. It is insufficient to rely on ancient texts that date hundreds (and in some cases, thousands) of years later. Moreover, it must be acknowledged that like these texts, the products which they describe would have been produced and consumed in discrete cultural contexts in societies with drastically different trajectories of social, economic and political development.

Wylie (1985, 1988) and numerous other scholars (Stahl 1993; Lyman and O’Brien 2001; Feinman 1997) have discussed the dangers of using historic analogies, which will not be repeated here. However, what must be underscored is that these warnings are especially salient for the Mediterranean in general and Prehistoric Bronze Age Cyprus, in particular. The reason being that while Cyprus from the later Protohistoric Bronze Age into the Classical periods
represent periods of hellenization to various degrees, the Prehistoric Bronze Age precedes this process of cultural and linguistic influences from the Greek world (Dikaios 1962; Fisher 2009b; Frankel and Webb 2000; Karageorghis 2002; Leriou 2005; Peltenburg 1996; Stewart 1962). Thus, the specific descriptions noted in the Classical Greek texts would be more associated with later cultural formations on the island. Beyond the mere identification of the types of prestigious products made and the ingredients used to make them is the more informative consideration of contexts in which they were used, since these are indicative of the broader social, economic and political landscape of the period.

As will be discussed in the next chapter, the preparation and consumption of prestigious substances is often accomplished in highly significant, communal events that have specific social, economic, political and religious goals (Bray 2003; Dietler and Hayden 2001; Dietler 2006; Mintz and DuBois 2002). As such, any use of subsequential textual descriptions inherently requires one to accept the assumption that the same substances would have been consumed in similar social contexts with the same ideological implications. Reliance on such assumptions does not serve the aim to document the range of substances that were produced and consumed in the past by ancient peoples and the significance that was attributed to them. While the ancient documents discussed above are most certainly useful in providing insights into general patterns of behavior in the ancient Mediterranean world, similarities in the substances that were produced and the social contexts in which they were consumed must be demonstrated materially, rather than imagining a continuity in practice.

To accomplish this in a prehistoric setting, a systematic program of organic residue analysis is required that is focused on ritual and serving vessels that are likely containers for the categories of prestigious products outlined above. In this kind of product-centered approach, targeting a range of substances that includes psychoactive substances, medicines and perfumes is particularly suited for a prehistoric context because:
1) The chemical compounds found in these products have a more restricted range than many food stuffs,
2) The ethnohistoric record from around the world, the Mediterranean included, consistently documents the importance attributed to these specialized products, and
3) In smaller scale societies with emerging, but not yet established, social complexity, such substances may be associated with communal events that served a variety of social functions.

The latter point should be underscored because prestigious products would have been highly valued, held ritual or symbolic value, and would have conferred prestige on their owners and users, particularly when consumed and used in public, communal settings, such as feasts (Appadurai 2003:3). Feasts are defined as repetitive events that mark important occasions that require significant inputs of time and resources and during which members of one or more communities would come together to accomplish a series of goals (Dietler 1996, 2006; Dietler and Hayden in Dietler and Hayden 2001).

These goals may include:

1) the commemoration of a religious holiday or political success,
2) the celebration of a rite of passage, such as a birth or a marriage,
3) the redistribution of food, drink and other gifts, or
4) the building of alliances and the creation of a series of social debts (Appadurai 2003; Rosenswig 2007; Spielmann 2002).

The feast, whatever the scale or purpose, seems to serve as a central social point in which the religious, the political, and the economic intersects. Feasts also serve as occasions on which opportunistic individuals may exert their influence to gain and incrementally consolidate their power over time (Brun 2000; Joffe 1998; Rigby 1985).

The significance of such communal events within the broader scope of social evolution is being acknowledged by an increasing number of anthropologists and archaeologists. To that end, one of the goals of this project was to highlight how residue analysis studies may be utilized not
only to document of range of organic products that were used in ancient times, but also to elucidate long-term social processes. As I discuss in the Chapter Two, the social processes under consideration pertain to the development of social complexity and the mechanisms by which such change is enacted. Questions concerning societal development has long dominated anthropological discourse with interpretative schemes shifting from identifying typological characteristics of “the state” towards an acknowledgement that the path to complexity is dynamic and multifaceted (Blanton et al. 1996; Bray 2003; Cobb 2003; D’Altroy and Earle 1985; Fried 1967; Kristiansen 1998; Friedman and Rowlands 1978; Service 1971).

Archaeological models for politico-economic evolution have frequently focused on the analysis of state-level societies with an emphasis on social differentiation and competition. In order to address the mechanisms that resulted in complex society, such a model must account for both social differentiation and social evaluation (D’Altroy and Earle 1985; Renfrew 2004b, 1986; Schortman and Urban 1994). A model centered on feasting addresses both centrifugal and centripetal social mechanisms, while enabling the identification of contexts of interactions that would have served as arenas for the performance of social, economic, and political negotiations and transformations (Appadurai 2003; Bray in Bray 2003; Dietler and Hayden in Dietler and Hayden 2001; Pollack in Bray 2003; Twiss 2008). Central to the connection between these ideas about emerging social complexity and residue analysis is the basic notion that what is prepared and consumed at commemorative events is just as significant as the event itself.

In Chapter Three, I argue that the prehistoric Bronze Age on the island of Cyprus represents a good case study for examining the role of prestigious products in a social context of emerging complexity. What makes Cyprus a good case study can be summarized in three main points:

1) it is the only island in the Eastern Mediterranean,
2) it has a long record of occupation that spans some 10,000 years, and
In connection with the focus on prestigious products, it may be noted that, like elsewhere in the Eastern Mediterranean region, finely made and highly decorated containers begin to appear in Cyprus during the Chalcolithic period and Bronze Ages, approximately dating to 3900-2400 cal B.C.E and 2500-1000 B.C.E., respectively. These containers, which largely occur in the shapes of jugs, bottles, flasks, and small bowls and would have been well-suited for the storage of liquid products, have been taken as evidence for the production of fermented beverages, such as beer and wine (Knapp 2008:70, 1993:90; Manning 1993:45; Steel 2004a:13, 113; 2004b:282; 2002:107-8). These suggestions echo Sherratt’s (1987) proposition that the appearance and spread of the drinking vessels in Europe and the Near East indicates that fermented beverages likely played a role in the emergence of social complexity in these societies. However, as I highlighted above, it is insufficient to assume that function of these vessels based on later socioeconomic developments in the region.

In Chapter IV, I outline the analytical program that was developed for investigating the presence of the three categories of prestigious substances in pottery vessels that span the Bronze Age on Cyprus. In addition to reviewing and evaluating the various techniques that have been used to analysis different kinds of residues, I discuss the results of taphonomic studies on opium, the range of plants and other products that would have been available on the island during the Bronze Age and for which reference chemical data were collected, as well as the strategy employed for collecting samples from archaeological objects.

In Chapters V and VI, I describe the chemical analysis and provide an in-depth interpretation of the data for a total of 112 separate pottery samples. This large sample set consists of:

1) pottery samples (predominantly potsherds) from five stratified sites, spanning the Bronze Age. These include: Episkopi Bamboula, Alamba Mouttes, Marki Alonia, Politiko Troullia, and Sotira Kaminoudhia.

2) museum objects from the Semitic Museum at Harvard University, as well as two collections held at the University at Albany, all of which lacked provenience information.
Chapter V also includes a description of the contexts from which the samples were collected and a summary of the products that were identified in the various vessels, as well as discussion of some the general patterns of use.

In Chapter VII, I discuss the chronological and spatial patterns in the types of products being utilized on the island, how these data are informed by the social, economic and political landscape of the Bronze Age, as well as the specific roles that prestigious products would have played in the emergence of complex society on the island. I also highlight some problems with the data set, issues involved in the synthesis of chemical data with social phenomena in prehistoric settings, and draw attention to drawbacks in the methodology.

Chapter VIII summarizes the major questions posed, reviews key observations, and suggests some directions for future work.

The Appendix consists of all of the analytical reports that were generated in the course of the analysis and that served as the basis for the interpretations discussed in Chapters V and VI, which includes reference samples, experimental work, as well as the full set of archaeological samples. Due to the size of the dataset, it will be made available online in The Digital Archaeological Record (tDAR).
II. FEASTING AND THE EMERGENCE OF SOCIAL COMPLEXITY

II.A. Introduction

One of the key concerns in anthropological discourse deals with the origins of complex society. Over the last decade, interpretative perspectives have shifted from preoccupations with identifying typological characteristics of “the state” to an acceptance that the trajectories towards social complexity are numerous and multidirectional. There has been an increasing focus on feasting as a theoretical model for identifying contexts of interaction that would have served as arenas for social, economic and political changes (Blanton et al. 1996; Bray 2003; Cobb 2003; D’Altroy and Earle 1985; Fried 1967; Kristiansen 1998; Friedman and Rowlands 1978; Peltenburg 2012; Potter 2000; Service 1971). From an anthropological perspective, feasts are repetitive events that mark important occasions that require a significant input of time and resources and serve as central social points in which the religious, the political, and the economic intersect. In application, the use of the feasting model has focused on:

1) standards for identifying feasting in archaeological contexts (Dietler 2001; Hayden 2001),

2) the examination of the role of feasting in the domestication of plants (Hayden 2009, 2003; Twist 2008), and

3) the maintenance of state power (Pollack 2003; Rosenswig 2007).

However, in most cases little consideration is given to the products that are being consumed during these highly significant social events. From the perspective that feasts tend to be large, communal or inter-communal affairs, the identity of the products that are prepared, consumed, discarded and displayed is essential to the significance of the event. Inasmuch as feasts require large investments of labor, resources, and planning, what is produced and provided during the course of a feast is of great consequence.

II.B. The Feasting Model

Feasts are defined as accumulations of singular and repetitive events that represent the intersections of dynamic society. This is not limited to singular considerations of the religious,
economic, political, or social, but rather a central point of intersection in which a combination of strategies are played out that have specific transformative results. Accepting the notion that feasting events constituted important occasions that required a significant input of time and resources, it is argued that place, actions, and products involved during these events are also significant (Appadurai 2003:10-15; Bray 2003; Dietler 2001:76-81; Hayden 2001:2-30; Rosenswig 2007:2). The implication for the scope of my dissertation research is that an integrated approach centered on the examination of the role of feasting in strategies of social distinction and systematic organic residue analysis provides a framework for examining formative processes of social change from the ground up.

Communal consumption, both of food and non-food products, is socially, politically, and economically significant. The various forms of communal consumption have been grouped under the collective term of feasting, which involves repeated events that operate as arenas for the performance and negotiation of diverse agendas (Bray 2003:95-7; Dietler 2001:76-7; Mintz and DuBois 2002:108; Twiss 2007:51). A theoretical model based on feasting aims to identify the contexts of such transformative interactions by acknowledging that feasting events constitute central points of intersection in which a combination of strategies are enacted that have specific results (Bray 2003:93-4; Dietler 2001:103-4; Twiss 2008:436).

II.B.1 A Review of Strategies of Social Distinction

Attempts to identify feasting contexts have largely emphasized funerary ritual and competitive displays of wealth, both of which fall under the label of conspicuous consumption. However, these are just two types of feasting practices that only consider competition. Feasts are contexts in which participants engage in various social transactions that simultaneously create opportunities for individuals to distinguish themselves while reproducing communal solidarity that results in building relationships (Appadurai 2003:21-5; Bray 2003:94; Dietler, Hayden in Dietler and Hayden 2001; Hayden 2001:24-5; Pollack 2003; Rosenswig 2007:5; Twiss 2008:436). In
order to get the full picture, it is necessary to view both categories of feasting\(^7\) as complementary and in diachronic perspective.

Feasting represents a social practice characterized, above all by the communal consumption of both subsistence and non-subsistence comestibles and other specialized objects and is distinguished from daily consumption (Bray 2003:97-9; Dietler in Dietler and Hayden 2001). The communal aspect highlights the fact that feasts are contexts in which participants engage in various social transactions that result in building relationships and fostering social solidarity. The consumption aspect highlights the number of resources required for such events to take place and, therefore, participation may simultaneously create a series of debts or social obligations, as well as conferring prestige or status on major players. Thus, feasts constitute competitive arenas for the deployment of various strategies of social distinction (Appadurai 2003:23-5; Bray 2003:94; Dietler 1996; Dietler and Hayden 2001; Rosenswig 2007; Spielmann 2002).

That residue analysis is the selected methodology of this project necessarily orients feasting in a product-focused approach. Products viewed as commodities are embodied with value through exchange (Appadurai 2003:3). Thus, the conception of value, whether economic, social, or political, is ultimately a fluid thing that changes depending on the nature of the exchange. A product-focused approach that acknowledges that commodities are invested with meaning permits the analysis of these variable transactions of value. The identity of these products, commodities, and objects are significant and our understanding of them is related to the understanding of the functioning of the social, economic, and political system and the evolution of society. Numerous scholars have focused on the mechanics of complex economies and how they affect the constitution and evolution of society. However, limited attention has been given to the identity of commodities that are the basis of these economies with the most significant differentiation being between luxury and bulk goods (Blanton et al. 1996:2-7, 12; D’Altroy and Earle 1984:188-9, 194-5; Earle 1987; Flannery 1972; Knapp 1990; 1996; 2008; Muhly 1996; Renfrew in Renfrew and Cherry 1986). Such a differentiation inherently centers the discussion on

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\(^7\) These two categories of feasting include: 1) those promoting social cohesion, and 2) those promoting social distinction through competition.

This focus on an elite social class consisting of aggrandizers in competition with each other has been characterized as the driving force behind the emergence of rank and the development of social complexity and has led to an auxiliary emphasis on the politics and economics of prestige (Clark and Blake 1994; D’Altroy and Earle 1985:187, 196; Earle 1987; Rosenswig 2007:2). In this respect, social structural differences associated with economies based on staple versus luxury goods have been highlighted and the fundamental role of prestige goods in all economic formulations acknowledged (Blanton et al. 1996:5-6; D’Altroy and Earle 1985:187-8). Cobb (2003:74-5), Kristiansen (2005, 1998:248-50, 263), Renfrew (2003:143-4) and Stein (1998:5-6, 23-4) have demonstrated the variable types, sources, and constitutive roles that prestige goods play in pre-state societies. To this end, while Blanton et al. (1996:4-5) elaborated the kinds of power strategies enacted by individuals seeking to differentiate themselves, there has been little consideration of the social context in which they would have played out. A further issue is that models for politico-economic evolution frequently focus on the analysis of state-level society which is the end result, rather than addressing the mechanisms that led to it (D’Altroy and Earle 1985; Renfrew 2004; Schortman and Urban 1994). Thus, the consideration of formative processes and the social contexts in which they would have been enacted has been largely relegated to issues of social competition and distinction to overly simplistic notions of competitive emulation.

The latter is one aspect of the economic theory of conspicuous consumption proposed by Thorstein Veblen (1899) (Aglaze 2001:205-7; Dabney et al. 2004; Hamilikas 1999; Lev-Tov and McGeough 2007; Renfrew 1986; Steel 2004b). The central tenet of the theory is the emergence of a leisure class that continually accumulates wealth through the fruits of the working class (Trigg 2001:99-101; Veblen 1899). Accordingly, members of the leisure class communicate their status by transforming their wealth into status through the social performance of display and discard (Trigg 2001:101). The aspect of display refers to the fact that “wealthy individuals often consume highly conspicuous goods and services to advertise their wealth” with individuals in lower points
of the social hierarchy emulating this pattern of consumption in an effort to likewise increase their social status (Bagwell et al. 1996:349; Trigg 2001:99). These concepts were adopted into the anthropological discourse under the labels of conspicuous consumption, competitive feasting, and competitive display. However, these terms are frequently used interchangeably, rarely defined, and less frequently demonstrated materially.

As mentioned above, characterizations of prestige-goods economies frequently incorporate the general notion of conspicuous consumption by putting “wealth ‘in evidence’”... individuals were “rewarded with preferential treatment by social contacts” (Bagwell et al. 1996:353). Although this makes the mobilization of prestige goods a legitimate strategy of distinction, still lacking is the identification of the social context in which such a strategy would be employed and its material correlates. Thus, there are two major issues regarding the archaeological application of Veblen’s ideas. First elite emulation, competitive feasting, and conspicuous consumption are all different strategies with particular goals (Dietler 2001; Hayden 2001:45). Second, they are all strategies of social distinction and differentiation. Clark and Blake (1994) discuss the necessary conditions for which an anthropological theory addressing social evolution must account: social differentiation and social evaluation. Competitive strategies account only for the first, social distinction. From this perspective, it is argued that a product-centered approach to feasting accounts for the pitfalls of a conspicuous consumption approach. Feasts then are social contexts that simultaneously foster social solidarity, while providing occasions for individual social maneuvering within culturally acceptable ways (Dietler and Hayden 2001; Twiss 2008:427, 436).

II.B.2. The Role of Prestigious Products in Feasting Practices

The third proposition stems from the basic acknowledgement that the identity of the products that are prepared, consumed, discarded, or displayed is essential to the significance of the feasting event itself. However, insufficient attention has been given to the role of non-subsistence products within feasting events, despite their inherent value and capacity to confer prestige onto their owners, producers and users. One of the key goals of a feast is the provision
and consumption of food and drink, which achieves the goal of contributing to the welfare of participants and society at large by feeding the body. As Dietler (2001:95-99) details in the feasts held by the Luo in Kenya, large quantities of beef and beer, foods reserved for these special occasions, are provided over a series of days in special containers. This is especially the case for the beer, which is prepared in large pots and consumed through long, bamboo straws. A similar method for drinking beer is depicted in Egyptian wall paintings and Mesopotamian seals (Collard 2011:116; Jennings et al. 2005; McGovern 2009:70; Thone 1931:379). Both Collard (2011:116) and Crewe and Hill (2012) discuss representations of drinking rituals in Cyprus, one of which is a seal8 showing a seated figure drinking from a straw.

Numerous scholars highlight the culinary provisions at feasting events (Ben-Shlomo et al. 2009; Dabney et al. 2004; Rosenswig 2007; Twiss 2008, 2007; and others). However, a secondary function infrequently addressed is the contribution to the welfare of participants in mind, which relates to the triad of prestigious products outlined in the introductory chapter. In this vein, medicines and perfumes may serve to heal, anoint and purify, while psychoactive substances may serve to ease social relations and facilitate communication with the supernatural (Brun 2000; Fappas 2008; Furst 1990; Goodman et al. 1995; McClenon 1997; Price 2001; Rudgley 1993). In the Luo case, the provision of large quantities of beer both feeds and eases social relations (Dietler 2001). Examples of the use of perfumed substances in Egyptian banquets were discussed in the introductory chapter. In his discussion of the use of perfumed oils in feasting activities in Mycenaean palaces, Fappas (2008:370) highlights that "...the practice of providing perfumed oils together with various other materials and foodstuffs for feasting activities was not confined to the Mycenaean, but was practi[s]ed throughout the contemporary ancient Near East..."9.

Furthermore, in as much as feasts require a large investment of labor, energy, and resources, what is produced and provided during the course of a feast is of great consequence from a socioeconomic perspective (Bray 2003:93; Dietler 2001:82; Weissner 2001:117). Jennings

8 Likely of Mesopotamian influence.
9 It is important to note Bushnell’s (2012:198-9) argument that the use of perfumed substances was predominantly an Eastern Mediterranean tradition and not a Mycenaean one.
et al. (2005) discuss aspects of labor and resource investment involved in the alcohol production in Mesopotamian political feasts. The manipulation of such prestigious products within discrete social settings constitutes a fundamental material means for individuals seeking to differentiate themselves and to exert and maintain their influence (Brun 2000; Joffe 1998; Ridgy 1985). Here it must be noted again that the social scale of the societies in which feasting is typically examined (e.g., pharaonic Egypt, Hittite Anatolia, Babylonian and Assyrian Mesopotamia, palatial Greece) represents a situation of fully emergent complexity. As such the role of feasting is modeled in the maintenance and renewal of political structures, rather than illustrating the role that more informal variations of feasting contributed to the emergence of social and political structures. Some key exceptions are discussed by Twiss (2008), Kuijt (2009) and Hayden (2009), who highlight the role of feasting in small scale societies in the domestication of plants and the emergence of agriculture.

II.B.3. Characteristics and Types of Feasts

The ethnographic literature on feasting in small scale societies has been particularly instructive in illustrating the diversity in feasting practices, in both scale and kind, as well as the degree to which feasting is situated at the intersection of the social, economic, religious, and political spheres. For instance, Bower (1998) highlights the role of elaborate feasting among the Aka people in Northern Thailand, who otherwise lead a meager existence. Here, “feasts act as an all-purpose ritual oil that lubricates Aka society’s interconnected parts, from struggling nuclear families to powerful coalitions of village chiefs” (Bower 1998:331). This also echoes the notion outlined in the introductory chapter, that the feast is a communal event that achieves a series of specific goals. One of these goals that applies equally to Aka society as it does to the prehistoric Bronze Age in Cyprus is that feasts also serve as “platforms for leaders to forge political alliances that feed their authority” (Bower 1998:332).

From this perspective, there is sufficient evidence in the anthropological and archaeological literature that suggests that feasting, in all its formulations, does in fact serve as a major mechanism for social change. Admittedly, numerous anthropological perspectives have
proved lacking when attempting to connect theoretical constructs to archaeological data. In this respect, it is acknowledged that individual feasts may not be easily identifiable in the archaeological record. However, from the perspective that feasting is a practice, Hayden (2001), Rosenswig (2007), Twiss (2008) and Weissner (2001) have defined a series of material correlates that, taken in sum, are indicative of feasting (see Table 2.1). It should be noted that all feasts will not have the same characteristics and, as such, their material correlates should not be treated as a trait list (Twiss 2007:54-5).

It may be noted here that Hayden’s list is perhaps most comprehensive, covering a wide range of possibilities that may manifest themselves at various social scales. Rosenswig (2007:6) relates these ideas to the archaeology by defining categories of traits and connecting them to specific feasting behaviors and the material evidence to which they may be correlated. On the one hand, Weissner’s components appear to be tailored to the specific circumstances associated with her ethnographic study of Enga feasting in New Guinea. However, this level of specificity is perhaps of limited utility when considering feasting practices in a prehistoric archaeological setting.

<table>
<thead>
<tr>
<th>Table II.A Comparison of Characteristics of Feasts</th>
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<tbody>
<tr>
<td>Hayden’s Archaeological Signatures of Feasts (After Hayden 2001:40-1)</td>
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<tr>
<td>1) Rare, labor-intensive, or special food items</td>
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<tr>
<td>2) Preparation vessels of unusual types, sizes, and/or numbers</td>
</tr>
<tr>
<td>3) Serving vessels of unusual quantity, size, and/or numbers</td>
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<tr>
<td>4) Facilities for food preparation of unusual size, number, location and/or construction</td>
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<tr>
<td>5) Features indicating special use and discard (e.g., bone deposits, fires, middens)</td>
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<tr>
<td>6) Feasting facilities consisting of specialized structures for individuals of higher rank</td>
</tr>
<tr>
<td>7) Special locations (mortuary, non-habitation sites, large communal spaces)</td>
</tr>
<tr>
<td>8) Conspicuous consumption or display of prestige items</td>
</tr>
<tr>
<td>9) Ritual containers or other paraphernalia for consumption of prestigious drinks</td>
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<tr>
<td>10) Paraphernalia associated with public performance (e.g., masks, costumes)</td>
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<tr>
<td>11) Evidence of hierarchy and elites</td>
</tr>
<tr>
<td>12) Recordkeeping</td>
</tr>
<tr>
<td>13) Pictorial representations and written descriptions of feasts</td>
</tr>
<tr>
<td>14) Facilities for food storage</td>
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<tr>
<td>15) Evidence of surplus, intensified exploitation and abundance</td>
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<tr>
<th>Weissner’s Components of Feasting (After Weissner 2001:116-7)</th>
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<tbody>
<tr>
<td>1) Aggregation of people</td>
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<tr>
<td>2) Food sharing and food distribution</td>
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<tr>
<td>3) Feast marking special occasion</td>
</tr>
<tr>
<td>4) Competitive display of food, objects, individuals or groups</td>
</tr>
<tr>
<td>5) Consumption of abundant surplus</td>
</tr>
<tr>
<td>6) Changing patterns of land use</td>
</tr>
</tbody>
</table>
Rosenswig’s Behavior and Material Expectation for Documenting Feasting Archaeologically (After Rosenswig 2007:6)

1) Facilities:
   a. Food preparing facilities: distinct hearths, roasting pits
   b. Special feasting location: distinct houses, mounds
2) Food preparation
   a. Food processing (grinding/cutting): manos and mutates, chert obsidian,
   b. Food cooking: boiling pots, fire cracked rock
3) Food presentation
   a. Serving food: fancy dishes and platters
   b. Serving drink: fancy cups and jars
   c. Serving larger groups: large vessels and distinct size classes
4) Food Consumption:
   a. Specialized use of meat: distinct species/cuts of meat
   b. Specialized use of grain: distribution of macrobotanicals

More informative is Dietler’s (2001:76-82) delineation of different types of feasts and the ways that they functioned within the broader politico-economic landscape (Rosenswig 2007:5). There are three broad types of feasts: 1) empowering or entrepreneurial feasts, 2) patron-role feasts, and 3) diacritical feasts. The first is based on the “manipulation of commensality hospitality” with the aim of accumulated social capital in the form of personal prestige, social or economic debts, or political influence. While this type of feast may not necessarily be outright competitive, there is a degree of social negotiation and typically is found in societies with incipient rank (Dietler 2001:76-82; Rosenswig 2007:5).

The second type, the patron-role feast, represents a formalized version of the empowering feast, but with the focus being on the legitimization of asymmetrical power relationships. In this situation, commensal hospitality and redistribution is viewed as the duty of the patron, but with no “expectation of equal reciprocation” (Dietler 2001:82-3). The diacritical feast is differentiated from the patron-role feast in that emphasis is on exclusionary commensality based on style and taste with no obligation of hospitality (Dietter 2001: 85). Steel (2004b:284) defines diacritical feasts as “symbols of exclusive membership…. characterized by distinctive cuisines (exotic foods or complicated modes of preparation) and elaborate dining sets, and frequently make reference to specialized knowledge of external, exotic social practices as a means of demonstrating their exclusivity”, such as in the case of the Classical Greek symposium.

Hayden (2001:38) also differentiates between types of feasts based on their social function, which overlap with Dietler’s scheme to some degree. These categories include:
1) alliance or cooperation feasts, which aim to build solidarity, political support, and reciprocity,

2) economic feasts, which are centered on political or economic gain, and

3) diacritical feasts, which are based on sumptuous consumption and competitive display for expressing exclusivity and distinction (Hayden 2001:38).

However, as Rosenswig (2007:5) highlights,

“[T]ogether feasts of all these types ‘…act as the modal context that articulate regional exchange systems’ (Dietler, 1996, p. 91) and encompass virtually all ceremonial and ritual occasions. Such economic and ceremonial systems provide the mechanisms of social solidarity and establish long-term obligations that form the glue of social relations (Mauss, 1990[1924]).”

Thus, it must be acknowledged that feasting behavior, particularly in the case of smaller scale societies with incipient ranking, cannot be considered as a separate political, economic or ritual phenomenon, but rather represents that culmination and intersection of all of these aspects. To that end, it may be noted that in her consideration of the distribution and variability of ritual sites in Neopalatial Crete (1700-1450 B.C.), Adams (2004:26) draws attention to the fact that religious ritual served as a performative practice that both expressed Cretan identity and signified politico-economic action. Twiss (2008:424) echoes the existence of a strong correlation between feasting and ritual performance through “ostentatious displays” and the consumption of food and drink.

II.C. A Product-Focused Approach to Emergent Complexity

From the perspective that feasts tend to be large, communal or inter-communal affairs, the identity of the products that are prepared, consumed, discarded and displayed is essential to the significance of the feasting event. Such a product-focused approach centered on the identification of the prestigious products discussed in the previous chapter makes chemical analysis an ideal methodology for examining feasting behavior as it relates to social complexity.
The focus is on prestigious products, such as psychoactive substances, medicines, and perfumes, because:

1) constituent compounds (alkaloids and essential oils) have a more restricted range than many food stuffs,

2) the ethnohistoric record from around the world documents the role of specialized products in feasts and other communal events, and

3) in smaller scale societies, such as the Prehistoric Bronze Age on Cyprus, with emerging but not established complexity, such substances may be more indicative of special functions than subsistence products.
III. THE PREHISTORIC BRONZE AGE ON CYPRUS: A CASE FOR EMERGING COMPLEXITY

III.A. Background

The island of Cyprus has a land area of 9,251 km\(^2\) making it the third largest in the Mediterranean basin (Knapp 1994:390; Stanley-Price 1977:27; Steel 2004a). The island has four major geographical zones, namely the Kyrenia, or Pentadaktylos, Mountains in the north, the central Mesoaria plain, the Troodos Massif, and the Coastal Belt in the south. The Troodos is a “largely infertile, igneous formation, surrounded by a ring of pillow lavas in the lower zone”, which are the source of the copper ores from which Cyprus derives its name (Steel 2004a:2-3). Human occupation of the island dates back to the 11\(^{th}\) millennium B.C., when the Akrotiri Peninsula was inhabited on a temporary and presumably seasonal basis. Sustained human occupation of island begins in the 9\(^{th}\) millennium B.C., with, what Alan Simmons terms, the Pre-Pottery Neolithic agro-pastoral settlements along the southern coast (Simmons 2007; Butzer and Harris 2007:1934-6).

The settlement record of Cyprus is punctuated by a series of settlement discontinuities, which occur at the boundaries of the Aceramic and Ceramic Neolithic, the Chalcolithic, and Bronze ages.

Cypriot prehistory is unique in the island archaeology of the Mediterranean in that it is the only island located in the Eastern Mediterranean and has never been connected to the mainland. Cyprus’s physical location has influenced the course of the island’s development and its interactions with surrounding mainland societies (Butzer and Harris 2007:1932-4; Evans 1973:517-8; Evans 1977:13-15; Held 1989; Knapp 2008:67-68, 1997:163-5; 1994:393-4; Shackleton et al. 1984; Simmons 2008:22-3; van Andel and Shackleton 1982).

Besides geography, the characteristic of Cyprus that had the greatest affect on social development on the island is the concentration of copper ores in the central Troodos Mountains. The local rise of social and political complexity was fundamentally tied to control over this lucrative resource (Fisher 2009b; Knapp 2008, 1993, 1990; Steel 2004a; Swiny 2008).

Archaeologists have examined various aspects of the Bronze Age in order to understand how complex society developed on the island and how it is related to the histories of its surrounding polities. The focus has invariably been on the Protohistoric or Late Bronze Age, which was an
urban-centered society that played an increasing role in the international trade networks of the Eastern Mediterranean. However, this is a fully developed urban situation, wherein relationships of power had already been firmly established (Fisher 2009b; 2007; Knapp 2008, 1996, 1993; Muhly 1996; Swiny 1997, 1989; Webb et al. 2006). Thus, archaeologists are focusing on the end result, rather than taking a diachronic approach in an effort to identify processes and mechanisms of change. I argue that it is during the Prehistoric or Early and Middle Bronze Age that individuals and groups were negotiating the social, political, and economic relationships that are firmly established and evident in the later Protohistoric Bronze Age.

III.B. Cyprus in the Bronze Age

The Bronze Age on Cyprus has long been characterized as a dynamic period. A number of significant social, economic, political and cultural changes occurred during the beginning of the Protohistoric Bronze Age (Middle Cypriot III-Late Cypriot I, c. 1700-1400 BCE), and which ultimately led to the “urban-oriented” society in the latter part of the Protohistoric Bronze Age (Late Cypriot II-III, c. 1400-1000 BCE) (Dikaios 1962; Fisher 2009b; 2007; Keswani 1989; Knapp 2008, 1990; Steel 2004a). These changes included:

1) demographic growth,
2) social stratification,
3) intensification in agricultural production and copper exploitation,
4) greater participation in the international trade networks of the Eastern Mediterranean,
5) the development of writing, and
6) the establishment of urban centers.

The relationships that lead to these social changes would have been negotiated in the preceding Prehistoric Bronze Age. It is generally held that the rise of sociopolitical complexity was linked to the control of the copper trade and therefore it has been argued that elites established themselves in positions of power by controlling copper sources, its processing into a valuable commodity, and the networks for its trade (Fisher 2007; Keswani 2005, 1989; Keswani and
Knapp 2003; Knapp 1986, 1988; Knapp and Cherry 1994; Manning 1993; Muhly 1996; Swiny 1997, 2008). However, the strategies employed by elite members of society to differentiate themselves are insufficiently considered. This partially stems from a research bias focused on the Protohistoric Bronze Age (Fisher 2007; Keswani 2005, 1989; Knapp 2008, 1993; Manning 1993).

In this respect, the Prehistoric Bronze Age has commonly been characterized as a simple, egalitarian village-based society. This perspective largely derived from antiquated views of prehistoric society in Cyprus as being resistant to change and generally lagging behind its mainland counterparts in Anatolia, Egypt, Greece, and Mesopotamia. Similar to archaeology in other regions, much consideration had been focused on identifying states and their characteristics. In Cyprus, the major focus had been on comparison with and the identification of Classical or Near Eastern cultural components and in determining why the island’s society did not develop along the same trajectory or timeline as surrounding polities (Dikaios 1962; Fisher 2009b; Karageorghis 2002; Knapp 1994:378; Leriou 2005; Peltenburg 1996; Stewart 1962). In addition the Prehistoric Bronze Age is poorly understood due to the limited number of stratified settlements dating to this period (Herscher in Swiny 2003:145; 1997:173-5; Webb and Frankel 1999:3).

In the last decade, the necessary historical deconstruction of biases in Cypriot archaeology has been accomplished with a new generation of scholars applying new theoretical models (Bolger 2003; Fisher 2009a, 2009b, 2007; Knapp 2008; 1994:378; Steel 2004a, 2002). Moreover, an increasing number of settlement sites dating to the Prehistoric Bronze Age have been excavated, which creates a distinct opportunity to examine processes of social distinction in a diachronic perspective (Coleman et al. 1996; Falconer et al. 2010; Fall et al. 2008; Frankel and Webb 2000; Swiny 2008, 2003, 1986). As a result of this work, Knapp (1994) proposed a revised chronology that better accounts for the social developments of this period. The bases for the revisions have been discussed in-depth elsewhere (Bolger 2003; Fisher 2007; Knapp 1994) and will not be repeated here (see Tables III.A.1 and Table III.A.2 for a complete chronology for Cypriot prehistory).
I follow Knapp (2008; Knapp 1994:377-8) in arguing that the prehistoric Bronze Age must be understood in its own terms, rather than in comparison to the increasingly cosmopolitan protohistoric Bronze Age (Knapp 2008; Steel 2004a:13-18). To that end and to adequately connect the theoretical position outlined in the previous chapter, it is instructive to review the evidence for feasting and incipient social complexity on Cyprus leading up to the Bronze Age. Comparing the developments of the latter Bronze Age to that of the Neolithic, Chalcolithic and even the Prehistoric Bronze Age tends to overshadow incipient developments in emerging complexity.

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**Table III.A.1. Chronological Scheme for Early Cyprus**

<table>
<thead>
<tr>
<th>Cultural Designation</th>
<th>Chronological Period</th>
<th>Years B.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akrotiri Phase</td>
<td>Epipaleolithic</td>
<td>10,000-9500?</td>
</tr>
<tr>
<td>Cypro-PPNA</td>
<td>Early Aceramic Neolithic</td>
<td>8500-7000</td>
</tr>
<tr>
<td>Cypro-PPNB</td>
<td>Ceramic Neolithic</td>
<td>4500-3900</td>
</tr>
<tr>
<td>Khirokitian</td>
<td>Early Aceramic Neolithic</td>
<td>7000-5500</td>
</tr>
<tr>
<td>Sotira Culture</td>
<td>Ceramic Neolithic</td>
<td>4500-3900</td>
</tr>
<tr>
<td>Early Erimi Culture</td>
<td>Early Chalcolithic</td>
<td>3900-3400</td>
</tr>
<tr>
<td>Middle Erimi Culture</td>
<td>Middle Chalcolithic</td>
<td>3400-2800</td>
</tr>
<tr>
<td>Late Erimi Culture</td>
<td>Late Chalcolithic (see Table III.A.2)</td>
<td>2800-2400</td>
</tr>
</tbody>
</table>

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**Table III.A.2 Traditional and Revised Chronological Scheme for Bronze Age Cyprus**

<table>
<thead>
<tr>
<th>Revised with Dates</th>
<th>Traditional</th>
<th>Years B.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prehistoric Bronze Age 1</td>
<td>Late Chalcolithic</td>
<td>2700-2500</td>
</tr>
<tr>
<td>2700-2000</td>
<td>Philia phase</td>
<td>2500-2400</td>
</tr>
<tr>
<td></td>
<td>Early Cypriot I-II</td>
<td>2350-2400</td>
</tr>
<tr>
<td>Prehistoric Bronze Age 2</td>
<td>Early Cypriot III</td>
<td>2000-1700</td>
</tr>
<tr>
<td>2000-1700</td>
<td>Middle Cypriot I-II</td>
<td></td>
</tr>
<tr>
<td>Protohistoric Bronze Age 1</td>
<td>Middle Cypriot III</td>
<td>1700-1650</td>
</tr>
<tr>
<td>1700-1400</td>
<td>Late Cypriot IA</td>
<td>1650-1550</td>
</tr>
<tr>
<td></td>
<td>Late Cypriot IB</td>
<td>1550-1450</td>
</tr>
</tbody>
</table>
III.C. Emergent Complexity through Feasting: A View from Early Cyprus

As noted above, human occupation on the island dates back to at least the 11th millennium B.C. when the Akrotiri Peninsula (Akrotiri Aetokremnos) was inhabited on a temporary and presumably seasonal basis primarily for the exploitation of dwarf hippos and elephants that inhabited many Mediterranean islands in the Pleistocene. Sustained human occupation of island begins in the 9th millennium B.C., with the appearance of agro-pastoral settlements along the southern coast of the island (Butzer and Harris 2007:1934-6; Simmons 2012:86-7; 2007:34, 2001).

III.C.1. Aceramic Neolithic

There are some general similarities with contemporary occupations on the Levantine mainland but Cypriot culture is already divergent by the Aceramic Neolithic, which suggests that a process more complicated than a direct migration from the southern Levant occurred (Simmons 2007:253-4; Stanley Price 1977:31; Steel 2004a:33-5, 45). Recent work has uncovered a small number of sites (Ayia Vavarva Asprokremnos, Ayios Tihonas Klimnos) that date to the early Aceramic Neolithic, which has led to a subdivision of the period into the Cypro-Pre-Pottery Neolithic A (or Cypro-PPNA) with which the two aforementioned are associated, and the Cypro-Pre-Pottery Neolithic B (Cypro-PPNB), the defining characteristic of which is permanent settlement (Simmons 2012:86-7). Archaeological sites dating to the Cypro-PPNB typically are short-lived, established on virgin ground, with architectural and storage features being dug into underlying bedrock, making it possible to identify more ephemeral architectural remains. For

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10 This is not intended to serve as a comprehension review of all of the archaeological sites and social developments that occurred during the early prehistory of the island; rather, the purpose of this contracted review is to highlight those elements that are characteristic of emerging complexity as detailed in the feasting model in the previous chapter.
instance, at the site of Parekklisha Shillourokambos, there was a series of cylindrical wells and basins, ditches, post- and stake-holes within trapezoidal and circular enclosures. The later occupation of the site indicated the construction of small, circular houses with stone foundations, large quantities of finished obsidian artifacts from Anatolia and a number of finely made ground stone bowls. A burial with a single inhumation in contracted position without any grave goods was located under a house floor and later used as a pit for a large quantity of rich meat-bearing bones. The large quantity of food remains in a burial feature could suggest the kind of informal feasting typical of small-scale agricultural societies discussed by Twiss (2008, 2007) (Bolger 2003:215-7; Guilaine and Briois 2001; Steel 2004a:36-7).

There were also a series of monumental constructions, most notably a series of wells at the site of Kissonerga Mylouthkia. Similar to the burial at Shillourokambos, the wells at Mylouthkia also suggest a funerary and feasting component. For instance, in Well #133, two depositional events are represented. The first consisted of the disarticulated remains of four individuals, which suggests a secondary burial practice focused on the cranium. The second contained a cranium and upper vertebrae of a male with cranial deformation. Between these two human mortuary components were twenty unbutchered goats and sheep (Bolger 2003:215-17; Peltenburg et al. 2001; Peltenburg 2003) 11.

Another case of monumental construction that would have required a greater mobilization of labor is represented at the site of Khirokitia Vouni, which is a settlement that is entirely enclosed by a stone-faced wall with a controlled entrance that included a stairway. The conclusion that the construction was not defensive in nature is supported by the fact that there is little evidence for the existence of weapons and violence in the skeletal material. In general, there were few imports, which were usually deposited in subfloor graves. A key observation is the differential burial treatment based on gender with the females tending to be buried with ritually broken stone bowls and basins (Åström 1987; Le Brun 2003, 2001:114-5; Simmons 2007:246; Steel 2004a:47-51). The fact that the containers are broken may be related to what Grinsell

11 It is acknowledged that the lack of evidence for butchering may be more consistent with sacrifice.
(1961:475) terms “the ceremonial ‘killing’ of objects at funerals” and which may have been practiced for a series of reasons. These may include, but are not limited to: 1) releasing the spirit of the object, 2) to prevent looting and quarrels of surviving relatives, 3) fear of contamination or pollution, 4) to frighten away spirits, 5) to symbolize the importance of the deceased, or 6) to show that a funerary toast with wine, beer or another beverage was completed (Grinsell 1961:476-9).

In terms of the settlement architecture, the buildings tended to be small, circular and organized in groups around an unroofed space or courtyard. There is no evidence of storage in the way of pits or bins, which is notable since one of the characteristics of feasts detailed by Hayden (2001:40-1) is the evidence of surplus, intensified exploitation and abundance. However, it may be noted that while there was a general lack of differentiation between households, there were two exceptional structures that were located in close proximity to each other at the center of the site. Both were slightly larger than the other houses in the site with one having two piers that would not have served a structural function and with the other containing a large rectangular platform (Bolger 2003:217; Le Brun 2003, 2001; Steel 2004a:47-51). Thus, there appears to be evidence for incipient social distinction in differential burial treatment on the basis of gender and the construction of architectural units that served a special and perhaps communal function.

The later period at Kalavasos Tenta shows a similar set of relatively prominent and centrally-placed buildings. One such building contained a series of elaborated decorated ground stone bowls in conjunction with a raised floor that has been interpreted as a granary, but with no other real evidence of open or public spaces. Three other structures (14, 17, and 26) had a slightly more complex plan with atypical features, such as radial cells and remains of red plaster. In close proximity was structure 11, which contained two figures with upraised arms painted in red on the building’s internal piers, similar in construction to the building at Khirokitia (Bolger 2003:217; Knapp 1994:405; Todd 2001; Steel 2004a:51-2).
III.C.2. Ceramic Neolithic

The end of the Aceramic Neolithic, approximately 5000 B.C., represents a period of punctuated abandonment, after which emerges the Ceramic Neolithic, c. 4600 B.C., with a fully developed ceramic technology, novel forms of architecture, as well as changes in the location of settlements, the organization of domestic space, and funerary practices (Bolger 2003:218; Knapp 1994:406-7). These changes are evident at the inland site of Philia Drakos A, which consisted of a large subterranean complex of shafts and tunnels with multiple entrances and benches. In terms of ceramic material, the impermanent Dark Face Burnished tradition emerges and is later replaced by the Red-on-White pottery that is characteristic of the period. Accompanying this new range of cultural material is the suggestion of feasting behavior in the form of large quantities of animal bone and a cache of unused stone axes (Knapp 1994:406-7; Stanley Price 1977:34; Steel 2004a:64-6).

There is no discernible variation in house type, size, or contents at the plateau site of Sotira Teppes, but the associated Red-on-White ceramic repertoire has a particular emphasis on spouted bowls and other liquid containers (Bolger 2003:27, 218; Dikaois 1961; Knapp 1994:408-9). While direct evidence for social differentiation and any feasting-oriented practices is lacking, the appearance of these new shapes may suggest an increased emphasis on presentation and consumption, perhaps, Steel (2004a:54, 56, 64-6) has suggested, of an alcoholic beverage, though milk or another culinary mixture is equally likely.

Two sites that are contemporaries of Sotira Teppes, Epiktitos Vrsyi and Klepini Troulia, were also located in prominent locations on the north coast. The former involved the construction of massive hollows measuring 6 meters deep with houses built inside and were initially made of wood. During the later occupation of the site, the houses were replaced with stone and plaster constructions and the settlement expanded to south with the northern portion being separated by a ridge. Although there were no public spaces for gatherings, some level of social differentiation is indicated by a greater distribution of artifacts and ritual equipment north of the ridge and a more crowded arrangement of houses in the south. Two houses in the northern section shown additional differentiation in size and function. House 1, which was located at the center of the
settlement and occupied the longest, had several upright standing stones that were carved and covered in matting. House 7 was distinct from other units with plaster and stone bins, lacking normal domestic utensils associated with food production, as well as a variety of animal or plant remains. The former seems to suggest a ritual function, while the latter may have been used as a communal storage facility (Bolger 2003:219, 250; Peltenburg 1985, 1982; Steel 2004a:65-73).

Klepini Troulli was located on a promontory and contained similar contiguous architecture. At its high point sat one of the largest Neolithic structure measure 25 square meters. At both of these sites, there is an increasing emphasis on highly decorated ceramic liquid containers which occur in a limited range of shapes, including spouted bowls, jugs, bottles, and hole-mouth jars (Dikaios 1962:63; Knapp 1994:407; Steel 2004a:65-72).

III.C.3. Chalcolithic

The end of the Neolithic represents another period of island-wide abandonment, despite some key cultural features that continue into the Chalcolithic, such as the pottery tradition, an agro-pastoral economy that is supplemented with deer hunting, and some symbolic elements. There is however a shift in the location of settlement to southwestern part of island, a shift in ideology centered on children and birthing with picrolite being an especially important medium, as well as the first copper exploitation (Knapp 1994:409-10, 412; Steel 2004a:81-3). There is also more direct evidence for various feasting activities.

For instance, the site of Kalavaos Ayious consists of a substantial subterranean complex of pits and shafts interlinked by tunnels, which were accessed by stepped entrances and blocked by large stone slabs. In one tunnel, there was a large deposit of broken figures, which could be another example of the ceremonial killing of ritual objects (Åström 1987; Grinsell 1961; Todd 1991:4-11; 1996:325-9). A further example comes from the early Chalcolithic occupation at Kissonerga Mylouthkia, which contained a variety of hearths and bell-shaped pits used for large

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12 A variety of blue and green serpentine that was collected, most notably, from the Kouris River bed, and used in quantity during the Chalcolithic period in the production of ornaments and cruciform figurines that played a role in birthing ideology (Peltenburg 1993b:108-9).
scale storage, as well a substantial feasting deposit that included bone pins and awls, spouted stone bowls, stone tools, jugs that were ochre-stained, and unfinished axes (Steel 2004a:84-6).

At the site of Lemba Lakkous, among the typical circular houses was Building 1, which was positioned in a spatially discrete location at the edge of a terrace with no other architectural remains. While the floor plan was typical, the wall were more substantially constructed and the building contained a large amount of artifacts, which included storage jars, bowls, flasks, a cache of stone axes, and a large stone figurine referred to as the "Lemba Lady". Immediately north of the building was concentration of graves, which contributed to the specialized function of the building (Peltenburg 1985; Steel 2004a:86-89, 91-3, 98-100).

In addition, Crewe and Hill (2012:212) point to the Late Chalcolithic occupation of the site and specifically in the vicinity of Building 7, which may represent an installation for beer production. The building itself consisted of a series of horseshoe-shaped basins, a built-in mortar, and various other implements used for grinding and crushing in association with spouted flasks that likely would have been used for pouring the liquid (Peltenburg1985:121-3, 328; Steel 2004b:286-7). While there is no direct chemical evidence that the substance being produced at Lemba Lakkous was in fact beer, perhaps that greatest indication of pre-Bronze Age social complexity and feasting activities comes from the site of Kissonerga Mosphilia, which is a multi-period site ranging from the Middle to the Late Chalcolithic.

The earlier period is characterized by larger houses, a more complex division and use of domestic space, and with the delineation of a discrete area at the site use for ceremonial purposes. The Middle Chalcolithic period occupation consists of a series of “spatially discrete” households with a distinctive architectural style that included well-executed stone foundations and the application of a thick plaster on the floors. The buildings contained evidence of a pendant workshop, had a concentration of highly decorated open bowls, and lead to an open area with a concentration of hearths. Further suggesting the ceremonial function of this area was the discovery of a pit under one of the walls of the largest houses in the area. The pit contained small stones, fire cracked rock, plant material, and over fifty artifacts, including a Red-on-White ceramic model of a house that showed similar internal features as other houses at the site, as well as a

These features have been taken to suggest the emergence of property rights and the emergence of “some consensual caretaker” or even the existence of a ‘rudimentary social rank’ amongst social elders”, who presided over a communal feast in which food was distributed (Held 1993:28-9; Knapp 1994:412-3; Peltenburg 1991:12-22, 39-55; Steel 2004a:102-10). What should also be noted is the role that figurines made out of picrolite and an overall emphasis on a birthing ideology played in ceremonial life in the Chalcolithic period (Peltenburg 1993:14-5).

At the end of the Middle Chalcolithic and beginning of the Late Chalcolithic at Kissonerga Mosphilia, there is a major shift characterized by a standardization and intensified of production with an emphasis on surplus storage and redistribution, greater evidence of an emerging elite class, foreign trade contacts, as well as changes in the pottery product, overall ideology, and funerary ritual (Knapp 1994:413-4; Steel 2004a:106-16; 2004b:286-7). Steel (2004b:287) highlights that all these characteristics seem to foreshadow further developments in the Bronze Age. These are illustrated at Kissonerga Mosphilia in a change in social organization by a decrease in overall house size, the near disappearance of picrolite figurines and other material culture associated with a birthing ideology, and the development of a new monochrome ceramic tradition that was centered on bowls and flasks. Most notable, however, is the large structure that was built over the remains of the Middle Chalcolithic buildings, had a large amount of deer faunal remains, and contained a large number of storage jars\(^\text{13}\), or pithoi. In addition, this “Pithos House” contained a substantial deposit of deer bone (having high status connotations), a series of “ladle-handled bowls”, a deposit of conical stones that have been interpreted as tokens, and evidence of metallurgical production (Knapp 1994:413-4; Steel 2004a:106-16). Based on this evidence, Steel (2004b:286-7; Peltenburg 1993:15) has argued that this represents these characteristics indicate the bulk production, storage and control of agricultural produce, would have been utilized in a patron-client relationship. This development was short-lived, with the Pithos House being violently

\(^{13}\text{With a capacity of 4000 liters of a presumably liquid commodity that has been speculated to be olive oil (Knapp 1994:413-4; Steel 2004:106-16).}\)
destroyed and the site being abandoned at the end of the Middle Chalcolithic period (Knapp 1994:413-4; Steel 2004a:106-16; 2004b:286-7).

Based on this review of archaeological evidence from Early Cyprus, there are a series of punctuated periods progressing from homogeneity to hierarchical differentiation and ending in community fissioning, abandonment, or reoccupation, culminating in a short-lived emergence of “asymmetrical social” during the Middle Chalcolithic (Peltenburg 1993:17; Peltenburg 1991:27). In translating these to the overall feasting model, Steel (2004b:285-8) suggested that feasting during the Chalcolithic period would have occurred within a single community “with no clear evidence for exclusivity in location, consumption or paraphernalia” in the form of an empowering (entrepreneurial) and patron-role feast. However, in Dietler’s (2001:82-3) definition, a patron-role feast, is a formalized version of an empowering feast that focuses on the legitimization of asymmetrical power relationships, in which commensal hospitality and redistribution is viewed as a duty of the patron with “no expectation of equal reciprocation”. This characterization seems more typical of the more formalized feasting that occurs in the later Prehistoric and Protohistoric Bronze Ages. The aim of the empowering feast, on the other hand, is to manipulate conceptions of hospitality in order to acquire social capital in the form of personal prestige, social or economic debts, or political influence through the kind of communal, social negotiation typical of societies with incipient complexity (Dietler 2001:76-82; Rosenswig 2007:5).

Thus, the elements that indicate incipient social complexity in early Cyprus include:

1) social differentiation in location and size of architectural units,
2) differential burial treatment,
3) mobilization of labor for monumental works,
4) specialized containers, and
5) deposits of animals and artifacts ceremonially killed or otherwise taken out of circulation.
III.D. Feasting and Emergent Complexity on Cyprus in Later Prehistory

The transition from the Chalcolithic period to the Early Bronze Age was not well understood for quite some time. This largely derived from the fact that the majority of the evidence for the period came from a series of rich cemeteries, particularly along the north coast of Cyprus\textsuperscript{14}, with very few stratified settlements (and even less that could be associated with the aforementioned cemeteries). A key element in understanding this transitional period was the way in which the Philia cultural material, which represents a distinct cultural component that has a degree influence from southwestern Anatolia, fits into the picture (Falconer 2012; Knapp 2008:72-3; Manning 1993:37-8; Webb and Frankel 1999:4-6). It is now known that this Philia phase was intermediate (in certain parts of the island), but partially overlapped with the Late Chalcolithic and ensuing Early Bronze periods (Falconer and Fall Forthcoming; Knapp 2008:71-2; Swiny 1997:178-9). To this end, Webb and Frankel (1999:4-6) highlight that Philia cultural material\textsuperscript{15} was present at period 5 at Kissoneraga Mosphilia, two sites along the southern coast (Sotira Kaminoudhia and Episkopi Phaneromeni), and at various sites in the north and northwest (see Webb and Frankel 1999 for full details).

At issue is the fact that there are a number of changes observed in the archaeological record at the beginning of the Bronze Age. The main characteristics are summarized as follows: (Knapp 2008:69-70; 1994:58; Steel 2004a:119-142; Swiny 1997:178, 195-6)

1) subrectangular (rectilinear) and multicellular architecture,
2) the introduction of the plough, cattle, equids, and screw-horn goats,
3) different burial practices (chamber tombs with multiple interments, pithos burials),
4) mold-cast copper tools, weapons, and ornaments, some of which are made of tin bronze,
5) first use of electrum and/or gold,
6) wider use of textile-related technology (spindle whorls, loom weights),
7) several distinct pottery wares, particularly Red Polished,

\textsuperscript{14}To which researchers no longer had access after 1974.
\textsuperscript{15}Chief among which includes a characteristic ceramic repertoire, a range of metal tools, weapons and ornaments, and technology associated with textile production (Steel 2004:122).
8) a new set of pottery shapes focused on large and elaborate storage, pouring and serving vessels,

9) increase in settlement number and size,

10) increased foreign contacts, and

11) change in ideology, especially a shift away from iconography based on women, birthing and children to one focused on, above all, animals.

To some scholars, Frankel and Webb (2001, 2000; Frankel 1999; Webb and Frankel 1999) in particular, the Anatolian connection evidenced by Philia material at a series of sites that seem to span the Late Chalcolithic and into the Early Bronze Age indicates the immigration of a population from the mainland, bringing with them the knowledge, technology, and international contacts that initiated the major changes listed above. From this perspective, there are undeniable connections in technology, style and economic adaptation to the Anatolian mainland with the main impetus being the rich copper reserves available in the Troodos Mountains. Others, Knapp (2008:104-108, 1994, 1990) and Manning (1993) in particular, argue that while a certain set of artifacts (spindle whorls, pottery wares and shapes, metal and shell artifacts, urn burials) (Bolger 2003:62, 197, 222) indicates an Anatolian cultural influence (Swiny 2008:49; 1997:172-81),

“there cannot have been an external knowledge and interest in Cypriot copper until the inhabitants of Cyprus had first found an interest in their local copper reserves, and had begun to develop, and so advertise, them. Sophisticated and knowledgeable external demand therefore appeared as a subsequent process after the prior, real, initial developments on Cyprus” (Manning 1993:35).

A key element is the existence of a slightly later series of rich cemeteries along the northern coast, most notably Lapithos Vrysi tou Barba and Bellapais Vounous, that contain, among other things:

1) collective burials, which are taken to indicate the rise of elite families and inheritable power and wealth,
2) significant amounts of metal objects in a limited range of shapes (especially weapons) deposited in a limited number of tombs,

3) various prestigious objects that were imported from the mainland and other areas, which represented the major sources of wealth, and

4) a complex of large, elaborate, and highly decorated serving vessels (especially bowls and jugs) that presumable would have been used in the consumption of various liquids, perhaps alcoholic beverages (Keswani 2005; 2004:63-80; Knapp 2008:73-6; Manning 1993:35-46; Steel 2004a:119, 139-42; Swiny 1997:174, 191-3).

However, since the settlements associated with these cemeteries are not known, the degree to which these ostentatious deposits were reflected in everyday life is unclear. The picture has certainly changed in light of new information from a series of Prehistoric Bronze Age settlements, namely Alambra Mouttes, Marki Alonia, Sotira Kaminoudhia, Episkopi Phaneromeni and more recently, the cemetery at Psematismenos Treloukkas, Politiko Troulia, and Kissonerga Skalia.

A major contribution comes from Marki Alonia, which represents the most extensively documented Philia assemblage excavated on the island thus far. But, inasmuch as the Philia culture purportedly represents the arrival of a new population from Anatolia, which was attracted to Cyprus for its copper reserves and which is associated with the evidence for elites in the north, Keswani (2005:363) highlights that at Marki there was “minimal differentiation in the scale or quality of housing and no evidence for supra-household-level storage, accumulated wealth, or social stratification”. It must be pointed out, however, that Marki Alonia, the only known Philia settlement, has the earliest evidence for the production of copper artifacts by mold-casting and is situated in close proximity to copper resources (Frankel and Webb 2006; Knapp 1994:59; Manning 1993:73; Steel 2004a:129, 135, 138; Webb and Frankel 1999; Webb et al. 2006). Thus, a connection between copper and external influence and trade is clear.

What is not clear is the direction of that influence. Along with an increasing number of scholars (Kassiandiou and Knapp 2005; Manning 1993, Peltenburg 1993), Knapp (2008:110-1, 114) argues that there is little that suggests a colonization or a migration and, instead, “wealthy
burials and elaborate mortuary rituals, prestige goods and imports, and signs of Cypriot involvement in an emerging Mediterranean interactions sphere" that began in the Late Chalcolithic period indicates a complex process of cultural hybridization based on “internal production and consumption in the northern part of the island”. Further points made by Knapp (2008:105-6) include the fact that there does not appear to be conflict or separation between an indigenous and immigrant population and the fact that Philia material forms and styles cannot be connected to any specific Anatolian culture on the mainland. (Keswani 2004:81). On the latter point, Peltenburg (in Steel 2004a:126) argues for two separate cultural manifestations, the first being represented earlier in Late Chalcolithic sites in the southwest of the island, and the second occurring in the later Prehistoric Bronze Age 1, at sites in the northern Cyprus. Manning (1993:39) also emphasizes the degree to which there is some variation in Philia styles as manifested different island region, which may further suggest a more complex, internal process of social change at work.\footnote{This continues into Prehistoric Bronze Age 1 with distinctive pottery styles in the north, center, and south of the island (Webb et al. 2008:102).}

The other major aspect of this transition is related to intensification in production. This is not only evident in the incidence of rich cemeteries and an emerging group of elites controlling the flow of prestigious goods along the north coast and the exploitation, processing and trade of copper ores, but also in new modes of agro-pastoral production. As noted above, this is documented by the introduction of the plow, cattle, equids and screw-horn goats, as well as a general increase in population, site frequency and size (Knapp 2008:78-9; 1994:69; Manning 1993:44; Swiny 1997:195-6). The significance of an increase in agricultural production cannot be overstated because the securing of a food surplus permitted a diversion of labor to other production activities and is indicated archaeologically by a shift in household organization, namely in the placement of production and storage facilities within households (Swiny 1997:196-7). Knapp (2008:79) summarizes the process as follows:
“Larger tracts of arable land, specialized animal husbandry, facilities for (household) storage and an increased level of managerial control over the entire system all served to promote a more efficient agro-pastoral economy, provided a surplus that elites mobilized and manipulated, and thus helped to satisfy the social, economic, and ideological needs of elites and commoners alike”.

These three needs intersect in funerary displays in which cattle symbolism and ceremonial drinking played a integral role (Steel 2004a:127) and which are represented in two categories of objects in the Prehistoric Bronze Age ceramic industry: 1) a wide repertoire of elaborate and highly decorated vessels designed for storage, pouring, drinking and eating, and 2) a series of clay models (or genre scenes) depicting communal activities and (presumably) the production association with such activities. Both of these categories of material culture are intimately tied to the focus of my dissertation project. In her discussion of the social context of the elaborate ceramic industry represented in the Prehistoric Bronze Age 2 cemetery of Deneia, Webb (2010:174-9) documents the use of large Red Polished vessels with elaborate shapes and intricate decoration\(^{17}\) to signal community identity and to legitimize the politico-economic position of different lineages and the land, copper reserves, and a trade relationships which they controlled. The expanding role of drinking and eating in funerary practice is further documented at the Prehistoric Bronze Age 1 cemetery of Psmatismenous Trelloukka, where the “presence of a large bowls (probably used for food presentation), round and cutaway jugs, and large number of small bowls suggests consumption of food and drinking with death and burial (Georgiou et al. 2011:355; Webb et al. 2008:93, 102).

While the mortuary record from the Prehistoric Bronze Age does seem to suggest that funerary practice served as a major arena for the negotiation of the various social, economic and political relationships discussed in this and the previous chapter, the clay models show aspects of everyday life, namely:

\(^{17}\) Some of which have affiliations to north coast styles (Webb 2010:175).
1) the mobilization of labor in the production of the ever-important agricultural surplus,

2) an ideological complex centered around animals (predominantly, cattle though deer and other animals are also represented),

3) how various activities may connect to the material culture (e.g., the use of jugs/juglets and bowls together, presumably in mixing substances), and

4) the comparatively different social positions of individuals.

Perhaps the most famous of the clay models is a circular model from a tomb in Bellapais Vounous. Wright (1922:fig. 87 in Swiny 2008:44) describes a circular scene from Bellapais Vounous as illustrating a

“tripartite arrangement of pilasters, perhaps supporting bucrania, against the wall opposite the entrance. The greater frequency of figurines and figurines and relief decoration representing figurines and relief decoration representing cattle relative to those depicting other species indicates the importance of cattle to the islanders at this time”

While the model is an extraordinary find, there are other hints to ideological role of cattle in the penned animals, structures and artifacts that may parallel the tripartite wall structure and the existence of elite members of society whose distinction is religious in nature, as well as economic and political. The potential intersection among these various realms is intriguing and may have major implications for the tendency for archaeological interpretation to separate the social, political, economic and religious into different domains. In terms of themes in the clay models, ritual does seem to be a major and perhaps unified element with the tripartite wall (with and without bucrania) appearing in other models, sometimes with multi-bowled vessels. One example from Kotchati should a figure standing before a tripartite wall with three bucrania with a large storage jar, perhaps making an offering (Swiny 1997:201, 204; Washbourne 1998:63, 198, 204-5).
There are also a series of models and scenes on the upper bodies of ceramic vessels showing people engaging in various production activities, such as plowing, grinding, and perhaps baking. On the Pierides Bowl from Marki, there are a series of scenes encircling the rim of the bowl with what may be the communal baking of bread, but which generally is describes as men, women, children and animals working around various basins and troughs in what some interpret as a life cycle (Bolger 2003; Morris in Knapp 2008:90; Swiny 1997:204-5). Overall, the clay models seem to document major aspects of life and death as they would have played out in the every day in villages as well as in the distinctive at the grave side.

III.E. A Product-Centered Perspective to the Feasting Model for Investigating Social Complexity in Cyprus during the Prehistoric Bronze Age.

In sum, the prehistoric period of Cyprus provides sufficient evidence to suggest that feasting, in its various informal and formal manifestations, played a significant role in the negotiation of interpersonal relationships in the social, economic, political and religious realms. The Prehistoric Bronze Age represents an excellent opportunity to further examine the dynamics at play in both everyday and mortuary contexts. The use of liquid substances, whether those are culinary, medicinal, cosmetic or psychoactive in nature, played an increasingly significant role in these multifaceted, transformative interactions, which makes taking a product-centered approach to this investigation a logical endeavor.

At the social scale under discussion, feasting would not have been as large of an endeavor as in the later Protohistoric Bronze Age. As illustrated by this chapter, the underlying principles still apply. The key points that make this model applicable to emerging complexity are that:

1) feasting is embedded within the larger social and economic system.

On this point, it may be added that during the Prehistoric Bronze Age, Cyprus was participating in the international trade networks in the Eastern Mediterranean on a moderate basis and that basis was largely focused on prestigious objects and raw materials. As such, from a methodological
perspective, it is assumed that the prestigious products being consumed during this period would have derived from organic products available on the island.

2) feasts would have been smaller in scale, tied to communal events centered on agricultural cycles, copper mining, and funerary rituals.

3) feasts occurred as three major types:
   a. communal feasts which fostered social solidarity
   b. entrepreneurial feasts which created opportunities for individuals to create alliances, accumulate debts, and move into positions of influence, and
   c. conspicuous consumption in associated with mortuary ritual.
IV. METHODOLOGY

The methods utilized for this product-focused research program primarily involved the analysis of organic residues in a series of ceramic containers dating to the Bronze Age in Cyprus.

IV.A. Introduction to Residue Analysis in Archaeology.

The development of residue analysis as an area of study within Archaeology was the direct result of the paradigm shift in anthropological theory in the mid 20th century. In the post-Boasian era, there was a renewed interest in nomothetic approaches, collectively designated as Cultural Neo-evolutionism, the aim of which was elaborating the evolution of societies through empirical methods. The subsequent objective to make Archaeology a science can largely be attributed to this theoretical shift (Erikson and Murphy 2003:117-122). During this period, the fields of archaeological chemistry, which involved the application of chemical knowledge and scientific analysis to archaeological problems, and archaeological science developed (Pollard and Heron 2008:vii). Within the purview of the latter were, among other things, dating methods; artifact studies focusing on provenance, technology and use; ecological studies that examined various human-environment relationships; data analysis methods; remote sensing techniques; and conservation (Pollard and Heron 2008:2; Ciliberto 2000:1-4). More specifically, Christopher Hawkes coined the term archaeometry in the early 1950s “to describe the increased emphasis on dating, quantification and physical chemical analysis of archaeological material” (Pollard and Heron 2008:8).

From this broader area of archaeometry, residue analysis arose from material characterization studies, the initial purpose of which was determining the geographical origin of various materials in an attempt to empirically document cultural contacts. Following Thornton’s (1970) chromatographic analysis of “bog butter”, there was a steady increase in attention to biological materials in the last thirty years which encompasses natural products, such as resins, waxes, lipids, and alkaloids; accidentally preserved food residues and other products; and animal, plant, or human biochemicals, including DNA and proteins (Pollard and Heron 2008:9; Evershed 2000:179).
Since the field’s inception some thirty years ago, residues analysis has taken an increasing role in research programs in archaeology. The analytical approaches applied to archaeological materials are increasingly diverse, resulting in the expansion of the breadth of potential research questions. However, the actual utilization of a particular technique depends on the availability of resources in the form of funding, access to instruments, and technical expertise in both archaeology and chemistry. Beyond these limiting factors, the scope of research questions, the type of residue, and state of preservation, as well as the artifact or medium on which the residue is preserved further dictate which analytical method will be selected (Loy 1993:44; Eerkens 2007:89; Evershed 2000:177-9).

There are two factors that are directly related to the success of residue analysis projects. These are expertise in the methods and interpretation schemes of both archaeology and chemistry and having an intimate understanding of the taphonomy of residues (Evershed 2008:895-902; 2000:177-9). The first inherently places this field in the interdisciplinary arena and functions to address some of the major criticisms of the utilization of residue analysis and other archaeometric approaches (Wadley et al. 2004:1491). Primary concerns relate to the accurate interpretation of analytical results, integration with other archaeological data and anthropological and archaeological theoretical frameworks. Caution has been advised with this avenue of research so as to avoid implicit overreliance on a single technique (Eerkens 2005:98-9; Evershed 2000:179). This tendency has been demonstrated throughout the history of archaeological research, in which new theoretical, interpretative, and methodological approaches are initially overemphasized, but ultimately become more balanced as they are integrated with the accepted methodology of the discipline (Trigger 1989:4-7,406-10). This is evident in the surge of residue analysis projects in the nineties, in particular. In the last decade, the complications and limitations of various analytical methods have been acknowledged, as has the fact that much of the research done to that point entailed establishing a coherent methodology (Loy 1993:44-5). In recent years, residue analysis has assumed a complementary role in respect to traditional archaeological data, being integrated into and often functioning to corroborate interpretative schemes (Eerkens 2005:98-9; Malainey 2007: 88; Heron and Pollard 2008:9-11).
This point of disciplinary integration is important because this field was for some time rather unapproachable for many archaeologists. Much of the earlier residue analysis work was initiated, executed, and interpreted by specialists outside of the fields of archaeology and anthropology (Vandenabeele et al. 2007:675-6; Barnard et al. 2007:42). The unfortunate result was that limited information regarding methodology and reasons for particular methodology is disclosed (Helena Wylde Swiny, personal communication 2009; Arnott et al. 2009). Moreover, until the last decade or so, ancient samples were not regularly processed by chemical analysts and, as such, the specific chemical modifications that may occur in the *longue durée* were likely not accounted for (Evershed 2008:895). Approaches in experimental archaeology have been particularly effective in elucidating nuances in the preservation and chemical alterations of ancient and highly degraded materials (Romanus et al. 2009:901; Evershed 2000:203-4, 215). This fundamental aspect of modern residue analysis will be discussed in greater detail later.

Furthermore, in cases where analysis of artifacts are conducted without collaboration with archaeologists, the results may have been inferred from other archaeological data and, therefore, the work does not contribute any knowledge other than the capabilities of a particular technique (Vandenabeele et al. 2007:675-7,681-2; Sendova et al. 2005). Although establishing the scope of an analytical technique certainly constitutes a significant contribution, if the material being analyzed may also be of archaeological interest, collaboration would be a more constructive approach.

One such case is the petrographic analysis conducted by Sendova et al. (2005) using micro-Raman spectroscopy. Sendova et al.'s (2005:829) goal was the application of a non-destructive technique that has been used to elucidate "the nature of the raw materials and the technology implemented for production of the ceramic artifacts, e.g., the firing, temperature, and the nature of the firing atmosphere". A variety of minerals, including quartz, albite, calcite, ilmenite, anatase, rutile, hematite and maghemite, were identified in two Red Polished potsherds from a tomb in northern Cyprus. Based on the characterization of chemical structure and behavior of these minerals, the authors concluded that color variations were determined by quantities and grain size of hematite and that the ceramics were fired at low temperatures “in an oxidizing
atmosphere” (Sendova et al. 2005:832). The potential for non-destructive analysis is of enormous interest and relevance in archaeology. However, these are basic technological aspects of the production of Cypriot pottery that has long been recognized by archaeologists (Hocking 2001; Herscher in Swiny 2003).

There are a few things to consider regarding the case discussed above and the manner in which residue analyses should proceed in the future. First, consultation with archaeologists working in Cyprus surely would have resulted in the construction of a more informative and, therefore, more robust, research question. In cases where ancient materials are the objects of analysis, collaboration between chemists and archaeologists can only be mutually beneficial. Archaeologists obtain data outside the repertoire of traditional archaeological methods (Eerkens 2005:83-6,98-9). Particularly desirable is the potential for non-destructive types of analysis (Vandenabeele et al. 2007:678). Chemical analysts are afforded the opportunity to extend the range of applications of a particular analytical method and to work with materials in various stages of preservation that are not frequently encountered and that may prove useful in forensic applications (Stauffer 2006:1016, 1030). Despite these shared objectives, the amount of time and other resources that the latter party is willing or able to commit to such projects is justifiably substantially less than archaeological or anthropological problems require (Vandenabeele et al. 2007:678). As such, it is advisable to bring this line of research within the purview of fundamental archaeological methodology. This requires that archaeologists interested in this area of research have an understanding of the various analytical methods that may potentially be utilized in the analysis of archaeological residues, as well as the chemistry of the residues that may be of archaeological interest (Evershed 2008:897-8; 2000:177-9).

IV.B. Discussion of Analytical Techniques

A wide variety of analytical techniques have been utilized in ever-increasing archaeological applications. The majority of these fall into one of two categories: techniques based on interactions between light and matter and techniques based on separation (Lambert
1997:129). Since the chosen analytical technique falls under the latter category, the former will not be discussed here.

IV.B.1. Separation Techniques

Analytical techniques based on the separation and identification of chemical compounds are ideal for the study of complex, organic mixtures and therefore the technique is frequently used for the chemical analysis of ancient organic residues.

IV.B.1.a. Gas Chromatography

The fundamental concept of Gas Chromatography (GC) is that chemical components of a mixture are separated by volatilization and plotted as a function of retention time\(^\text{18}\). A typical GC instrument consists of a sample inlet attached to a long, narrow glass column that leads to a detector. The sample inlet functions as an evaporation chamber that volatilizes the sample. The column consists of a mobile phase and a stationary phase. The mobile phase is a carrier gas, usually helium or nitrogen, that is maintained at a steady flow through the column. The stationary phase is a thin-layer of liquid coating the interior of the column that attracts volatilized molecules in the sample (Barnard et al. 2007:48; Kitson et al. 1996:3-6; Skoog et al. 2000:667-72; Pollard and Heron 2008:61, 63; Message 1984:103, 106; Heron and Evershed 1993:265). Upon injection of the sample, the mobile and stationary phases compete for sample molecules. As the temperature increases incrementally, the molecules will be eluted, or will leave the stationary phase, and emerge from the column. The time that this takes to occur is the Retention Time (RT), with the most abundant molecule being set to 100% and all other molecules being plotted relative to that. The final result is a Total Ion Current (TIC), which displays all the molecules detected (Barnard et al. 2007:49; Rafferty 2002:900; Skoog et al. 2000:646-7; Pollard and Heron 2008:62; Heron and Evershed 1993:265; Evershed 2000:196).

\(^{18}\) The retention time is the amount of time that it takes for a chemical compound with a particular mass to emerge from the GC (Pollard and Heron 2008:62).
One of the major disadvantages of this technique is that only compounds that are stable and volatile can be subjected to GC analysis. This limitation can be mediated by derivatization, which increases volatility and stability in compounds such as acids, amino acids, amides, drugs, etc. (Kitson et al. 1993:5-6; Barnard et al. 2007:48-9; Pollard and Heron 2008:65). This requirement, however, further extends an already time-consuming sample preparation process, the general aim of which is the extraction and concentration of organic components in a sample and, often, conversion into stable and volatile analytes. The exact nature of the preparation is dictated by the physical state of the sample, the medium on which it is presumed to be preserved (such as organic residues absorbed into the fabric of a ceramic vessel), and the kind of residue one expects to find, such as lipids, alkaloids, etc. Different combinations of organic solvents are generally utilized in one or more rounds of extraction, usually involving heating, and controlled concentration (Stauffer 2006:1016-9; Rafferty 2002:899; Eerkens 2005:88; Beck et al. 2004:15; Bisset et al. 1994:103-4).

There are many varieties of chromatographic instruments depending on the physical state of the stationary phase. Most common variants have a gas or liquid mobile phase and a liquid or solid stationary phase. High-Performance Liquid Chromatography (HPLC) has been utilized in the separation and determination of organic, inorganic, and biological species (Skoog et al. 2000:683-4). The term "high-performance" refers to modern variations of Liquid Chromatography (LC). The primary difference between GC and HPLC is the use of “a liquid mobile phase and a very finely divided stationary phase” (Skoog et al. 2000:684). In practice, the mobile phase, which consists of one or more types of solvents stored in one or more reservoirs, is pumped in the column, while a sample dissolved in a solvent utilized in the mobile phase is released into the mobile phase stream in fixed volumes (Pollard and Heron 2008:64-5).

GC can be utilized in both quantitative and qualitative analyses. Quantitative analyses entail determining the concentration of organic constituents in a sample by the comparison of the height or area of peaks within a chromatogram. This is frequently accomplished by the addition of an internal standard of known composition and concentration (Skoog et al. 2000:678; Message 1984:200-1). Qualitative analyses, which investigate “the presence or absence of components in
mixtures that contain a limited number of species whose identities are known," are frequently performed in archaeological applications and entail comparison of peaks obtained from the analysis of a sample to those of a known standard (Skoog et al. 2000:677; Message 1984:204, 213). This type of analysis is further facilitated with the coupling of a Mass Spectrometer.

**IV.B.1.b. Mass Spectrometry and Gas Chromatography/Mass Spectrometry**

Mass Spectrometry (MS) involves the separation of ionized molecules and the accurate measurement of their mass-to-charge ratio\(^{19}\), which aids in the identification of constituents of a sample. Mass spectrometers are frequently used in tandem with GC instruments, making GC/MS a powerful technique in the analysis of archaeological organic residues. Mass spectrometers, used on their own or coupled with chromatographic instruments, generally include an ion source, a mass (or m/z) analyzer, and a detector. As in GC, samples are vaporized; when coupled with a GC instrument, the column feeds into a MS where molecules are converted into ions, which are atoms or molecules with a net positive or negative charge (Barnard et al. 2007:50-1; Kitson et al. 1996:8-9; Watson and Sparkman 2007:22; Gerhardt 1990:44; Message 1984:33, 35). Ionization is "achieved by inserting or extracting an electron, a proton (H\(^+\)), or a small ion" (Barnard et al. 2007:51). It should be noted that this process may result in fragmentation of the molecule, the most common method, electron ionization (EI), involves the production of ions from analyte molecules in the gas phase which then fragment in characteristic ways determined by the chemical composition of the ion (Watson and Sparkman 2007:317; Barnard et al. 2007:51; Kitson et al. 1996:16-7; Message 1984:36; Evershed 2000:184-8). Molecular ions are then fed into the mass analyzer where they are separated based on differences in respective behaviors while in an electromagnetic field (Barnard et al. 2007:52; Message 1984:60). A typical mass analyzer includes four metal rods parallel to each other with two carrying a high voltage DC potential and two carrying a high frequency AC potential. "All detectors are designed to amplify the impact of single ions", which is turned into an electric current that is measured by an ion detector and the

\[^{19}\]"The mass of the ion on the atomic scale divided by the number of charges that ion possesses" (Watson and Sparkman 2007:4). Calibration against ions of known m/z permits the determination of the abundance of ions produced from the analyte (Kitson et al. 1996:9).
relative frequency of which is plotted against time on a mass spectrum (Barnard et al. 2007:52; Kitson et al. 1996:13).

A fundamental aspect of a MS instrument is the resolving power because it relates to the accuracy of the measurements made by a particular instrument. Resolution refers to an instrument’s ability to distinguish compounds that have the same mass, but different chemical compositions (Kitson et al. 1996:11; Message 1984:64, 74). In some cases, resolution may be improved by running MS or GC/MS in Selected Ion Monitoring (SIM) mode, in which the instrument is programmed to “record the ion current at selected masses that are characteristic of the compound of interest in an expected retention time window” (Kitson et al. 1996:19; Rafferty 2002:901; Message 1984:213; ). Running the analysis in this mode can be particularly useful in qualitative archaeological applications when the sample is a mixture, the target compound is known, and the resulting spectrum may be compared to standard spectra. Scan mode is a more inclusive approach, though with reduced analytical sensitivity (Kitson et al. 1996:19-20; Rafferty 2002:901; Evershed 2000:191-3).

IV.B.1.c. Mass Spectra Interpretation

In modern GC/MS instruments, a digital database $^{20}$ with one or more libraries allows comparison of the fragmentation patterns that result from ionization and separation of an unknown compound in MS and provides detailed information about that compound (Barnard et al. 2007:51). Such an approach should not, however, be taken as absolute, especially in archaeological applications. Issues regarding organic preservation in archaeological contexts will be addressed in great detail later.

Particularly in the case of degraded or fragmented compounds, the interpretation of mass spectra may require additional examination beyond initial comparisons with existing libraries. The first step is to determine the molecular ion, which is designated M+ or M- depending on its charge.

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$^{20}$ Scientific and Technical Databases of Mass Spectral Data provided by NIST (National Institute of Science and Technology) [http://www.nist.gov/srd/nist1a.htm](http://www.nist.gov/srd/nist1a.htm)
This determination is guided by a variety of rules, including but not limited to the Nitrogen Rule\textsuperscript{21} and that the molecular ion "must contain the highest number of atoms in each element present" (Watson and Sparkman 2007:25; Gerhardt 1990:44; Evershed 2000:194-5). The structural type of the compound may be determined by the occurrence of one or more characteristic ions. For example, alcohols and ethers constitute one structural type that is indicated by the presence of the ions 31, 45, 59. (Kitson et al. 2003:26-7). Although a library search does not match a particular compound, its structural type may be given. Further information may be elucidated by examining fragment ions "to determine the mass of neutral fragments that were lost from the molecular ion", as well as subsequent calculation of the number of carbon rings and double bonds (Kitson et al. 2003:27; Young et al. 1996:1). Ultimately, the method of interpretation is dependent on the scope of the study, the type of compounds being analyzed, method of sample preparation, and instrumentation variation. In the present study, the large data set precludes such a manual approach to the interpretation of the mass spectra.

IV.C. Approaches in the Analysis of Archaeological Residues

Equally as important as understanding the analytical instruments and their underlying principles is understanding approaches in the analysis of certain types of compounds. In organic residue analysis, lipids have received the greatest attention. However, with the acknowledgement that lipid analysis often results in limited information about biomarkers and that such research is normally limited to subsistence products, an increasing number of archaeologists are researching residue analysis based on the identification of alkaloids and essential oil compounds, an area that has the potential to identify not only non-subsistence products, but also may permit more specific identification of plants species than lipid analysis allows (Barnard et al. 2007:41-2; Rafferty 2007:179; Derham 2004:187-90; Tushingham et al. 2012).

\textsuperscript{21} The Nitrogen Rule states that the molecular ion produced by electron ionization “is of even mass if the unknown contains either an even number or no nitrogen atoms” (Watson and Sparkman 2007:25).
IV.C.1. The Analysis of Lipids

Lipid analysis constitutes the most common type of organic residue analysis performed by archaeologists. They comprise a “diverse group of organic molecules that includes, among others, fatty acids, fats (including triacylglycerols), waxes, steroids (including cholesterol), and terpenoids” (Barnard et al. 2007:41; Lambert 1997:164-6; Evershed 2000:204-7). Their analytical popularity stem from the fact that they do not readily dissolve in water, making them likely candidates for preservation even in variable environments (Barnard et al. 2007:41-2; Kimp et al. 2004:1503; Heron and Evershed 1993:268). Fatty acids, which are the primary constituents of fats and essential oils of both plants and animals, are the most common lipids analyzed due to their relative stability and ease of their extraction. The primary disadvantage of the analysis of fatty acids and other lipids from archaeological contexts is that they occur in numerous plants (and animals) in varying ratios and, therefore, it can be rather difficult to attribute their presence to plant categories, let alone specific plant species (Eerkens 2005:89; Malainey 2007:77).

Fatty acids (FA, hereafter) are strings of CH₂ (methylene) groups that comprise the hydrophobic part of the lipid and that terminate in “an acidic (hydrophilic) COOH group attached to one end (α-carbon)” (Barnard et al. 2007:42; Lambert 1997:164-6, 264). FAs exist in both natural and synthetic products, which contribute to the general problem of contamination and its detection. In general, FAs that originate in plants tend to have an even number of carbons, providing a preliminary level of differentiation. Odd-numbered chains tend to occur in ruminant animals or are synthetic in origin (Barnard et al. 2007:44-5; Eerkens 2007:90-1). There are two primary types of FAs, saturated and unsaturated, both of which occur in natural oils. The former are long-chain carboxylic acids (-COOH) with 12 to 24 carbons that lack double bonds. The latter contain one or more double bonds, which cause the molecule to degrade more easily, and occur more readily in foods of vegetable origin (Newman 1998:49; Barnard et al. 2007:44-5). Single, double or triple FAs can attach to glycerols (CH₂OH-HCOH-CH₂OH) by ester bonds. They are referred to as monoacylglycerol (MAG), diacylglycerol (DAG), and triacylglycerol (TAG), respectively, and are fats (Barnard et al. 2007:45; Lambert 1997:164-6; Regert et al. 1998:2027). Free fatty acids (FFAs) refer to parts of a larger FA molecule that would have broken off during
the degradation of the molecule (Newman 1998:49). The majority of lipid-based analyses have focused on molecular determinations from “solvent extractable lipid components” (Regert et al. 1998:2027). However, Regert et al. (1998:2027-8) focused on the experimental identification of oxidation products of unsaturated FAs, which may include short-chain dicarboxylic acids (or diacids), \( \omega \)-hydroxy acids, and longer-chain hydroxyl and dihydroxy acids, by additional treatment with a base in the extraction process. The procedure was applied to samples from two well preserved sites, the first being Nubian site of Qasr Ibrim and the second the French waterlogged site of Chalain. It was observed that “the nature of the oxidation products of unsaturated lipids is dependent on the precursors present in the processed materials, the duration and intensity of vessel and burial conditions”, which highlights the potential limitations in attempts to distinguish plant types by ratios of solvent extractable FAs (Regert et al. 1998:2030).

As discussed in the analytical section, derivatization procedures are incorporated into the preparation of samples in order to make them more volatile, thermally stable, and, therefore, amenable to GC/MS analysis. In lipid analysis, derivatization involves the replacement of “the active hydrogen of the COOH-group by a non-polar group” and may be accomplished by two fundamental processes (Barnard et al. 2007:47). In esterification, or methylization, FAs are converted into fatty acid methyl esters (FAMEs) by the replacement of an active hydrogen with a methyl group (CH\(_3\)) (Barnard et al 2007:47). In silylation, the active hydrogen is replaced by a trimethylsilyl group (\(\text{Si}-(\text{CH}_3)_3\)) (Barnard et al. 2007:47). These procedures follow the extraction of organic compounds from a pulverized potsherd by treatment with various non-polar organic solvents, such as dichloromethane and hexanes (Stauffer 2006:1016). Pulverization “maximizes contact between residues and solvent”, increasing the amount of organic material that is extracted (Barnard et al. 2007:46).

There are several issues that should be addressed at this juncture. First, despite the fact that FAs are relatively stable and tend to preserve in various environments, they are subject to various chemical processes associated with their formation, alteration, and preservation that ultimately affects their capacity for analytical detection (Eerkens 2007:91; Heron and Evershed 1993:269). The state of preservation of an archaeological residue is a function of not only the
burial environment and depositional history, but also, and more specifically, the characteristic
decomposition over time. It has long been acknowledged that
anaerobic environments, those that lack or have little oxygen, are ideal conditions for organic
preservation. Such environments include water-logged environments, such as European peat-
bogs and submerged shipwrecks, arid environments, such as Egyptian tombs, or cold
environments, such as the Peruvian highlands. Ultimately, the key to preservation is consistency
Heron and Evershed 1993:253). The fundamental process in the degradation of organic products
is oxidation, which is “the loss of electrons by a species” (Skoog et al. 2000:389; Lambert
1997:268). However, pathways of degradation are specific to chemical composition, burial
environment, and seasonal and long-term conditions therein and are, therefore, poorly
understood. Secondly, it should be noted that solvents “can only take up a fixed amount of
specific lipids” with the ratio of lipids differing from the residue, the ratio of which is already
different from the original product due to preservation (Barnard et al. 2007:42). Further, initial
residue analyses used extracts from fresh plant materials to generate spectra for comparisons to
archaeological samples. However, the chemical composition of fresh plant material differs from
the same plant that has been cooked or processed in some other way, not to mention degraded

IV.C.2. The Analysis of Alkaloids

As noted above, modern residue analysis has largely focused on lipids due to their
relatively stability and ease of analysis. However, their wide distribution and that they are not
specific to particular plant species has limited the interpretative value of their analysis. Moreover,
the analysis of lipids has also somewhat restricted the scope of residue analysis in archaeology
to primarily subsistence and minimally to industrial considerations (Heron and Evershed
1993:250-1). An increasing number of archaeologists have looked to another class of
biomolecules, the alkaloids, that may introduce the specificity lacking with lipids and address
additional areas of human behavior, namely ideological and ritual (Rafferty 2007:179-80; Pollard and Heron 2008:257-60).

Alkaloids are relatively small organic molecules that contain one or more nitrogen atoms, occur frequently in plants, rarely in animals, and are “distinguished by their remarkable physiological activity” (Hess 1981:2; Rafferty 2007:179). Due to the latter characteristic in particular, the identification of alkaloids in ancient residues has the potential to elucidate a particular range of human behaviors, associate specific contexts of use for artifacts involved, and potentially identify particular plant species utilized. There has been some question as to whether alkaloids can survive extensive periods of degradation (Rafferty 2002:898), which has opened the field to artificial aging and chemical alteration experiments. Derham (2004:193-6) has conducted such experiments with a variety of drug compounds, including harmine, kava, codeine, caffeine, atropine, and tetrahydrocannabinol. There are an increasing number of residue analysis experiments that have successfully identified alkaloids in various stages of preservation in various types of artifacts. An exceptional example includes the analysis of preserved cannabis in the 2700 year old grave of what appears to be a shaman of Caucasian descent in central China (Russo et al. 2008). Direct use of harmine has been demonstrated in the analysis of hair samples preserved in mummies in the Chilean Andes (Ogalde et al. 2007). Alkaloids have also been identified in context of less extraordinary preservation.

IV.C.3. The Analysis of Essential Oils

Essential oils are “odoriferous bodies of an oily nature obtained almost exclusively from vegetable sources, generally liquid… at ordinary temperatures, and volatile without decomposition” (Parry 1922:1). They derive from various parts of plants and are ubiquitous ingredients in perfumes and ointments, both medicinal and cosmetic in nature (Bowles 2003; Daferera et al. 2000:2576; Derham 2004:185-6; Dietler 2006:234; Mills and White 1994:238). Therefore, targeting essential oils in conjunction with alkaloids allows for the identification of a broader range and more complex prestigious products. While it is acknowledged that essential oils may also be constituents in some subsistence products, the fact that small, ornate, and high
quality vessels are targeted for analysis necessarily eliminates a quotidian use. Methodologically, essential oils are more widely distributed than alkaloids, but occur in particular combinations that are characteristic of a specific plant, making it possible to identify plant oils based on the presence of multiple constituents. It should be noted that while having a wider distribution, the analysis of essential oils is inherently more specific than of lipids.

IV.D. The Taphonomy of Residues and Experimental Archaeology

Loy (1993:44) argued that the increasing role of residues analysis in archaeological research has shifted the focus of taphonomic studies from sites to artifacts. Geological and chemical processes involved in the creation, preservation and degradation of residues in archaeological contexts are paramount and may be elucidated by experimental archaeological approaches. Such approaches have been instrumental in not only creating a baseline for the comparison of archaeological residues, but also in the heuristic elucidation of the chemical behavior over extensive periods of time.

Although Eerkens (2007:90) echoes Loy’s (1993) assertion that artifact studies that focus on residue analysis have the potential of elucidating the form and function relationships of artifacts, he maintains that information obtained from such studies be integrated with and be utilized to evaluate the interpretative frameworks developed from traditional archaeological data. In this respect, numerous experimental studies have focused on elucidating the decomposition of organic materials in specific archaeological contexts. Such studies have taken three primary approaches. The first approach is directly applicable to lipids with the aim of establishing the ratios of FAs in a particular plant material and monitoring its changes in an attempt to associate those ratios with particular products in archaeological samples. Marchbanks (1989 in Malainey et al. 1999:95) proposed “a method for discriminating samples of uncooked plants, land mammals, and fish on basis of their relative fatty acid composition” and that these could “also be used to identify parent materials of archaeological residues”. The method was based on the following
ratio of saturated FAs (%S), where \( %S = \frac{(C12:0 + C14:0)}{(C12:0 + C14:0 + C18:2 + C18:3)} \)^{22}. However, Skibo (1992 in Malainey et al. 1999:96), unable to confirm this ratio because of the paucity of C12:0 and C14:0 in modern foods, linked "uncooked foods to residues extracted from cooking pots... when only one food type was prepared" using the ratios of C18:0/C16:0 and C18:1/C16:0^{23}. However, Malainey et al. (1999:96) state that the composition of these FAs changes during decomposition and that the ratios of modern samples would not correspond to ratios in archaeological samples. Skibo's aim was to be able to differentiate between cooked and uncooked samples. To address this issue of decomposition alterations, Malainey et al. (1999:96-7) prepared artificial residues of 130 North American plants by different methods of cooking and compared the residues, both of which were subjected to artificial aging in an oven at 75°C for 30 days, as they absorbed into ceramic matrices to uncooked counterparts. They observed a general trend of saturated FAs increasing to a small extent and unsaturated FAs increasing decreasing (Malainey et al. 1999:99-100).

One of the major problems in the application, interpretation and acceptance of residues analysis results is the issue of contamination. This is particularly problematic for the analysis of lipids absorbed into the matrix of ceramic vessels because lipids are widely distributed in many organisms (including plants, animals, and bacteria), which complicates the task of differentiating between post-depositional contamination due to environmental leaching and handling and laboratory contamination (Malainey et al. 2007:81). Regarding the propensity of lipids, FAs in particular, for environmental degradation, Eerkens (2007:90-1) highlights that FAs are stable in temperatures below 200°C, which falls far below the range of temperatures required for firing pottery, thus demonstrating that any present FAs are not related to constituents of the pot itself. Lab contamination is frequently assessed by running blanks to evaluate potential contamination. The argument that groundwater leaching destroys FAs preserved in a vessel is not likely due to

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^{22} C12:0, dodecanoic acid (lauric acid)
C14:0 tetradecanoic acid (myristic acid)
C18:2 octadecadienoic acid (linoleic acid)
C18:3 octadecatrienoic acid (linolenic acid)

^{23} C16:0 hexadecanoic acid (palmitic acid)
C18:0 octadecanoic acid (stearic acid)
C18:1 octadecenoic acid (oleic acid)
the fact that lipids are insoluble in water (Eerkens 2007:90-1). Such a conclusion is perhaps an oversimplification; however, the point remains that although lipids are subject to a variety of potential contaminants and eroding processes, the effects are potentially minimal. With the proper handling and laboratory protocols, the results can with relative confidence be associated with products that a vessel actually contained in the history of its use, particularly when degradation pathways have been demonstrated experimentally and corroborate data from archaeological samples. Another potential contamination issue relates to the contribution of microbial growth to lipid profiles. Dudd et al. (1998:1345-6) performed a series of degradation studies with milk and olive oil, monitoring bacterial growth. In addition to demonstrating that bacteria-associated lipids contributed only “a minor amount to the overall lipid distribution”, Dudd et al. confirmed that small amounts of “branched chain fatty acids containing 15 and 17 carbon atoms” represented bacteria markers (1998:1352, 1353).

One issue about which archaeologists are not yet certain is what absorbed lipids actually represent. It is unclear whether residues represent the first products to come in contact with the vessel, “after which the available binding sites are saturated”, the last products with older residues being replaced through the vessel’s use, or “a combination of all food ever to be inside the vessel…with the molecules that makeup the residue competing for available binding sites” (Barnard et al. 2007:56; Barnard et al. 2007b:35; Heron and Evershed 1993:261). There is also the distinct possibility that detected residues represent organic sealants that were used to line the interior of the vessel to prevent seepage. Romanus et al. (2009:908) addressed the possibility that amphora treated with pitch may have hindered lipid permeation into the vessel wall. What was determined was that oil permeated non-pitched vessels easily and was hindered in pitched vessels. However, wine permeated easily, even in pitched vessels, which seemed contrary to historical records that indicated “pitched amphorae were preferentially used for the transport of wine” (Romanus et al. 2009:908). Treatment of vessels with both oil and wine demonstrated not only that oil hindered the penetration of wine into pitched vessels and that wine appeared to enable permeation of the pitch layer by oil. The implications of this case are rather vast. Not only did the experimental work indicate a functional relationship between two commodities for which
the Eastern Mediterranean was well-known, it elucidates technological relationships in the production and overseas transport of liquid commodities. The functional relationship between wine and oil as demonstrated here seems also to suggest a mechanism for preventing the evaporation of wine during transport, namely the potential sealing of the wine with a layer of oil. Additionally, this has implications for considerations of the multiple uses of vessels and how organics absorb into vessel walls (Hamilakis 1999; Romanus et al. 2009:904-8). This case seems to suggest not only that the individuals involved in the production and transport of these materials were certainly familiar with the effects determined experimentally, but also that the absorption of organics is a complex process that may depend on the characteristics of the substances involved.

The second taphonomic approach entails the elucidation of the differential absorption of organics in different parts of a vessel. A fundamental aim of this approach is to inform the sampling process so as to maximize the likelihood that samples will contain organics. Charters et al. (1997:1-2) examined whether there was a pattern of lipid accumulation in different parts of a vessel in the processing of cabbage leaves (Brassica) and whether it could be utilized as an indication of vessel use. A variety of both replica and reconstructed vessels from the Late Saxon and medieval settlement of West Cotton were utilized to assess the temporal absorption and differential accumulation of lipids down the profile of the vessel (Charters et al. 1997:2-5). Experimental cooking and sampling at different stages of cooking (e.g., after one cooking event, after extensive cooking events, etc.) demonstrated when boiling, “the floatation of lipids released from the foodstuff on the surface of the water” lead to the “preferential absorption of the lipids in the fabric of the upper parts of the vessel” (Charters et al. 1997:6). Extractions from corresponding parts (rim, body, base) from the vessels from the archaeological site exhibited the same pattern, indicating that the vessels from the site were utilized in the same manner as the experimental replicas (Charters et al. 1997:7). Specifically, nonacosane, nonacosen-15-one, and nonacosane-15-ol were associated with the leafy vegetables (Lambert 1997:130, 132). The results of this study certainly improved sampling strategies for lipid analysis. However, it should be noted that such a pattern is specific to the mode of food preparation (boiling, in this case), the nature of the food stuff, and perhaps the form of the vessel. Moreover, an increasing number of
residue analysis projects are incorporating various experimental approaches into their research programs, which ultimately result in not only the corroboration of analytical data from archaeological samples, but also elucidating the specific behavior of an increasing number of archaeologically and historically significant products. It is also important to note that various lines of evidence suggested that cabbage leaves were prepared in the two vessel types that were examined, which echoes Eerkens’ (2005:98-9) assertion that residue analysis in archaeology plays a supplemental role.

The third approach focuses on the artificial creation of residues, simulating and monitoring their aging or chemical alteration, and comparing the results with archaeological samples that other lines of archaeological evidence point to containing the same substance. Derham (2004:192) argues that the goals of accelerated aging experiments should include the following: 1) elucidating specific decay rates, 2) experimentally creating degradation products, and 3) developing “analytical procedures that could effectively extract the amorphous residues into solution and to provide unambiguous analytical data”. Extensive work has been done on beeswax and various resins using this approach. Mills and White (1989:37) analyzed 100 Canaanite amphorae from the Late Bronze Age shipwreck at Ulu Burun off the southern coast of Turkey. A substantial percentage contained preserved remains of a resin. The primary candidates for the resin were mastic and turpentine, which were largely documented as Chios (Chio or Chian) turpentine and Cyprus balsam (Mills and White 1989:38-9). Previous work in the aging and monitoring of chemical alterations in various resins (Pollard and Heron 2008:242-5; Mills and White 1989:40-2) permitted the identification of β-Amyrin and various derivatives of oleanonic, moronic, and masticadienonic acids, which are characteristic of specific mastic resins.

There has been extensive work done with honey and beeswax, particularly in the Aegean and Eastern Mediterranean where its position as an important commodity has been demonstrated to at least the Neolithic (Namdar et al. 2009:629; Regert et al. 2001:549; Evershed 2000:201-3). Regert et al. (2001:549) conducted a series of aging experiments over the course of seven months, which demonstrated that modern beeswax differed significantly from aged samples. Essential observations included “modification of hydrocarbon profiles in beeswax, characterized
by preferential loss of lower molecular weight n-alkanes” (Regert et al. 2001:567). The flavonoid\textsuperscript{24} content in beeswax has a characteristic phenolic structure in modern beeswax, but which was demonstrated experimentally to degrade into benzoic and cinnamic derivates, an identification that had not previously been made. Subsequent analysis of archaeological samples of different geographic origin demonstrated different stages of degradation as related to the degradation pathway detailed by the experimental studies (Regert et al. 2001:560, 567).

Pitthard et al. (2006) conducted a series of accelerated aging experiments in an attempt to examine alterations of pigments and binding materials in objects held at the Kunsthistorisches Museum in Vienna. Their protocol included the creation, simulated aging by UV light irradiation, and monitoring of various drying oils. The authors generally observed that “UV exposure cause[d] the greatest changes in composition” and determined that both photooxidation and decomposition processes occurred (Pitthard et al. 2006:563, 565). More specific observations related to work with dammar resin and beeswax. In the former, oxidation products, such as ocottillone, greatly increased their concentrations and thereby constituting veritable biomarkers of the aged material. In the latter, it was determined that despite extensive decomposition, patterns of long-chain alkanes characteristic of beeswax survived (Pitthard et al. 2006:566-7). Namdar et al. (2009) similarly experimented with chemical alterations associated with the heating of beeswax. However, the scope of their study was the application of their experimental data not only for comparison to archaeological residues, but in an attempt to distinguish the function of cornets, a cone-shaped vessel used during the Chalcolithic in Israel and Jordan, from two other vessel types, all for which ritual functions have been suggested (Namdar et al. 2009:629-30). It was, however, demonstrated that the cornets were likely utilized for illumination. “The conical shape, variable size, presence or absence of solid appendages, and the fact that they were found in different contexts… are all consistent with cornets being used as vessels for beeswax candles”, a conclusion that is also consistent with the absence of sooting (Namdar et al. 2009:635).

\textsuperscript{24} Responsible for color and aroma in plants (Regert et al. 2001:560).
IV.E. Methods Utilized

The specific methods utilized in this project involved taphonomic studies, the construction of a spectral library of reference samples for Eastern Mediterranean plants and products, and finally, the analysis of archaeological pottery samples from both stratified sites and museum specimens, some of which lack provenience information.

IV.E.1. Taphonomic Studies

Taphonomic studies were conducted on various opium mixtures in an attempt to simulate chemical processes of degradation that might be expected to occur in archaeological contexts and to identify decomposition products that are most likely to be preserved over time. Data gathered on the latter may then be utilized to more effectively target those products in the analyses of archaeological samples.

IV.E.1.a. Opium

The taphonomic study on opium was conducted as part of a research study on alkaloids funded by the National Science Foundation (0822493) and awarded to Dr. Sean M. Rafferty and Dr. Stuart Swiny of the Anthropology Department and Dr. Igor Lednev of Chemistry at the University at Albany, State University of New York. The aim of the study was the identification of opium and tobacco alkaloids in prehistoric ceramic artifacts from the Eastern Mediterranean and the North American Northeast, respectively, using Raman Spectroscopy and Gas Chromatography/Mass Spectrometry. The results of these studies have been published in the Journal of Archaeological Science (Rafferty et al. 2012, “Current research on smoking pipe residues) and the Journal of Ethnoarchaeology (Chovanec et al. 2012, “Opium for the Masses: An Experimental Archaeological Approach in Determining the Antiquity of the Opium Poppy”). Only the study on opium is discussed here.
A standard solution of scientific-grade opium\(^{25}\) in ethanol was prepared. With the assistance of Colin Henck of the University at Albany, State University of New York Chemistry Department, analytical protocols\(^{26}\) for the analysis of opium alkaloids were developed and a reference spectrum of the opium-ethanol solution was obtained. This was accomplished using a Hewlett Packard 6890 gas chromatograph used in tandem with a 5972 selective mass detector, which was equipped with a 1 μL auto-injector and fitted with an HP-5 capillary column that measured 30 m in length, 250 μm in diameter with 5% phenylmethylsiloxane, and a film thickness of 0.25 μm. The analytical parameters (method, hereafter) included an initial temperature of 150°C which was held for 1 minute then ramped up to 280°C at 15°C per minute and held for 3 minutes, making a total method run time of 12.67 minutes. There was a splitless interface to the quadrupole mass selective detector with a 2 minute solvent delay and a mass range from 50 to 500.

Samples were run in two modes: first in scan mode, in which data are collected on all chemical constituents within the sample and, second, in SIM (Selected Ion Monitoring) mode, in which data are collected only for compounds with a specific set of ions. The latter is useful for targeting trace amounts of specific compounds, such as opium alkaloids. Running the instrument in scan mode proved to be most effective, but it should be noted that one of the outcomes of the study was determining the ions required to target opium alkaloids and successfully identify them in analytical samples.

For the purposes of the taphonomic study, identifications were made manually by clicking on peaks and recording compound matches and qualities. In this way, five opium alkaloids (noscapine, codeine, morphine, thebaine, and papaverine) were identified in the solution. Two things must be mentioned at this stage. First, this initial spectrum was based entirely on the immediate dissolution of these alkaloids into the ethanol, without any heating, concentration or other extraction procedures. Second, while I note the match for noscapine here, the match for the alkaloid was very low, at a quality of 9 (out of 100). However, based on retention time

\(^{25}\) Since opium is a scheduled drug, the Principal Investigator, Sean M. Rafferty, obtained a DEA (Drug Enforcement Administration) license for the use of scheduled drugs for research purposes.  
\(^{26}\) Later referred to as the alkaloid method.
comparisons throughout the study, the peak indicated in this figure as noscapine does in fact represent that alkaloid.

The process of chemical degradation was simulated by sealing samples of the opium-ethanol reference solution in two glass flasks. One sample was placed in a laboratory oven at 70°C and the second sample under an ultraviolet lamp (250 nm). The flasks were removed after one week, two months and four months, at which point a sample of the solution underwent organic extraction, concentration\(^{27}\), and analysis using the parameters noted above, in an attempt to experimentally monitor stages of chemical degradation.

The background, methods, and results of this study are more fully discussed in Chovanec et al. 2012\(^{28}\). The results and implications of the study will be summarized here. At the most basic level, this study demonstrates a series of known pathways for the formation and decomposition of several opium alkaloids by means of molecular characterization. These pathways are related to three classes of opium alkaloids.

The first involves the phthalidisoquinoline alkaloid, noscapine\(^{29}\), which decomposes into four products: cotarnine\(^{30}\), hydrocotarnine\(^{31}\), meconic acid\(^{32}\), and opianic acid\(^{33}\) (Chovanec et al. 2012:18-19; Stewart 1920:138-142). In terms of the degradation simulation, “noscapine did not survive the aging experiments, which indicates that the compound decomposes rapidly” (Chovanec et al. 2012:19). Additionally, using the analytical methods described above, cotarnine and hydrocotarnine could not be distinguished, since they eluted at the same retention time range of between 3.621 and 3.651. However, the combined cotarnine-hydrocotarnine peak as well as meconic acid survived both of the aging experiments even though they exhibited some reduction.

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\(^{27}\) Organic compounds in the samples were extracted into solution using a reflux apparatus in which a mixture of ethanol and methanol (25 mL, 1:1, v/v) was heated. After three hours, the solution was filtered and concentrated under a control stream of nitrogen gas to 1 mL, which was then injected into the GC.


\(^{29}\) (3S)-6,7-Dimethoxy-3-[(5R)-5,6,7,8-tetrahydro-4-methoxy-6-methyl-1,3-dioxolo[4,5g]isoquinolin-5-yl]-1(3H)-isobenzofuranone

\(^{30}\) 4-methoxy-6-methyl-5,6,7,8-tetrahydro-[1,3]dioxolo[4,5-g]isoquinoline

\(^{31}\) 2-hydroxycotarnine

\(^{32}\) 1(3H)-Isobenzofuranone, 6,7-dimethoxy

\(^{33}\) 6-formyl, 2,3-dimethoxybenzoic acid
in abundance after four months. In terms of the specific processes affecting these compounds, 
opianic acid and meconic acid were most affected photo-oxidation (degradation induced by UV 
light), while hydrocotarnine and cotarnine were affected by both photo-oxidation and thermally-
induced oxidation but to a lesser degree (Chovanec et al. 2012:19-22).

The second pathway involved the benzylisoquinoline alkaloid, papaverine\(^\text{34}\), and the 
benzyltetrahydroisoquinoline alkaloids, laudanosine\(^\text{35}\) and laudanine\(^\text{36}\). During the course of the 
experiment, there appeared to be some fluctuation in the abundances of these three alkaloids, 
which is due to a rather complex series formation and decomposition pathways. While a number 
of secondary decompositions were not demonstrated, the relationship between the three 
alkaloids was. Specifically, laudanosine was show to be an important precursor to papaverine 
and laudanine as the product into which laudanosine decomposes. Overall, papaverine seems to 
persist in most conditions, while laudanosine and laudanine survived thermally-induced oxidation 
more readily (Chovanec et al. 2012:22; Hosztafi 1998; Piotrowska et al. 2002; Stewart 1920:138-
142).

The third and most significant pathway involved the morphinan alkaloids, morphine\(^\text{37}\), 
codeine\(^\text{38}\), thebaine\(^\text{39}\) and their degradation products. As is the case with the benzylisoquinoline 
and benzyltetrahydroisoquinoline alkaloids, the formation and decomposition of the morphinan 
alkaloids consists of a series of complex interactions (Chovanec et al. 2012:23, 28-29). The most 
significant observation relates to morphine, the alkaloid that occurs in opium in the greatest 
quantity. During the course of the aging experiments, morphine appeared to degrade rapidly, 
particularly under the UV-light. While some of this reduction is related to fluctuations in the other 
morphinan alkaloids, especially codeine, the implication for future archaeological studies is that 
morphine, though the major constituent in the opium, does not appear to preserve well and 
therefore future studies attempting to identify opium in archaeological contexts should not solely

\(^{34}\) 1-(3,4-dimethoxybenzyl)-6,7-dimethoxyisoquinoline

\(^{35}\) (+)-1,2,3,4-tetrahydro-6,7-dimethoxy-2-methyl-1-veratryl-isoquinoline

\(^{36}\) 2-methoxy-5\{-[1,2,3,4-tetrahydro-6,7-dimethoxy-2-methyl-1-isoquinoyl\}methyl\]

\(^{37}\) Morphinan-3,6-diol,7,8-didehydro-4,5-epoxy-17-methyl-,\((5\alpha,6\alpha)\)

\(^{38}\) Morphinan-6-ol, 7,8-didehydro-4,5-epoxy-3-methoxy-17-methyl-,\((5\alpha,6\alpha)\)

\(^{39}\) 6,7,8,14-tetradehydro-4,5α-epoxy-3,6-dimethoxy-17-methyl-,\((5\alpha)\)
target this alkaloid. Codeine, on the other hand, survived both experiments with some fluctuation in its abundance. Thebaine, which normally appears as two small peaks also survived the experiments. Even though the peaks tend to be rather small, the compound exhibits relative chemical stability in cases of both photo- and thermally-induced oxidation. In addition, it should be noted that another morphinan degradation product, thebaol, was identified at points in the experiment when both morphine and codeine had degraded to a significant degree (Chovanec et al. 2012:23, 26-30; Horn et al. 1978:1895-1898; Oustric-Mendes et al. 1997; Preininger 1986:23; Pšenak 1998:105-110; Stewart 1920:164-165; Theuns et al. 1985).

The results discussed above led to a series of conclusions about the degradation behavior of opium alkaloids.

1. First and foremost, the most abundant alkaloid, morphine, degrades rapidly, is unlikely to survive in archaeological artifacts and therefore future analyses of presumed opium residues should not focus on the identification of this compound.

2. Alkaloids that are most likely to preserve are the decomposition products of noscapine (cotarnine, hydrocotarnine, meconic acid), papaverine, and thebaine (Chovanec et al. 2012:30).

3. To this end, a major methodological outcome of this study was the identification of the molecular ions for seven opium alkaloids that are required for the identification of those alkaloids using the GC/MS in SIM mode.

4. These ions are as follows:

<table>
<thead>
<tr>
<th>Opium Alkaloid</th>
<th>Molecular Ions for SIM mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine</td>
<td>115, 124, 162, 174, 215, 268, 284, 285, 286</td>
</tr>
<tr>
<td>Codeine</td>
<td>115, 124, 162, 188, 214, 229, 299, 300</td>
</tr>
<tr>
<td>Noscapine</td>
<td>147, 193, 205, 220, 221</td>
</tr>
<tr>
<td>Meconic Acid</td>
<td>92, 107, 121, 135, 147, 165, 176, 194</td>
</tr>
</tbody>
</table>

It should be noted for thebaine and papaverine, characteristic ions are 296 and 311 and 324, 338, and 339, respectively. For reasons likely relating to SIM parameters, the longer list of ions was required in some cases. The same was true of morphine, codeine, and noscapine. It should also be noted that the ions for meconic acid and hydrocotarnine may need adjustment.
IV.E.1.a.1  Additional Experimental Work With Opium Residues

Additional reference spectra were obtained by dissolving the opium in heptane, in olive oil from Cyprus, red wine, beer, and by burning a sample of opium. The reasoning behind these mixtures was to evaluate differences in the detectability of opium alkaloids after varied treatment.

The primary routes of administration of opium is smoking or drinking after dissolving the opium in a liquid. For a prehistoric context in the Mediterranean, smoking is unlikely, but data concerning the chemical composition and alteration may be useful for researchers in historic contexts. Merrillees (1962, 1968), Koschel (1996), and Muzio (in Bisset al. 1994) have all alluded to the fact that the narrow necks of the containers in which opium presumable was held would have required the drug to be in liquid form. While some sort of vegetable oil has been suggested in a few analytical studies, the identity of the solvent liquid is open to speculation. Obvious candidates for the Eastern Mediterranean include wine, beer, olive oil or honey.

Another aim in making these opium solutions was to determine whether opium alkaloids would dissolve in them and could be identified analytically. This proved to not be possible for the opium and olive oil mixture since no alkaloids were found to have dissolved in the oil. It may be noted that two peaks with low abundances occurred within the retention time range for papaverine, but there was no compound match. The molecular ions for those peaks were: 1) 324 and 338, and 2) 338, respectively, which suggests the presence of papaverine but not in acceptable levels.

The mixtures of opium in beer and wine were more informative. In the former, peaks eluted at retention times that corresponded to meconic acid, noscapine, codeine, morphine, laudanosine, thebaine and papaverine. However, only codeine and thebaine returned library matches at qualities of 81 and 74, respectively. The mixture was then stored in a beaker that was covered loosely to allow air flow, but to avoid the introduction of contaminants. One year later, the
liquid had evaporated and the resulting residue was extracted and analyzed using the same procedures detailed above. Noscapine, codeine, morphine, thebaine, and papaverine were all identified in the sample. The difference between the initial reference spectrum and the spectrum from a year later is likely related to the fact that the opium in the sample was concentrated in the resulting residue and perhaps did not have sufficient time to dissolve in the beer. A major difference between these results and those from the opium degradation study is that noscapine did not dissociate into its decomposition products. The presence of noscapine in archaeological samples, rather than its products, may help determine the liquid solvent into which it was mixed.

For the wine, four different samples were prepared. Opium mixtures were made with modern red wine, a modern white wine, and a white wine from Cyprus and allowed to sit for one week. No opium or wine compounds were detected in the modern white wine. In comparison, peaks appeared at retention times for all opium alkaloids (meconic acid, hydrocotarnine/cotarnine, noscapine, codeine, morphine, thebaine, laudanosine, and papaverine) in the sample of Cypriot white wine; however, thebaine was the only compound to return a library match (at a quality of 47). It may be noted that for meconic acid, codeine, and papaverine, the most characteristic of the molecular ions were present, but as noted above, these are frequently insufficient for an adequate compound identified using the NIST02 library.

The situation was quite different for the sample of modern red wine. Meconic acid, codeine, morphine, thebaine and papaverine were all identified at qualities of 95 or above. It should be noted that morphine exhibited clearly fragmentation between 7.396 and 7.457, which further corroborates the conclusion that (Chovanec et al. 2012:30; Chovanec ND) morphine decomposes rapidly. In addition, peaks were present at the retention times for noscapine, neopine, thebaol, laudanosine and laudanine. Furthermore, a coumarin compound that was identified in the opium aging study within the retention time range of hydrocotarnine and cotarnine (and likely a further degradation product of noscapine) was identified at a quality of 45. Based on these results, it seems that opium alkaloids are most soluble in red wine and thebaine appears to be the most soluble and most stable compound in a variety of circumstances.
It should be noted that the reference sample of the red wine did not return any results for tartaric acid or other biomarkers of grapes or red wine (Guash-Jané 2006:98; McGovern et al. 2003:17596-7; Michel et al. 1993:411-2). Since all such identifications would have been made from ceramic containers, a sherd was taken from a larger pottery vessel made in the modern Cypriot village of Kornos\textsuperscript{41}. This sherd was immersed in a sample of the modern red wine for a week to determine if the fabric would absorb it and if any characteristic compounds could be identified. Isobutyric acid\textsuperscript{42} was identified, which is a compound that plays a role in the fermentation of red wines and vinegars (Ferriera et al. 2002:4048-50; Guth 1997:3027; Lambert 1997:37; Rocha et al. 2004:257-8). However, the compound was not identified in the red wine and opium mixture.

In order to further examine the chemical degradation process of opium in red wine, like the opium in beer, the mixture was loosely covered to allow air flow for one year, after which the remaining residue underwent extraction, concentration and analysis. While isobutyric acid was not identified, \textit{\alpha}-D-Glycopyranoside, methyl (a glucose derivative) (Wrolstad 2012:40) was identified at a quality of 47. In addition, meconic acid, hydrocotarnine, codeine, neopine, morphine, thebaol, both peaks of thebaine, papaverine, and a compound likely related to laudanine were identified in the sample. Two additional opium alkaloids, thalicarpine and protopine, also appeared in the sample, both of which are minor alkaloids found in the opium poppy and other plants in the Papaveraceae order, as well as plants in Fumariaceae (Henry 1913:10; Wu and Huang 2006:41-2). The greater results may be due to a greater concentration of opium constituents due to evaporation.

To further examine potential degradation, the residue was permitted to sit for a second year, after which the residue was extracted, concentrated and analyzed using the procedures and parameters described above. It is important to note here that the GC parameters previously used for the analysis of the opium mixtures had unknowingly been changed and, therefore, the results from the second year are not comparable based on retention time, but since these experimental

\textsuperscript{41} The village to the south of the capital Nicosia, is known for continuing traditional pottery production.

\textsuperscript{42} Propanoic acid, 2-methyl-, hexyl ester
studies have already demonstrated much in regards to the longitudinal alteration of opium alkaloids, a few qualitative observations may still be made. Specifically, meconic acid is the only opium alkaloid yet discussed that shows up in the analysis intact, with a quality of 99. In addition, the compound, (-)-1,2,3,4-Tetrahydroisoquinolin- 6-ol-1-carboxylic acid, 7-methoxy- 1-methyl-, methyl ester, was identified at a quality of 80 and is a benzyltetrahydroisoquinoline alkaloid that likely represents a further degradation product in the papaverine-laudanine biosynthetic pathway, as detailed by Chovanec et al. (2012:23). These data seem to corroborate earlier findings that the morphinan alkaloids are unlikely to survive into the present – with the exception of thebaine in some cases, but that the degradation products of noscapine – meconic acid, particularly – and the degradation products of papaverine are the most likely candidates for compounds that should be targeted in future analyses.\footnote{It should also be added that the sample was analyzed in SIM mode targeting codeine, hydrocotarnine, meconic acid, morphine, noscapine, papaverine, and thebaine. Potential matches were identified for codeine (quality of 83), morphine (quality of 91), and noscapine (quality of 64). As has been indicated elsewhere, the SIM protocol for meconic acid, hydrocotarnine, and thebaine may require further work. These SIM results indicate that there are trace amounts of these compounds present in the sample.}

IV.E.2. Collection of Reference Sample Data

A major component of any archaeological residue project is the collection of reference spectra for constituent compounds in plants and other natural products that may be expected to be encountered during the analysis of archaeological artifacts.

IV.E.2.a. Botanical Plants from the Island of Cyprus

One group of reference spectra were obtained from a series of plants and products obtained from the island of Cyprus. These include:

1) olive oil, 2) white wine, 3) honey, 4) bay leaf, 5) carob, 6) everlasting, 7) fig leaf, 8) myrtle, 9) pine, 10) pink rockrose, 11) pink oleander, 12) sage, 13) thyme, 14) white rockrose, and 15) an unidentified plant potentially related to sage and perhaps in the \textit{Artemisia} family. Six of these are from specific areas on the island. The carob bean, fig leaf, and pink oleander were obtained from
the village of Episkopi near the sites of Episkopi-Bamboula and Sotira-Kaminoudhia. Two varieties of pink rockrose were collected, one of which came from the Troodos mountains near Kaledonia Falls. The unidentified plant was collected near Alassa.

IV. E.2.a.1. Additional Extraction and Analytical Procedures

To adequately characterize the chemical constituents of these reference samples, three additional extraction techniques were utilized. The first of these was adapted from Stauffer’s (2006) analytical scheme for the analysis of vegetable oil residues specifically for the purpose of characterizing the fatty acids present in olive oil. The procedure involved the extraction of fatty acids (triglycerides, in particular) and their derivatization and conversion into fatty acid methyl esters (FAMEs). To extract the vegetable oil, several boil stones were placed in a 10 mL round bottomed flask into which 1 mL of dichloromethane:methanol (2:1, v/v) and 1-2 mL of methanol:hydrochloric acid (100:1, v/v) were added along with 2-3 drops of the olive oil sample. This solution was refluxed for 1 hour, maintaining a temperature of 70°C. After this time, the condenser was removed and the solution continued to be heated at a low heat for approximately 15-20 minutes, to ensure that the reaction is completed because hydrochloric acid cannot be put into the GC. Once complete, 1-2 mL of hexanes were added to the flask, stirred for one minute and allowed to settle, which resulted in two visible layers in the solution. The top layer was carefully collected and injected into the GC.

The GC method include an initial temperature of 75°C which was held for 2 minutes then ramped up to 280°C at 15°C per minute and held for 30 minutes, making a total method run time of 45.00 minutes. There was a splitless interface to the quadrupole mass selective detector with a 3 minute solvent delay, which in this case was heptane, and with a mass range from 50 to 500.

44 Hereafter referred to as the lipid method.
45 The adoption of all extraction protocols was accomplished through consultation with Mr. Colin Henck, Lab Coordinator in the Chemistry Department at the University at Albany.
46 Issues and definitions relating to the analysis of lipids and fatty acids were discussed above in the analytical section.
The second method involved the extraction of a sample (whether botanical reference samples or pulverized archaeological pottery samples) placed in a vial with 5-10 mL of dichloromethane:methanol (2:1, v/v). The sample was then placed into a bath ultrasonicator for 2 hours and allowed to sit for 24 hours. In some cases the solution was filtered and/or centrifuged and concentrated to 1-2 mL, which was then injected into the GC. Alternatively, a 1-2 mL sample was taken from the solution and injected into the GC, a procedure that was often applied to reference samples. Samples extracted from pulverized pottery material was, as a rule, filtered and centrifuged, while for botanical reference samples this was often not necessary due to the clarity of the solvent.

The third technique involved the steam distillation of botanical reference samples for the purpose of extracting their essential oils. The procedure involves boiling the botanical material in water at 100°C in a 100 mL round bottom flask, which is connected to a condenser that is positioned at a downward angle and which is leads to another flask positioned in ice water. As the steam in the sample flask condenses, the volatile essential oil collects in the secondary flask. After collection, 1 mL of the collected oil is injected into the GC using the lipid and alkaloid analytical methods.

IV.E.2.b. Botanical Plants of Unknown Sources

Reference spectra were also obtained from other sources, including: scientific standards from Fisher Scientific and botanical sources from Bouncing Bear Botanicals. For the former category, spectra were obtained for: 1) atropine, 2) ephedrine, 3) harmine & harmaline, 4) nicotine (though not relevant to the question of residues in the Eastern Mediterranean), 5) as well as the opium used in the degradation study.

It is acknowledged that the source of the latter category is somewhat less reputable, but was utilized nonetheless since obtaining a broad range of ethnobotanicals can be difficult. That being said, it was expected that the chemical content would not meet expectations for some

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47 This approach was often utilized for archaeological samples since chemical constituents were expected to be in far lower concentrations in ancient samples.
samples and this proved to be true for: 1) *Amanita pantherina*, 2) *Ephedra* seeds, 3) poison hemlock (*Conium maculatum*) seeds, 4) mandrake (*Mandragora officinarum*) root, and 5) sacred lotus (*Nymphaea caerulea*) petals. In all cases, the psychoactive constituent characteristic of the plant was not identified and with no or few other constituents identified. Possible explanations for this may be that the constituent compounds are not soluble in the utilized solvents, that the form of the samples (seeds, in particular), or that the botanical samples themselves were not adequate examples of the species. The following, however, seem to be representative of the botanical species: 1) anise (*Pimpinella anisum*) seeds, 2) belladonna (*Atropa belladonna*) leaves, 3) hyssop (*Hyssopus officinalis*) flowers, 4) lavender (*Lavandula officinalis*) flowers, 5) lemon balm (*Melissa officinalis*) flower, 6) peppermint (*Mentha piperita*), 7) poppy (*Papaver somniferum*) seeds, 8) syrian rue (*Peganum harmala*) seeds, 9) henbane (*Hyoscyamus niger*) seeds, and 10) wormwood (*Artemisia absinthium*) extract and foliage.

**IV.E.3. Archaeological Samples**

Archaeological samples fall into two categories: 1) samples from stratified Bronze Age sites, and 2) samples from museum and university collections. With the exception of one sample of visible residue from Marki *Alonia*, all samples were either scrapings from the interiors of pottery vessels or consisted of pulverized potsherds.

**IV.E.3.a. Samples from Stratified Bronze Age Sites**

The stratified samples come from five archaeological sites: 1) the Early-Middle Bronze Age site of Alambra-Mouttes, 2) the Late Bronze Age tombs at Episkopi-Bamboula, 3) the Early-Middle Bronze Age site of Marki-Alonia, 4) the Middle Bronze Age of Politiko-Troullia, and 5) the Early Bronze Age site of Sotira-Kaminoudhia.

**IV.E.3.b. Samples from Museum Collections and Other Samples**

Additional samples were obtained from the Jane Barlow and Belcher Collections held at the University at Albany and the Semitic Museum at Harvard University.
IV.E.3.c Methods of Analysis

The analytical methods involved the organic extraction using the alkaloid protocol (ethanol:methanol), lipid protocol (dichloromethane:methanol, hydrochloric acid:methanol, hexanes), or the sonication protocol (dichloromethane:methanol) and GC analysis using the alkaloid parameters (total run time 12.67 minutes) or the lipid parameters (total run time 45.67 minutes) described above. Specific information regarding samples, methods, data, and interpretation are presented in the following chapter.
V. DATA ANALYSIS AND INTERPRETATION: THE STRATIFIED SAMPLES

V.A. EPISKOPI BAMBOULA

V.A.1 Site Background

The site of Episkopi Bamboula is located on the northern part of a ridge that runs between the Kouris River and the village of Episkopi. The site was known to have been occupied from the Late Bronze Age to the Roman period (Flourentzos 2006:63-4; Åström 1972:14-16). Much of the research into Bamboula has dealt with the site in the Iron Age and later periods under the name of Kourion Bamboula and Ancient Curium. The Late Bronze Age settlement was investigated by John Franklin Daniel between 1932 and 1948 with the delineation of six Areas (A-F) between 1937-1939 (Daniel 1938; Weinberg 1983:xi; 1-2). Much of the architectural remains from the site were identified in Areas A and E, located east and northwest of a threshing floor and well at the center of the site and in close proximity to a circuit wall that surrounded the settlement, which was occupied from LIC1A (1600-1550 B.C.) to LCIIIB (1100-1050 B.C.) (Åström 1972:14-16; Weinberg 1983:3).

Architecturally, two distinct types of houses were present, a rectangular house on a tripartite plan, which is known elsewhere in Cyprus later in the Bronze Age, and an L-shaped house, which seems to have developed locally (Åström 1972:14-16, 38; Weinberg 1983:1-2, 58-9, Fig. 1). The site includes a necropolis, though a number of tombs are present in streets and open areas. According to Keswani (2004:87), “the juxtaposition of tombs and houses seems to have been established in the earliest phases of the settlement with tombs located…where the living pursued their daily activities”. It is further suggested that this burial arrangement is indicative of increasing privatization as it pertains to familial bonds and signals growing inter-communal competition (Keswani 2004:88).

The samples selected for residue analysis derived from excavations undertaken by Dr. Gisela Walberg in 2002 and 2004 in Areas VIII and XII (Flourentzos 2006:63-4; Flourentzos 2008:54-5). The samples consist of Base Ring I\textsuperscript{48} ware from three tombs, 6, 9, and 10\textsuperscript{49}. The data

\textsuperscript{48} The fabric of BRI ware is well-mixed, light brown to dark grey with sand and white, brown, or black grits and is hard and metallic in character. The slip ranges from red to black and is
for these contexts have yet to be published, but both Keswani (2004) and Benson (1972) make mention of Tomb 6. Keswani (2004:100-3) gives a date of LCIIB to LCIIIC for a set of disarticulated skeletal remains in an intact section of the tomb. The timeline is less clear for a large pile of bones in its eastern section with which no objects were found and which Benson (1972:24) suggests is an intentional arrangement.

Base Rings were intentionally obtained from this kind of mortuary context with the intention of evaluation Merrillees’ [2003(1962)] proposition that the Base Ring juglets were modeled and decorated to resemble an inverted opium poppy capsule and served as specialized containers for the storage, transport and advertisement of the vessels’ contents: opium. While the samples discussed below presently lack contextual data, the chronological distribution of the ware and the deposition of containers designed for liquids in tombs suggests the vessels and their contents were highly valued.

V.A.2 SAMPLES

A total of eight samples were obtained from the Late Bronze Age tombs at Episkopi-Bamboula. All samples consisted of sherds of Base Ring I closed vessels, presumably jugs or juglets. They were collected, exported and analyzed with the permission of Dr. Gisela Walberg, the director of excavations at the site, and Dr. Maria Hadjicosti, Director of the Cyprus Department of Antiquities. The sample numbers and provenance information are provided below. All images were taken in the field with permission of Dr. Walberg.

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burnished to a high luster (Åström 1972 IV:1C:137). Decoration occurs in the form of relief bands and incisions, which tend to be arranged in symmetrical, vertical patterns on vessel bodies, constitute the most common decoration, and ultimately “degenerate[s] into wavy lines, antithetic curves, and spirals” with time (Åström 1972 IV-1C:171).

49 An additional sample was obtained from Area VIII, but did not come from a tomb.

50 Steel (2004:293) highlights that in LCI (1650-1450 B.C.), Base Ring ware occurred in limited concentrations (1%) at Episkopi Bamboula, but the percentage rose to 12% and 18% in LC IIA and LCIIB, respectively.
<table>
<thead>
<tr>
<th>Sample</th>
<th>Year</th>
<th>Area</th>
<th>Lot</th>
<th>Bag</th>
<th>Count</th>
<th>Provenance</th>
<th>Fragment Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>74</td>
<td>EB02</td>
<td>VIII</td>
<td>2</td>
<td>053</td>
<td>1</td>
<td></td>
<td>Base Ring I shoulder</td>
</tr>
<tr>
<td>75</td>
<td>EB04</td>
<td>XII</td>
<td>J28W-2</td>
<td>060</td>
<td>1</td>
<td>Pit A Chamber, Tomb 9</td>
<td>Base Ring I closed body with handle</td>
</tr>
<tr>
<td>76</td>
<td>EB02</td>
<td>VIII</td>
<td>2AE</td>
<td>107</td>
<td>1</td>
<td>Tomb 6</td>
<td>Base Ring I juglet body fragment near base</td>
</tr>
<tr>
<td>77</td>
<td>EB02</td>
<td>VIII</td>
<td>2AE</td>
<td>107</td>
<td>1</td>
<td>Tomb 6</td>
<td>Base Ring I neck fragment</td>
</tr>
<tr>
<td>78</td>
<td>EB02</td>
<td>VIII</td>
<td>2</td>
<td>062</td>
<td>1</td>
<td>Tomb 6 East</td>
<td>Base Ring I ring base</td>
</tr>
<tr>
<td>79</td>
<td>EB02</td>
<td>VIII</td>
<td>2E</td>
<td>065</td>
<td>1</td>
<td>Tomb 6</td>
<td>Base Ring I base fragment</td>
</tr>
<tr>
<td>80</td>
<td>EB02</td>
<td>VIII</td>
<td>2E</td>
<td>065</td>
<td>1</td>
<td>Tomb 6</td>
<td>Base Ring I body fragment with relief decoration</td>
</tr>
<tr>
<td>81</td>
<td>EB04</td>
<td>XII</td>
<td>I28W-4</td>
<td>077</td>
<td>1</td>
<td>Tomb 10 Chamber 4</td>
<td>Base Ring I body fragment near base</td>
</tr>
</tbody>
</table>

**V.A.3 METHODOLOGY**

All samples underwent one of three organic extraction procedures followed by analysis by Gas Chromatography/Mass Spectrometry using one of two programs. These procedures were detailed in the previous chapter as the Alkaloid, Lipid, and Sonication protocols. The GC parameters that were used were the alkaloid (12.67 minutes) and the lipid (45.67 minutes) methods. Samples were generally run in SCAN mode. When possible, they were also analyzed in SIM mode, targeting the following opium alkaloids: codeine, hydrocotamine, meconic acid, morphine, noscapine, papaverine, and thebaine.

**V.A.4 SUMMARY OF RESULTS**

Below is a summary of the samples in which chemical residues were identified and a description of the product that the vessel likely contained. A detailed discussion is provided in the next section. The chemical data discussed in the following section deals only with identification relevant to final interpretations.
74 EB02 VII Lot 2 053 (Base Ring I Shoulder)
The contents of this vessel was likely an herbal infusion which included rose, anise, and hyssop. The substance may have been a fermented beverage to which a tree resin was added. Possible sources for the resin are likely juniper or a torchwood species, though pine, fir, laurel, or woundwort are could be possible.

75 EB04 XII J28 W 2 060 (Base Ring I Closed Body with Handle)
The vessel likely contained a complex, medicinal mixture with minor psychoactive properties with the primary ingredient being a species of wormwood. While uncertain whether the species is white wormwood (*Artemisia herba-alba*) or absinthe wormwood (*Artemisia absinthium*), both plants have medicinal properties. Potential additional ingredients include peppermint, spike lavender, myrtle, oregano, pine, rosemary, sage, and marjoram.

76 EB02 VIII T6 2AE 107 (Base Ring I Juglet Body Fragment near Base)
The sample exhibited extensive contamination. If the detected constituents are inherent in the sample and not the product of contamination, the substance contained in the vessel may have been a fermented beverage with a species in the *Artemisia* family, and a resin from willow tree, though extracts from anise and buckwheat are also possible.

77 EB02 VIII T6 2AE 107 (Base Ring I Neck Fragment)
The vessel contained a substance with a tree resin base with possible medicinal properties. The tree resin derived from pine, fir, or cypress trees, which may suggest the presence of turpentine. The suggested medicinal element is based on the identification of an alkaloid structure that may represent the decomposition of the opium alkaloid, noscapine. Additional ingredients may include sage, black currant, and non-aromatic grapes or grape wine.
78 EB02 VII 2 062 (Base Ring I Ring Base)
While there was some contamination present, it is likely that the vessel contained some sort of aromatic fermented beverage. Potential aromatic plants include lavender, basil, myrtle, and sage, while coriander, thyme, wormwood, marjoram, and oregano are also possible.

79 EB02 VIII T6 2E 065 (Base Ring I Fragment)
The vessel exhibited extensive contamination with no identifiable compounds.

80 EB02 VIII T6 2E 065 (Base Ring I Body Fragment with Relief Decoration)
While the presence of a single degradation compound (that has not been demonstrated in experimental studies) is rather limited evidence, the possibility does remain that this vessel, like others from Episkopi Bamboula, contained a fermented beverage.

81 EB04 XII I28W 077 (Base Ring I Body Fragment near Base)
The vessel probably contained a fermented beverage (probably a grape wine) that was seasoned with a species of sage, rosemary, annual or white wormwood, oregano, myrtle, or lavender. The beverage likely also had medicinal benefits.
V.A.5. ANALYTICAL DATA AND DISCUSSION

V.A.5.a. 74 EB02 VII Lot 2 053 (Base Ring I Shoulder)

The sample was extracted with the alkaloid, lipid, and sonication protocols and analyzed using the alkaloid and lipid methods. All data files showed extensive plastic contamination. Anisole\(^{51}\), the primary constituent in anise, was detected in the sonication sample at a Retention Time (RT) 14.259 and at a quality\(^{52}\) of 64. While anisole was not detected in the lipid protocol, four fatty acids and three essential oils were identified. The fatty acids included stearic acid (C18, octadecanoic acid), caprylic acid (C8, octanoic acid), pelargonic acid (C9, nonanoic acid), and palmitic acid vinyl ester.

Fatty acids generally have a wide distribution. It may be noted, however, that caprylic acid is commonly found in milk products and pelargonic acid is natural constituent in plants in the genus *Pelargonium*. However, in this case both pelargonic acid and the vinyl ester are likely the result of plastic contamination (Beeston et al. 2006; Lalli 2005:311-2).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.533</td>
<td>Propanoic acid, 2-methyl-, hexyl ester</td>
<td>Isobutyric acid, hexyl ester</td>
<td>Alkaloid/Alkaloid</td>
<td>12.0</td>
<td>38</td>
</tr>
<tr>
<td>14.259</td>
<td>-Benzene, 1-methoxy-3-(2-phenylethenyl)-, (E)-</td>
<td>Anisole derivative</td>
<td>Sonication/Lipid</td>
<td>12.0</td>
<td>64</td>
</tr>
<tr>
<td>5.166</td>
<td>Octanoic acid, methyl ester</td>
<td>C8, caprylic acid</td>
<td>Lipid/Lipid</td>
<td>12.0</td>
<td>83</td>
</tr>
<tr>
<td>6.235</td>
<td>Nonanoic acid, methyl ester</td>
<td>C9, pelargonic acid</td>
<td>Lipid/Lipid</td>
<td>12.0</td>
<td>90</td>
</tr>
<tr>
<td>16.284</td>
<td>-(2,6,6-Trimethylcyclohex-1-enyl) cyclopropanecarboxylic acid</td>
<td>A damascene/beta-ionone derivative?</td>
<td>Lipid/Lipid</td>
<td>12.0</td>
<td>47</td>
</tr>
</tbody>
</table>

\(^{51}\) Benzene, 1-methoxy-3-(2-phenylethenyl)-, (E)-
\(^{52}\) The quality is a measure from 1-99 that determines the likelihood of the match. While higher qualities are more reliable, it should be noted that these are ancient residues that likely have undergone chemical degradation, meaning that lower qualities might indicate a more degraded form of that compound. The likelihood of the match is also based on what is in the spectral library (NIST02), making it possible that the form or structural isomer (similar structure) of that compound may not be in the library.
<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>M/z</th>
<th>Abundance</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.541</td>
<td>Palmitic acid vinyl ester</td>
<td>Lipid/Lipid</td>
<td>12.0</td>
<td>52</td>
</tr>
<tr>
<td>27.026</td>
<td>Octadecanoic acid, ethenyl ester</td>
<td>C18:0, stearic acid</td>
<td>Lipid/Lipid</td>
<td>12.0</td>
</tr>
<tr>
<td>32.521</td>
<td>Cyclohexanemethanol</td>
<td>Benzyl alcohol, hexahydro?</td>
<td>Lipid/Lipid</td>
<td>12.0</td>
</tr>
<tr>
<td>32.531</td>
<td>Bicyclo[3.1.1]heptane, 2,6,6-trimethyl-α,α,4-trimethyl-3-(1-methylethylidene)-1-vinylcyclohexane</td>
<td>Alpha-pinene or isopinocamphone</td>
<td>Lipid/Lipid</td>
<td>12.0</td>
</tr>
<tr>
<td>33.887</td>
<td>Stearic acid, hydrazide</td>
<td>C18:0, stearic acid derivative</td>
<td>Lipid/Lipid</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Episkopi-Bamboula  
74 EB02 VII Lot 2 053  
Sonication-Lipid

2-(2,6,6-Trimethylcyclohex-1-enyl) cyclopropanecarboxylic acid, methyl ester identified at RT 16.284 may be related to one or more damascenes, which are aromatic compounds commonly found in rose oil. A likely candidate is beta-ionone ((E)-4-(2,6,6-trimethyl-1-cyclohexenyl)but-3-en-2-one; p-menth-1-en-8-ol) (Mookherjee et al. 1990; Van Ouwerkerk et al. 1977). Additionally the peak for cyclohexanemethanol may represent a fragment of elemol (Cyclohexanemethanol, 4-ethenyl-α,α,4-trimethyl-3-(1-methylethenyl)-, [1r-(1α,3α,4β)]-, which is a major conmstituent in hyssop. It is related to elemene (1-Methyl-2,4-bis(1-methylethylidene)-1-vinylcyclohexane ) which is common in juniper berries, myrrh, torchwood and a minor constituent in fir, laurel, woundwort, pine, yarrow, oregano, basil, and rose (Alves-Pereira and Fernandes-Ferreira 1998; Dev et al. 2011; Grandi et al. 1972; Rohmer et al. 1977; von Rudloff 1975; von Rudloff et al. 1980; Roussis et al. 1995; Sáez 1995; Skaltsa et al. 2001; Smedman et al. 1969; Rusanov et al. 2011). However, it should be noted that all three, beta-ionone, elemol, and elemene are found in Rosa damascene (Rusanov et al. 2011). The final essential oil identified in the lipid sample, Bicyclo[3.1.1]heptane, 2,6,6-trimethyl-α,α,4-trimethyl-3-(1-methylethylidene)-1-vinylcyclohexane, is
likely related to isopinocamphone (2,6,6-Trimethylbicyclo[3.1.1]heptan-3-one), a known constituent in *Cistus* and *Mentha* species, but *Hyssop officinalis* in particular (Oller-López 2005; Lincoln et al. 1986; Bowles 2003; Lu et al. 2002; Schulz et al. 2006; Oumzil et al. 2001).

Another possibility is *Stachys palustris* L., a species of Lamiaceae, which has benzyl alcohol (benzyl alcohol, hexahydro- = cyclohexanemethanol), beta-damascone, beta-elemene, and alpha-pinene. *S. palustris* belongs to the mint family and is commonly referred to as a hedgenettle or a marsh woundwort. Overall it seems that the vessel contained a perfumed oil that likely contained Lamiaceae species that may have been related to mint such as the hedgenettle or hyssop, possibly also rose (Senatore et al. 2007; NIST [http://webbook.nist.gov/cgi/cbook.cgi?ID=100-49-2&Units=SI]).

The same fatty acids that were identified in the lipid extraction were identified in the alkaloid extraction and therefore will not be repeated here. One other compound was identified, propanoic acid, 2-methyl-, hexyl ester, which plays a role in the fermentation of red wines and vinegars (Ferriera et al. 2002:4048-50; Guth 1997:3027; Lambert 1997:37; Rocha et al. 2004:257-8). While the presence of this compound might indicate a fermented grape beverage, tartaric acid, the biomarker found in grape skins, was not identified. The alkaloid sample was also analyzed in Selected Ion Monitoring (SIM) mode, targeting ions associated with the opium alkaloids morphine, codeine, thebaine, papaverine, noscapine, hydrocotarnine, and meconic acid. None of these were identified.

The contents of this vessel was likely an herbal infusion included rose, anise, and hyssop. The substance may have been a fermented beverage to which a tree resin was added. Possible sources for the resin are likely juniper or a torchwood species, though pine, fir, laurel, or woundwort are could be possible.

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53 It should be noted that the RT for Cyclohexanemethanol and the isopinocamphone are 32.521 and 35.531, respectively, and may represent the same peak.
The sample was extracted using the alkaloid, lipid, and sonication protocols and analyzed using the alkaloid and lipid methods. Two essential oil compounds were detected. In the alkaloid sample, alpha-terpineol (4-methyl-1-(1-methylethyl)-1,3-cyclohexadien) was identified at a quality of 90, which is a constituent in white wormwood as alpha-terpineol acetate as well as cis-beta-terpineol and L-4-terpineol (Nezhadali et al. 2008). Additional constituent plants include lemongrass, cardamom as alpha-terpineol as well as alpha-terpinyl acetate and terpinen-4-ol, spike lavender, marjoram, sweet marjoram, nutmeg as alpha- and gamma-terpineol, myrtle, lemon catnip, species of oregano, pine, rosemary, clary sage, and vervain as beta-terpineol (Bowles 2003; Farah et al. 2006; Wesołowska et al. 2011; Alves-Pereira and Fernandes-Ferreira 1998; Daferera et al. 2000). In addition, terpineol was identified in a botanical reference sample of peppermint as 4-terpineol. The alkaloid sample was also analyzed in SIM mode with no results.

The second essential oil compound, alpha-fenchene (Bicyclo[2.2.1]heptane, 7,7-dimethy1-2-methylene-) was identified in the sonication sample at lower quality of 27 and is related to fenchone (1,3,3-Trimethylbicyclo[2.2.1]heptan-2-one). Both are minor constituents in absinthe (Kordali et al. 2005), but not white wormwood. Fenchone is a major constituent of fennel with gamma-terpinene and terpinen-4-ol as minor constituents (Emmert et al. 2004; Piccaglia and Marotti 2001).

An alkene and fatty acid were identified in the lipid sample. While the alkene (5-tetradecene) and fatty acids in general, have a wide distribution, it may be noted that members of Myristicaceae, a genus that includes nutmeg, are a major source of myristoleic acid ((Z)-Tetradec-
9-enoic acid) (Bowels 2003:197). However, in this case, there is nothing to suggest that the vessel contained nutmeg. Rather, the contents of the vessel likely contained a species of wormwood and/or fennel with a long list of possible additives, noted above. Myristoleic acid makes up 74.9% of nutmeg oil (Keela 2008:169). Nutmeg also has alpha-terpineol, but lacks alpha-fenchone. Myristoleic acid is also found in adipose fat in both marine and terrestrial animals (https://www.lipomics.com/).

Based on these results, the vessel likely contained a complex, medicinal mixture with minor psychoactive properties. The primary ingredient was likely a species of wormwood. While it is uncertain whether the species is white wormwood (Artemisia herba-alba) or absinthe wormwood (Artemisia absinthium), both plants have medicinal properties. Potential additional ingredients include peppermint, lemon grass, cardamom, spike lavender, myrtle, oregano, pine, rosemary, sage, and marjoram.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.802</td>
<td>Bicyclo[2.2.1]heptane, 7,7-dimethyl 1,2-methylene-</td>
<td>Alpha-fenchone</td>
<td>Sonication/Lipid</td>
<td>12.0</td>
<td>35</td>
</tr>
<tr>
<td>5.963</td>
<td>p-menth-1-en-8-ol</td>
<td>Alpha-terpineol</td>
<td>Lipid/Lipid</td>
<td>12.5</td>
<td>90</td>
</tr>
<tr>
<td>5.973</td>
<td>3-Cyclohexene-1-methanol, .alpha.,.alpha.,4-trimethyl-, (S)-</td>
<td>Alpha-terpinyl acetate</td>
<td>Lipid/Lipid</td>
<td>12.5</td>
<td>72</td>
</tr>
<tr>
<td>15.600</td>
<td>Myristoleic acid</td>
<td>C14:1n5, in adipose, myristaceae</td>
<td>Lipid/Lipid</td>
<td>12.5</td>
<td>23</td>
</tr>
<tr>
<td>16.313</td>
<td>5-Tetradecene, (E)-</td>
<td>Myristoleic acid</td>
<td>Lipid/Lipid</td>
<td>12.5</td>
<td>43/42</td>
</tr>
</tbody>
</table>
The sample was extracted with the lipid, alkaloid, and sonication protocols and analyzed with the alkaloid and lipid methods. The lipid sample yielded no data. The alkaloid sample exhibited extensive field and storage contamination by both plastics and sun block. Due to this observation, the squalene detected at a quality of 91 is likely related to this contamination. The two fatty alcohols (2-Pentadecanol and 2-Tetradecanol) are likely products of storage contamination. As in the previous samples, the sonication sample exhibited extensive contamination.

Despite this, isobutyric acid, heyl ester was identified at quality of 64. The compound was noted in EB74, has been known to play a role in the fermentation of red grape wines and vinegars, and was identified in a reference sample of red wine that had absorbed into a sherd of Cypriot pottery (Ferrier et al. 2002:4048-50; Guth 1997:3027; Lambert 1997:37; Rocha et al. 2004:257-8). Two salicylate compounds were identified. The first, prenyl salicylate, was present at a quality of 23 using the alkaloid method and the second, salicylic acid, was identified at a
quality of using the lipid method. The latter may be the result of human-introduced contamination. However, salicylate was originally derived from willow trees in the genus *Salix*. Another sources include *Pimpinella anisum* (anise) as salicylic acid glucoside (Reichling et al. 2005) and *Fagopyrum esculentum* (buckwheat) as salicylaldehyde (Janeš and Kreft 2008). It is important to noted that the storeroom that housed the artifacts from the site had recently had its shelves revarnished, which may have introduced contamination into the samples.

Other constituents included alpha-fenchene, which was detected at a quality of 22. As noted for the previous sample, this compound is related to fenchone, both of which being constituents in species of wormwood (Emmert et al. 2004). However, a single essential oil compound at a low quality is insufficient for an acceptable identification, particularly with a high level of contamination. The bicyclo[3.3.1]non-2-en-9-ol, anti-is likely 1-phenyl-bicyclo[3.3.1]-non-2-en-9-ol benzoate, which is a constituent in *Artemisia monosperma* (found in Israel, Egypt), a mugwort in which alpha-fenchone is also a constituent (Zohary 1982:34).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.515</td>
<td>Propanoic acid, 2-methyl-, hexyl ester</td>
<td>Isobutyric acid, hexyl ester</td>
<td>Alkaloid/Alkaloid</td>
<td>12.0</td>
<td>64</td>
</tr>
<tr>
<td>3.437</td>
<td>Hexanoic acid</td>
<td>C6, caproic acid</td>
<td>Sonication/Lipid</td>
<td>12.0</td>
<td>59</td>
</tr>
<tr>
<td>5.790</td>
<td>Benzoic acid, 2-hydroxy-, 3-methyl-2-butenyl ester</td>
<td>Prenyl salicylate</td>
<td>Alkaloid/Alkaloid</td>
<td>12.0</td>
<td>23</td>
</tr>
<tr>
<td>5.798</td>
<td>Bicyclo[2.2.1]heptane, 7,7-dimethy l1-2-methylene-</td>
<td>Alpha-fenchone</td>
<td>Sonication/Lipid</td>
<td>12.0</td>
<td>22</td>
</tr>
<tr>
<td>11.007</td>
<td>Bicyclo[3.3.1]non-2-en-9-ol, anti-</td>
<td>Sonication/Lipid</td>
<td>12.0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>11.136</td>
<td>Salicylic acid</td>
<td>Alkaloid/Lipid</td>
<td>12.0</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>17.155</td>
<td>2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-,</td>
<td>Squalene</td>
<td>Alkaloid-Lipid</td>
<td>12.0</td>
<td>91/90</td>
</tr>
</tbody>
</table>

If the other constituents in the sample are inherent in the sample and not the product of contamination, the substance contained in the vessel may have been a fermented beverage with a species in the *Artemisia* family, and a resin from willow tree, though extracts from anise and buckwheat are also possible.
The sample was extracted and analyzed using the alkaloid and lipid methods. Like all the samples from Episkopi-Bamboula, the alkaloid sample was further analyzed in SIM mode, targeting opium alkaloids. Similar to the previous sample, there was extensive contamination with only the alkaloid sample returning results. At RT 5.930, 4-caranol (Bicyclo[4.1.0]heptan-3-ol, 4,7,7-trimethyl-, (1.alpha.,3.beta.,4.alpha.,6.alpha.)-) was identified at a low quality of 12. The compound may be related to delta-3-carene (3,7,7-trimethylbicyclo[4.1.0]hept-3-ene), which are constituents in pine, fir, and cypress trees and therefore might suggest the presence of a turpentine. In addition, 4-carene is a minor constituent in a number of plants, including but not limited to black currants, non-aromatic grapes and wines, and sage (Le Quere and Latrasse 1190; Nasi et al. 2008; Bowles 2003). However, the low quality of the matches makes any determination uncertain.

As in the previous sample, two salicylate compounds were identified: prenyl salicylate (benzoic acid, 2-hydroxy-, 3-methyl-2-butenyl ester) and aspirin. The latter may be the result of human-introduced contamination. However, aspirin is chemically known as acetylsalicylic acid and was originally derived from willow trees in the genus Salix. Another sources include Pimpinella anisum (anise) as salicylic acid glucoside (Reichling et al. 2005) and Fagopyrum esculentum (buckwheat) as salicylaldehyde (Janeš and Kreft 2008). Anise is a potential candidate due to the fact that anise alcohol (Benzenemethanol, 4-methoxy-) was identified at a similar RT in a re-analysis of the alkaloid sample. The final compound detected in the sample is an alkaloid skeleton identified at RT 12.019. Indolo[3,2-b]quinoline, 10-methyl- 2-nitro- was identified in a vessel from Politiko-Troullia that contained the remnant of an aromatic medicine the

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54 It has been mentioned before that the low qualities may be indicative of degradation products that do not exist in the spectral library, but appear to be similar to other compounds – hence the low quality.
comprised rockrose resin and noscapine ((3S)-6,7-Dimethoxy-3-[(5R)-5,6,7,8-tetrahydro-4-methoxy-6-methyl-1,3-dioxolo(4,5g)isoquinolin-5-yl]-1(3H)-isobenzofuranone), an opium alkaloid. In the Troullia sample, the alkaloid structure may be a decomposition product of noscapine and the same may be true for this sample. However, this compound was not identified in any of the degradation studies and therefore any relationship to opium is speculative. However, it does seem certain that the vessel contained a substance of medicinal value. This determination is due to the fact that indoloquinolines are biologically active structures that have been utilized in medicinal chemistry in the synthesis of antimicrobial and antibiological agents (Kapoor 1995:162, 166-7; Petri and Mihalik in Bernáth 1998:50; Kumar Suresh et al. 2008).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.930</td>
<td>Bicyclo[4.1.0]heptan-3-ol, 4,7,7-trimethyl-, (1.alpha.,3.beta.,4.alpha.,6.alpha.-)</td>
<td>4-caranol</td>
<td>Alkaloid/Lipid</td>
<td>13.0</td>
<td>12</td>
</tr>
<tr>
<td>11.138</td>
<td>Aspirin</td>
<td></td>
<td>Alkaloid/Lipid</td>
<td>13.0</td>
<td>33</td>
</tr>
<tr>
<td>11.712</td>
<td>Benzoic acid, 2-hydroxy-, 3-methyl-2-butenyl ester</td>
<td>Prenyl salicylate</td>
<td>Alkaloid/Lipid</td>
<td>13.0</td>
<td>37</td>
</tr>
<tr>
<td>11.712</td>
<td>Benzenemethanol, 4-methoxy-</td>
<td>Anise alcohol</td>
<td>Alkaloid/Lipid</td>
<td>13.0</td>
<td>30</td>
</tr>
</tbody>
</table>

Based on these results, the vessel contained a substance with a tree resin base with possible medicinal properties. The tree resin derived from pine, fir, or cypress trees, which may suggest the presence of turpentine. The suggested medicinal element is based on the
identification of an alkaloid structure that may represent the decomposition of the opium alkaloid, noscapine. Additional ingredients may include sage, black currant, and non-aromatic grapes or grape wine.

V.A.5.e 78 EB02 VII 2 062 (Base Ring I Ring Base)

The sample was extracted and analyzed using the alkaloid and lipid methods. One fatty acid, caproic acid (C6, hexanoic acid), was detected, most likely the product of contamination. It should be noted that the GC column was cleaned after the initial run; to ensure the analysis was accurate, the sample was run a second time. There were a few differences that should be noted. First, the caproic acid was identified as malonic acid, propyl-, dimethyl ester (Propanedioic acid, propyl) at slightly lower quality of 74. While it’s possible that the latter compound is related to fermentation in some way, it is more likely that the peak with which the identification is associated derives from contamination.

The same is likely true for presence of the sesquiterpene alcohol, farnesol (2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-, (E,E)-), in the first run and as squalene (2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (2E,6E,10E,14E,18E)-), a widely distributed triterpene that frequently is a source of contamination, in the second run. A similar situation was observed for compounds identified at RT 5.802 with the same quality. In the initial run, it was identified as linalool (1,6-Octadien-3-ol, 3,7-dimethyl-, formate), but as p-Menth-8-ene, trans-(Cyclohexane, 1-methylene-4-(1-meth ylthethyl)-) in the second. The former has a wide distribution, but is found in larger concentrations in coriander, fig tree, absinthe wormwood, sweet marjoram, oregano, sage in the Phlomis family, rose, thyme and is the primary constituent in
lavender and basil (Bowles 2003; Amor et al. 2011; Daferera et al. 2010; Ferraro et al. ND; Muanda et al. 2011; Teixeira da Silva 2004; Zhou et al. 2011). It was also identified experimentally in reference samples of lavender, as well as fig leaf, myrtle, and sage from Cyprus. The distribution of p-Menth-8-ene, trans- is less clear and likely is a degradation product, perhaps of alpha-terpineol, making linalool the more likely candidate.

In addition, there were two additional compounds identified which suggest the presence of a fermented beverage and which were identified in both runs of the sample. These include isobutyric acid, hexyl ester (Propanoic acid, 2-methyl-, hexyl ester) and another compound (Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester) that is likely one of its degradation products. As mentioned elsewhere, the isobutyric acid and its derivatives are known constituents in red wine and vinegars, play a role in fermentation, and have been identified in reference samples of red wine (Ferriera et al. 2002:4048-50; Guth 1997:3027; Lambert 1997:37; Rocha et al. 2004:257-8). However, it should be noted that tartaric acid was not identified.

While there was some contamination present, it is likely that the vessel contained some sort of aromatic fermented beverage. Potential aromatic plants include lavender, basil, myrtle, and sage, while coriander, thyme, wormwood, marjoram, and oregano are also possible.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.431</td>
<td>Hexanoic acid/Propanedioic acid, propyl C6:0, Caproic acid/ Malonic acid, propyl-, dimethyl ester;</td>
<td>Alkaloid/Lipid/Alkaloid/Lipid/Rerun</td>
<td>12.0</td>
<td>83/74</td>
<td></td>
</tr>
<tr>
<td>5.802</td>
<td>1,6-Octadien-3-ol, 3,7-dimethyl-, formate/Cyclohexane, 1-methylene-4-(1-methylethenyl)-Linalool/p-Menth-8-ene, trans-</td>
<td>Alkaloid/Lipid/Alkaloid/Lipid/Rerun</td>
<td>12.0</td>
<td>38/38</td>
<td></td>
</tr>
<tr>
<td>7.380</td>
<td>Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester Degradation of isobutyric acid?</td>
<td>Alkaloid/Lipid/Rerun</td>
<td>12.0</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>7.567</td>
<td>Propanoic acid, 2-methyl-, hexyl ester Isobutyric acid, hexyl ester</td>
<td>Alkaloid/Lipid/Alkaloid/Lipid/Rerun</td>
<td>12.0</td>
<td>64/78</td>
<td></td>
</tr>
<tr>
<td>16.964</td>
<td>2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-, (E,E)/2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-</td>
<td>Farnesol/Squalene</td>
<td>Alkaloid/Lipid/Alkaloid/Lipid/Rerun</td>
<td>12.0</td>
<td>59/64</td>
</tr>
</tbody>
</table>
The sample was extracted and analyzed using the alkaloid and lipid methods. Only one compound was identified - the compound proposed to be a degradation compound of isobutyric acid. It was identified in both the alkaloid and lipid analyses of the alkaloid extraction. While the presence of a single degradation compound (that has not been demonstrated in experimental studies) is rather limited evidence, the possibility does remain that this vessel, like others from Episkopi Bamboula, contained a
fermented beverage.

### Table 1: Compounds Identified in the Sample

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.482</td>
<td>Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester</td>
<td>Degradation of isobutyric acid?</td>
<td>Alkaloid-Lipid</td>
<td>12.0</td>
<td>74</td>
</tr>
</tbody>
</table>

**V.A.5.h 81 EB04 XII I28W 4 077 (Base Ring I Body Fragment near Base)**

The sample was extracted using the alkaloid, lipid and sonication protocols and analyzed using the alkaloid and lipid methods. A single compound, alpha-terpineol (p-menth-1-en-8-ol), was identified in the sonication sample, which is a constituent in spike lavender, sweet and regular marjoram, nutmeg, myrtle, oregano, rosemary, a species of pine (*Pinus pinaster*) non-aromatic grapes and wines, and is a minor constituent in white wormwood (Amore et al. 2006; Bowles 2003; Daferera et al. 2000; de Martino et al. 2009; Nasi et al. 2008). The compound was also identified in hyssop, as well as pine and myrtle from Cyprus. It was also present in the alkaloid extraction and lipid analysis at a similar quality.
Two additional essential oil compounds were detected, both of which were identified in the alkaloid extraction using the lipid analytical method. 3-Diazo-1,7,7-trimethylbicyclo[2.2.1]heptan-2-one is related to camphor (Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, (1R,4R)-), which is a constituent in annual, white and absinthe wormwood, coriander, lavender, rosemary, sage, oregano, wild fennel and tansy, as well as Taurus cedar in small amounts. It is also found in basil and thyme, though it was not identified in a reference sample of Cypriot thyme. It was however identified in reference samples of lavender and Cypriot sage (Başer and Demirçakmak 1995; Bowles 2003; Daferera et al. 2000; Fasseas et al. 2007; Ferraro et al. ND; Lee et al. 2005; Nezhadali et al. 2008; Piccaglia and Marotti 2001; Radulović and Blagojević 2010; Teixeira da Silva 2004; Veličkovič et al. 2003). The presence of camphor is interesting since it was known in antiquity to be useful for coughs, in the reduction of fevers, to soothe gums and epilepsy (Aboelsoud 2010; Plin. Nat. 20.19). While the camphor known by ancient authors was most likely the camphor laurel, a plant not indigenous to Cyprus and therefore is perhaps not the source of the camphor compound here, the fact that the camphor laurel is a major source of the compound camphor might suggest that other plants with this compound as a constituent may also have similar medicinal applications.

The second compound is 2-hydroxy-1,8-cineol (2-Oxabicyclo[2.2.2]octan-6-ol, 1,3,3-trimethyl-), which is related to 1,8-cineole and is also known as eucalyptol (1,3,3-trimethyl-2-oxabicyclo[2.2.2]octane). 1,8-cineole is a major constituent in annual wormwood, lavender and spike lavender in particular, a species of sage (Salvia wiedemanni), sage species in the Phlomis family, and is general a common constituent in the larger Salvia genus. (Amor et al. 2009; Bowles 2003; Daferera et al. 2000; Kaya et al. 2009:552; Kordali et al. 2005; Radulović and Blagojević 2010). It is also a constituent in peppermint, spearmint, rosemary, basil, thyme and oregano, tansy, and a species of rockrose (Cistus ladaniferus), as well as in a species of popular (Populus nigra) in small amounts (Bowles 2003; Daferera et al. 2000; De Martino et al. 2009; Isidorov and Vinogorova 2003; Lee et al. 2005; Oller-López et al. 2005; Teixeira da Silva 2004:707-8). The

\[\text{(55) It should be noted that while the compound is listed as a constituent in basil and thyme species in the chemical literature, it was not identified experimentally in a reference sample of thyme obtained from Cyprus.}\]
compound was also identified experimentally in reference samples of peppermint, lavender, as well as species of bay leaf and myrtle from Cyprus.

Four additional compounds were identified in the alkaloid extraction analyzed using the lipid method. Two of these are compounds associated with fermentation, isobutyric acid, hexyl ester and a compound that is likely its degradation product, both of which have been identified in other Base Rings from Episkopi-Bamboula. As elsewhere, the presence of these compounds may suggested the presence of a red grape wine. It may also be noted that isobutyric acid, hexyl ester was also identified in the alkaloid analysis of the alkaloid extraction.

One of the issues with the samples from Episkopi-Bamboula was the potential for contamination during storage. The squalene identified in the sample may be associated with this contamination, but is also a known constituent in various plant and animal-derived oils making the assignment of a source rather difficult. The final compound detected in the sample is Indolo[3,2-b]quinoline, 10-methyl-2-nitro-, which may be a degradation product of noscapine. The reason for this suggestion is that the compound was identified in the sample pottery sample as the opium alkaloid, noscapine, from Politiko-Troullia. The nature of the analysis in question was that scrapings of the vessel were first collected and analyzed, followed by destructive analysis (pulverization) of a sherd of the vessel. In the former, noscapine was identified and in the latter, the indoloquinoline compound was identified, which may or may not suggest a relationship. It may be added that the compound in question was not identified in any of the degradation studies on opium. Regardless, indoloquinolines are biologically active structures that have been utilized in medicinal chemistry in the synthesis of antimicrobial and antibiological agents (Kumar et al. 2008). However, this compound has been identified in a series of other samples, which then suggests that the compound is a contaminant. Future work should address the nature of this compound.

Based on these results, the vessel probably contained a fermented beverage (probably a grape wine) that was seasoned with a species of sage, rosemary, annual or white wormwood, oregano, myrtle, or lavender. The inclusion of opium at this stage cannot be proposed with any confidence. What may be stated is that the beverage likely also had medicinal benefits.
<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.509</td>
<td>Propanoic acid, 2-methyl-, hexyl ester</td>
<td>Isobutyric acid, hexyl ester</td>
<td>Alkaloid-Akalkoid</td>
<td>12.0</td>
<td>40</td>
</tr>
<tr>
<td>5.790</td>
<td>p-menth-1-en-8-ol</td>
<td>Alpha-terpineol</td>
<td>Sonication-Lipid</td>
<td>12.0</td>
<td>83</td>
</tr>
<tr>
<td>5.909</td>
<td>p-menth-1-en-8-ol</td>
<td>Alpha-terpineol</td>
<td>Alkaloid-Lipid</td>
<td>13.0</td>
<td>90</td>
</tr>
<tr>
<td>6.126</td>
<td>3-Diazo-1,7,7-trimethylbicyclo[2.2.1]heptan-2-one</td>
<td>Related to camphor?</td>
<td>Alkaloid-Lipid</td>
<td>13.0</td>
<td>64</td>
</tr>
<tr>
<td>6.235</td>
<td>2-Oxabicyclo[2.2.2]octan-6-ol, 1,3,3-trimethyl-, acetate</td>
<td>exo-2-Hydroxy cineole acetate</td>
<td>Alkaloid-Lipid</td>
<td>13.0</td>
<td>40</td>
</tr>
<tr>
<td>7.483</td>
<td>Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester</td>
<td>Degradation of isobutyric acid?</td>
<td>Alkaloid-Lipid</td>
<td>13.0</td>
<td>56</td>
</tr>
<tr>
<td>7.681</td>
<td>Propanoic acid, 2-methyl-, hexyl ester</td>
<td>Isobutyric acid, hexyl ester</td>
<td>Alkaloid-Lipid</td>
<td>13.0</td>
<td>74</td>
</tr>
<tr>
<td>17.165</td>
<td>2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-</td>
<td>Squalene</td>
<td>Alkaloid-Lipid</td>
<td>13.0</td>
<td>90</td>
</tr>
</tbody>
</table>
V.B. **ALAMBRA MOUTTES**

V.B.1 Site Background

Alambra-Mouttes is a Middle Bronze Age or Prehistoric Bronze Age 2 village located 8 km southeast of Marki *Alonia* that was excavated in the 1980s by Cornell University. The settlement at the site consists of seven buildings that are predominantly domestic in nature with the exception of Building IV. The unusual features, differentiated plan, and atypical distribution of artifacts led the excavators to attribute a feasting function to it (Coleman et al. 1996:75-89; Crewe and Hill 2012:224; Frankel 1999:207; Knapp 2008:75, 80).

The building consists of Rooms 6, 8, 13, 23 and 27. Room 13 is the only room at the site with a backdoor, abuts Room 6 and leads back to Space 27. It is suggested that Room 8 is the oldest part of the structure with the remaining space at the site perhaps being unroofed at some earlier stage. Space 27, on the other hand, was large courtyard that sloped into the rear hillside, measured 5 x 12 meters, and may have been used as a pen for animals (Coleman et al. 1996:75-8, 84-5).

Room 13, which contained the densest concentration of animal remains at the site, had several unusual features, including two wall projections and a short two-course masonry pedestal where the room communicated with Room 23, as well as a group of 15 complete pots located near the two projections originating from a party wall shared with Room 8. Eleven of these were juglets, large and small bowls, a pyxis, and a tripod vessel and may have fallen from a shelf above (Coleman et al. 1996:77-83).

Room 8 is the largest enclosed area measuring 6 x 7.6 meters with the largest hearth and the greatest concentration of burnt bone at the site. The hearth contained ash, blackened pottery, and bones and was surrounded by semi-circular curb. Like Room 13, there were a series of juglets and small bowls, perhaps used in pairs, concentrated along the party wall near the

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56 Little is known about the role of Room 23 in this building due to heavy erosion.
57 A space that had gone out of use and had been blocked and filled.
58 If we assume that this building did in fact have a special function, the fact that its construction as a roofed space in what appears to be a planned layout predates the covering of the remaining areas may suggest that such a function was the original intention of the structure.
59 Nine ground stone axes were also recovered from the room.
hearth. A total of 28 nearly complete vessels (14 juglets, 13 small bowls, and 1 large bowl) recovered in this area were interpreted as a potentially belonging to a drinking set used in a community space (Coleman et al. 1996:77-8, 85-9; Crewe and Hill 2012:224).

Coleman et al. (1996:89) maintain that juglets and bowls are often linked in Early and Middle Bronze Age models of ritual representations, which are referred to as genre scenes. They are thought to depict the production of bread or wine. Herscher (1997 in Knapp 2008:89) suggests for a scene from Pyrgos Tomb 35 “the pressing of grapes in the production of alcohol to be consumed in funerary feasts”. The Vounous bowl found in Tomb 22 at Bellapais Vounous clearly depicts a gathering that is elite in nature, due to the differential placement and stature of one particular male figure. In several unprovenanced examples depict juglets and bowls being used in combination. In one particular instance, an offering table holds a juglet and two bowls, which might suggest mixing different substances together (Coleman et al. 1996:89; Dikaios 1940:50; Crewe and Hill 2012:225; Knapp 2008:87; Webb and Frankel 2010:192).

While Coleman (1996 in Keswani 2005:362-3) finds no indication of status differentiation in the way of wealth or authority at Alambra, there does appear to be a greater level of architectural planning involved at the site, which seems to further suggest that the special function that Building IV clearly served was its original intent. Based on the unusual character of the rooms in Building IV and the deposit of seemingly individualized juglets and bowls in Rooms 8 and 13, as Coleman et al. (1996:89) originally suggested, feasting or other consumption of drink (perhaps alcoholic beverages) in a communal setting seems to be indicated. However, it must be mentioned that the population estimate for the village was 800 people in some 16 households, making it impossible for the space in Building IV to accommodate the entire community. A more feasible explanation may be that representatives of those households convened together in Room 8, with the other rooms in the building being utilized in preparation or for the accommodation for a larger group.

As noted by Keswani (2005:362-3), authority figures may have existed at this stage, but “their realm of influence may have been limited to their extended households”. While further excavation at the site may be necessary to fully understand the extent of any communal activities,
the current evidence may indicate an expansion of this limited influence beyond the household level and for this reason the ceramic assemblage in Rooms 8 and 13 represent an ideal case for examining what prestigious products would have been prepared and consumed during the middle part of the Bronze Age.

V.B.2 SAMPLES

Samples from ten juglets from Rooms 8 and 13 juglets were collected by scraping the interiors of vessels. While it would have been ideal to sample both juglets and bowls, previous attempts with open shapes, particularly when using scrapings, have yielded limited results. Another issue is that all of the Alambra vessels had been curated, which means that collecting scrapings from the interiors of these bowls would have damaged the visible interiors of these museum specimens. Therefore, it was deemed that the juglets were the best candidates for analysis. Other factors affecting the selection of samples included the degree of conservation since reconstructed vessels would have been contaminated with glues, putty and other materials, the hardness of fabric, and the size of the vessel since a certain sample size is required to obtain results. All samples were collected with the permission of Dr. John Coleman, the director of the Alambra-Mouttes excavations, Dr. Maria Hadjicosti, the Director of the Cyprus Department of Antiquities, and the permission of the Cyprus Archaeological Museum in Nicosia. All images were taken in the museum with the permission of Dr. Coleman.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Building</th>
<th>Room</th>
<th>Ware</th>
<th>Shape</th>
<th>Provenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3/P15</td>
<td>IV</td>
<td>8</td>
<td>RPA</td>
<td>Juglet with round spout</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
<tr>
<td>F82/P95</td>
<td>IV</td>
<td>8</td>
<td>RPB</td>
<td>Juglet with cutaway spout, undecorated</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
<tr>
<td>F84/P33</td>
<td>IV</td>
<td>8</td>
<td>RPB</td>
<td>Juglet with round spout, undecorated</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
</tbody>
</table>

60 The difference between the two numbers is that the F number is the museum accession number; the P number is the field number noted in the excavation publication.
<table>
<thead>
<tr>
<th>Site</th>
<th>Period</th>
<th>Inv</th>
<th>Provider</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>F86/P3</td>
<td>IV</td>
<td>13</td>
<td>RPB</td>
<td>Juglet with round spout, undecorated</td>
<td>Cat. 4; immediately above floor 2; found in deposit</td>
</tr>
<tr>
<td>F87/P69</td>
<td>IV</td>
<td>8</td>
<td>RPB</td>
<td>Juglet with round spout, undecorated</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
<tr>
<td>F92/P4</td>
<td>IV</td>
<td>13</td>
<td>RPB</td>
<td>Juglet with cutaway spout, undecorated</td>
<td>Cat. 4; immediately above floor 2; found in deposit</td>
</tr>
<tr>
<td>F98/P68</td>
<td>IV</td>
<td>8</td>
<td>RPB</td>
<td>Juglet with round spout, decorated</td>
<td>Cat. 2, filling; findspot noted</td>
</tr>
<tr>
<td>F103/P35</td>
<td>IV</td>
<td>8</td>
<td>RPB</td>
<td>Juglet with cutaway spout, undecorated</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
<tr>
<td>F106/P42</td>
<td>IV</td>
<td>13</td>
<td>RPB</td>
<td>Juglet with cutaway spout, undecorated mini</td>
<td>Cat. 5, upper filling; found in jugs/bowls deposit</td>
</tr>
<tr>
<td>F118/P36</td>
<td>IV</td>
<td>8</td>
<td>RPB</td>
<td>Juglet with indeterminate spout</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
<tr>
<td>F119/P39</td>
<td>IV</td>
<td>8</td>
<td>RPB</td>
<td>Juglet with indeterminate spout</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
<tr>
<td>F120/P68</td>
<td>IV</td>
<td>8</td>
<td>RPB</td>
<td>Juglet with indeterminate spout</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
<tr>
<td>F391/P11</td>
<td>IV</td>
<td>8</td>
<td>WP/PW</td>
<td>Juglet with round spout</td>
<td>Cat. 2, filling; found in jugs/bowls deposit</td>
</tr>
</tbody>
</table>

V.B.3 METHODOLOGY

All samples underwent one of two organic extraction procedures followed by analysis by Gas Chromatography/Mass Spectrometry using one of two programs. These procedures were detailed in the previous chapter as the Alkaloid and Lipid protocols. The GC parameters that were used were the alkaloid (12.67 minutes) and the lipid (45.67 minutes) methods. Samples were generally run in SCAN mode.

V.B.4 SUMMARY OF RESULTS

Below is a summary of the samples in which chemical residues were identified and a description of the product that the vessel likely contained. A detailed discussion is provided in the next section. The chemical data discussed in the following section deals only with identification relevant to final interpretations.
F3/P15 (RPA Juglet with Round Spout – Room 8)
Based on these results, the contexts of the vessel likely consisted of milk or another dairy product that has been seasoned with pine oil or marjoram.

F82/P95 (RPB Juglet with Round Spout, Undecorated – Room 8)
While a few peaks were observed, the abundances were rather low and could not be attributed to any chemical compounds in the spectral library.

F84/P33 (RPB Juglet with Round Spout, Undecorated – Room 8)
The sample showed extensive contamination with a few alkanes (tetradecane, nonadecane) being detected that are likely also the product of contamination.

F86/P3 (RPB Juglet with Round Spout, Undecorated – Room 13)
While a few peaks were observed, the abundances were rather low and could not be attributed to any chemical compounds in the spectral library. Contamination in the sample was extensive.

F87/P69 (RPB Juglet with Round Spout Undecorated – Room 8)
While there was contamination present in the sample, three compounds were identified that suggest that presence of white wormwood. If these identifications are correct, then the vessel may have contained a medicine used to treat asthma, sore throats, and gastrointestinal ailments.

F92/P4 (RPB Juglet with Round Spout, Decorated – Room 13)
The vessel exhibited extensive contamination with no identifiable compounds.

F98/P64 (RPB Juglet with Round Spout, Decorated – Room 8)
A substance consisting of red grapes may be indicated, but the identification is based on a single compound in a sample exhibiting extensive contamination.
F103/P35 (RPB Juglet with Cutaway Spout, Undecorated – Room 8)
The vessel showed extensive contamination and no evidence of a preserved residue.

F106/P42 (RPB Juglet with cutaway spout, undecorated mini – Room 13)
The vessel showed extensive contamination and no evidence of a preserved residue.

F118/P36 (RPB Juglet with Indeterminate Spout – Room 8)
The vessel may have contained beer based on the presence of a compound associated with baker’s yeast; however, other biomarkers were absent which makes the identification uncertain.

F119/P39 (RPB Juglet with Indeterminate Spout – Room 8)
The vessel may have contained beer based on the presence of a compound associated with baker’s yeast; however, other biomarkers were absent which makes the identification uncertain.

F120/P68 (RPB Juglet with Indeterminate Spout – Room 8)
The vessel showed extensive contamination and no evidence of a preserved residue.

F391/P11 (WP/PW Juglet with Round Spout – Room 8)
The substance contained in this small, decorated vessel was likely the aromatic oil of a species of sage, rosemary, or white wormwood. Latter has been known to serve as series of medicinal functions, such as in the treatment of asthma, sore throats, and various gastrointestinal ailments.
V.B.5. ANALYTICAL DATA AND DISCUSSION

V.B.5.a. F3/P15 (RPA Juglet with Round Spout – Room 8)

The sample was extracted with the alkaloid protocol and analyzed using the alkaloid and lipid methods. All data files showed extensive plastic contamination. 2H-Pyran-2-one, tetrahydro-6,6-dimethyl- was identified at 5.480 minutes in the alkaloid analysis of the sample. The compound is likely related to gamma-hexadecalactone, one of a series of compounds that are found in milk, cheese, and other dairy products (Mariaca et al. 2001:3). One other compound was identified in the lipid analysis of the alkaloid extraction.

(+)-Sylvestrene/m-Mentha-6,8-diene (Cyclohexene, 1-methyl-5-(1-methylethenyl)-, (R)-) is a long known constituent of turpentine or pine oil as well as marjoram (Daferera et al. 2000:2578; Parry 1922:65; http://webbook.nist.gov/cgi/cbook.cgi?ID=C1461274&Mask=200). It is also a constituent in a plant related to wild carrot, Daucus glaber that is indigenous to the Eastern Mediterranean and that acts as an antimicrobial (Mansour et al. 2004:373; http://www.flowersinisrael.com/Daucusglaber_page.htm). However, since the period of time under discussion generally precedes Cyprus’ involvement in the regional trade network of the Eastern Mediterranean, the fact that D. glaber is not documented in the indigenous flora of the island makes the turpentine or marjoram a more likely identification for the compound (Hadjikyriakou 2007; Meikle 1977, 1985; Tsintides et al. 2002).

Based on these results, the contexts of the vessel likely consisted of milk or another dairy product that has been seasoned with pine oil or marjoram. However, it should be noted that the use of turpentine to seal the interiors of vessels has been documented experimentally as well as historically. It is unclear if the turpentine in this sample is inherent in the substance contained in the vessel or related to the preparation of the container (Mariti 1984; Pecci et al. 2010:617; Romanus et al. 2009:900-1).
<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.480</td>
<td>2H-Pyran-2-one, tetrahydro-6,6-dimethyl-</td>
<td>Related to gamma-hexadecalectone?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>40</td>
</tr>
<tr>
<td>6.391</td>
<td>Cyclohexene, 1-methyl-5-(1-methylene)-, (R)-</td>
<td>(+)-Sylvestrene/ m-Mentha-6,8-diene</td>
<td>Alkaloid-Lipid</td>
<td>12.0</td>
<td>72</td>
</tr>
</tbody>
</table>

Abundance

[Graph showing abundance over time with peaks at RT 5.480 and 6.391, labeled 'Sylvestrene' and 'Alambra-Mouttes AP15-F3 Room 8 Alkaloid-Lipid']
V.B.5.b F82/P95 (RPB Juglet with Round Spout, Undecorated – Room 8)

The sample was extracted and analyzed using the lipid method. While a few peaks were observed, the abundances were rather low and could not be attributed to any chemical compounds in the spectral library.

V.B.5.c F84/P33 (RPB Juglet with Round Spout, Undecorated – Room 8)

The sample was extracted with the alkaloid protocol and analyzed with the alkaloid and lipid methods. The lipid sample yielded no relevant data. The alkaloid sample showed the presence of a few alkanes (tetradecane, nonadecane), but these are widely distributed and, due to the extensive field and storage contamination present in the sample, likely are not inherent in the sample.
V.B.5.d F86/P3 (RPB Juglet with Round Spout, Undecorated – Room 13)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. Like the previous two juglets of similar type, there was extensive contamination but no compounds inherent in the residue were identified. The lipid analysis showed a couple of very small peaks that had low abundances and with no compound matches. In addition, the alkaloid sample was analyzed in SIM mode, targeting the ions associated with noscapine, hydrocotarnine, and thujone, none of which returned matches.

V.B.5.e F87/P69 (RPB Juglet with Round Spout Undecorated – Room 8)

This juglet was the largest that was samples and contained a dark, ashy residue, which is illustrated below. A sample of this free residue was collected and analyzed separated from the interior scrapings of the vessel. Two compounds were identified in the free residue. The first of these was camphene, which was identified experimentally in reference samples of hyssop, wormwood, and a species of thyme indigenous to Cyprus.
It is also a known constituent in a number of species in the *Artemisia* family (including white wormwood), tansy, dittany, sage, rockrose, wild fennel, aniseed, rosemary, and minor in oregano and coriander (Alves-Pereira and Fernandes-Ferreira 1998:796; Azeez 2008:230-1; Bowles 2003:34; Ferraro et al. ND:3; Gunawardena et al. 2002:201; Kordali et al. 2005:1411; Leela and Vipin 2008:333; Liolios et al. 2009:80; Nezhadali et al. 2008:557, 559; Oller-López et al. 2005:554; Piccaglia and Marotti 2001:241; Teixeira da Silva 2004:707-710; Veličkovič et al. 2003:19-20). The second compound is hexadecane, a sixteen carbon alkane that cannot easily be attributed to a source.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.567</td>
<td>1,5-Cyclooctadiene, 1,6-dimethyl-/Cyclohexanol, 2-methyl-5-(1-methylethenyl)-, acetate, (1.alpha.,2.beta.,5.alpha.)-</td>
<td>Contaminant?/(-)-dihydrocarveryl acetate?</td>
<td>Alkaloid-Alkaloid-Scraping</td>
<td>12.0</td>
<td>37/10</td>
</tr>
<tr>
<td>2.568</td>
<td>Camphene</td>
<td></td>
<td>Alkaloid-</td>
<td>12.0</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alkaloid-Ash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.572</td>
<td>2,7-Octadiene-1,6-diol, 2,6-dimethyl, (E)-8-hydroxy linalool</td>
<td></td>
<td>Alkaloid-Alkaloid-Scrapping</td>
<td>12.0</td>
<td>9</td>
</tr>
<tr>
<td>5.521</td>
<td>Tetradecane/Hexadecane</td>
<td></td>
<td>Alkaloid-Alkaloid-Scrapping</td>
<td>12.0</td>
<td>78/78</td>
</tr>
<tr>
<td>6.178</td>
<td>Hexadecane</td>
<td></td>
<td>Alkaloid-</td>
<td>12.0</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alkaloid-Ash</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The analytical result of the scrapings is more complicated. The issue largely revolved around the identification of camphene in the residue at 2.568, the uncertain identification of the peak at 2.567 minutes in the scrapings, and the low quality of the compound at 2.572 minutes in the scraping sample. At 2.567, the compound (-)-dihydrocarveyl acetate was identified in more than one standard reporting, but both times at low qualities of 10 and 9. It has been stated before that integrated peaks with low qualities may indicate that the compound is a degradation product that does not exist in the spectral library. However, in this case, a compound that is likely a contaminant was identified in yet another report at a higher quality. If the lower quality compound were to be accepted, then white wormwood may be indicated as it is a minor constituent in white wormwood (Kordali et al. 2005:1412; Nezhadali et al. 2008:559). The compound may also be related to dicarvone or carvacrol, which is a major constituent in spearmint and tansy oils and a minor one in caraway, dittany, and a species of sagebrush that indigenous to the Turkish mainland (Bowles 2003:77, 80, 88-9; Iacobellis et al. 2005:57-8; Loliios et al. 2009:80; Teixiera da Silva 2004:707-10, 717).

The same low quality issue exists for the peak at 2.572, which is also uncommonly close to the other peak. (E)-8-hydroxylinalool ((2E)-2,6-dimethylocta-2,7-diene-1,6-diol) (http://webbook.nist.gov/cgi/cbook.cgi?ID=C75991616). Again, the quality is at a low quality of 9. Under normal circumstances, this compound would not be reported because it is below a quality of 10, but I mention it here because of the uncertainty surrounding the peak at 2.567 minutes. I also mention it because this compound, like camphene and (-)-dihydrocarveyl acetate, is also a constituent in white wormwood (Kordali et al. 2005:1412; Nezhadali et al. 2008:559).

Since the camphene was identified from a free residue, it is perhaps most prudent to disregard the low qualities and uncertain identifications found in the scrapings. Despite these misgivings, the possibility does remain that the vessel contained white wormwood. If this is the case, then this may constitute evidence for a medicine, since white wormwood has historically

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61 Per verbal communication with Colin Henck and David Burz in the Chemistry Department at the University at Albany.
been used in the treatment of asthma, sore-throats, as well as for expelling parasites and other gastrointestinal against intestinal worms (Lev 2006:5, 7; Zohary 1982:184).

V.B.5.f F92/P4 (RPB Juglet with Round Spout, Decorated – Room 13)

The sample was extracted and analyzed with the lipid method. The samples exhibited extensive contamination with no other identifiable compounds inherent in the residue.
V.B.5.g F98/P64 (RPB Juglet with Round Spout, Decorated – Room 8)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. There was extensive contamination in this vessel with a series of alkanes (hexadecane, nonadecane, tetradecane, heptadecane) and alkanols (1-tetracosanol) present. These compounds are likely associated with contamination. One additional compound, prenol (3-Buten-1-ol, 3-methyl-) was identified in the alkaloid analysis of the sample. Prenol is present in various plants, including grapes and grape juice (http://www.thegoodscentscompany.com/data/rw1032261.html).

In addition, the compound was identified in the modern Cypriot potsherd that was treated with red grape wine. According to Lee et al. (2005:134), it is a minor constituent in thyme, but it was not identified in the reference sample of Cypriot thyme. While the presence of the prenol may suggest the presence of a beverage containing red grapes, the absence of any other relevant compound makes it questionable.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.659</td>
<td>3-Buten-1-ol, 3-methyl-</td>
<td>Prenol</td>
<td>Alkaloid-Alkaloid</td>
<td>11.5</td>
<td>12</td>
</tr>
</tbody>
</table>

Abundance

Alambra-Mouttes
F98/P64 Room 8
Alkaloid-Alkaloid
V.B.5.h F103/P35 (RPB Juglet with Cutaway Spout, Undecorated – Room 8)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. Like the previous sample, the lipid analysis showed no results and the alkaloid analysis showed extensive contamination with only a few alkanes (undecane, hexadecane) present. There was no evidence of a preserved residue in the vessel.

V.B.5.i F106/P42 (RPB Juglet with cutaway spout, undecorated mini – Room 13)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. The alkaloid sample was also analyzed in SIM mode targeting hydrocotamine and thujone. Other than contaminants, there were no compounds identified that would indicate the presence of an organic residue.
V.B.5.j F118/P36 (RPB Juglet with Indeterminate Spout – Room 8)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. The lipid analysis showed no relevant compounds. Other than contaminants and nondescript alkanes, one compound was identified that may be inherent in a preserved residue.

According to Fronza et al. (1987:2986-8), 1,6;3,4-Dianhydro-2-deoxy-.beta.-d-lyxohexopyranose is a carbohydrate compound associated with the fermentation action of baker's yeast. This might suggest the presence of beer, but other biomarkers, such as beerstone⁶², were absent (McGovern 2009:67; Michel et al. 1993:411).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.037</td>
<td>1,6;3,4-Dianhydro-2-deoxy-.beta.-d-lyxohexopyranose</td>
<td>Related to baker's yeast?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>25</td>
</tr>
</tbody>
</table>

Beerstone is an insoluble compound that precipitates during the brewing process and often is the only archaeological indication of beer production.
V.B.5.k F119/P39 (RPB Juglet with Indeterminate Spout – Room 8)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. The lipid analysis showed no relevant compounds. Other than contaminants and nondescript alkanes, one compound was identified that may be inherent in a preserved residue. The only compound detected in the alkaloid sample was the same baker’s yeast compound identified in the previous vessel. Again, this may suggest the presence of beer, but it lacks any other biomarkers.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.609</td>
<td>1,6;3,4-Dianhydro-2-deoxy-(\beta)-d-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>25</td>
</tr>
</tbody>
</table>

Abundance

Alambra-Moutes  
F119/P39 Room 8  
Alkaloid-Alkaloid
V.B.5.1 F120/P68 (RPB Juglet with Indeterminate Spout – Room 8)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. Other than contaminants and nondescript alkanes, no compounds associated with a preserved residue were detected.

V.B.5.m F391/P11 (WP/PW Juglet with Round Spout – Room 8)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. The alkaloid analysis showed no relevant compounds. The lipid analysis, on the other hand, showed the presence of a single compound, camphor, with a high abundance and at a high quality of 91. Camphor is a constituent in annual, white and absinthe wormwood, coriander, lavender, rosemary, sage, oregano, wild fennel and tansy, as well as Taurus cedar in small amounts. It is also found in basil and thyme, though it was not identified in a reference sample of Cypriot thyme.

It was however identified reference samples of lavender and Cypriot sage (Başer and Demirçakmak 1995:17; Bowles 2003:25-6, 34, 71, 85; Daferera et al. 2000:2578; Fasseas et al. 2007:1191; Ferraro et al. ND:1, 3; Lee et al. 2005:134; Nezhadali et al. 2008:557, 559-60; Piccaglia and Marotti 2001:241; Radulović and Blagojević 2010:1117-9; Teixeira da Silva 2004:707-10, 712-3; Veličkovič et al. 2003:17, 19-20).
As noted in the discussion of the Base Ring I juglet (sample 81) from Episkopi *Bamboula*, camphor was used in antiquity for easing coughs, reducing fevers, soothing gums, and in treating epilepsy (Aboelsoud 2010:85; Plin. Nat. 20.19).

Based on the large amount of camphor found, it seems like that the substance contained in this small, decorated vessel was the aromatic oil of a species of sage, rosemary, or white wormwood. As noted for F87/P69, white wormwood served as series of medicinal functions, such as in the treatment of asthma, sore throats, and various gastrointestinal ailments (Lev 2006:5, 7; Zohary 1982:184).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.931</td>
<td>Camphor</td>
<td></td>
<td>Alkaloid-Lipid</td>
<td>12.0</td>
<td>91</td>
</tr>
</tbody>
</table>

Abundance

Alambra-Mouttes
F391/P11 Room 8
Alkaloid-Lipid
V.C. MARKI ALONIA

V.C.1 Site Background

Marki Alonia is a village located in the foothills of the Troodos Mountains that was occupied from approximately 500 years from the Philia Phase to Middle Bronze Age. Excavations were directed at the site by Dr. David Frankel and Dr. Jennifer Webb from La Trobe University from 1999 to 2000. The site consists of nine occupational phases (A-I), which range from the Philia Phase to Middle Cypriot II and cover a time period from approximately 2500-2000 B.C. (Frankel and Webb 2006:1-3). The Philia Phase represents a distinct cultural component that overlaps with the emergence of the Bronze Age and which is characterized by a degree of Anatolian influence (Frankel and Webb 2006, 2000; Knapp 2008:100-6; Manning 1993:36-8; Manning and Swiny 1994:150-1; Steel 2004:121-2; Webb and Frankel 1999:4-6). Knapp (1990:148; 2008:71), having redefined the Bronze Age chronology on Cypriot into the Prehistoric Bronze Age and the Protohistoric Bronze Age, would place phases A through D (Philia to Early Cypriot II) into Prehistoric Bronze Age 1 and phases E through I (Early Cypriot III to Middle Cypriot II) in Prehistoric Bronze Age 2 (Fisher 2007:299; Keswani 2005:343; Steel 2004:13), with the site being abandoned at the end of this period (Frankel and Webb 2006:1-3).

Architecturally, Marki Alonia resembles Sotira Kaminoudhia in that domestic units consisted of two or three rooms that were entered doorways (typically in corners of rooms) and contained various installations (floor emplacements, benches, mealing bins, storage bins, hearths). Lime plaster was frequently used to construct these installations and as a veneer for the mudbricks used in the construction of the superstructure (Frankel and Webb 2006:7-15: Knapp 2008:123). The nine occupational phases at the site indicate regular and rather intensive construction events, in which floors were removed, the size and boundaries of households shifted, courtyards were expanded, and streets built. While some of these spatial rearrangements indicate the development of ideas about private space and ownership, there was no discernible differences in the size of households or any other indications of social differentiation (Frankel and Webb 2001:120; Keswani 2005:363; Webb and Frankel 2006:12-21, 37-40).
The artifact assemblage consisted of limestone bowls, ground stone tools, beads, copper objects (needles and earrings), mold-cast copper artifacts (chisels, awls, axes, flat-tanged knives) and a rich repertoire of ceramics (Knapp 2008:75; Steel 1997-8:138; Webb and Frankel 1999:31). While the most significant element of the site is the range of Philia material culture, the episode from which all of the samples submitted for residue analysis derived was the Early Cypriot III phase.

V.C.2 SAMPLES

Samples from eight ceramic containers were collected from four contexts from Phase E-1, which dates to the Early Cypriot III. The samples were obtained as either as scrapings from curated vessels held at the Cyprus Archaeological Museum in Nicosia or sherd fragments obtained from vessels held in the storeroom in Larnaca. All samples were collected with the permission of Dr. David Frank and Dr. Jennifer Webb, the directors of the Marki-Alonia excavations, Dr. Maria Hadjicosti, the Director of the Cyprus Department of Antiquities, and the permission of the Cyprus Archaeological Museum in Nicosia. All images were taken in the museum with the permission of Dr. Jennifer Webb.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Unit-Episode</th>
<th>Phase</th>
<th>Compound</th>
<th>Sample Type</th>
<th>Ware</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P15122</td>
<td>CXII-6</td>
<td>E-1</td>
<td>15</td>
<td>Sherd</td>
<td>Black Polished</td>
<td>Small closed</td>
</tr>
<tr>
<td>P15370</td>
<td>CXIV-3</td>
<td>E-1</td>
<td>13</td>
<td>Sherd</td>
<td>Red Polished</td>
<td>Large closed pithos</td>
</tr>
<tr>
<td>P15381</td>
<td>CXII-6</td>
<td>E-1</td>
<td>15</td>
<td>Sherd</td>
<td>Red Polished</td>
<td>Small closed juglet with cutaway spout</td>
</tr>
<tr>
<td>P15656</td>
<td>CXXI-4</td>
<td>E-1</td>
<td>09</td>
<td>Scraping</td>
<td>Red Polished</td>
<td>Large closed pyxis</td>
</tr>
<tr>
<td>P16098</td>
<td>CXX-4</td>
<td>E-1</td>
<td>09</td>
<td>Scraping</td>
<td>Red Polished</td>
<td>Small miniature vessel</td>
</tr>
<tr>
<td>P16171</td>
<td>CXXII-5</td>
<td>E-1</td>
<td>S7</td>
<td>Sherd</td>
<td>Red Polished</td>
<td>Small closed vessel with cutaway spout</td>
</tr>
<tr>
<td>P16254</td>
<td>CXXII-5</td>
<td>E-1</td>
<td>S7</td>
<td>Sherd</td>
<td>Red Polished</td>
<td>Small closed amphora with round spout</td>
</tr>
<tr>
<td>P16854</td>
<td>CXX-4</td>
<td>E-1</td>
<td>09</td>
<td>Sherd</td>
<td>Red Polished</td>
<td>Small closed gourd juglet</td>
</tr>
</tbody>
</table>
V.C.3 METHODOLOGY

All samples underwent one of three organic extraction procedures followed by analysis by Gas Chromatography/Mass Spectrometry using one of two programs. These procedures were detailed in the previous chapter as the Alkaloid, Lipid and Sonication protocols. The GC parameters that were used were the alkaloid (12.67 minutes) and the lipid (45.67 minutes) methods. Samples were generally run in SCAN mode.

V.C.4 SUMMARY OF RESULTS

Below is a summary of the samples in which chemical residues were identified and a description of the product that the vessel likely contained. A detailed discussion is provided in the next section. The chemical data discussed in the following section deals only with identification relevant to final interpretations.

P15122 (BP Small Closed Vessel – Compound 15)
The sample showed extensive contamination with a few alkanes being detected that are likely also the product of contamination.

P15370 (RP Large Closed Pithos – Compound 13)
The sample showed extensive contamination with no indication of a preserved residue.

P15381 (RP Small Closed Juglet with Cutaway Spout – Compound 15)
The vessel may have contained a red grape wine.

P15656 (RP Pyxis – Compound 9)
The product contained in the pyxis is likely a mixture that contained a species of wormwood scented with rose and possibly hyssop in a cedar or juniper resin base. Possible additional ingredients may have included rosemary, rockrose, birthwort or caper.
P16098 (Small Miniature Vessel – Compound 9)
A single compound potentially related to baker’s yeast was identified, which might suggest the presence of fermented grain product, such as beer.

P16171 (Small closed vessel with cutaway spout – Space 7)
The substance contained in the small decorated vessel likely consisted of a fir or juniper resin-based ointment that was scented with thyme, pink rockrose, or hyssop, but a series of other aromatic plants are also possible.

P16254 (RP Small Closed Amphora with Round Spout – Space 7)
There was extensive contamination in this vessel with no indication of a preserved residue.

P16854 (RP Small Closed Gourd Juglet – Compound 9)
The vessel showed extensive contamination and no evidence of a preserved residue.

V.C.5. ANALYTICAL DATA AND DISCUSSION
V.C.5.a. P15122 (BP Small Closed Vessel – Compound 15)
The sample was extracted with the lipid protocol and analyzed using the alkaloid and lipid methods. The lipid analysis showed no compound matches, while the alkaloid analysis showed extensive contamination and no evidence of an inherent residue with the exception of a few nondescript alkanes.
V.C.5.b  P15370 (RP Large Closed Pithos – Compound 13)

Scrapings were obtained from the interior section of a large Red Polished pithos. The sample was extracted using the alkaloid protocol and analyzed using both the alkaloid and lipid method. Other than some contaminants, no compounds associated with a preserved residue were detected.

V.C.5.c P15381 (RP Small Closed Juglet with Cutaway Spout – Compound 15)

The sample was extracted with the alkaloid protocol and analyzed with the alkaloid and lipid methods. Two compounds of significance were detected. The first is alpha-ketoisocaproic acid, which is a yeast species that McGovern et al. (2004:17957) refer to as a “wine yeast” found in honey and in sugar-rich fruit skins10. In addition, a compound was detected that may be the degradation product of isobutyric acid, which plays a role in fermentation and is present in red and white wines and vinegars (http://www.ymdb.ca/compounds/YMDB0038).

However, tartaric acid, a compound found in red grape skins and therefore a biomarker for red grape wine, was not identified (Ferriera et al. 2002:4.48-50; Guth 1997:3007; Lambert
1997:37; Rocha et al. 2004:1578-8). Based on these two compounds, a red grape wine may be indicated.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.825</td>
<td>4-Methyl-2-oxovaleric acid</td>
<td>Alpha-ketoisocaproic acid</td>
<td>Alkaloid-Alkaloid</td>
<td>11.5</td>
<td>32</td>
</tr>
<tr>
<td>7.440</td>
<td>Propanoic acid, 2,2-dimethyl-, 2-ethylhexyl ester</td>
<td>Related to isobutyric acid?</td>
<td>Alkaloid-Alkaloid</td>
<td>11.5</td>
<td>40</td>
</tr>
</tbody>
</table>

V.C.5.d P15656 (RP Pyxis – Compound 9)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. A total of compounds were detected in the sample. Camphor, which was identified in the unique juglet from Alambra-Mouttes, was present in the lipid analysis. As noted in the analytical discussion of the Alambra samples, camphor is a constituent in annual, white and absinthe wormwood, coriander, lavender, rosemary, sage, oregano, wild fennel and tansy, as well as Taurus cedar in small amounts. It is also found in basil and thyme, though it was not identified in Cypriot thyme.
It was however identified reference samples of lavender and Cypriot sage (Başer and Demirçakmak 1995:17; Bowles 2003:25-6, 34, 71, 85; Daferera et al. 2000:2578; Fasseas et al. 2007:1191; Ferraro et al. ND:1, 3; Lee et al. 2005:134; Nezhadali et al. 2008:557, 559-60; Piccaglia and Marotti 2001:241; Radulović and Blagojević 2010:1117-9; Teixeira da Silva 2004:707-10, 712-3; Veličković et al. 2003:17, 19-20).

Further, the presence of camphor in the sample suggests a medicinal application. The range of ailments for which camphor was prescribed in antiquity is detailed in the discussion of a Base Ring I juglet (sample 81) from Episkopi Bamboula and a White Painted juglet (sample F391/P11) from Alambra Mouttes (Aboelsoud 2010; Plin. Nat. 20.19).

The second compound, ionone, is a major compound in rose and two species of rockrose, as well capers, basil, and time (Angelopolou et al. 2001:167-170; Mookherjee et al. 1990:1359; Oller-López et al. 2005:555; Romeo et al. 2007:1275, 1277; Van Ouwerker et al. 1977). A related compound, beta-ionone epoxide, was identified in the alkaloid analysis and likely represents a degradation of ionone (Baldarov and Veltcheva 2011:323, 325).

Two additional compounds were identified in the alkaloid analysis. Artemiseole indicates the either presence of a wormwood (or sagebrush) since the compound was found in a reference sample of wormwood and is a known constituent of two other species in the Artemisia family (Gunawardena et al. 2001:198, 200-1; Teixiera da Silva 2004:707-10). Another possibility is rockrose because the compound was identified in both white and pink varieties of the plant that grow in Cyprus. The second compound, alpha-nerolidol, is a constituent in a species of woundwort in the Stachys family, a species of birthwort that is indigenous to the Mediterranean basin, as well as capers, hyssop, and series of plants in the Artemisia family (Francisco et al. 2008:171-2; Kordali et al. 2005:1411-2; Romeo et al. 2007:1275, 1277; Skaltsa et al. 2001:234-40; Senatore et al. 2007:137; Teixiera da Silva et al. 2004:707-10).

The presence of a wormwood, sagebrush or other Artemisia species is further suggested by the presence of cis-sabinene hydrate in the lipid analysis. This compound is related to sabinene and thujone, both of which are constituents in absinthe wormwood and the latter of which was once thought to be the psychoactive principle in absinthe (Emmert et al. 2004:352-4;
The sabinene derivative is also present in the birthwort, marjoram, sage, peppermint, a species of juniper, and coriander (Bowles 2003:57-8; Chempakam and Sindhu 2008:41-58; Francisco et al. 2008:170; Parry 1922:56; Parthasarathy and Zachariah 2008: 190-210).

The final compound identified in the sample either represents longipinene epoxide or carvone oxide, trans-. If it is the former, a tree resin may be indicated since it is found in various pine species and is a minor constituent in cedar. The compound is also a constituent in two species of hyssop and species of wormseed in the *Artemisia* family (Başer and Demirçakmak 1995:17; Cakir et al. 2004:63-6; Kordali et al. 2005:1412). If the latter identification is correct, a species of wormwood may be indicated (http://www.thegoodscentscompany.com/data/rw1511401.html).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.960</td>
<td>Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, (1S)-</td>
<td>Camphor</td>
<td>Alkaloid-Lipid</td>
<td>14.0</td>
<td>95</td>
</tr>
<tr>
<td>5.049</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.217</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.089</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.762</td>
<td>1-Cyclohexene, 1,3,3-trimethyl-2-(1-methylbut-1-en-3-on-1-yl)/1-Penten-3-one, 1-(2,6,6-trimethyl-1-cyclohexen-1-yl)-</td>
<td>Alpha-Ionone?/Beta-Ionone, methyl-</td>
<td>Alkaloid-Lipid</td>
<td>14.0</td>
<td>58/58</td>
</tr>
<tr>
<td>8.120</td>
<td>Artemiseole</td>
<td></td>
<td></td>
<td></td>
<td>27</td>
</tr>
<tr>
<td>8.130</td>
<td>1,6,10-Dodecatrien-3-ol, 3,7,11-trimethyl-, (E)-</td>
<td>Alpha-nerolidol</td>
<td>Alkaloid-Alkaloid</td>
<td>14.0</td>
<td>16</td>
</tr>
<tr>
<td>9.019</td>
<td>Bicyclo[3.1.0]hexan-2-ol, 5-methyl-, (1.alpha.,2.beta.,5.alpha.,)</td>
<td>Cis-Sabinenhydrate/trans-4-Thujuanol</td>
<td>Alkaloid-Lipid</td>
<td>14.0</td>
<td>17</td>
</tr>
<tr>
<td>9.034</td>
<td>3-Buten-2-ol, 2-methyl-4-(1,3,3-trimethyl-7-oxabicyclo[4.1.0]hept-2-yl)-</td>
<td>Beta-Ionone epoxide?</td>
<td>Alkaloid-AlkaloidB</td>
<td>14.0</td>
<td>12</td>
</tr>
<tr>
<td>13.365</td>
<td>Longipinene epoxide/Carvone oxide, trans-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on these data, the product contained in the pyxis is likely a mixture that contained a species of wormwood scented with rose and possibly hyssop in a cedar or juniper resin base. Possible additional ingredients may have included rosemary, rockrose, birthwort or caper.
The scrapings of this miniature vessel was extracted using the sonication protocol and analyzed using the alkaloid and lipid methods. The only compound identified in the alkaloid analysis was the compound, 1,6;3,4-Dianhydro-2-deoxy-.beta.-d -lyxo-hexopyranose, tentatively identified as baker’s yeast.
This might suggest the presence of beer, but other biomarkers, such as beerstone, were absent (Fronza et al. 1987:29686-8; McGovern 2009:67; Michel et al. 1993:411). No other compounds were identified in the sample, with the exception of a series of contaminants.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.236</td>
<td>1,6;3,4-Dianhydro-2-deoxy-β-d-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Scraping</td>
<td>12.0</td>
<td>25</td>
</tr>
</tbody>
</table>

V.C.5.f P16171 (Small closed vessel with cutaway spout – Space 7)

The sample was extracted with the alkaloid and lipid protocols and the former was analyzed using both the alkaloid and lipid methods. The lipid analysis returned no results. The alkaloid extraction, on the other hand, showed the presence of seven compounds. Interestingly, two fatty acids were identified (C13:0 Tridecanoic acid and C16:0 Hexadecanoic acid/Palmitic acid) that did not appear in the lipid extraction.

Beerstone is an insoluble compound that precipitates during the brew brewing process and often is the only archaeological indication of beer production.
The former is not frequently identified in archaeological samples and is not utilized in determining the botanical or faunal source of lipids (Eerkens 2005:92-6; Malainey et al. 1999:102). The latter has a much wider distribution in plant and animal oils, but on its own cannot provide much evidence for its source.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.350</td>
<td>Tridecanoic acid, methyl ester</td>
<td>C13:0</td>
<td>Alkaloid-Lipid</td>
<td>13.5</td>
<td>80</td>
</tr>
<tr>
<td>7.175</td>
<td>7-Oxabicyclo[4.1.0]heptane, 1-methyl-4-(2-methyleneoxiranyl)-</td>
<td>Alpha-limonene diepoxide</td>
<td>Alkaloid-Lipid</td>
<td>13.5</td>
<td>25</td>
</tr>
<tr>
<td>7.432</td>
<td>7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-</td>
<td>Alpha-bisabolol/Fragment of limonene?</td>
<td>Alkaloid-Lipid</td>
<td>13.5</td>
<td>38</td>
</tr>
<tr>
<td>12.350</td>
<td>Hexadecanoic acid, methyl ester</td>
<td>C16:0, Palmitic acid</td>
<td>Alkaloid-Lipid</td>
<td>16.0</td>
<td>98</td>
</tr>
<tr>
<td>13.053</td>
<td>1-Cyclohexene-1-carboxylic acid, 4-(1,5-dimethyl-3-oxohexyl)-, methyl ester, [S-(R*,R*)]-</td>
<td>(+)-Juvabione</td>
<td>Alkaloid-Lipid</td>
<td>16.0</td>
<td>64</td>
</tr>
</tbody>
</table>

Three of the five remaining compounds may be related to limonene. The first of these is alpha-limonene diepoxide, which was identified in reference samples of thyme and pink rock rose. A related compound, limonene oxide, was found in pink oleander, wormwood and a plant commonly called everlasting that is in the Helichyrsium family. The second compound, 7-oxabicyclo[4.1.0]heptane, 1-methyl-, is likely a fragment of limonene, which occurs in a large number of essential oils. It is however a major constituent of thyme, pine, caraway, a species of sage in the Phlomis family, anise, wild fennel, oregano, rosemary, the resin of cypress and a species of juniper, as well as peppermint (Amor et al. 2009:183, 188-90; Bowles 2003:58, 88-9, 35; Mastelić et al. 2008:795, 797). The last compound, 7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-, may either represent another fragment of limonene or a fragment of alpha-bisabolol (4-[(1Z)-1,5-Dimethyl-1,4-hexadienyl]-1-methyl-7-oxabicyclo[4.1.0]heptane). Thus, if the latter identification is
correct, then thyme, pink rockrose, wormwood, basil, oregano or germander may be indicated (De Martino et al. 2009:2737; Lee et al. 2005:134; Vukovic et al. 2007:18-19).

In addition, epimanyol oxide (1H-Naphtho[2,1-b]pyran, 3-ethenyldodecahydro-3,4a,7,7,10a-pentamethyl-, [3S-(3.alpha.,4a.alpha.,6a.beta.,10a.alpha.,10b.beta.)]-), which is a major constituent in pink rockrose, juniper resin, and a plant referred to as mountain tea (Sideritis condensate), was identified. But it must be noted that the compound is a cytotoxin and would have been harmful if consumed regularly (Adams et al. 1999:167; Angelopoulou et al. 2001:168; Gumuscu 2011). Therefore, the substance was probably an ointment or other cosmetic applied externally. This identification is further corroborated by the presence of (+)-juvabione, a major constituent in fir (Abies) resin (http://webbook.nist.gov/cgi/inchi/InChI%3D1S/C16H26O3/c1-11%282%29-2910-12%283%29-13-5-7-14%288-6-13%2916%2819-4/h7,11-13H,5-6,8-10H2,1-4H3).

Based on this evidence, the substance contained in the small decorated vessel likely consisted of a fir or juniper resin-based ointment that was scented with thyme, pink rockrose, or hyssop, but a series of other aromatic plants are also possible.
V.C.5.g P16254 (RP Small Closed Amphora with Round Spout – Space 7)

The sample was extracted using the sonication protocol and analyzed using the alkaloid and lipid methods. There was extensive contamination in this vessel with no indication of a preserved residue.

V.C.5.h P16854 (RP Small Closed Gourd Juglet – Compound 9)

The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. Like the previous sample, the lipid analysis showed no results and the alkaloid analysis showed extensive contamination with only a few alkanes (undecane, hexadecane) present. There was no evidence of a preserved residue in the vessel.
V.D. SOTIRA KAMINOUDHIA

V.D.1. Site Background

Sotira Kaminoudhia is an Early Bronze Age site located on the south coast of the island of Cyprus, 15 kilometers west of Limassol. The site of Sotira was initially described by Porphyrios Dikaios in 1934 during his excavations of the Neolithic hill site of Sotira-Teppes. Excavations at the site of Sotira-Kaminoudhia were directed by Stuart Swiny sponsored by the American Schools of Oriental Research in 1981, 1983 and 1986 and then the University at Albany 2001-2004. Kaminoudhia documents the early Prehistoric Bronze Age along the south coast, including both domestic and mortuary contexts as well as cultural material associated with the Philia phase (Manning and Swiny 1994; Rapp and Swiny 2003:1-2; Steel 2004; Swiny et al. 2003).

Excavations were carried out in three major areas of the settlement (Areas A, B, and C), as well as two cemeteries in the valley.

Architecturally, the village consisted of rectilinear stone-built domestic structures that were connected by a series of long and narrow alleys. Individual domestic units consisted of two or three rooms that contained hearths, benches, lime plaster bins, and other immobile emplacements. The artifact assemblage included numerous functional objects, including a typical range of lithic artifacts (querns, rubbers, pounders, sickle blades), ceramics (Red Polished bowls, jugs, jars, spindle whorls), a small number of metal objects (knives, axes, awls, needles), as well as a numerous personal ornaments of picrolite and a few of metal. The occupants of this Early Bronze Age village had an agropastoral economy based on maintaining cattle, pigs, goats and sheep and on the cultivation of cereals and pulses (Hansen 2003:449-52; Rapp and Swiny 2003:1-2, 5-7; Swiny 2003:9-10). A total of twelve samples for residue analysis were obtained by Swiny from Areas A, B in the settlement, as well as two tombs from CemeteryA.

Area A was most extensively excavated, covering an area of 40 meters x 20 meters, and consisting of two phases of building activity that began with the earliest Bronze Age occupation of the village, followed by a subdivision of architectural units, the construction of internal features such as benches, and an increase in the exploitation of goats, pigs, and sheep. (Swiny 2003a:9-
10). Radiocarbon dates give Phases I and II a date from of 2400-2174 B.C.E. (Rapp and Swiny 2003:5-7).

Area B located 35 meters to the west of Area A is centered on Unit 12, which may represent a non-domestic and perhaps ritual structure (Crewe and Hill:2012:212; Swiny 2003a:9-10; Swiny 2008:48). The structure is an unroofed, but enclosed area that is arranged on a tripartite plan that is centered on a courtyard (Unit 12) that is separated by adjacent rooms (Units 12a, 12b, and 12c) with a series of low, parapet walls (Swiny 2008:48-9). The installations, which include, amongst other things, a large, plastered stone backdrop that would have been seen entering the complex, a large stone basin, a grinding platform, benches lining the walls, a comparatively small assemblage of stone, shell, and copper artifacts (percussion tools, a few querns, axe, chisel, copper earrings and other ornaments), a number of gaming stones, and a small assemblage of pottery vessels that primarily would have been used for the storage and consumption of liquids (juglets, small and large bowls, and dippers)(Swiny 2008:48-9).

Area C, which lay 50 meters to the south, is comparable to the other two areas in its variable architectural plan and comparable to the Unit 12 Complex in the atypical character of its internal features, as well as paucity of artifacts, some of which may indicate activities associated with the storage and use of liquids (Swiny 2003:40-6; Swiny 2008:43). The tombs from which samples were obtained both were located in Cemetery A, which was located N-NE of the settlement in the western portion of a narrow valley (Swiny and Herscher 2003:103-4).

V.D.2 SAMPLES

A total of twelve samples were obtained from the Early Bronze Age settlement and tombs at Sotira-Kaminoudhia. The samples consisted of various shapes (a trays, bowls, jars, juglets, and bottles) in various wares (Red Polished, Red Polished Mottled, Brown Polished, Drab Polished Blue Core, Coarse ware) and came from two areas of the settlement (Areas A and B) and two tombs from Cemetery A. The samples were originally collected by Stuart Swiny with the

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64 The association between small bowls or cups and containers for liquids have been demonstrated in Area C at Sotira Kaminoudhia and Space 8 at Alambra-Mouttes with an additional association possibly identified at Politiko-Troulia.
permission Dr. Pavlos Flourentzos, then Director of the Cyprus Department of Antiquities. The sample numbers and provenance information are provided below. All images were taken by and used with permission by Swiny.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Provenance</th>
<th>Fragment Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Area B, Unit 13.10, Lot 71</td>
<td>Red Polished Mottled rim sherd</td>
</tr>
<tr>
<td>2</td>
<td>Area B, Unit 13.24 Lot 79</td>
<td>Red Polished sherd from bowl with flat base</td>
</tr>
<tr>
<td>3</td>
<td>Area B, Unit 12b, FN 157</td>
<td>Coarse ware tray sherd</td>
</tr>
<tr>
<td>4</td>
<td>Area A, Unit 27, Lot 3, P185</td>
<td>Storage jar sherd</td>
</tr>
<tr>
<td>5</td>
<td>Tomb 4, P27</td>
<td>Brown Polished Bottle sherd</td>
</tr>
<tr>
<td>6</td>
<td>Area A, Unit 44, P169</td>
<td>Drab Polished Blue Core juglet sherd</td>
</tr>
<tr>
<td>7</td>
<td>Tomb 19, P105</td>
<td>Brown Polished bottle pottery sherd</td>
</tr>
<tr>
<td>8</td>
<td>Area A, Unit 5, P74</td>
<td>Red Polished Black-topped bottle sherd</td>
</tr>
<tr>
<td>9</td>
<td>Area A, Unit 18, Lot 14, FN 2, P148</td>
<td>Drab Polished juglet sherd</td>
</tr>
<tr>
<td>10</td>
<td>Tomb 4, P29</td>
<td>Brown Polished bottle sherd</td>
</tr>
<tr>
<td>11</td>
<td>Area B, Unit 13.34, Lot 77, 1</td>
<td>Red Polished bowl sherd</td>
</tr>
<tr>
<td>12</td>
<td>Area A, Unit 7, G17C, 3</td>
<td>Brown Polished bottle sherd</td>
</tr>
</tbody>
</table>

V.D.3. METHODOLOGY

All samples underwent one of three organic extraction procedures followed by analysis by Gas Chromatography/Mass Spectrometry using one of two programs. These procedures were detailed in the previous chapter as the Alkaloid, Lipid, and Sonication protocols. The GC parameters that were used were the alkaloid (12.67 minutes) and the lipid (45.67 minutes) methods. Samples were generally run in SCAN mode. When possible, they were also analyzed in SIM mode, targeting the following compounds: atropine, codeine, ephedrine, harmine, hydrocotamine, meconic acid, morphine, noscapine, papaverine, thebaine, and thujone.
V.D.4. SUMMARY OF RESULTS

1) Area B, Unit 13.10, Lot 71, 1 Red Polished Mottled rim sherd from a bowl
The bowl was used in the production of a substance that likely contained pink rockrose (*Cistus*) in the form of labdanum, which plays an important role in perfumery. Alternatively, the substance may have been a conifer (lark or fir) resin, a degradation of rose oil, or a species of sage. A similar compound was identified in a vessel from Politiko-Troulia.

2) Area B, Unit 13.24, Lot 79, Red Polished sherd from a bowl with a flat base
The vessel contained an herbal mixture that likely included white wormwood, sage, or tansy together with pomegranate bark and lilac or white campion flowers. The mixture may have been a fermented grain beer, but could have included a number of other ingredients.

3) Area B, Unit 12b, FN 157, Coarse Ware tray
A preserved residue was not detected.

4) Area A, Unit 27, Lot 3, P185, Storage Jar sherd
A preserved residue was not detected.

5) Tomb 4, P27 Brown Polished bottle sherd
The bottle likely contained a medicinal mixture include the plant *Zizipora tenuiora* L., a known medicinal plant found in Southwest Asia. This identification is based on the presence of alpha-bisabolol, 1-Hentetracontanol, and germacrene.

6) Area A, Unit 44, P169, Drab Polished Blue Core juglet sherd
Other than a few nondescript fatty alcohols and a series of contaminants, no other compounds were detected that would suggest the presence of a preserved residue.
7) Tomb 19, P105 Brown Polished bottle
The bottle likely contained an aromatic oil or unguent that included a species of mint, the fragrance of rose, caper, rockrose or honeysuckle flowers, and pine resin. Additional ingredients may have included myrtle, sage, wormseed, or yarrow.

8) Area A, Unit 5, P74 Red Polished bottle
Based on these results, the substance contained in the small bottle from the Cypriot north coast likely had medicinal or mildly psychoactive properties and probably consisted of pennyroyal, fringed rue, rockrose, and a species of wormwood. A number of other ingredients are also possible, including but not limited to a tree resin, bay leaf, yarrow, rose, mountain tea, and thyme.

9) Area A, Unit 18, P148 Drab Polished juglet
The substance contained in this juglet likely contained an aromatic oil scented with lavender and germander as primary ingredients with the possible addition of fringe rue and a thujone-containing plant, both of which may have psychoactive or medicinal properties. A series of additional ingredients are possible, including but not limited to Lilac Chaste tree, sage, white campion flowers, myrtle, rose, wormseed or wormwood, bay leaf, oregano and/or basil.

10) Tomb 4, P29 Brown Polished bottle
The substance contained in this bottle may have included beer mixture flavored with white wormwood, thyme, oregano, myrtle, sage, rosemary, or rockrose. Additional ingredients may have included anise, coriander, fennel, vervain, savory, or oregano.

11) Area B, Unit 13.34, Lot 77, 1 Red Polished bowl sherd
It is unclear whether or not a preserved residue is indicated. If the compounds present are associated with the residue, a lavender or sage oil may be indicated.
12) **Area A, Unit 7, G17C, 3 Brown Polished bottle sherd**

The bottle likely contained a medicinal or mildly psychoactive substance was present in the bottle. Hyssop was likely an ingredient, as was absinthe or white wormwood, sage, myrtle or wormseed. Additional aromatic plants in the mixtures may have included myrtle, thyme, rose, rockrose, or a tree resin. The presence of fringed rue may also be indicated.

**V.D.5. ANALYTICAL DATA**

**V.D.5.a. 1 Area B, Unit 13.10, Lot 71, (Red Polished Mottled rim sherd from a bowl)**

The sample was extracted with the alkaloid, lipid and sonication protocols and analyzed using the alkaloid and lipid methods.

Using the sonication extraction and lipid analysis method, a number of peaks were identified, only one of which was a compound with sufficient qualities other than contaminants. The compound (1-Naphthalenepropanol, \(\alpha\)-ethenyldecahydro-5-(hydroxymethyl)-\(\alpha\),5,8a-trimethyl-2-methylene-, \([1S-[1.\alpha.(R^*),4a.\beta.,5.\beta.,8a.\alpha.]]) was identified at 19.703 minutes and at a quality of 64 using the Peak Average report option. The compound is a labdane diterpene (Labda-8(20),14-diene-13,18(or19)-diol, (13R)) that has been identified in pottery samples from Politiko-Troullia, as well as in a botanical reference sample of pink rockrose (*Cistus*) endemic to Cyprus.

The resin of *Cistus incanus* (Pink rockrose) was known as labdanum and was highly prized in antiquity because its aromatic properties resembled that of ambergris (Bolster 2002:42-3; Plin. Nat. 12.37; Zohary 1982:194). According to Miller and Miller (1990:38), labdanum’s esteem continues to be appreciated in the modern-day perfume industry in that it serves as one of three alternatives to the animal-derived ambergris. Using the Apex – Start of Peak report option, the peak at 19.703 was identified as 1,3,3-Trimethyl-2-hydroxymethyl-3,3-dimethyl-4-(3-methylbut-2-
enyl)-cyclohexene, which is a rose-like aromatic compound that may be related to ionone ((E)-4-(2,6,6-trimethyl-1-cyclohexenyl)but-3-en-2-one) or damascene ((E)-1-(2,6,6-Trimethyl-1-cyclohexenyl)but-2-en-1-one) (Rusanov et al. 2011:2214-5; Van Ouwerkerk et al. 1977). These compounds are typically found in rose oil, but have also been identified in the botanical sample of pink rock rose and myrtle, both of which are from Cyprus, which makes the pink rock rose identification plausible. However, another possibility is dehydro-gamma-ionone (4-(2,6,6-trimethylcyclohexa-1,3-dien-1-yl)but-3-en-2-one), which Oritani (1998:9) identifies as one of the aromatic compounds of ambergris.

Alternatively, it may be noted that diterpenes and labdane alcohols are common constituents in the resins of conifers, such as members of Pinaceae, Cupressaceae, Araucanaceae (Bolster 2002:5-7). The most widely used resins in Mediterranean history are resins from Pinus species, which "contain abietane, pimarane, and labdane skeletons" (Pollard and Heron 2008:239). The labdane alcohols are present in high concentrations in species of lark (Larix) and fir (Abies) (Colombini et al. 2009:1489; Romanus et al 2009:901; Weitemeyer and Döhler 2009:270). However, it may be noted that other characteristic compounds found to be present in resins of Pinaceae species were not identified. (Pecci et al. 2010:618-9; Pollard and Heron 2008:239-242).

The labdane diterpene was also identified in the sample of pink rock rose, everlasting (Helichyrsum) as well as sage, which was also collected from Cyprus and likely belongs to the genus Salvia (Meikle 1977:1287-98). A sample of yellow-flowered everlasting was collected from the Troodos Mountains of Cyprus near Kato Platres. The dried flowers and stem were extracted and analyzed using the alkaloid and lipid protocols. In addition to the labdane diterpene, allo-aromadendrene, calamenene, Butyric acid, β-hydroxy-, ethyl ester and alpha-Bisabolene epoxide were also major constituents in the Cypriot everlasting sample. According to Tsintides et al. (2002:403-4), two species of everlasting (H. italicum and H. conglobatum) are indigenous to Cyprus with the former likely representing the collected botanical sample. It may be mentioned that the plant was known in classical antiquity, being mentioned by Theophrastus as "helichyrsos" or flower of gold which was "one of the plants traditionally used to make wreaths" (Tsintides et al.
Pliny mentions that the flower was used to decorated statues of deities in Ptolemaic Egypt. In addition, it was known to be used in a few medicinal preparations, including in a poultice for burns which mixes the flowers with honey and ash and as a repellent for snakes in which the flowers are added to wine (Tsintides et al. 2002:403).

The dried leaves of the sage sample were extracted using the sonication protocol and analyzed using the alkaloid and lipid methods. The labdane was identified at RT 6.750 and RT 12.735, respectively. If this identification is correct, the substance contained in the vessel may have had some medicinal properties. The main reason for this assertion is that a major constituent in the Cypriot sage reference sample is thujone, (Bicyclic[3.1.0]hexan-3-one, 4-methyl-1-(1-methylethyl)-, (1S,4S,5R)-), which is the psychoactive constituent found in absinthe (Höld et al. 2001:589, 590-1). Further constituents detected in the botanical sample of sage include camphene, camphor, cymene, eucalyptol, ipsenol, linalool, gamma-selinene, 3-carene, and Vitamin A. Based on the botanical reference spectra, additional constituents of the pink rockrose, on the other hand, include fatty acids (palmitic and linoleic acids), essential oils (limonene, bisabolol, menthol), terpenes (cedron-diol, 8S, 14 and artemiseole). Two additional compounds were identified that may complicate interpretations of the use of this plant. Epi-manoyl oxides (1H-Naphtho[2,1-b]pyran, 3-ethenyldodecahydro-3,4a,7,7,10a-pentamethyl-, [3S-(3.alpha.,4a.alpha.,6a.beta.,10a.alpha.,10b.beta.)]-), which exhibits dermal toxicity according to Angelopolou et al. (2001:167-69); this affect may be minimal since it comprises not more than 10 percent of the total constituents. The second compound, Card-20(22)-enolide, 3-[(2,6-dideoxy-4-O-.beta.-D-glucopyranosyl-3-O-methyl-.beta.-D-ribo-hexopyranosyl)oxy]-5,14-dihydroxy-19-oxo-, (3.beta.,5.beta.-), is a cardenolide identified as K-Strophantin-beta, which is a toxic glucoside. While toxic, such substances do have medicinal applications in cases of heart failure. It should be noted that according to Georgiades (1987:8-9), strophanthin as well as adonitoxin ((3b,5b,16b)-3-[(6-Deoxy-a-L-mannopyranosyl)oxy]-14,16-dihydroxy-19-oxocard-20(22)-enolide) are found in two species of Pheasant’s Eye (Adonis annua L. and Adonis microcarpa L.). However, Georgiades (1987:8-9) highlights that adonitoxin and strophanthin in these two plants had medicinal value in limited doses. However, Derham (2004:188) highlights that arrow poisons were
made out of species in the *Strophanthus* family in Eastern and Western Africa, which contain similar cardiac glycosides.

It should also be noted that there is some variation in the biochemistry of *Cistus* species. For example, a botanical species of white rockrose from Cyprus lacks the labdane diterpene, but contains a series fatty acids and alcohols (palmitic acid, linoleic acid, undecanoic acid), essential oil compounds (anisole, dihydrocamphene), resinous compounds (conipheryl alcohol), as well as the toxic cardenolide compound mentioned above. Other species of this plant in the Mediterranean basin have shown the presence of similar compounds: bornyl acetate, pinocarveol, sabinyl acetate, ledol, viridiflorol, and aromadendrene in *Cistus ladaniferus* and primarily 13-epi-manoyl oxide and beta-ionone in *Cistus monspeliensis* (see Oller-López et al. 2005). While the specific compounds and concentrations may vary, the species seem to share an amber-like scent that is highly prized in perfumery with potential antimicrobial and pharmacological benefits (Oller-López et al. 2005:554-5).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.703</td>
<td>(1-Naphthalenepropanol, .alpha.-ethyldecahydro-5-(hydroxymethyl)-.alpha.,5,8a- trimethyl-2-methylene-, [1S[1.alpha.(R*),4a.beta.,5.beta .8a.alpha.]]-</td>
<td>Labdane diterpene (Labda-8(20),14-diene 13,18(or19)-diol, (13R))</td>
<td>Sonication-Lipid-Peak Average</td>
<td>12.0</td>
<td>64</td>
</tr>
<tr>
<td>19.703</td>
<td>1,3,3-Trimethyl-2-hydroxymethyl-3,3-dimethyl-4-(3-methylbut-2-enyl)-cyclohexene</td>
<td>Possibly related to ionone or damascene (rose oil)</td>
<td>Sonication-Lipid-Minus Start of Peak</td>
<td>12.0</td>
<td>43</td>
</tr>
</tbody>
</table>

In addition to these two compounds, there are a number of other integrated peaks, but the qualities are below 10 and therefore not accepted. There were no identifiable compounds detected in the alkaloid or lipid extractions. The alkaloid extraction was also analyzed in SIM mode, targeting atropine, codeine, ephedrine, harmine, hydrocotamine, noscapine and thebaine. A peak was identified in the codeine scan at 6.970 minutes, which is within the RT range for the compound, at a quality of 39. In the comparison of the mass spectra, all ions are present, but
there does appear some discrepancy in the abundances of the ions\textsuperscript{65}. The case is similar with the hydrocotamine SIM scan, with the alkaloid being identified within the range but with the ion abundances not matching up. In either case, it seems unlikely that an opium compound was present in the vessel. More likely is a perfume-related substance. It should also be noted that the vessel seems an unlikely container for such a substance; thus, it may be suggested that the Red Polished Mottled bowl was utilized in some stage of perfume production.

\textsuperscript{65} For an adequate match in SIM mode, peaks must be evaluated manually with the ions and ion abundances matching up.
V.D.5.b.  2 Area B, Unit 13.24 Lot 79, Red Polished sherd from bowl with flat base

The sample was extracted with the alkaloid, lipid and sonication protocols and analyzed using the alkaloid and lipid methods. In the lipid extraction, a number of peaks for 2-Chloro-9,10-bis(p-methoxyphenyl)anthracene were identified. The compound is a blue chromophore (Cheon, et al. 2004), but likely the result of contamination. In addition, acitretin was identified at 25.271 minutes at a quality 43, which is an analog of vitamin A. The source of this compound is also unclear, but may also be contamination that resulted from handling the sample as the compound is related to vitamin A (Feldman et al. 2011:1897), a compound found in skin.

The sonication sample was analyzed with the alkaloid and lipid methods. The alkaloid method showed evidence of contaminants and a series of alkanes that could not be tied to specific plant sources. The alkaloid extraction exhibited some plastic contamination and a fatty alcohol using the alkaloid method.

Using the lipid method, one compound, Indolo[3,2-b]quinoline, 10-methyl- 2-nitro-, which was identified at 12.544 minutes at a quality of 50, deserves mention. The compound was initially identified in a pottery sample from Politiko-Troullia in which the opium alkaloid, noscapine, was identified; the compound may be a degradation of this alkaloid but this has yet to be demonstrated experimentally. Regardless of whether the compound is in fact a decomposition product of noscapine, indoloquinolines are biologically active structures that have been utilized in medicinal chemistry in the synthesis of antimicrobial and antibiological agents (Suresh et al. 2008:538).
The alkaloid method showed the presence of several compounds, a few of which seem to be in trace amounts. These include thujanol (Bicyclo[3.1.0]hexan-3-ol, 4-methyl-1-(1-methylethyl)-) which was identified at 6.611 minutes at a quality of 35, an alkaloid related to pseudopelletierine (9-Azabicyclo[3.3.1]nonan-3-one, 9-hydroxy), which was identified at 7.148 minutes and at a quality of 43, and limonene oxide (7-Oxabicyclo[4.1.0]heptane, 1-methyl-4-(2-methyloxiranyl)-), which was identified at 6.471 minutes and at a quality of 35. The first is a monoterpene alcohol related to thujone (1-Isopropyl-4-methylbicyclo[3.1.0]hexan-3-one). Thujone and its derivatives are major constituents in Artemisia absinthium, or absinthe wormwood, (Emmert et al. 2004:352-4; Ott 1993:389-393; Parry 1922:56-58), Aristolochia clematitis, or birthwort, (Barceloux 2008:383-5; Francisco et al. 2008:171-2), sage, including Salvia officinalis (Daferera et al. 2000:2578), as well as tansy or Tanacetrum vulgare (Teixeira da Silva 2004:707-710). The compound was also identified in a botanical sample of sage obtained from Cyprus.

The second is likely pseudopelletierine (9-Methyl-9-azabicyclo[3.3.1]nonan-3-one), which is an alkaloid found in the bark of the pomegranate tree (Henry 1913:115-6; Seeram et al. 2006:8). The final compound may be related to limonene oxide, which is a constituent in pistachio (Pistachia atlantica) resin (Delazar et al. 2004:24) but was also identified in botanical reference samples of wormwood, pink oleander, and everlasting, the latter two being obtained from Cyprus. The compound is likely related to limonene, which occurs in a large number of essential oils.

Some of the Mediterranean plants in which limonene is a constituent include thyme, pine, caraway, a species of sage in the Phlomis family, anise, fennel, oregano, rosemary, myrtle, rue (Ruta graveolens); the resin of cypress and a species of juniper, as well as peppermint (Amor et al. 2009:183, 188-90; Azeez 2008a:229-232, 237-238; Bowles 2003:35, 55-8, 88-9, 199; Farah et al. 2006:351-3; Iacobellis et al. 2005:53, 59-60; Leela and Vipin 2008:333; Mastelić et al. 2008:795, 797; Piccaglia and Marotti 2001:239, 241-3); members of the genus Stachys (Skaltsa et al. 2001:235-7; Zhou, et al. 2011:132). It is also a minor constituent in nutmeg and the rockrose species Cistus ladaniferus and C. monspeliensis (Leela 2008a:169-175; Oller-López, et al. 2005:554). It may be noted that the compound, 7-Oxabicyclo[4.1.0]heptane, 3-oxiranyl, was also

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66 Based on the height of the peaks.
identified in ephedra seeds, but the primary psychoactive constituent, ephedrine, was not identified. In addition, D-Limonene was identified in a reference sample of henbane, but like the ephedra, the primary alkaloid was not identified in the reference sample.

One compound was identified that may indicate beer brewing. An oxalic acid compound (Oxalic acid, monoamide, monoamidrazone, N-phenyl) was identified at 5.702 minutes and with a quality of 50. The compound may be related to beerstone (calcium oxalate), which is a compound left over from the beer brewing process (McGovern 2009:67; Michel et al. 1993:412). However, it is unclear if the two compounds are related. In addition, alpha-D-Glucopyranosiduronic acid, methyl 2-O-methyl-, methyl ester was identified at 7.633 minutes at a quality of 38. This compound is a disaccharide sucrose, a sugar derivative (Wrolstad 2012:40). This does not necessarily indicate the kind of sugar conversion associated with fermentation.

In addition, two potential aromatic compounds were identified. Lilac aldehyde D was identified as a small peak at 6.996 minutes at a quality of 10, which is just at the boundary of identification67. Lilac aldehyde is also present in white campion flowers in *Silene* genus, a species of which is endemic to the Cypriot Troodos mountains (Dötterl et al. 2007:499). The second compound, alpha-farnesene, was identified at 6.459 minutes at a quality of 25 and was identified in a reference sample of wormwood, as well as lilac flowers (Li et al. 2006:43). The beta isomer, beta-farnesene, has a wider distribution, being present in chamomile, sage species in the *Phlomis* family, caper flowers, juniper berries, and germander, as well as lilac flowers (Amor et al. 2009:183, 88-9; Bowles 2003:57-8, 60-2; Romeo et al. 2007:1277; Tsintides et al 2002:353, 356; Vukovic et al. 2007:19). It should also be noted that the related sesquiterpene alcohol, farnesol (2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-), is a known constituent in rose oil, a minor constituent in white wormwood (*Artemisia herba*), coriander and lemon catnip (Bowles 2003:71-2; Nezhadali et al. 2008:560; Rusanov et al. 2011:2212; Wesolowska et al. 2011:173; Zhou et al. 2011). It was also identified in a reference sample of lavender. Since both compounds are found in lilac flowers, it seems possible that they were one of the ingredients in the mixture.

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67 Due to the trace amount of this compound, it is likely that lilac flower is not indicated, but rather is a minor constituent in another plant.
The problem with the lilac identification is that it is not indigenous to the island. However, it was known in Ugarit in the first millennium B.C., which might suggest the trees initial source (Watson 2004:110). Any suggestion of botanical importation requires further research. The possible presence of lilac should not be interpreted as evidence for contact, trade or otherwise, with the northern Levantine coast during this time, especially with the low match quality. However, further investigation into the botanical history of lilac in the Eastern Mediterranean may be interesting due to the fact that the lilac aldehyde was also identified in another sample from Sotira-Kaminoudhia (see below).

Taken together, the data from this sample seem to suggest the presence of an herbal mixture that likely contained white wormwood, sage, or tansy together with lilac and pomegranate bark. The mixture may have been a fermented grain beer, but may have included a number of other ingredients.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.271</td>
<td>Acitretin</td>
<td>Vit A/contaminant</td>
<td>Lipid-Lipid</td>
<td>43</td>
</tr>
<tr>
<td>15.692, 16.692</td>
<td>13-Tetradecen-1-ol acetate</td>
<td>Coriander constituent?</td>
<td>Alkaloid-Lipid</td>
<td>83/59</td>
</tr>
<tr>
<td>5.702</td>
<td>Oxalic acid, monoaicd, monoaimidrazone, N-phenyl</td>
<td>Beerstone?</td>
<td>Alkaloid-Aldol-Peak Average</td>
<td>50</td>
</tr>
<tr>
<td>6.459</td>
<td>(Z,Z)-alpha.-Farnesene</td>
<td>Trace?</td>
<td>Alkaloid-Aldol-Peak Average</td>
<td>25</td>
</tr>
<tr>
<td>6.611</td>
<td>Bicyclo[3.1.0]hexan-3-ol, 4-methyl-1-(1-methyl)</td>
<td>Thujanol (trace)</td>
<td>Alkaloid-Aldol-Apex</td>
<td>35</td>
</tr>
<tr>
<td>6.996</td>
<td>Lilac aldehyde D/</td>
<td>Lilac constituent/</td>
<td>Alkaloid-Aldol-Peak Average</td>
<td>10</td>
</tr>
<tr>
<td>7.148</td>
<td>9-Azabicyclo[3.3.1]nonan-3-one, 9-hydroxy</td>
<td>Related to pseudopelletierine (trace)</td>
<td>Alkaloid-Aldol-Apex</td>
<td>43</td>
</tr>
<tr>
<td>7.633</td>
<td>alpha.-D-Glucopyranosiduronic acid, methyl 2-O-methyl-, methyl ester</td>
<td>Glucose derivative?</td>
<td>Alkaloid-Aldol-Minus Start Peak</td>
<td>40</td>
</tr>
</tbody>
</table>
The sample was extracted with the sonication protocol and analyzed with the lipid method. A number of peaks were identified, but the majority appears to be contaminants perhaps associated with pesticides. Several compounds were identified in the lipid extraction that may indicate the presence of an organic residue. The first, diepicedrene-1-oxide, was identified at 11.586 at a low quality of 10.
Variations of the compound have also been identified in trace amounts in two species of sage in the *Salvia* genus, a diepicedrene, diepi-alpha-Cedreneoxide, 7-Cedren-13-ol acetate, Cedren-13-ol, alpha-Cedrene oxide (Salimpour 2011:1798-1800). Cedran-diol, 8S,14 was also identified in the sample at 17.419 minutes at a quality of 28. In addition to alterations of the compound being identified in the Mediterranean sage varieties, Cedran-diol, 8S,14 was also present in Cypriot pink rockrose, but was not identified in the endemic species of sage that was obtained from the island.

The second compound, dihydroartemisinin, 2-nitro-5-[carboxymethoxy]benzyl ether, is probably related to artemisinin, which is a “sesquiterpene lactone belonging to the cadinane series” derivatives of which have anti-malarial action (Ferreira et al. 1997:347). While it is synthetically prepared for modern medicinal applications, it originally derived from annual wormwood (*Artemisia annua*) as artemisinic acid (Ferriera et al. 1997:348).

The third compound, Mandelic acid di(tert-butyldimethylsilyl)-, was identified at 15.524 minutes at a quality of 27. In his chapter on exotic trees and unguents, Pliny (Plin. Nat. 13.2) describes “metopium”, an unguent that was made of bitter almonds. Elsewhere, he describes a cough remedy consisting of fifty bitter almonds that are shelled in honey and to which anise is added (Plin. Nat. 20.73). It should be noted, however, that bitter almonds contain amygdalin ([6-OC6H4-O-(1R,2R)-bis(1R,2R)-d-glucopyranosyl]oxyphenyl)acetonitrile), a toxic cyanogenic glucoside (Shragg et al. 1982:65) from which mandelic acid is derived.

The fourth compound, trans-isolongifolene (2H-2,4a-Methanonaphthalene, 1,3,4,5,6,7-hexahydro-1,1,5,5-tetramethyl-,(2S)-) was identified at 15.624 minutes at a quality of 32. The compound is a sesquiterpene, variations of which are found in Taurus cedar as longifolene and 8,9-dehydronoisolongifolene. Longifolene is also found in turpentine made from fir (*Abies*) resin (Başer and Demircakmak 1995:17; Smedman et al. 1969:1471; http://www.thegoodscentscompany.com/data/rw1020031.html). It should also be noted that beta-cedrene is also found in Taurus cedar, making it possible that the cedrene related compounds noted above may be related to the presence of a fir or cedar tree resin. However, it should also be mentioned that a related compound, isolongifolanol-8-ol, was also identified, which was identified in a reference
sample of hyssop and a sample of everlasting that was collected from Cyprus, making a floral
component possible as well (Mastelić et al. 2008:797; Tsintides et al. 2002:403-4).

There were also several peaks for the omega-6 fatty acid, 1-Monolinoleoylglycerol
trimethylsilyl ether. The compound is likely a degradation of linoleic acid (C18:2n6; 9,12-
Octadecadienoic acid (Z,Z) - 2,3-bis[(trimethylsilyl)oxy]propyl ester) (http://webbook.nist.gov/
cgi/cbook.cgi?ID=C54284456&Units=SI; https://www.lipomics.com/). The fatty acid, however, is
widely distributed in plants species and therefore cannot be associated with a particular source.

The final compound, Labda-8(20),12,14-trien-19-oic acid, methyl ester, (Z)-, was
identified at 17.697 minutes at a quality of 25. The compound is a labdane diterpene that may be
a constituent in one of the tree resins, but this needs to be confirmed with comparative chemical
material from these resins.

Together, the results seem to suggest the presence of a residue containing a tree resin
derived from cedar, fir or pine, but may also include annual wormwood, bitter almonds, sage or
pink rockrose. It should be noted that the most likely use of the trays from Sotira-Kaminoudhia
would have been for food preparation. Swiny (personal communication) describes basins at
Episkopi-Phaneromeni as tray-like objects with some evidence of burning on underside suggest
use in preparation of food. Frankel and Webb (2006:14-5, 24-5) reiterated the use of trays in food
preparation and differentiate them from mealing bins that would have been used for processing
food by grinding or drying. In most cases, residues in artifacts come from wet foodstuffs. Thus, it
must be noted that the tree resin-like residue may not be associated with a food residue, but
rather may represent a coating used to insulate the tray.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.586</td>
<td>Diepicedrene-1-oxide</td>
<td>Possible bacterial growth?</td>
<td>Lipid-Lipid Peak Avg</td>
<td>12.0</td>
</tr>
<tr>
<td>14.195</td>
<td>Dihydroartemisinin, 2-nitro-5- (carboxymethoxy)benzyl ether</td>
<td>Artemisinin derivative</td>
<td>Lipid-Lipid Peak Avg</td>
<td>12.0</td>
</tr>
<tr>
<td>15.524</td>
<td>Mandelic acid di(tert-butyldimethylsilyl)-</td>
<td>In bitter almonds/ Contaminant?</td>
<td>Lipid-Lipid  Apex</td>
<td>27</td>
</tr>
<tr>
<td>15.624</td>
<td>2H-2,4a-Methanonaphthalene, 1,3,4,5,6,7-hexahydro-1,1,5,5-tetramethyl- (2S)-</td>
<td>trans-Isolongifolen; commonly in pine</td>
<td>Lipid-Lipid Minus Start Peak</td>
<td>12.0</td>
</tr>
<tr>
<td>16.854</td>
<td>Isolongifolan-8-ol</td>
<td>In hyssop; related to ones in everlasting</td>
<td>Lipid-Lipid Peak Avg</td>
<td>12.0</td>
</tr>
</tbody>
</table>
The sample was extracted using the alkaloid, lipid and sonication protocols and analyzed using the alkaloid and lipid methods. The lipid extraction showed some peaks, but none returned any compound matches of sufficient qualities. The other two extractions returned no results.
The sample was extracted and analyzed with the alkaloid and lipid methods. The alkaloid sample using the alkaloid analysis method showed contamination by plastics and inks, as well as the presence of several alkanes, alkenes, and fatty alcohols. Several other compounds were identified that are related to the substance contained in the juglet. 7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl- was identified at 5.857 minutes at a quality of 30 and 10.621 minutes at a quality of 45. The compound is likely related to alpha-bisabolol (4-[(1Z)-1,5-Dimethyl-1,4-hexadienyl]-1-methyl-7-oxabicyclo[4.1.0]heptane), which is a major constituent in chamomile and a minor constituent in sage (Bowles 2003:62, 73; Velickovic et al. 2003:21).

The compound is also found in aniseed and fenugreek (Leela and Vipin 2008:333, 335; Leela and Shafeekh 2008:245). The compound, 1-Hentetracontanol, was identified at 9.367 minutes at quality of 76 and is a constituent of Ziziphora tenuior L. 68, which is also a major source of pulegone (Mehmood et al. 2010:1397; Sezik et al. 1991:101-2; Verdian-Rivi 2008:185, 187). However, pulegone was not identified in the sample.

The analysis of the alkaloid sampling using the lipid method showed the presence of four compounds. Three of these are fatty acids, palmitic acid (C16:0, Hexadecanoic acid, methyl ester) stearic acid (C18:0, Octadecanoic acid, methyl ester), and behenic acid (C22:0, Docosanoic acid, methyl ester), which were identified at qualities from 50 to 94. These fatty acids are among the most common and are widely distributed in a variety of plant oils (www.lipomics.com).

68 While the species that was submitted for analysis derived from Turkey, there is likely a species endemic to Cyprus.
The third compound, Germacrane (isomers B, C, D) (1,7-Dimethyl-4-(1-methylethyl) cyclodecane) was identified at 15.697 minutes at a quality of 59. It is a constituent in caraway (Iacobellis, et al. 2005:57, 59; Wichtmann and Stahl-Biskup 1987:83), chicory root (Piet et al. 1995:6303), spiny starwort (Sanz and Marco 1991:2788-9), yarrow (Achillea) (Bozin et al. 2008:2060), tansy (Teixeria da Silva 2004:717), juniper (San Feliciano et al. 1995:1059), laurel (Cisero 1992:2537; Pedro, et al. 2001:246), oregano (Alves-Pereira and Fernandes-Ferreira 1998:796), a European species of Aristolochia (Barxelous 2008:384-5), as well as varieties of sage in the Phlomis genus (Amor et al. 2009:183, 188-90) and Ziziphora tenuoir (Mehmood et al. 2010:1397; Verdiian-Rivi 2008:185, 187). It should be noted that this compound was also identified in a reference sample of belladonna, but none of the plant’s alkaloids were identified in the sample. The alkaloid sample was also analyzed in SIM mode in which codeine and hydrocotarnine were targeted, but no identifiable matches were identified.

While a series of compounds were detected in the sample, in combination an aromatic or medicinal mixture may be indicated that includes an unknown plant oil with possible extracts from a species of Ziziphora may be indicated, though sage or a series of other plants are also possible.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.857</td>
<td>7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-</td>
<td>Alpha-bisabolol</td>
<td>Alkaloid-Alkaloid-</td>
<td>14.0</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Peak Avg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.807</td>
<td>Docosanoic acid, methyl ester</td>
<td>C22:0, behenic acid</td>
<td>Alkaloid-Alkaloid-</td>
<td>14.0</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minus Start Peak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.367</td>
<td>1-Hentetracontanol</td>
<td>In Ziziphora</td>
<td>Alkaloid-Alkaloid-</td>
<td>14.0</td>
<td>43/76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Peak Avg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.943</td>
<td>1,7-Dimethyl-4-(1-methylethyl)cyclodecane</td>
<td>Germacrene B, C,</td>
<td>Alkaloid-Alkaloid-</td>
<td>14.0</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>Peak Avg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.340</td>
<td>Hexadecanoic acid, methyl ester</td>
<td>C16:0, Palmitic acid</td>
<td>Alkaloid-Lipid-Apex</td>
<td>94/93</td>
<td></td>
</tr>
<tr>
<td>12.796</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.627</td>
<td>Octadecanoic acid, methyl ester</td>
<td>C18:0, Stearic acid</td>
<td>Alkaloid-Lipid-Apex</td>
<td>94/90</td>
<td></td>
</tr>
<tr>
<td>14.033</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.697</td>
<td>1,7-Dimethyl-4-(1-methylethyl)cyclodecane</td>
<td>Germacrene B, C,</td>
<td>Alkaloid-Lipid-Apex</td>
<td></td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
V.D.5.f. 6 Area A, Unit 44, P169, Drab Polished Blue Core juglet sherd

The sample was extracted using the alkaloid and lipid protocols and was analyzed using both the alkaloid and lipid methods. The sample was also run in SIM mode, targeting atropine, hydrocotamine, codeine, papaverine and thujone. Other than a few nondescript fatty alcohols and a series of contaminants, no other compounds were detected that would suggest the presence of a preserved residue.
The sample was extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. In addition, the sample was analyzed in SIM mode, in which hydrocotarnine and thujone were targeted. Using the alkaloid method of analysis, a number alkanes, fatty alcohols, and contaminants were identified. In addition, several essential oil compounds were identified. The first of these, 2-Cyclopenten-1-one, 3-methyl-2-(trimethylsilyl)-, was identified at 7.206 minutes at quality of 37. The compound is likely related to jasmone (2-Cyclopenten-1-one, 3-methyl-2-(2-pentenyl)-, (Z)-) (http://webbook.nist.gov/cgi/cbook.cgi?ID=C6261183), which is the primary constituent of jasmine.

However, since this plant is not indigenous to the Eastern Mediterranean, another source is probable. It is also found in smaller concentrations in honeysuckle flowers, basil, three species of yarrow (genus Achillea), and a species of Levantine Wormseed (Artemisia santonicum) (http://webbook.nist.gov/cgi/cbook.cgi?ID=488-10-8; Kordali et al. 2005:1412; Lee et al. 2005:134; Mookherjee et al. 1990; Teixeira da Silva 2004:707; http://www.thegoodscentscompany.com/data/rw1016891.html).

The second of these, menthol (Menthol, 1’-(butyn-3-one-1-yl)-, (1S,2S,5R)-) was identified at 7.594 minutes and a quality of 46. It is the primary constituent in peppermint and a major constituent in spearmint and pennyroyal (Bowles 2003:70, 88-89). A related compound, isopulegol (Cyclohexanol, 5-methyl-2-(1-methyleneyl)-), was identified at 7.698 and at a quality of 46. Like menthol, it is a major constituent in peppermint, pennyroyal, and spearmint (Bowles 2003: 25-6, 69-71, 85, 88-9). It was also identified in botanical reference samples of peppermint and lemon balm.
It may be noted that pennyroyal (*Mentha pulegium*) likely represents the final ingredient in the list of ingredients (barley, water, blechon) used to make the kykeon of the Eleusinian Mysteries (Ott 1993:142; Ruck 2006:19). The identity of the sacred kykeon, the preparation of which was dictated by the Greek goddess Demeter, has been suggested to be the opium poppy (Merlin 1984), ergot (*Claviceps purpurea*) that infects grasses (Wasson et al. 1978, 2008), as well as the fly-agaric mushroom (*Amanita muscaria*) (Ruck 2006:24-8). It may be noted, however, that two constituents in pennyroyal oil, pulegone and menthofuran, are toxic to the liver in large quantities (EMEA 2005; Sullivan et al. 1979:2873-4).

In addition, Pliny (Plin. Nat. 20.54) describes two varieties of pennyroyal. The first, which is referred to simply as pennyroyal, was used in "restoring consciousness in fainting fits", used as a pain reliever, against nausea, and gastrointestinal problems. The Wild Pennyroyal, on the other hand, is given "to persons afflicted with spasms" in a drink of honey and salt (Plin. Nat. 20.55). Pennyroyal has also been utilized in treating female ailments, as well as an abortifacient (Sullivan et al. 1979:2873-4).


The compound, 2-Butanone, 4-(2,6,6-trimethyl-2-cyclohexen-1-yl)-, (R)-, was identified at 7.803 minutes and is likely related to either beta-ionone ((E)-4-(2,6,6-trimethyl-1-cyclohexenyl)but-3-en-2-one) or damascene ((E)-1-(2,6,6-Trimethyl-1-cyclohexenyl)but-2-en-1-one). Both are major constituents in rose oil, but were also identified in reference samples of pink rockrose and myrtle leaf from Cyprus (Bowles 2003:71-2; Rusanov et al. 2011:2214-5; Van Ouwerkerk et al. 1977). Alternatively, the compound may be either alpha-ionone (3-Buten-1-one,
4-[2,6,6-trimethyl-1(or 2)-cyclohexen-1-yl]-) or tetrahydroionone (4-(2,2,6-Trimethylcyclohexyl
)-2-butane), both of which are constituents in species of rockrose - the former in reference
samples of pink rockrose from Cyprus and the latter noted in the species *Cistus monspeliens* that
is indigenous to the Mediterranean basin (Oller-López et al. 2005:554).

The compound, Bicyclo[4.1.0]heptan-2-ol, 3,7,7-trimethyl-, (1.alpha.,2.alpha.,3.beta.,
6.alpha.-), was identified at 9.153 minutes with a quality of 43 and is likely related to carene
(3,7,7-trimethylbicyclo[4.1.0]hept-3-ene). This compound is a bicyclic terpene that is found in
various species of pine and fir, as well as the turpentine made from it (Bowles 2003:54-5;
Daferera et al. 2000:2577). Carene and its isomers were identified in reference samples of bay
leaf, myrtle, pine, sage, and thyme, all obtained from the island of Cyprus. It is a major constituent
in clary sage (*Salvia sclarea*), caper flower buds, wild dittany (*Origanum dictamnus*), wild fennel
and a plant referred to as mountain tea in the Eastern Mediterranean (*Sideritis congesta*)
(Gumuscu et al. 2011; Liolios et al. 2009:80; Piccaglia and Marotti 2001:241; Romeo et al.

4-Methoxycinnamic acid (2-Propenoic acid, 3-(4-methoxyphenyl)) was identified at 8.836
minutes and at quality of 50. The compound has a wide distribution in plants and therefore cannot
be associated with a particular plant source. The same is true for squalene, which was identified
at 11.937 minutes at a quality of 83. The alkaloid sample was also analyzed in SIM mode with no
results.

Using the lipid method of analysis, two fatty acids were identified. Stearic acid (C18:0,
Octadecanoic acid) was identified at 12.799 minutes with a quality of 72 and behenic acid (C22:0,
docosanoic acid) was identified at 14.027 with a quality of 43. The former has a wide distribution
in animal and vegetable oils and the latter particularly present in nut oils (www.lipomics.com). In
both cases, the compounds cannot securely be associated with a particular source, but may
suggest that the matrix of the substance held in the bottle was oil-based.

Taken together, it seems likely that the substance contained in the vessel consisted of an
aromatic oil or unguent that contained a species of mint, the fragrance of rose, caper, rockrose or
honesuckle flowers, and pine resin. Additional ingredients may have included myrtle, sage, wormseed, or yarrow.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.997</td>
<td>2-Cyclopenten-1-one, 3-methyl-2-(trimethylsilyl)-</td>
<td>Related to jasmon?</td>
<td>Alkaloid-Alkaloid</td>
<td>15.0</td>
<td>37</td>
</tr>
<tr>
<td>7.206</td>
<td>Limonene oxide, cis-</td>
<td></td>
<td>Alkaloid-Alkaloid</td>
<td>15.0</td>
<td>35</td>
</tr>
<tr>
<td>7.594</td>
<td>Menthol, 1'-(butyn-3-one-1-yl)-, (1S,2S,5R)-</td>
<td>Menthol derivative</td>
<td>Alkaloid-Alkaloid</td>
<td>15.0</td>
<td>46</td>
</tr>
<tr>
<td>7.803</td>
<td>2-Butanone, 4-(2,6,6-trimethyl-2-cyclohexen-1-yl)-, (R)-</td>
<td>Related to beta-ionone or damascone</td>
<td>Alkaloid-Alkaloid</td>
<td>15.0</td>
<td>25</td>
</tr>
<tr>
<td>11.937</td>
<td>2,6,10,14,18,22-Tetracosahexaene,2,6,10,15,1 9,23-hexamethyl-, (all-E)-</td>
<td>Squalene</td>
<td>Alkaloid-Alkaloid</td>
<td>15.0</td>
<td>72</td>
</tr>
<tr>
<td>12.799</td>
<td>Octadecanoic acid, ethyl ester</td>
<td>C18:0, Stearic acid</td>
<td>Alkaloid-Lipid</td>
<td>12.0</td>
<td>72</td>
</tr>
<tr>
<td>14.027</td>
<td>Docosanoic acid, ethyl ester</td>
<td>C22:0, Behenic acid</td>
<td>Alkaloid-Alkaloid</td>
<td>15.0</td>
<td>43</td>
</tr>
</tbody>
</table>
V.D.5.h. 8 Area A, Unit 5, P74 (Red Polished Black-topped bottle)

The sample was extracted using the alkaloid, lipid and sonication protocols and analyzed using the alkaloid and lipid methods. The alkaloid sample was also analyzed in SIM mode, targeting codeine, ephedrine, harmine, hydrocotamine, atropine, thebaine, and thujone, which returned no results. The lipid extraction also did not indicate the presence of a preserved residue. However, five compounds were detected in the alkaloid and sonication extractions.

The first of these, vanillin, was identified at 3.099 minutes and at a quality of 97 in the alkaloid sample. This identification may be problematic due to the fact that vanilla is indigenous to the Americas and Southeast Asia and therefore may be the result of contamination (Azeez 2008:287; Lloyd 1921:340-349). However, vanillin does occur as a constituent in the essential oils of other plants. One such plant is aniseed, which has been shown to contain a vanillic acid...
glucoside, (Reichling and Galati 2004:92). Vanillin is also a minor constituent in basil (Dev et al. 2011:199, 201-3).

Isopulegol (Cyclohexanol, 5-methyl-2-(1-methylethenyl)-) was identified at 7.410 minutes with a quality of 35 and may be one of two essential oil compounds. The compound is an isomer of pulegol and related to either (+)-pulegone ((R)-5-Methyl-2-(1-methylethylidine)cyclohexanone) or (+)-isomenthone (Cyclohexanone, 5-methyl-2-(1-methylethyl)-, (2S-cis)-), both of which are constituents in Pennyroyal (Mentha pulegrium) and Peppermint (Mentha piperita). The latter was also identified in a reference sample of peppermint (Bowles 2003:25-6, 69-71, 85, 88-9). As noted above, isomenthol is also the primary constituent in a reference sample of lemon balm. Several isomers of isopulegol occur in trace amounts in Pelargonium species (Lalli 2005:69-70). As noted above, pennyroyal (Mentha pulegium) has been suggested to be the final ingredient in the list of ingredients (barley, water, blechon) used to make the kykeon of the Eleusinian Mysteries (Ott 1993:142; Ruck 2006:19).

In the sonication extraction, artemiseole (1,6,6-Trimethyl-4-ethenyl-exo-2-oxabicyclo[3.1.0] hexane) was identified at 7.413 minutes with a quality of 43. As the name suggests, the compound is a major constituent in Artemisia species. The presence of this compound indicates either the presence of a wormwood or sagebrush since the compound was found in a reference sample of wormwood and is a known constituent of two other species in the Artemisia family (Gunawardena et al. 2001:198, 200-1; Teixiera da Silva 2004:707-10). Another possibility is rockrose because the compound was identified in both white and pink varieties of the plant that grow in Cyprus.

Two additional compounds were identified in the alkaloid extraction. The first, cyclohexanemethanol, 4-methyl-, cis, was identified at 9.373 minutes with a quality of 23 and may represent a fragmentation of elemol (Cyclohexanemethanol, 4-ethenyl-α,α,4-trimethyl-3-(1-methylethenyl)-, [1r-(1α,3α,4β)]-). It should be noted that Cyclohexanemethanol, 4-methylene- was identified in a reference sample of henbane seeds, but no tropane alkaloids were identified. Cyclohexanemethanol, perhaps a greater degradation of elemol, was identified in wormwood extract. Elemol, a sesquiterpene alcohol (Parry 1922:157), is also a constituent in rose (Rusanov

According to Parry (1922:157) elemol transforms into elemene, which has three isomers, beta (1-Ethenyl-1-methyl-2,4-di(prop-1-en-2-yl)cyclohexane), delta (3-Isopropenyl-1-isopropyl-4-methyl-4-vinyl-1-cyclohexene), gamma (1-Methyl-2,4-bis(1-methylethylidene)-1-vinylcyclohexane), to which the fragment may be related. The beta isomer is a major constituent in rose (Rusanov et al. 2011:2215), yarrow (*Achillea ageratum*) (Grandi et al. 1972), a species of wormwood (*Artemisia santonicum*) (Kordali et al. 2005:1412), as well as a species of woundwort (*Stachys palustris*), which also has beta-ionone (Senatore et al. 2007:135, 137). Beta-elemene is also a minor constituent in species of *Sideritis* (Gumuscu et al. 2011), a reference sample of henbane seeds in conjunction with the elemol noted earlier, and potentially in a reference sample of pink rockrose from Cyprus. The delta isomer is the primary constituent in myrrh (*Commiphora myrrha*) with beta-elemene as a lesser constituent (Bowles 2003:25-6). It is also a major constituent in black currants (Le Quere and Latrasse 1990:3) and two species of fir (*Abies magnifica* and *A. procera*) (Smedman et al. 1969:1471, 1474-5). The gamma isomer is a constituent in oregano, basil, juniper berries, as well as a minor constituent in coriander (Alves-Pereira and Fernandes-Ferreira 1998:796; Bowles 2003:256; De Martino et al. 2009:2738; Dev et al. 2011:203; Zhou et al. 2011:32).

The second compound identified was 2,3-Dihydrofuro(2,3-b)quinoline at 9.633 minutes with a quality of 46. While the identity of this compound is somewhat unclear, it is at the very least a fragment of a quinoline alkaloid. According to Michael (2005:223), a series of furo[2,3-b]quinoline alkaloids are present in fringed rue (*Ruta chalepensis*), a plant that is indigenous to Cyprus with medicinal properties that were known in Classical times. Specifically, the plant was used as an antidote in aconite poisoning (Tsintides et al. 2002:248). These alkaloids have also been identified in *Rutaceae* plants in the *Haplophyllum* genus from Turkey. Possible alkaloids
from which the fragment may have derived include dictamnine (4-Methoxyfuro[2,3-b]quinoline), fagarine (4,8-Dimethoxyfuro[2,3-b]quinoline), or pteleine (4,6-Dimethoxyfuro[2,3-b]quinoline), heliparvifoline (4,6-dimethoxy-9H-furo[2,3-b]quinolin-7-one). If this identification is accurate, it may be noted that *Haplophyllum* species have a range of other alkaloids, one of which includes scopoletin, a constituent found in psychoactive plants known to have tropane alkaloids (Ulubelen and Öztürk 2008:54-5, 58, 65).

Based on these results, the substance contained in the small bottle from the Cypriot north coast likely had medicinal or psychoactive properties and probably consisted of pennyroyal, fringed rue, rockrose, and a species of wormwood. A number of other ingredients are also possible, including but not limited to a tree resin, bay leaf, yarrow, rose, mountain tea, and thyme.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.099/8.423</td>
<td>Vanillin</td>
<td>Alkaloid-Alkaloid</td>
<td>Alkaloid-Lipid</td>
<td>12.0</td>
<td>97/91</td>
</tr>
<tr>
<td>7.410</td>
<td>Cyclohexanol, 5-methyl-2-(1-methylethenyl)-</td>
<td>Isopulegol</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>35</td>
</tr>
<tr>
<td>7.413</td>
<td>Artemisole</td>
<td>Sonication-Alkaloid</td>
<td>12.0</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>9.373</td>
<td>Cyclohexanemethanol, 4-methyl-cis</td>
<td>Fragment of Elemol?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>23</td>
</tr>
<tr>
<td>9.633</td>
<td>2,3-Dihydrofuro(2,3-b)quinoline</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>
The sample was extracted with the alkaloid protocol and analyzed using the alkaloid and lipid methods. In addition, the sample was analyzed in SIM mode, in which ephedrine, harmine, hydrocotarnine, atropine, thujone and thebaine were targeted. The alkaloid extraction\textsuperscript{70} showed the presence of contaminants, fatty acids, and alkanes. Several compounds were identified that are likely related to the contents of the vessel. One of two possible compounds was identified in the first peak at 5.489 minutes both at a quality of 12. The compound is either a contaminant, dimethyl fumarate (2-Butenedioic acid, 2,3-dimethyl-, dimethyl ester), or Isodi-hydrolavandulyl aldehyde (2-Isopropyl-5-methylhex-2-enal).

The latter was identified in a botanical reference sample of Cypriot myrtle. However, the compound may be a degradation of lavandulyl acetate or lavandulol, major constituents in

\textsuperscript{70} The alkaloid sample underwent analysis by GC/MS twice; compounds that did not appear in the initial reports are noted separately.
lavender flowers. Lavender flowers have long been used in the production of perfumes and are mildly anti-bacterial (Bowles 2003:35-6, 195; Matthews 1973:37, 45, 48).

Another floral compound, lilac aldehyde C, was identified in the second run of the sample. This compound as well as its isomers occurs primarily in lilac flowers (Li et al. 2006:43). Problems with the identification of lilac in Cyprus during the prehistoric Bronze Age were already mentioned above due to the fact that that plant is not indigenous to the island. However, the compound is also present in white campion flowers in Silene genus, a species of which is endemic to the Cypriot Troodos mountains (Döttler et al. 2007:499; Hand 2000:56).

Two additional compounds were identified in the alkaloid extraction. The first, beta-Bergamotene (Bicyclo[3.1.1]heptane, 6-methyl-2-methylene-6-(4-methyl-3-pentenyl)-, [1R-(1.alpha.,5.alpha.,6.beta.)]), was identified at 6.337 minutes at quality of 33. Its name derives from the bergamot orange (Bowles 2003:191; Parry 1922:275), but is a constituent in aniseed, rose, lavender, parsley and hardy mums (Chrysanthemum morifolium) (Schmidt 2002:175; Teixeira da Silva 2004:707). The alpha isomer of bergamotene is a constituent in nutmeg, everlasting, a species of sage, as well as germander, two species of which are endemic to Cyprus (Leela 2008:170; Mastelić 2008:796-7; Salimpour et al. 2011:1800; Tsintides et al. 2002:353, 356; Vukovic et al. 2007:19).

The compounds identified at 8.021 and 9.363 minutes, Cyclohexanemethanol, 2-methyl-, and cyclohexanemethanol, respectively, are likely both fragments of elemol (Cyclohexanemethanol, 4-ethenyl-α,α,4-trimethyl-3-(1-methylethenyl)-, [1r-(1α,3α,4β)]-). As noted for the previous sample, elemol is a constituent in rose, a species of torchwood, thyme, wormseed, pine needles, and bay leaves (Kordali et al. 2005:1412; Lee et al. 2005:134; Parthasarathy et al. 2008:428; Petrakis et al. 1994:359; Rohmer et al. 1977; Rusanov et al. 2011:2215; Sáez 1995:822; Teixeira da Silva 2004:706-7). The isomers of elemene are found in yarrow, wormwood, woundwort, species of Sideritis, myrrh, black currants, two species of fir, oregano, basil, juniper berries, and coriander (Alves-Pereira and Fernandes-Ferreira 1998:796; Bowles 2003:256; De Martino et al. 2009:2738; Dev et al. 2011:203; Grandi et al. 1972; Gumuscu...

Three fatty acids were identified in the lipid analysis of the alkaloid extraction. Palmitic acid (16:0, hexadecanoic acid), stearic acid (C18:0, octadecanoic acid), and arachic acid (C20:0, eicosanoic acid). All three have a rather wide distribution in plants and animals (www.lipomics.com). The trans-Verbenone (Bicyclo[3.1.1]hept-3-en-2-one, 4,6,6-trimethyl-, (1S)-), in the sample was identified experimentally in a reference sample of Cypriot sage. It is also a constituent in annual wormwood (Artemisia alba), rosemary, vervain, a species of germander (Teucrium montanum), as well the Lilac Chaste or Monk’s Pepper Tree (Vitex agnus-castus), which is a member of the Verbenaceae family and was used in Ancient Greece in annual festival honoring the goddess Demeter (Ardakani et al. 2003:40; Bowles 2003:35; Radulović and Blagojević 2010:1117-9; Tsintides et al. 2002:350; Vukovic et al. 2007:19).

The quinoline, 2,3-Dihydrofuro(2,3-b)quinoline, compound that was identified in the previous sample was also present. A mentioned earlier, this compound may represent a fragment of a furo[2,3-b]quinoline alkaloid, such as is found fringed rue and various species in the Haplophyllum genus (Michael 2005:223; Tsintides et al. 2002:248; Ulubelen and Öztürk 2008:54-5, 58, 65). A second quinoline compound, indolo[3,2-b]quinoline, 10-methyl-2-nitro-, that has been identified in fifteen other samples was also identified. As mentioned elsewhere, it is unclear whether this compound is inherent in a residue or an analytical artifact. A third quinoline compound, Isoquinolin-6-ol, 7-methoxy-1-methyl-, was also identified, which is a tetrahydroisoquinoline alkaloid derivative. While the exact source is unknown, the compound may be a derivative of papaverine or one of its degradation products\(^7\). However, this degradation pathway has not been demonstrated experimentally and there is no other unequivocal evidence for opium-related alkaloids in the sample.

\(^7\) See Chovanec et al. 2012.
The final compound in the sample is 1,6;3,4-Dianhydro-2-deoxy-β-d-lyxo-hexopyranose, which according to Fronza et al. (1987) is a carbohydrate compound associated with the fermentation action of baker’s yeast. This might suggest the presence of beer, but other biomarkers, such as beerstone, were absent (McGovern 2009:67; Michel et al. 1993:411).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.489</td>
<td>2-Butenedioic acid, 2,3-dimethyl-, dimethyl ester/2-Isopropyl-5-methylhex-2-enal</td>
<td>Dimethyl fumarate – contaminant?/Isodihydrolavandulyl aldehyde</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>12/12</td>
</tr>
<tr>
<td>5.496</td>
<td>Lilac aldehyde C</td>
<td></td>
<td>Alkaloid-Alkaloid-Rerun</td>
<td>12.0</td>
<td>14</td>
</tr>
<tr>
<td>6.337</td>
<td>Bicyclo[3.1.1]heptane, 6-methyl-2-methylene-6-(4-methyl-3-pentenyl)-[1R-(1.alpha.,5.alpha.,6.beta.)]</td>
<td>Beta-Bergamotene</td>
<td>Alkaloid-Alkaloid-Rerun</td>
<td>12.0</td>
<td>33</td>
</tr>
<tr>
<td>8.021</td>
<td>Cyclohexanemethanol, 2-methyl-</td>
<td></td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>32</td>
</tr>
<tr>
<td>9.363</td>
<td>Cyclohexanemethanol</td>
<td>Fragment of Elemol?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>25</td>
</tr>
<tr>
<td>9.628</td>
<td>2,3-Dihydrofuro(2,3-b)quinoline</td>
<td>Quinoline alkaloid</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>38</td>
</tr>
<tr>
<td>11.610</td>
<td>1,6;3,4-Dianhydro-2-deoxy-β-d-lyxo-hexopyranose</td>
<td>Baker’s yeast</td>
<td>Alkaloid-Alkaloid-Rerun</td>
<td>12.0</td>
<td>25</td>
</tr>
<tr>
<td>11.860</td>
<td>Bicyclo[3.1.1]hept-3-en-2-one, 4,6,6-trimethyl-,(1S)-</td>
<td>Trans-Verbenone</td>
<td>Alkaloid-Lipid</td>
<td>11.0</td>
<td>10</td>
</tr>
<tr>
<td>12.355,12.801</td>
<td>Hexadecanoic acid, methyl ester Hexadecanoic acid, ethyl ester</td>
<td>C16:0, Palmitic acid</td>
<td>Alkaloid-Lipid</td>
<td>11.0</td>
<td>96/93</td>
</tr>
<tr>
<td>12.544</td>
<td>Indolo[3,2-b]quinoline, 10-methyl-2-nitro-</td>
<td></td>
<td>Alkaloid-Lipid</td>
<td>11.0</td>
<td>47</td>
</tr>
<tr>
<td>13.633,14.029</td>
<td>Octadecanoic acid, methyl ester Octadecanoic acid, ethyl ester</td>
<td>C18:0, Stearic acid</td>
<td>Alkaloid-Lipid</td>
<td>11.0</td>
<td>98/93</td>
</tr>
<tr>
<td>14.108</td>
<td>Isoquinolin-6-ol, 7-methoxy-1-methyl-</td>
<td>Tetrahydroisoquinoline alkaloid</td>
<td>Alkaloid-Lipid</td>
<td>11.0</td>
<td>64</td>
</tr>
<tr>
<td>16.256</td>
<td>Eicosanoic acid, ethyl ester</td>
<td></td>
<td>Alkaloid-Lipid</td>
<td>11.0</td>
<td>42</td>
</tr>
</tbody>
</table>
The sample was analyzed in SIM mode, targeting atropine, ephedrine, harmine, hydrocotamine, thujone and thebaine. The thujone scan may have two potential matches. The presence of thujone in the SIM scan is consistent with the identification of wormwood, sage, myrtle and bay leaf as probable ingredients in the substance in the vessel.
Based on these data, the substance contained in this juglet likely contained an aromatic oil scented with lavender and germander as primary ingredients with the possible addition of fringe rue and a thujone-containing plant, both of which may have psychoactive or medicinal properties. A series of additional ingredients are possible, including but not limited to Lilac Chaste tree, sage, white campion flowers, myrtle, rose, wormseed or wormwood, bay leaf, oregano and basil.
V.D.5.j. 10 Tomb 4, P29 (Brown Polished Bottle)

The sample was extracted using the alkaloid and lipid extraction protocols and the alkaloid and lipid analysis methods. The sample was also analyzed in SIM mode, targeting atropine, codeine, thujone and thebaine. All analyses showed extensive contamination. The alkaloid analysis of the alkaloid sample primary contained contaminants, alkanes and fatty alcohols. In addition, four compounds were identified that are likely related to the substance contained in the vessel.

At 4.246 minutes, di-iso-amyl oxalate (Ethanedioic acid, bis(3-methylbutyl) ester) was identified at a quality of 25 (http://webbook.nist.gov/cgi/cbook.cgi?ID=C2051005&Mask=4). The compound may be related to beerstone. But this identification is uncertain since the compound appears to be an oxalate derivative, rather than the usual calcium oxalate (McGovern 2009:67; Michel et al. 1993:411-2). Since the compound is toxic and should not be consumed, a greater question is whether beerstone would be found in drinking vessel or would more readily be found in the vessel in which fermentation occurred. Thus, the identification of beerstone should be treated as tentative.

At 7.407 minutes, either limonene oxide (7-Oxabicyclo[4.1.0]heptane, 1-methyl-4-(1-methylethenyl)-) or a compound related to carvone oxide (5-Isopropenyl-2-methyl-7-oxabicyclo[4.1.0]heptan-2-ol) is present. The former occurred at a quality of 38, while the latter at 43. Both are mentioned here because of their structural similarity. If the former identification is correct, then possible sources may include anise, caraway, rue, rosemary, coriander, fennel, myrtle, and vervain (Azeez 2008:229-232, 237-238; Bowles 2003:35, 55, 57, 88-9, 199; Farah, et al. 2006; Iacobellis, et al. 2005; Leela and Vipin 2008:333; Piccaglia and Marotti 2001:239, 241-3; Zhou, et al. 2011:132). Limonene is also a minor constituent in cardamom (Chempakam and
nutmeg (Leela 2008:169-175), peppermint, sage, scotch pine (Bowles 2003:58) and members of the genus *Stachys* (Skaltsa et al. 2001:235-7). In addition, the compound, 7-Oxabicyclo[4.1.0]heptane, 3-oxiranyl, was identified in a reference sample of ephedra seeds, but ephedrine, the primary psychoactive constituent, was not identified. In addition, D-Limonene was identified in a reference sample of henbane, but like the ephedra, the primary alkaloid was not identified in the reference sample.

If the latter identification is correct, then possible sources may include rosemary and wormseed which contain carvone oxide (http://www.thegoodsentscompany.com/data/rw1511401.html). The related compound, carvone, is the primary constituent in caraway and is a major constituent in spearmint, costmary (*Balsamita suaveolens*), and oregano (Bowles 2003:199; Daferera et al. 2000:2577-9; Gallori et al. 2001:5907; Iacobellis, et al. 2005:57, 59) and a minor one in tansy, cardamom, coriander, fennel, fenugreek (Azeez 2008:235; Chempakam and Sindhu 2008:44; Leela and Shafeek 2008:247; Parthasarathy and Zachariah 2008:199-200; Teixera da Silva 2004). In addition, carvone epoxide is present as a minor constituent a species of rockrose (*Cistus ladaniferus*) (Oller-López, et al. 2005:554). A related compound, carveol (2-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)-, cis), is found in white wormwood (*Artemisia herba*) (Nezhadali et al. 2008:560). The phenol carvacrol is the primary constituent found in fig leaves, savory, oregano, and thyme (Bowles 2003:197, 199; Muanda et al. 2010:147, 153, 158; Sáez et al. 1995:819, 821-4).

The compound, 7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-, was identified at 8.421 minutes at lower quality of 16. The compound may represent a fragment of alpha-bisabolol (4-[(1Z)-1,5-Dimethyl-1,4-hexadienyl]-1-methyl-7-oxabicyclo[4.1.0]heptane), which is found in thyme, pink rockrose, wormwood, basil, oregano or germander (De Martino et al. 2009:2737; Lee et al. 2005:134; Vukovic et al. 2007:18-19). Alternatively, it may represent a further modification of limonene.

The final compound detected in the sample was the quinoline alkaloid, 2,3-Dihydrofuro(2,3-b)quinoline, identified in the last two samples. As mentioned earlier, this compound may represent a fragment of a furo[2,3-b]quinoline alkaloid, such as is found fringed

The alkaloid extraction was also subjected to SIM scans targeting atropine, codeine, thujone, and thebaine. The thujone scan may have returned a match, which is consistent the presence of white wormwood, myrtle, thyme or sage in the bottle. Taken together, the substance contained in the vessel likely included one or more of the following: white wormwood, thyme, oregano, myrtle, sage, rosemary, and rockrose. These plants may have been used to flavor a beer mixture. Additional ingredients may have included anise, coriander, fennel, vervain, savory, or oregano.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.246</td>
<td>Ethanedioic acid, bis(3-methylbutyl) ester</td>
<td>Di-iso-amyl oxalate; beerstone?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>25</td>
</tr>
<tr>
<td>7.407</td>
<td>7-Oxabicyclo[4.1.0]heptane, 1-methyl-4-(1-methylethenyl)-5-isopropenyl-2-methyl-7-oxabicyclo[4.1.0]heptan-2-ol</td>
<td>Limonene oxide/Carvone oxide</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>38/43</td>
</tr>
<tr>
<td>8.421</td>
<td>7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-</td>
<td>Alpha-Bisabolol?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>16</td>
</tr>
<tr>
<td>9.630</td>
<td>2,3-Dihydrofuro(2,3-b)quinoline</td>
<td></td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>43</td>
</tr>
</tbody>
</table>
V.D.5.k. 11 Area B, Unit 13.34, Lot 77, 1 (Red Polished bowl sherd)

The sherd was extracted using the lipid extraction and analytical method. The sample exhibited extensive contamination, but three compounds were detected that may be associated with a preserved residue. One fatty acid, behenic acid (C22:0, Docosanoic acid) was identified at 12.797 minutes.

While this compound occurs in some concentration in nut oil, it is found in a variety of plants and animals and cannot readily be attributed to a specific source. Squalene was also identified, which is found in liver oil and frequently is an indication of contamination (www.lipomics.com). The final compound, 1-Hexenol, 5-methyl-2-(1-methylethyl)-, was detected at 15.569 minutes at a quality of 50.

The compound is tetradhydrolavandulol which is a degradation of lavandulol, a constituent in lavender oil (Daramwar et al. 2012:70; Schmidt 2002:4). Lavandulol is also present in a species of sage (Salimpour et al. 2011:1801). Due to the level of contamination in the sample, it is unclear whether these compounds do in fact represent a preserved residue.
<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.797</td>
<td>Docosanoic acid, ethyl ester</td>
<td>C22:0, Behenic acid</td>
<td>Lipid-Lipid</td>
<td>13.5</td>
<td>72</td>
</tr>
<tr>
<td>15.430</td>
<td>Squalene/2,6,10,14,18,22-Tetracosahexaene,2,6,10,15,19,23-hexamethyl-(all-E)-</td>
<td>Lipid-Lipid</td>
<td>13.5</td>
<td>50/50</td>
<td></td>
</tr>
<tr>
<td>15.569</td>
<td>1-Hexenol, 5-methyl-2-(1-methylethyl)-</td>
<td>Tetrahydrolavandulol</td>
<td>Lipid-Lipid</td>
<td>13.5</td>
<td>50</td>
</tr>
</tbody>
</table>

V.D.5.l. 12 Area A, Unit 7, G17C, 3 (Brown Polished bottle)\textsuperscript{72}

The sample was extracted using the alkaloid and lipid protocols and analyzed using the alkaloid and lipid methods. In addition, the sample was analyzed in SIM mode, targeting codeine, hydrocotarnine, noscapine, papaverine, thebaine and thujone.

Both alkaloid and lipid samples showed contaminants, alkanes, and fatty alcohols. Four compounds were identified in the sample that may be associated with a preserved residue. At 3.218 minutes, thujone (Bicyclo[3.1.0]hexan-3-one, 4-methyl-1-(1-methylethyl)-, [1S-(1.alpha.,4.beta.,5.alpha.)]-) was identified with a quality of 38 and is a major constituent in absinthe and white wormwood, various species of sage, wormseed, tansy, sagebrush (Artemisia tridentata), and rosemary (Daferera et al. 2000:2578; Gunawardena et al. 2002:199, 201; Emmert et al. 2004; Kordali et al. 2005:1410; Ott 1993:389-393; Parry 1922:56-58; Salimpour et al.

\textsuperscript{72} The image of the sherd that was analyzed was lost, but is similar in type to the other Brown Polished bottles in the sample set.

177
2011:1802; Teixeira da Silva 2004:707-10; Veličković et al. 2003:17-20). Related compounds (various isomers of thujone) were also identified in botanical reference samples of hyssop, myrtle, bay leaf, thyme, and everlasting.

The compound, 7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-, was identified at 7.402 minutes at lower quality of 16. As noted above, the compound may represent a fragment of alpha-bisabolol (4-[(1Z)-1,5-Dimethyl-1,4-hexadienyl]-1-methyl-7-oxabicyclo[4.1.0]heptane), which is found in thyme, pink rockrose, wormwood, basil, oregano or germander (De Martino et al. 2009:2737; Lee et al. 2005:134; Vukovic et al. 2007:18-19).

At 9.159, either cis-Myrtanol or a compound related to beta-pinene was identified. If the former identification is correct, white wormwood, hyssop, or myrtle may indicated (Bowles 2003:93; Nezhadli et al. 2008:559; http://www.thegoodscentscompany.com/data/rw1012901.html). If the latter is correct, hyssop, rosemary, rose, rockrose, or the resins of fir, pine, or juniper may be indicated (Adams et al. 1999:167; Bowles 2003:35, 58-9; Oller-López et al. 2005:554; Rusanov et al. 2011:2214).

The last compound found in the sample is the quinoline alkaloid identified in three other samples from Sotira-Kaminoudhia. As mentioned earlier, this compound may represent a fragment of a furo[2,3-b]quinoline alkaloid, such as is found in fringed rue and various species in the Haplophyllum genus (Michael 2005:223; Tsintides et al. 2002:248; Ulubelen and Öztürk 2008:54-5, 58, 65). However, the possibility remains that the compound is a contaminant or an analytical artifact.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.218</td>
<td>Bicyclo[3.1.0]hexan-3-one, 4-methyl-1-(1-methylethyl)-, [1S-(1.alpha.,4.beta.,5.alpha.,)]-</td>
<td>Thujone</td>
<td>Alkaloid-</td>
<td>12.5</td>
<td>38</td>
</tr>
<tr>
<td>7.402</td>
<td>7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl</td>
<td>Alpha-bisabolol</td>
<td>Alkaloid-</td>
<td>12.5</td>
<td>27</td>
</tr>
<tr>
<td>9.632</td>
<td>2,3-Dihydrofuro(2,3-b)quinoline</td>
<td></td>
<td>Alkaloid-</td>
<td>12.5</td>
<td>46</td>
</tr>
</tbody>
</table>
Based on these results, either medicinal or mildly psychoactive substance was present in
the bottle. Hyssop was likely an ingredient, as was absinthe or white wormwood, sage, myrtle or
wormseed. Additional aromatic plants in the mixtures may have included myrtle, thyme, rose,
rockrose, or a tree resin. The presence of fringed rue may also be indicated.

![Chemical Abundance Graph]
V.E. POLITIKO-TROULLIA

V.E.1 Site Background

The excavation at Politiko Troullia is an ASOR-sponsored project and is co-directed by Dr. Steven Falconer and Dr. Patricia Fall of Arizona State University. The site is located approximately 20 kilometers southwest of Nicosia, the capital of the Republic of Cyprus in the northern foothills of the Troodos Mountains, and therefore in close proximity to the copper deposits that were integral to the development of social complexity on the island. The site roughly dates to the Middle Bronze Age on Cyprus, commonly referred to as the Middle Cypriot. The research goals pertaining to the site generally include assessing the ecological and landscape modification in rural Bronze Age Cyprus. Larger questions address the variable socioeconomic strategies employed in Cyprus as opposed to the Levantine mainland (Falconer et al. 2005:71-4; Fall et al. 2008:183-4; Fall et al. 2012:2335-6; Falconer and Fall ND:4-6).

The site was first identified in 2004 during the course of a larger surface and subsurface survey conducted as the Sydney Cyprus Survey Project. In 2006, preliminary excavations were conducted in the eastern portion of the site (Troullia East), which uncovered a Protohistoric Bronze Age occupation. In 2007, excavations began in Troullia West, which uncovered a substantial Prehistoric Bronze Age village (Falconer et al. 2005:71-4; Falconer and Fall ND:7-8; Fall et al. 2008:184-8, 193). Over the next four field seasons (2008-2011), four architectural phases dating to the Prehistoric Bronze Age were excavated, which consisted of two courtyards, one in the north and one in the south, that were surrounded by three domestic spaces and one alleyway in south (Falconer and Fall ND:7-9). The habitants of this earlier Bronze Age occupation were engaged in animal husbandry (sheep and goats), hunting (fallow deer, wild goat), arboriculture (olive, grape, fig, pistachio), as well as copper metallurgy (Falconer and Fall ND:5; Fall et al. 2012:2337-8).

Troullia East, on the other hand, represents a discrete compound consisting of a series of roofed structures, alleyways and outbuildings in which metallurgical finds characteristic of late Prehistoric and early Protohistoric Bronze Age were found, namely a carved limestone casting mold, crucible and furnace fragments, copper tongs, and various pieces of copper slag and ore.
chunks (Falconer and Fall ND:7-8, 13-4; Fall et al. 2012:2337; Fall et al. 2008:193). Metallurgical activities at the earlier Troullia West is documented by various copper slag fragments and unprocessed ores, as well as a series of finished artifacts (pins, needles, a fragment of a bronze dagger). A significant economic shift is evident at Troullia East where there is a great increase in the consumption of pig and marked decrease in hunted species, such as fallow deer (Falconer and Fall ND:12-3).

The material culture from Troullia West seems typical of the Prehistoric Bronze Age 2, with a ceramic assemblage dominated by Red Polished III wares (thought Red Polished IV, White Painted II-IV, Black Polished and Red Slip were also documented) in a diverse range of shapes (including large and small decorate bowls, jugs, juglets, bottles, storage vessels, trays, spindle whorls, etc.), a variety of ground stone tools used in the processing of food and raw materials, as well as a set of objects ideological in nature (including gaming stones, decorated but fragmentary plank figurines found together with a much larger stone figure in the plank style, ceramic animal figurines, and personal ornaments)(Falconer and Fall ND:9-11, 14-9, 25-8).

V.E.2 SAMPLES

Samples from a total of fifty-seven pottery artifacts were analyzed from the Bronze Age site of Politiko-Troullia. Six were obtained from the Late Bronze component of the site, known as Troullia East. The remaining, fifty-one samples, were obtained from the Middle Bronze Age and most extensively excavated component, known as Troullia West.

The destruction of artifacts for analytical purposes is an inherently sensitive issue in archaeology and for this reason exploring the potential of minimally destructive methods of sample and analysis is an important area of research. In acknowledgement of archaeology’s duty to preserve cultural material, the ultimate goal should be to utilize as much of an artifact as is necessary. To achieve this aim, two levels of sampling were performed during the 2009 and 2010 field seasons. In 2009, scrapings were collected from the interiors of vessels and sherds. In 2010, when possible fragments of the sample vessels that were sampled the year prior were collected for destructive analysis. The aim was to determine whether destructive analysis of an entire sherd
was necessary or if a semi-destructive analysis of interior scrapings could be sufficient to obtain analytical results. A series of additional samples were collected for destructive analysis from excavation unit from which samples had not yet been obtained. In cases where the artifact was unique and was deemed of greater value intact, only scrapings were obtained.

Each sample was subjected to at least one of three methods of organic extraction, followed by analysis by GC/MS. The number of analyses that were employed depended on the size of the sample. Larger samples were analyzed with all three methods to ensure the greatest amount of data was obtained from each sample. The data from the scrapings were compared to those from the sherd in an attempt to determine whether destructive analysis is necessary to obtain a satisfactory result.

All samples consisted of scrapings as well as sherds of a variety of wares (Red Polished, Black Polished, White Pained, Coarse Ware, Red Slip/Black Slip) in diverse shapes (juglets, jugs, storage jars, cooking pots, cups, small and large bowls, trays or basin). They were collected, exported and analyzed with the permission of Dr. Steve Falconer and Dr. Patricia Fall, the directors of excavations at the site, and Dr. Pavlos Florentzos and Dr. Maria Hadjicosti, Directors of the Cyprus Department of Antiquities in 2009 and 2010, respectively. The sample numbers and provenance information are provided below. All images were taken in the field with permission of Dr. Falconer.

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Excavation Year</th>
<th>Artifact ID Num</th>
<th>Description of Sherd Sampled</th>
<th>Sample Type(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008</td>
<td>W.006.78.42.1</td>
<td>Small spout of Red Polished vessel</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>2</td>
<td>2008</td>
<td>S.011.42.8</td>
<td>Neck/shoulder of Red Polished jug</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>3</td>
<td>2008</td>
<td>V.010.64.32</td>
<td>Flared spout of Red Polished vessel</td>
<td>Scraping</td>
</tr>
<tr>
<td>4</td>
<td>2008</td>
<td>Q.004.39.6</td>
<td>Red Polished spout</td>
<td>Scaping</td>
</tr>
<tr>
<td>5</td>
<td>2008</td>
<td>T.008.49.2</td>
<td>Neck of Red Polished jug</td>
<td>Scaping</td>
</tr>
<tr>
<td>6</td>
<td>2008</td>
<td>X.013.74.368</td>
<td>Spout/neck of Red Polished vessel</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>7</td>
<td>2008</td>
<td>W.006.78.29</td>
<td>Residue from Red Polished spout</td>
<td>Scaping</td>
</tr>
</tbody>
</table>

Seventeen additional samples were collected that were not analyzed. Fifteen including scraping samples and two included sherd samples which were determined to be unlikely to return results. This determination was based on the experience from running the rest of the sample.
<table>
<thead>
<tr>
<th></th>
<th>Date</th>
<th>Code</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2008</td>
<td>Q.009.49.49</td>
<td>Red Polished bowl spout</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>9</td>
<td>2008</td>
<td>S.011.76.110</td>
<td>High spout of Large Red Polished bowl</td>
<td>Scraping</td>
</tr>
<tr>
<td>10</td>
<td>2008</td>
<td>Q.009.49.30</td>
<td>Red Polished bottle</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>11</td>
<td>2008</td>
<td>T.007.44.49</td>
<td>Body of Red Polished closed vessel</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>13</td>
<td>2009</td>
<td>Z.0.18.1</td>
<td>Red Polished spout fragment</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>14</td>
<td>2009</td>
<td>U.002.13.1</td>
<td>Small Red Polished spout</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>15</td>
<td>2008</td>
<td>W.006.139.80</td>
<td>Red Polished body</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>18</td>
<td>2008</td>
<td>W.012.120.68</td>
<td>Red Polished spout</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>19</td>
<td>2009</td>
<td>W.012.120.69</td>
<td>Flared Red Polished spout</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>20</td>
<td>2009</td>
<td>W.012.120.70</td>
<td>Base of Red Polished juglet</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>21</td>
<td>2008</td>
<td>W.012.120.111.2</td>
<td>Footed base of Red Polished vessel</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>22</td>
<td>2009</td>
<td>V.010.53.12</td>
<td>Body of Black Polished juglet</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>25</td>
<td>2008</td>
<td>S.001.6.12.</td>
<td>Red Polished closed vessel sherds</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>26</td>
<td>2007</td>
<td>D.010.64.2</td>
<td>Body of White Painted vessel</td>
<td>Scraping</td>
</tr>
<tr>
<td>27</td>
<td>2007</td>
<td>G.003.16.1.4</td>
<td>Small Red Polished cup</td>
<td>Scraping</td>
</tr>
<tr>
<td>28</td>
<td>2007</td>
<td>A.005.46.7.1</td>
<td>Residue from part of White Painted neck</td>
<td>Scraping</td>
</tr>
<tr>
<td>29</td>
<td>2007</td>
<td>D.010.64.2</td>
<td>Neck of small White Painted vessel</td>
<td>Scraping</td>
</tr>
<tr>
<td>30</td>
<td>2007</td>
<td>D.010.67.1</td>
<td>White Painted vessel fragments</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>31</td>
<td>2009</td>
<td>U.006.17.1</td>
<td>Black-topped bowl</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>32</td>
<td>2009</td>
<td>P.004.36.1</td>
<td>White Painted bowl with high handle</td>
<td>Scrapings</td>
</tr>
<tr>
<td>33</td>
<td>2009</td>
<td>U.006.30.1</td>
<td>Red Polished cup</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>34</td>
<td>2009</td>
<td>U.006.30.2</td>
<td>Red Polished bowl</td>
<td>Scrapings</td>
</tr>
<tr>
<td>37</td>
<td>2009</td>
<td>P.004.54.4</td>
<td>Body of close Red Polished vessel</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>38</td>
<td>2007</td>
<td>D.030.48.5.1</td>
<td>Residue from fragment of White Painted small bowl with handle</td>
<td>Scrapings</td>
</tr>
<tr>
<td>39/41</td>
<td>2009</td>
<td>P.004.40.1.7</td>
<td>Small Black-topped bowl found in situ with RPIV jug</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>42</td>
<td>2009</td>
<td>P.004.41.2</td>
<td>Base of Red Polished IV Jug found in situ with Black-topped bowl</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>43</td>
<td>2009</td>
<td>W.018.190.1</td>
<td>Red Slip/Black Slip bowl</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>44</td>
<td>2009</td>
<td>P.004.23.1</td>
<td>Red Polished closed vessel base</td>
<td>Scrapings, Sherd</td>
</tr>
<tr>
<td>46</td>
<td>2009</td>
<td>O.008.77.1</td>
<td>White Painted closed vessel</td>
<td>Scrapings</td>
</tr>
<tr>
<td>49</td>
<td>2009</td>
<td>O.008.77.2</td>
<td>White Painted base</td>
<td>Scrapings</td>
</tr>
</tbody>
</table>

74 Scrapings and Sherd collected, but scrapings were not analyzed because the sample was too small.
<table>
<thead>
<tr>
<th></th>
<th>Year</th>
<th>Code</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>2009</td>
<td>O.009.85.1</td>
<td>Black Polished animal shaped vessel</td>
<td>Scrapings</td>
</tr>
<tr>
<td>51</td>
<td>2009</td>
<td>P.003.87</td>
<td>Red Polished amphoriskos</td>
<td>Scrapings</td>
</tr>
<tr>
<td>54</td>
<td>2009</td>
<td>O.009.98.1</td>
<td>Red Polished juglet neck</td>
<td>Scrapings</td>
</tr>
<tr>
<td>55</td>
<td>2009</td>
<td>U.034.232.1</td>
<td>Red Polished spout</td>
<td>Scrapings</td>
</tr>
<tr>
<td>57</td>
<td>2009</td>
<td>U.010.173.1</td>
<td>Residue from Red Polished Black Top Bowl Fragments</td>
<td>Scrapings</td>
</tr>
<tr>
<td>58</td>
<td>2009</td>
<td>Z.033.93.1</td>
<td>Red Polished bowl base</td>
<td>Scrapings</td>
</tr>
<tr>
<td>60</td>
<td>2010</td>
<td>O.011.103.47</td>
<td>Small cooking pot body</td>
<td>Sherd</td>
</tr>
<tr>
<td>61</td>
<td>2008</td>
<td>R.007.63.2</td>
<td>Storage jar body (near base)</td>
<td>Sherd</td>
</tr>
<tr>
<td>62</td>
<td>2008</td>
<td>R.007.62.2</td>
<td>Black Polished bowl, lime-filled incisions</td>
<td>Sherd</td>
</tr>
<tr>
<td>63</td>
<td>2008</td>
<td>R.007.76.3.2</td>
<td>Red Polished Black-topped bowl body, lime-filled incision</td>
<td>Sherd</td>
</tr>
<tr>
<td>64</td>
<td>2008</td>
<td>R.007.76.3.3</td>
<td>Red Polished Black-topped bowl body, lime-filled incision</td>
<td>Sherd</td>
</tr>
<tr>
<td>65</td>
<td>2008</td>
<td>R.014.61.3</td>
<td>Cooking pot button base</td>
<td>Sherd</td>
</tr>
<tr>
<td>66</td>
<td>2008</td>
<td>R.015.101.3</td>
<td>Red Polished III juglet base, lime-filled incisions</td>
<td>Sherd</td>
</tr>
<tr>
<td>67</td>
<td>2008</td>
<td>R.015.101.31</td>
<td>Red Polished III bowl rim/body, lime-filled incisions</td>
<td>Sherd</td>
</tr>
<tr>
<td>68</td>
<td>2008</td>
<td>R.022.108.6</td>
<td>Black Polished juglet body, lime-filled incisions</td>
<td>Sherd</td>
</tr>
<tr>
<td>69</td>
<td>2008</td>
<td>S.011.76.231</td>
<td>Red Polished Coarse ware basin</td>
<td>Sherd</td>
</tr>
<tr>
<td>70</td>
<td>2008</td>
<td>W.011.108.83</td>
<td>Red Polished footed closed body, incisions</td>
<td>Sherd</td>
</tr>
<tr>
<td>71</td>
<td>2008</td>
<td>X.010.9.78</td>
<td>Red Polished III juglet body, lime-filled incisions</td>
<td>Sherd</td>
</tr>
<tr>
<td>72</td>
<td>2008</td>
<td>Y.024.156.4</td>
<td>Red Polished III closed body, limed-filled incisions</td>
<td>Sherd</td>
</tr>
<tr>
<td>73A</td>
<td>2010</td>
<td>O.018.219.1</td>
<td>Storage vessel body fragment with attrition</td>
<td>Sherd</td>
</tr>
<tr>
<td>73B</td>
<td>2010</td>
<td>O.018.219.2</td>
<td>Storage vessel body fragment with carbon residue</td>
<td>Sherd</td>
</tr>
<tr>
<td>73C</td>
<td>2010</td>
<td>O.018.219.3</td>
<td>Storage vessel base fragment</td>
<td>Sherd</td>
</tr>
</tbody>
</table>

### V.E.3 METHODOLOGY

All samples underwent one of three organic extraction procedures followed by analysis by Gas Chromatography/Mass Spectrometry using one of two programs. These procedures were detailed in the previous chapter as the Alkaloid, Lipid, and Sonication protocols. The GC parameters that were used were the alkaloid (12.67 minutes) and the lipid (45.67 minutes) methods. Samples were generally run in SCAN mode. When possible, they were also analyzed in

---

Scrapings and Sherd collected, but scrapings were not analyzed because they derived from multiple fragments.

Samples 60-73 were not part of the sampling comparison; these samples were only collected for destructive analysis.
SIM mode, targeting the following compounds: atropine, codeine, ephedrine, harmine, hydrocotarnine, meconic acid, morphine, noscapine, papaverine, thebaine, and/or thujone.

V.E.4 SUMMARY OF RESULTS

Below is a summary of the samples in which chemical residues were identified and a description of the product that the vessel likely contained. A detailed discussion is provided in the next section. The chemical data discussed in the following section deals only with identification relevant to final interpretations.

1 W.006.78.42 (Small spout of Red Polished vessel) The substance was a coriander-based perfume (although lavender and rose are equally likely) along with the resin of the pink rockrose, a substance known as labdanum, which would have been used to fix or preserve the aromas.

3 V.010.64.32 (Flared spout of Red Polished vessel) The substance contained in the vessel likely included a psychoactive substance containing opium and sage.

5 T.008.49.2 (Neck of Red Polished juglet) The vessel contained a medicinal substance made for the Cypriot Lilac Chaste Tree, sage or white rockrose.

8 Q.009.49.49 (Red Polished bowl spout) The substance contained in the spouted vessel included caper leaves and flowers that had been pickled in vinegar.

14 U.002.13.1 (Small Red Polished spout) The substance contained in this small spouted vessel was a complex mixture of various aromatic, medicinal plants, including pennyroyal or another species of mint containing pulegone, lavender flowers, as well as one or more other flowers and herbs, such as rose and lemon balm, in an tree oil matrix that likely derived from a species of pine, juniper, or cypress. Honey or honeycomb may also have been an ingredient, though other
biomarkers of honey are absent. Additional ingredients may have included everlasting, fennel, or myrtle.

15 W.006.139.80 (Red Polished Closed Body) The vessel contained a complex mixture that likely contained thyme, mint and perhaps a species of tansy or yarrow as its main ingredients. The substance may have been a beer that included a species of rue, but this latter suggestion is based on uncertain identifications.

18 W.012.120.68 (Red Polished Spout) Based the presence of a series of fatty acids in conjunction with a compound that has been reported in liver or milk products, a dairy or other animal-derived product may be a more likely identification. The presence of a psychoactive substance, whether that be a fermented beverage or other substance containing indole and quinoline alkaloids, is unclear.

20 W.012.120.111.2 (Base of Red Polished juglet) This finely made juglet contained a psychoactive or medicinal substance, the primary constituents of which included poppy (not necessarily the cultivated opium poppy) and lupine beans in a plant oil matrix that likely derived from olives (though a series of other plants are possible) with the possible addition of a tree resin.

21 W.012.120.111.2 (Footed base of Red Polished vessel) While the essential oil content of the vessel is rather limited, the small footed vessel may have contained rose oil or petals in a plant oil matrix that likely derived from olives, but the source of which may be a series of other plants.

28 A.005.46.7 (White Pained Jug Neck) With only two chemical components, it is difficult to determine an overall substance, however the jug does seem to have contained a liquid substance that included a species of tansy, yarrow, or wormwood as well as a plant-derived oil.
30 D.010.67.1 (White Painted Small Closed Body) A fermented product that does not necessarily indicate alcohol, may be present. On the basis of two essential oils, an herbal mixture that may have had mild sedative or medicinal properties may be indicated in which a species of sage or germander were the primary ingredients.

32 P.004.36.1 (White Painted bowl with high handle) A perfumed substance that had pink rockrose, rose, lavender, sage, and possible wormwood as ingredients in an oil matrix that may have derived from olives or another seed oil.

34 U.006.30.2 (Red Polished bowl) The bowl may have included a mixture that included a species of thyme and a tree resin deriving from pine, juniper or cedar. The identity of the overall substance is uncertain.

37 P.004.54.4 (Body of close Red Polished vessel) The substance in this decorated closed vessel was a herbal mixture composed of a series of ingredients, which may include: the resin of pine or juniper, sage, myrtle, thyme, pink rockrose (its resin, labdanum), germander, and/or hyssop.

39:41 P.004.40.1.7 (Small Black-topped bowl found in situ with RPIV jug) The small bowl, which was found in situ with the base of an RPIV jug (PT42) may have contained wine or another fermented beverage.

42 P.004.41.2 (Base of Red Polished IV Jug found in situ with Black-topped bowl) The jug, which exhibits attrition perhaps associated with fermentation, may have contained an alcoholic beverage.

44 P.004.23.1 (Red Polished Closed Vessel Base) Based on this information, the contents of vessel likely contained a mixture with one or more of the following ingredients: rosemary, sage,
wormwood, rockrose, or caraway. A tree resin or oil from juniper, cypress, pine, or pistachio is possible, as are a variety other aromatics.

57 U.010.173 (Red Polished Black-Topped Bowl Fragments) The vessel likely contained a fermented beverage, perhaps a beer, that was seasoned with mint, rue, and perhaps a species of tansy or yarrow as its main ingredients. The contents may be similar to the mixture found in sample 15.

58 Z.033.93.1 (Red Polished Bowl Base) The bowl contained a fermented beverage, perhaps a beer or wine, that may included a plant species in the Rutaceae family as an additive.

63 R.007.76.3.2 (Red Polished Bowl Body) The bowl may have contained a fermented fruit beverage, but additional data are required for confirmation.

68 R.022.108.6 (Black Polished Decorated Juglet Base) The bowl may have contained a fermented fruit beverage, but additional data are required for confirmation.

70 W.011.108.83 (Red Polished Footed Closed Body) The substance contained in this footed vessel was an aromatic substance that likely contained thyme, a species of Artemisia (perhaps white wormwood), lavender, lemon balm, germander, pink rockrose or its resin (labdanum), but a tree resin (white willow or Aleppo pine) or medicinal plant (valerian or rue) may also be indicated. The presence of the pink rockrose in conjunction with various aromatic herbs might indicate that the mixture was a perfume, but it is also possible that if functioned as a medicine.

71 X.010.9.78 (Red Polished Juglet Body) The vessel contained a perfumed substance the primary ingredient of which was likely rose. Additional ingredients may have included thyme, a species of Artemisia, lemon balm, basil or germander. If a species Haplophyllum or fringed rue was included, then the mixture may also have had medicinal applications.
V.E.5. ANALYTICAL DATA AND DISCUSSION

V.E.5.a.1 W.006.78.42 (Small spout of Red Polished vessel)

Scrapings were extracted and analyzed with alkaloid protocol. The sherd was pulverized, extracted and analyzed using both the alkaloid and lipid protocols. The sherd was further analyzed in SIM mode, targeting atropine, codeine, hydrocotamine, meconic acid, noscapine and papaverine. Only the scrapings showed the presence of a residue. The SIM scans of the sherd showed no matches for the alkaloids noted above.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.474</td>
<td>4-(2,2-Dimethyl-6-methylene cyclohexyl)butanal</td>
<td>Fragment of ambergris odorant?</td>
<td>Scraping-Alkaloid</td>
<td>12.0</td>
<td>47</td>
</tr>
<tr>
<td>9.550</td>
<td>1-Naphthalene propanol, alpha-ethyl decahydro-5-(hydroxymethyl), alpha,.5a-trimethyl-2-methylene-[1S-1, alpha(R*), 4beta,.5, beta, 8a-alpha]</td>
<td>Labda-8(20), 14-diene-13, 18(or 19)-diol, (13R)</td>
<td>Scraping-Alkaloid</td>
<td>12.0</td>
<td>64</td>
</tr>
</tbody>
</table>

The first peak at 8.474 minutes may be related to the fragrant compound found in ambergris, which is a “precious animal perfume obtained as an intestinal concretion in the sperm whale” (Oritani 1998:9). The substance is produced in and expelled from the digestive system of male sperm whales (*Physeter macrocephalus*) after consuming squid and specifically the indigestible cephalopod beak. It occurs as a buoyant, spongy lump that ranges in size and color, which has been highly prized by perfumers for millennia (Miller and Miller 1990:37-8).

The primary chemical constituent is the non-volatile triterpene, ambreine ((1R,2R,8aS)-1-[(E)-6-[[1S]-2,2-dimethyl-6-methylene cyclohexyl]-4-methylhex-3-enyl]-2,5,5,8a-tetramethyl-3,4,4a,6,7,8-hexahydro-1H-naphthalen-2-ol). The volatile, and therefore detectable by GC-MS, components are the degradation products of ambreine. As detailed by Oritani (1998:9), those odoriferous products include: C11-γ-cyclohomogeronial, C13-dihydro- γ-ionone, C14- γ-coronal,
C16-ambrox, and C17-dehydroamba oxide. Similarly, Horiuchi et al. (1999) describe the decomposition of (±)-γ-Cyclohomogeraniol[2,(2',2'-dimethyl-6'-methylenecyclohexyl)ethanol] into the volatile ambergris compound (S)-γ-coronal[2-methylene-4-(2',2'-dimethyl-6'-methylenecyclohexyl)butanal]. It is the latter that was identified in the first peak (RT 8.747).

The identification of the second peak, at RT 9.550 requires greater discussion. By automated compound identification, geranyl linalool (1,6,10,14-Hexadecatetraen-3-ol, 3, 7,11,15-tetramethyl-, (E,E)-), was detected at a quality of 50. The compound is likely an intermediary compound in the transformation of one of two structurally similar compounds: geraniol and linalool. Bertsch et al (2004:701) identified geranyl linalool as a tertiary alcohol present in the labial gland secretions of the male bumblebee Bombus griseocollis, which may indicate the presence of honey. Alternatively, the compound may be related to geraniol, which a constituent in coriander, lemonbalm, rose, sage, vervain and was identified in botanical reference samples of myrtle and lavender. A related compound, geranyl acetate, is present in fig tree, rose, coriander, vervain, lemonbalm, and sage, but was not identified in the reference sample of sage. Linalool, on the other hand, is present in absinthe wormwood, fig tree, lavender, marjoram, basil, oregano, thyme, vervain, as well as reference samples of lavender, sage, and myrtle. Thus, the most likely source of the compound is coriander, rose, sage, myrtle, or lavender. The potential presence of coriander, rose or sage in conjunction with a perfume fixative may be intriguing since oils perfumed with the scent of coriander, rose and sage are documented in texts from Pylos and Knossos (Brun 2000:281; Shelmerdine 1985:18, 21-25)77.

However, using manual integration, the compound, Labda-8(20),14-diene-13,18(or19)-diol, (13R), was identified and chosen for reporting because it occurs at the same abundance, but at a greater quality (64) than that of geranyl linalool. Labda-8(20),14-diene-13,18(or19)-diol, (13R), (1-Naphthalenepropanol, .alpha-ethyldecahydro-5-(hydroxymethyl), alpha.,5,8a-trimethyl -2-methylene-, [1S-[1,α(R*),4α.β,5.β, 8α-α]]) is a labdane diterpene, a class of metabolites that are known constituents in the resin of Cistus species. The resin of pink rockrose

77 Coriander seed, in particular, was a major Mycenaean import; Pylos table Un 267 documents 720 liters of coriander seed being given to Theustas, the unguent boiler (Beck and Beck 1978:215).
was known as labdanum and was highly prized in antiquity because of its aromatic properties resembled that of ambergris (Bolster 2002:183-5; Zohary 1982:194). According to Miller and Miller (1990:38), labdanum's esteem continues to be appreciated in the modern-day perfume industry in that it serves as one of three alternatives to the animal-derived ambergris. Bolster (2002:184-5) also notes that the labdanes present in pink rockrose may be converted into ambergris fragrance compounds, which might explain the presence of ambreine.

However, it should be noted that the labdane diterpene was also identified in a botanical reference sample of sage that was collected from Cyprus and may represent Kythrean sage (Salvia crassifolia) (Meikle 1977:2), as well as pink rockrose (probably Cistus villosus creticus or crispus) and everlasting (Helichrysum stoechis or italicum) (Polunin and Huxley 1966). According to Tsintides et al. (2002:403-4), two species of everlasting (H. italicum and H. conglobatum) are indigenous to Cyprus with the former likely representing the collected botanical sample. It may be mentioned that the plant was known in classical antiquity, being mentioned by Theophrastus as "helichyrsos" or flower of gold which was "one of the plants traditionally used to make wreaths" (Tsintides et al. 2002:404). Pliny mentions that the flower was used to decorated statues of deities in Ptolemaic Egypt. In addition, it was known to be used in a few medicinal preparations, including in a poultice for burns which mixes the flowers with honey and ash and as a repellent for snakes in which the flowers are added to wine (Tsintides et al. 2002:403).

Taken together, the evidence seems to suggest the presence of a coriander-based perfume (although lavender and rose are equally likely) along with the resin of the pink rockrose, a substance known as labdanum, which would have been used to fix or preserve the aromas.
V.E.5.b  2 S.011.42.8 (Neck/shoulder of Red Polished jug)

Scrapings, which were extracted with the alkaloid protocol, yielded no results. The procedure was repeated with a portion of the pulverized sherd, which again yielded no results other than a series of non-descript alkanes that could not be associated with a particular source. The rest of the sherd sample was extracted using the lipid and the sonication methods. The lipid method also returned no results. The sonication sample, however, should the presence of one significant compound, 3-Azabicyclo[3.2.1]octan-8.alpha.-ol, 3-methyl-, anti-, which is a methamphetamine.

The compound may be related to atropine or hyoscyamine (Benzeneacetic acid, α-(hydroxymethyl)- 8-methyl-8-azabicyclo[3.2.1]oct-3-yl ester endo-(-/+-/-)) or (http://webbook.nist.gov/cgi/cbook.cgi?ID=C101315&Mask=200), which are constituents in the deadly nightshade (Atropa belladonna), henbane (Hyoscyamus niger), and mandrake root (Mandragora officinalis) and which were used as cosmetics, in medicine, and as additions to alcoholic beverages (Heath 2003, “Introduction”; Ott 1993:363-70; Wink 1998:20-1).
However, this identification must be taken with caution because the compound was only identified in the sonication extraction that was analyzed with the alkaloid method, and which appeared in the Apex Minus Start of Peak report. The mass spectrum for the compound could not be found manually. This fact taken with the lack of any other evidence for a psychoactive or any other substance indicates that the identification should be rejected.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
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<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
</table>

**V.E.5.c 3 V.010.64.32 (Flared spout of Red Polished vessel)**

Scrapings underwent alkaloid extraction and analysis by both alkaloid and lipid methods. The former returned results. At RT 6.760\(^\text{78}\) Noscapine ((3S)-6,7-Dimethoxy-3-[(5R)-5,6,7,8-tetrahydro-4-methoxy-6-methyl-1,3-dioxolo(4,5g)isoquinolin-5-yl]-1(3H)-isobenzofuranone) at 83%. The compound is a major alkaloid found in opium (Husain and Sharma 1983:29-32, 131; Kapoor 1995:162, 166-7; Petri and Mihalik 1998:50).

In addition, the labdane diterpene (Labda-8(20),14-diene-13,18(or19)-dial, (13R)) identified in sample 1 was present at quality of 68, which suggests the presence of pink rockrose or sage. The ambergis/rockrose odorant was identified at a quality of 47, but this identification is not retained because the plant sterol, cycloartenol, was identified at the same peak at a greater quality of 91.

The sherd underwent alkaloid extraction and analysis by both alkaloid and lipid methods. While the earlier compounds were not identified, at RT 4.118 the structure of an alkaloid was identified at a quality of 50. The compound may be a degradation of noscapine but this has yet to

\(^{78}\) The retention time is within the range observed by Chovanec et al. 2012.
be demonstrated experimentally. Regardless of whether the compound is in fact a decomposition product of noscapine, indoloquinolines are biologically active structures that have been utilized in medicinal chemistry in the synthesis of antimicrobial and antibiological agents (Suresh et al. 2008:538). However, the compound may also be a contaminant or an artifact from the analysis.

Based on the presence of noscapine, the spouted vessel likely contained a psychoactive substance, such as opium, that derived either from the opium poppy, *Papaver somniferum*, or a related species. Since no other opium alkaloids were detected, a wild poppy species may be possible. The fact that the noscapine was found in conjunction with the labdane diterpene might suggest the presence of psychoactive substance containing opium and sage.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.118</td>
<td>Indolo[3,2-b]quinoline, 10-methyl-2-nitro-</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>11.0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>6.760</td>
<td>Noscapine</td>
<td>Alkaloid-Alkaloid-Scraping</td>
<td>12.0</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>9.315</td>
<td>4-(2,2-Dimethyl-6-methylene cyclohexyl)butanal/9,19-Cyclolanost-24-en-3-ol, acetate, (3.beta.)-</td>
<td>Ambergris odorant?/Cycloartenol (plant sterol)</td>
<td>Alkaloid-Alkaloid-Scraping</td>
<td>12.0</td>
<td>47/91</td>
</tr>
<tr>
<td>10.365</td>
<td>1-Naphthalene propanol, alpha-ethyldecahydro-5-(hydroxymethyl), alpha, 5,8a-trimethyl-2-methylene- [1S-1.alpha(R*),4beta,5,beta, 8a-alpha]]</td>
<td>Labda-8(20),14-diene-13,18(or 19)-diol, (13R)</td>
<td>Alkaloid-Alkaloid-Scraping</td>
<td>12.0</td>
<td>68</td>
</tr>
</tbody>
</table>

Abundance

![Abundance Chart](chart.png)

**Politiko-Trouilia**

3 V.010.64.32

Alkaloid-Alkaloid Scaping

10.365 Labdane diterpene

6.760 Noscapine
V.E.5.d  4 Q.004.39.6 (Red Polished spout)

Scrapings underwent lipid extraction and were analyzed by both methods. No compounds were identified. The sample was not submitted for destructive analysis because it was unclear to what type of vessel may have belonged.

V.E.5.e  5 T.008.49.2 (Neck of Red Polished juglet)

Scrapings underwent heptane immersion and analysis using the alkaloid method. A single compound was identified in the sample. It is either, ledol (1H-Cycloprop[e]azulen-4-ol, decahydro-1,1,4,7-tetramethyl-\(1\alpha(1α,4α,4αβ,7α,7αβ,7βα)\)-), or a tropane alkaloid, 2,4-Dimethyl-3-nitrobicyclo[3.2.1]octan-8-one. While the latter was identified in the automated report at a higher quality (12) than ledol (10). Using manual integration, a match for ledol was found at a quality of 38, thus ledol is the more likely identification.
Possible sources of the compound include a species of Chaste Tree (genus *Vitex*), which acts as an antimicrobial and anti-inflammatory, or in a species of sage indigenous to the island\(^79\) (Kumar et al. 2010:193, 195). In relation to the former, it may be noted that a related species in the *Verbenaceae* family, the Lilac Chaste Tree (*Vitex agnus-castus*), is indigenous to the island (Tsintides et al. 2002:350). The compound is also a known constituent in a Moroccan variety of white rock rockrose (*Cistus ladaniferus*), but ledol was not found in the botanical sample of white rock rose obtained from Cyprus (Oller-López et al. 2005:554).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.611</td>
<td>Ledol</td>
<td>Heptane-Alkaloid-Scrapings</td>
<td>12.0</td>
<td>38/10(^80)</td>
<td></td>
</tr>
<tr>
<td>6.601</td>
<td>2,4-Dimethyl-3-nitrobicyclo[3.2.1]octan-8-one</td>
<td>Tropane alkaloid?</td>
<td>Heptane-Alkaloid-Scrapings</td>
<td>12.0</td>
<td>12</td>
</tr>
</tbody>
</table>

\(^79\) Ledol was identified in the botanical reference sample of sage obtained from Cyprus.

\(^80\) While Ledol was identified in the automated report at a quality of 10, a manual comparison showed a quality of 38; the mass spectra comparison for ledol below is based on the greater quality.
Due to the condition of the fragment, the sample was not submitted for destructive analysis. While no other compounds were identified in the sample, it seems likely that the vessel contained a medicinal substance made for the Cypriot Lilac Chaste Tree, sage or white rockrose.
V.E.5.f  6 X.013.74.368 (Spout/neck of Red Polished vessel)

Scrapings were immersed in heptane and analyzed with the alkaloid method with no results. Alkaloid extraction and analysis of the sherd showed plastic contamination.

The sherd was also analyzed in SIM mode, targeting ions associated with hydrocotamine, meconic acid, noscapine, papaverine, as well as harmaline and harmine, alkaloids found in Syrian Rue. There was no evidence of a preserved residue.

V.E.5.g  7 W.006.78.29 (Red Polished Spout)

Scrapings were extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. The sample was also analyzed in SIM mode, targeting atropine, codeine, hydrocotamine and thujone. Neither the scrapings nor the sherd showed the presence of preserved residue. There were a series of matches for thujone in the SIM scan with relatively high quality matches (64-70), but the abundances of the ions were not in the correct proportions, which suggests the presence of a different compound.
Scrapings were extracted and analyzed using the lipid protocol. The sherd was extracted and analyzed using the alkaloid, lipid and sonication protocols. The former was further analyzed in SIM mode, targeting codeine, hydrocotamine, noscapine and thebaine. The lipid extraction of the scrapings showed some plastic contamination, as well as straight-chain alkanes, the origin of which could not be determined.

The lipid analysis of the sherd showed a similar distribution of alkanes, but with fewer indications of plastic contamination. The sonication sample showed a number of alkanes and contaminants (plastics, pesticides, sunscreen). In addition, the sonication sample showed a number of the alkanes and contamination products identified in other analyses.

The alkaloid sample showed a similar range of alkanes and contaminants. In addition, several compounds of interest were detected. The first of these, isobutyric acid (Propanoic acid, 2-methyl-, butyl ester) was identified at 2.904 minutes at a quality of 47 and may indicate the presence of a fermented beverage. The compound plays a role in fermentation and is present in modern red and white wines and vinegars (Ferriera et al. 2002:4048-50; Guth 1997:3027; Lambert 1997:37; Rocha et al. 2004:257-8). Alternatively, the compound has also been identified in samples of propolis, a plant-based resinous substance collected by bees and used to seal their hives (Marcucci 1994:83-7). Butanoic acid, identified in the sonication sample at 2.906 at a slightly lower quality, is likely related to the same compound. A fatty acid, capric acid (C10:0, Decanoic acid) was also identified in the sonication sample. Due to the compound’s wide distribution, a particular plant source cannot be easily attributed; however, it may be noted that it is a constituent in caper (Romeo et al. 2007:1272).
The second compound identified in the alkaloid sample was Cyclohexanecarboxylic acid, octyl ester, which could be a decomposition of chlorogenic acid (\((1S,3R,4R,5R)-3-\{(2Z)-3-(3,4-dihydroxyphenyl)prop-2-enoyl\text{oxy}\}-1,4,5-trihydroxycyclohexanecarboxylic acid\))\(^{81}\). This compound is a major constituent in the essential oil of caper (\textit{Capparis spinosa}), the shoots and fruits of which are pickled in vinegar and eaten (Kulisic-Bilusic et al. 2012:261). The food was well-known in antiquity, being referenced by Galen, and is still eaten in Cyprus today (Tsintides et al. 2002:162; Zohary 1982:98). It may also be noted that methyl salicylate (Benzoic acid, 2-hydroxy-5-methyl-, methyl ester), was identified at 7.085 minutes at a quality of 32 in the sonication sample and Benzene, 1-isothiocyanato-2-methyl in the alkaloid sample at 12.048 minutes at quality of 74. The presence of both compounds further corroborates the caper determination based on the fact that the former comprises 17% of the essential oil of the plant and the latter comprises 92.06% of the essential oil from the plant’s leaves and flower buds (Kulisic-Bilusic et al. 2012:261). Methyl salicylate was also identified in pickled caper flower buds (Romeo et al. 2007:1272).

This evidence in conjunction with the presence of compounds found in red wine vinegars suggests the substance contained in the spouted vessel included caper leaves and flowers that had been pickled in vinegar.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.904</td>
<td>Propanoic acid, 2-methyl-, butyl ester</td>
<td>Isobutyric acid, butyl ester</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>47</td>
</tr>
<tr>
<td>2.906</td>
<td>Butanoic acid, hexyl ester</td>
<td></td>
<td>Sonication-Alkaloid-Sherd</td>
<td>12.0</td>
<td>45</td>
</tr>
<tr>
<td>6.392</td>
<td>Decanoic acid, methyl ester</td>
<td>C10:0, Capric acid</td>
<td>Sonication-Alkaloid-Sherd</td>
<td>12.0</td>
<td>64</td>
</tr>
<tr>
<td>7.085</td>
<td>Benzoic acid, 2-hydroxy-5-methyl-, methyl ester</td>
<td>Methyl salicylate, methyl ester/ contaminant?</td>
<td>Sonication-Alkaloid-Sherd</td>
<td>12.0</td>
<td>32</td>
</tr>
<tr>
<td>9.215</td>
<td>Cyclohexanecarboxylic acid, octyl ester</td>
<td>Fragment of chlorogenic acid?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>38</td>
</tr>
<tr>
<td>12.048</td>
<td>Benzene, 1-isothiocyanato-2-methyl</td>
<td></td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>74</td>
</tr>
</tbody>
</table>

\(^{81}\) This assertion needs to confirmed with chemical data.
V.E.5.i  9 S.011.76.110 (High spout of Large Red Polished bowl)

Scrapings were extracted and analyzed with the lipid method. Results included a variety of fatty alcohols and alkanes, which are frequently found in plant leaves and fruits. No specific plant sources can be identified. Due to poor overall results from large, coarse fabrics, a sherd was not collected for destructive analysis.

V.E.5.j  10 Q.009.49.30 (Red Polished bottle)

Both scrapings and the sherd were analyzed using the lipid protocol. No significant compounds were identified.

V.E.5.k  11 T.007.44.49 (Body of Red Polished closed vessel)

Scrapings were extracted and analyzed with the lipid method. Like sample 9, a few nondescript alkanes were identified at relatively high qualities, but to which specific sources could not be attributed. The sherd was extracted using the lipid and sonication protocols and analyzed using the alkaloid and lipid methods. The lipid extraction yielded no results. A single compound was identified in the sonication sample.
The compound, 1,6;3,4-Dianhydro-2-deoxy-.beta.-d-lyxo-hexopyranose, according to Fronza et al. (1987) is a carbohydrate compound associated with the fermentation action of baker’s yeast. This might suggest the presence of beer, but other biomarkers, such as beerstone, were absent (McGovern 2009:67; Michel et al. 1993:411).

In general, compounds should have a single peak because a compound elutes at a specific retention time as a result of its mass. It is true that the spectral database does not have all chemical compounds against which to compare spectra and, therefore, the second peak may be a fragment or variant of the compound that is not recognized. However, since this is the only chemical compound identified in the sample, it is somewhat unlikely that preserved residue is present.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.985, 6.912</td>
<td>1,6;3,4-Dianhydro-2-deoxy-.beta.-d-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Sonication-Alkaloid-Sherd</td>
<td>12.0</td>
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Abundance

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Sonication-Alkaloid-Sherd

Politiko-Troullia
11 T.007.44.49
Sonication-Alkaloid-Sherd
Scrapings were extracted using the sonication protocol and analyzed using the lipid and alkaloid methods. The sherd was analyzed using the sonication and lipid protocols. A number of straight-chain alkanes and contaminants were identified with no clear evidence of a preserved residue.

Scrapings and sherd were extracted and analyzed with the lipid method. The scrapings showed the remains of a complex mixture with multiple peaks. There were multiple instances of isopulegol (Cyclohexanol, 5-methyl-2-(1-methylethenyl), [1R-(1.alpha.,2.beta.,5.alpha.)]), which is the primary constituent in Mentha species, especially pennyroyal (Bowles 2003:70).

Zohary (1982:88) states that mint species were made into medicinal infusions used as stimulants, carminatives to prevent gas, and as pain killers. It was noted in the discussion of the Brown Polished bottle (sample 7) from Sotira Kaminoudhia, that pennyroyal (Mentha pulegium) likely represents the final ingredient in the list of ingredients (barley, water, blechon) used to make the sacred kykeon that was used in the Eleusinian Mysteries (Ott 1993:142; Ruck 2006:19). Another possibility is a species of Ziziphora\(^{82}\), which occurs in Turkey and the Levant and is a major source of pulegone in the Eastern Mediterranean (Mehmood et al. 2010:1397; Sezik et al. 1991:101-2; Verdian-Rivi 2008:185, 187). It may be noted, however, that two constituents in pennyroyal oil, pulegone and menthofuran, are toxic to the liver in large quantities (EMEA 2005; Sullivan et al. 1979:2873-4).

\(^{82}\) Ziziphora tenuior L., a species from mainland Turkey, is a major source of pulegone. While the species that was submitted for analysis derived from Turkey, there may be a species endemic to Cyprus.
As noted in the discussion of the Brown Polished bottle (sample 7) from Sotira Kaminoudhia, two varieties of pennylroyal are described by Pliny (Plin. Nat. 20.54). The first was used in “restoring consciousness in fainting fits”, as a pain reliever, against nausea, and gastrointestinal problems, while the other was given “to persons afflicted with spasms” in a drink of honey and salt (Plin. Nat. 20.55). Sullivan et al. (1979:2873-4) also mention the use of pennylroyal in treating female ailments and as an abortifacient. It should also be noted that pulegol is a minor constituent in a species of wormwood (*Artemisia spicigera*) (Kordali et al. 2005:1411-2), as well as in carob bean and pink rockrose, both of which are botanical reference samples obtained from Cyprus. A related compound, pulegone, is also found in a variety of apple mint (*Mentha suaveolens*) (Oumzil et al. 2002:727).

Three compounds were identified (Citronellyl-3-isobutanoate, Citronellyl isobutyrate, and Citronellol acetate), which may represent degradation variations of citronellol (6-Octen-1-ol, 3,7-dimethyl-, acetate), which was also present in the sample. Citronellol is a constituent in lemon balm and rose, while citronellyl isovalerate specifically is a constituent in valerian on the other hand, is a known constituent of valerian (*Valerian officinalis*), a medicinal plant with known sedative effects (Bowles 2003: 196, 198; Lopez 2011:5). Limonene diepoxide may represented in one of the peaks, rather than one of the citronellol derivatives. If this identification is correct, a series of plants may be indicated. A related compound, limonene oxide, is a constituent in pistachio (*Pistachia atlantica*) resin (Delazar et al.2004:24) but was also identified in botanical reference samples of wormwood, pink oleander, and everlasting, the latter two being obtained from Cyprus. Both are related to limonene, which occurs in a large number of essential oils. Some of the Mediterranean plants in which limonene is a constituent include thyme, pine, caraway, a species of sage in the *Phlomis* family, anise, fennel, oregano, rosemary, myrtle, rue (*Ruta graveolens*); the resin of cypress and a species of juniper, as well as peppermint (Amor et al. 2009:183, 188-90; Azeez 2008a:229-232, 237-238; Bowles 2003:35, 55-8, 88-9, 199; Farah et al. 2006:351-3; Iacobellis et al. 2005:53, 59-60; Leela and Vipin 2008:333; Mastelić et al. 2008:795, 797; Piccaglia and Marotti 2001:239, 241-3); members of the genus Stachys (Skaltsa et al. 2001:235-7; Zhou, et al. 2011:132). It is also a minor constituent in nutmeg and the rockrose

The presence of trans-farnesol\(^{83}\) may indicated the presence of lemon balm, rose, in propalis, honey, or lavender. The lavender identification is further suggested by the presence of lavandulol, a major aromatic constituent in lavender flowers (Bowles 2003:195). The presence of geranyl linalool further suggests the inclusion of aromatic oils from flowers in the vessel. The compound is likely an intermediary compound in the transformation of one of two structurally similar compounds: geraniol and linalool. As noted in the discussion of the small Red Polished spout (sample 1) from Politiko *Troullia*, the presence of geranyl linalool may indicate the presence of honey (Bertsch et al. 2004:701). The compound may also be related to geraniol, geranyl acetate, or linalool. Based on the list of plants in which these constituents occur, the most likely source of the compound is coriander, rose, sage, myrtle, or lavender. Moreover the presence of farnesol, lavandulol, and geranyl linalool seems to indicate that lavender flowers represent one of the ingredients in the vessel.

Three additional compounds were identified in the sample: beta-springene, trans-pinane, and a compound that may be related to fenchone \((1,3,3\text{-Trimethylbicyclo[2.2.1]heptan}-2\text{-one})\). Both isomers of springene (alpha, beta) are constituents in the labial gland secretions of the male bumblebee *Bombus griseocollis*, which may indicate the presence of honey, as is the geranyl linalool mentioned above (Bertsch et al (2004:701).

Trans-pinane and its isomer, pinene, were also present in the sample, which suggest that presence a series of plants, in which the alpha- and beta-isomers of pinene are constituents. The most likely sources include a tree resin\(^{84}\) from a species of pine, cypress, or juniper, in which pinene is the primary constituent. An aromatic herb may be indicated such as sage, rosemary, coriander, savory, fennel, or myrtle. Pinene is also a constituent in white wormwood, nutmeg,

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\(^{83}\) It should be noted that farnesol is structurally similar to squalene, which has a wide distribution but which is particularly present in fish oils and frequently represents human-introduced contaminants. The fact that both farnesol and squalene are present should be noted. However, the fact that a number of other chemical components are also present that derive from the same sources as farnesol, makes the uncertainty less of an issue.

\(^{84}\) Potential local species may include Aleppo pine or Atlas cedar (Yassaa et al. 2000).

The final compound, fenchone, is a constituent in absinthe wormwood, but is not present in white wormwood. It is also a major constituent in fennel, myrtle and a derivative compound is present in everlasting, as fenchol (Emmert et al. 2004:352, 354; Kordali et al. 2005:1411; Mastelić et al. 2008:797; Piccaglia and Marotti 2001:241-2). In addition, fenchyl alcohol, a related compound is present as a minor constituent in pickled caper flower buds, in which alpha-farnesene, menthol, limonene and beta-pinene are also minor components (Romeo et al. 2007:1277).

Based on these data, the substance contained in this small spouted vessel was a complex mixture of various aromatic, medicinal plants, including pennyroyal or another species of mint containing pulegone, lavender flowers, as well as one or more other flowers and herbs, such as rose and lemon balm, in an tree oil matrix that likely derived from a species of pine, juniper, or cypress. Honey or honeycomb may also have been an ingredient, though other biomarkers of honey are absent. Additional ingredients may have included everlasting, fennel, or myrtle. These results should be taken with caution due to the poor resolution of the peaks from which these identifications derive, particularly in the case of the sherd.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
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<tr>
<td>16.146</td>
<td>Bicyclo[3.1.1]heptane, 2,6,6-trime trimethyl-, (1.alpha.,2.beta.,5.alpha.)</td>
<td>(-)trans-Pinane</td>
<td>Lipid-Lipid-Sherd</td>
<td>11.75</td>
<td>28</td>
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<tr>
<td>17.393, 26.433</td>
<td>Bicyclo[2.2.1]heptan-2-ol, 3,3-dimethyl- Exo</td>
<td>Related to fenchone?</td>
<td>Lipid-Lipid-Sherd</td>
<td>11.75</td>
<td>50/47</td>
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<tr>
<td>17.403</td>
<td>Bicyclo[3.1.1]heptane, 2,6,6-trimethyl-, (1.alpha.,2.beta.,5.alpha.)</td>
<td>(-)trans-Pinane</td>
<td>Lipid-Lipid-Scraping</td>
<td>12.0</td>
<td>32</td>
</tr>
</tbody>
</table>

85 It must be stated that it is unusual for chemical compounds to elute at multiple peaks. The multiple instances may represent isomers of these compounds or other minor variations that may or may not be present in the spectral database. Due to the shear number, only the first instance of each compound is plotted on the chromatogram.
| 18.235 | 1-Methylene-2b-hydroxymethyl-3,3-dimethyl-4b-(3-methylbut-2-enyl)-cyclohexane/ Cyclohexanol, 5-methyl-2-(1-methyl ethenyl)-, \{1R-(1.alpha.,2.beta.,5.alpha.)\}- | / Isopulegol | Lipid-Lipid-Scraping | 12.0 | 37/37 |
| 19.126 | Bicyclo[3.1.1]heptan-3-one, 2,6,6-trimethyl-, \{1.alpha.,2.beta.,5.alpha.\}- | (-)trans-Pinan | Lipid-Lipid-Scraping | 12.0 | 37 |
| 22.215, 24.254, 24.769, 31.937, 32.125, 34.907 | Cyclohexanol, 5-methyl-2-(1-methylethenyl)-, \{1R-(1.alpha.,2.beta.,5.alpha.)\}- | Isopulegol | Lipid-Lipid-Scraping | 12.0 | 43/38/40/40 |
| 22.255, 24.443, 31.828 | Squalene | Lipid-Lipid-Scraping | 12.0 | 47/38/17 |
| 23.472, 23.740 | Butanoic acid, 3-methyl-, 3,7-dimethyl-6-octenyl ester | Citronellyl 3-methylbutanoate | Lipid-Lipid-Scraping | 12.0 | 32/43 |
| 23.740 | Butanoic acid, 3-methyl-, 3,7-dimethyl-6-octenyl ester/ 7-Oxabicyclo[4.1.0]heptane, 1-methyl-4-(2-methylcyclohexyl)- | Citronellyl 3-methylbutanoate/ alpha-Limonene diepoxide | Lipid-Lipid-Sherd | 11.75 | 43/38 |
| 22.314, 24.047, 30.937, 32.224 | 6-Octen-1-ol, 3,7-dimethyl-, acetate | Citronellol acetate | Lipid-Lipid-Scraping | 12.0 | 50/40/38/38 |
| 24.254 | Bicyclo[3.1.1]heptane-2-methanol, 6,6-dimethyl-, \{1S-(1.alpha.,2.alpha.,5.alpha.)\}- | Related to Pinene? | Lipid-Lipid-Scraping | 12.0 | 43 |
| 24.769, 27.769 | \((E,E)-7,11,15\)-Trimethyl-3-methylene-hexadeca-1,6,10,14-tetraene | Beta-Springene | Lipid-Lipid-Scraping | 12.0 | 25/23 |
| 25.334, 29.304 | Cyclohexanol, 5-methyl-2-(1-methyl ethenyl)-, \{1R-(1.alpha.,2.beta.,5.alpha.)\}- | Isopulegol | Lipid-Lipid-Sherd | 11.75 | 43/43 |
| 28.809, 36.135 | 2,6,10-Dodecatetraen-1-ol, 3,7,11-trimethyl-, \{2.E\}- | Trans-Farnesol | Lipid-Lipid-Scraping | 12.0 | 47/38 |
| 29.947 | Butanoic acid, 3-methyl-, 3,7-dimethyl-6-octenyl ester/ 6-Octen-1-ol, 3,7-dimethyl-, (R)- | Citronellyl 3-methylbutanoate/ Citronellol acetate | Lipid-Lipid-Scraping | 12.0 | 32/32 |
| 30.076 | Citronellyl isobutyrate | Lipid-Lipid-Scraping | 12.0 | 38 |
| 31.452 | 4-Hexen-1-ol, 5-methyl-2-(1-methyl ethenyl)-, acetate, (R)- | Lavandulol | Lipid-Lipid-Scraping | 12.0 | 40 |
| 32.957 | 1,6,10,14-Hexadecatetraen-3-ol, 3,7,11,15-tetramethyl-, \{E,E\}- | Geranyl linalool | Lipid-Lipid-Scraping | 12.0 | 45 |
In terms of the comparison between the scraping and sherd results, it is apparent that much of the preserved residue is removed in the scraping of the vessel, which on an entirely superficial level suggests a limitation in the depth to which liquid substances may permeate into the vessel wall. Such an assertion would need to be confirmed experimentally.
Scrapings were extracted using the sonication protocol, and analyzed using the alkaloid and lipid methods. The sherd was extracted using the alkaloid protocol and was analyzed using the alkaloid and lipid methods.

It was also analyzed in SIM mode, targeting codeine, hydrocotarnine, meconic acid, morphine, noscapine, papaverine and thebaine. The sample showed extensive contamination from plastics and other materials. Neither sample analyzed with the lipid method showed any evidence of a preserved residue.

Three compounds were detected in the scraping that warrant discussion. The first of these is thymol methyl oxide (Benzen, 2-methoxy-4-methyl-1-(1-methylethyl)-), which is a derivative of thymol. This latter compound is the primary constituent in thyme and was identified in a botanical reference sample of Cypriot thyme. It is also found in marjoram, oregano, dittany, basil (Daferera et al. 2000:2577; De Martino et al. 2009:2735-9; Lee et al. 2005:131-2, 135-6; Liolis et al. 2009:77-82). It is also found in a species of everlasting (Helichrysum italicum), but it was not identified in a botanical reference sample from Cyprus (Mastelić et al. 2008:796). In addition, it is a major constituent in two species of yarrow (Achillea biebersteini and teretifolia) and species of tansy (Tanacetum santolinoides) (Teixiera de Silva 2004:708-10). This last group of plants is intriguing because bicyclo[3.1.0]hexan-2-one, 1,5-di-tert-butyl-3,3-dimethyl-, a compound likely related to sabina ketone (Bicyclo[3.1.0]hexan-2-one, 5-isopropyl-) was identified in the sherd and is a minor constituent in basil and thyme. It is also structurally similar to sabinene hydrate, 4-thujuanl and sabinene, which are widely distributed in species of Tanacetum, Achillea, and Artemisia (Lee et al. 2005:134; Kordali et al. 2005:1411; Teixeira de Silva 2004:707-12).

Sabinene, cis-sabinene hydrate, and sabinyl acetate occur in many of these plants, as well as birthwort (Aristolochia), nutmeg, marjoram, mint, sage, a species of juniper (Juniperus
sabina), and coriander (Bowles 2003:57-8; Francisco et al. 2008:170; Leela 2008:165-189; Parry 1922:56; Parthasarathy and Zachariah 2008:190-210). In terms of use, Teixeria da Silva (2004:707-12) highlights that sabinene is used primarily in perfumery, while beta-sabinyl acetate is used as a convulsant. Further, Parry (1922:57) states that “[s]abinene appears to be fairly closely related to thujene (tanacetene) since both alpha-thujene and beta-thujene yield the same body, thujane,… as does sabinene.”

The second compound identified in the scrapings was tiglic acid, allyl ester (2-Butenoic acid, 2-methyl-, 2-proenyl ester, (E)-) was identified at 7.515 minutes at a quality of 38. According to Isidorov et al. (2003:355-8), the compound is a minor constituent in poplar buds. It should be noted however that the likely species is the black poplar (Populus nigra), since the white poplar (Populus alba) though known and utilized in Cyprus is not an indigenous species (Meikle 2000:1489-91; http://cypruswildflowers.com/cgi-bin/site/main.pl?action=medicinal). Another possibility is that the compound is a fragment of tigloidine (2-Methyl-2-butenoic acid [1a,3a(E),5a]- 8-methyl-8-azabicyclo[3.2.1]oct-3-yl ester), “a naturally occurring analogue of atropine” (Sanghvi et al. 1968:246). However, there is little else to suggest the presence of atropine.

The third compound, cyclohexanone, 2-(1-methyl-2-nitroethyl)- may be related to isomenthone (Cyclohexanone, 5-methyl-2-(1-methylethyl)-, cis-), a major constituent of plants in the Mentha family. one of two compounds found in the Mentha family (Bowles 2003:25-6, 69-71, 85, 88-9). In addition, menthone (or its isomer in alcohol form, menthol) was identified in a reference sample of lemon balm. While the compound identified in the scrapings was a big more fragmentary, a more certain identification for menthone was determined for a compound (Cyclohexanol, 4-ethyl-4-methyl-3-(1-methylethyl)-, (1.alpha.,3.beta.,4.alpha.)-, in the sherd. Four other compounds were identified in the sherd. The first (C4:0, butyric acid) and last (1,6;2,3-Dianhydro-4-deoxy-.beta.-d-ribo-hexopyranose) should be considered together. Present together, they may suggest an alcoholic beverage since butyric acid is one of several acids involved in fermentation. However, this short carbon chain lipid is also widely distributed elsewhere. According to Fronza et al. (1987), the latter compound is a carbohydrate compound
associated with the fermentation action of baker’s yeast. This might suggest the presence of beer, but other biomarkers, such as beerstone, were absent (Guth 1997:3027; McGovern 2009:67; Michel et al. 1993:411). The suggestion that beer was in the vessel should only be taken as that, since the clear biomarkers of the substance were not present.

The third compound, 2,3-Dihydrofuro(2,3-b)quinoline, was identified at 9.649 minutes with a quality of 38. While the identity of this compound is somewhat unclear, it is at the very least a fragment of a quinoline alkaloid. According to Michael (2005:223), a series of furo[2,3-b]quinoline alkaloids are present in fringed rue (Ruta chalepensis), a plant that is indigenous to Cyprus with medicinal properties that were known in Classical times. Specifically, the plant was used as an antidote in aconite poisoning (Tsintides et al. 2002:248). These alkaloids have also been identified in Rutaceae plants in the Haplophyllum genus from Turkey. Possible alkaloids from which the fragment may have derived include dictamnine (4-Methoxyfuro[2,3-b]quinoline), fagarine (4,8-Dimethoxyfuro[2,3-b]quinoline), or pteleine (4,6-Dimethoxyfuro[2,3-b]quinoline), heliparvifoline (4,6-dimethoxy-9H-furo[2,3-b]quinolin-7-one). If this identification is accurate, it may be noted that Haplophyllum species have a range of other alkaloids, one of which includes scopoletin, a constituent found in psychoactive plants known to have tropane alkaloids (Ulubelen and Öztürk 2008:54-5, 58, 65).

The final compound identified in the sherd, Cyclohexanemethanol, 4-methyl-, cis, may be a fragment of elemol (Cyclohexanemethanol, 4-ethenyl-α,α,4-trimethyl-3-(1-methylethenyl)-, [1r-(1α,3α,4β)]-, and has been identified in a reference samples of hyssop. Cyclohexane methanol, 4-methylene- was identified in a reference sample of henbane seeds, but no tropane alkaloids were identified. Cyclohexanemethanol, perhaps a greater degradation of elemol, was identified in wormwood extract. Elemol, a sesquiterpene alcohol (Parry 1922:157), is also a constituent in rose (Rusanov et al. 2011:2215), a species of torchwood (Amyris balsamifera) (Rohmer et al. 1977), a minor constituent in thyme (Lee et al. 2005:134; Sáez 1995:822), Santolina oblongifolia (Teixeira da Silva 2004:706-7), wormseed (Artemisia santonicum) (Kordali et al. 2005:1412), Aleppo and other pine needles (Roussis et al. 1994:359), as well bay leaf.
(Parthasarathy et al. 2008:428). However, the compound was not identified in the reference sample of Cypriot bay leaf.

As noted in the discussion of the Red Polished Black-Topped bottle (Sample 8) from Sotira Kaminoudhia, elemol transforms into one of three isomers of elemene (Parry (1922:157). Beta-elemene is a constituent in rose, yarrow, a species of wormwood, a species of Sideritis, henbane seeds, pink rockrose from Cyprus, as well as a species of woundwort that also has beta-ionone (Grandi et al. 1972; Gumuscu et al. 2011; Kordali et al. 2005:141; Rusanov et al. 2011:2215; Senatore et al. 2007:135, 137). The delta isomer is present in myrrh, black currants, and two species of fir (Bowles 2003:25-6; Le Quere and Latrasse 1990:3; Smedman et al. 1969:1471, 1474-5). The gamma isomer is a constituent in oregano, basil, juniper berries, as well as a minor constituent in coriander (Alves-Pereira and Fernandes-Ferreira 1998:796; Bowles 2003:256; De Martino et al. 2009:2738; Dev et al. 2011:203; Zhou et al. 2011).

Overall, the vessel contained a complex mixture that likely contained thyme, mint and perhaps a species of tansy or yarrow as its main ingredients. The substance itself may have been a beer that was seasoned with the above aromatic plants, along with rue and poplar buds, but these suggestions need further corroboration.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
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<tr>
<td>2.906</td>
<td>Butanoic acid, decyl ester</td>
<td>C4:0, Butyric acid</td>
<td>Alkaloid-—Alkaloid-Sherd</td>
<td>12.0</td>
<td>59</td>
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<tr>
<td>3.446</td>
<td>Bicyclo[3.1.0]hexan-2-one, 1,5-bis (1,1-dimethylethyl)-3,3-dimethyl-</td>
<td>Related to sabina ketone?</td>
<td>Alkaloid-—Alkaloid-Sherd</td>
<td>12.0</td>
<td>28</td>
</tr>
<tr>
<td>5.296</td>
<td>Benzene, 2-methoxy-4-methyl-1-(1-methylethyl)-</td>
<td>Thymol methyl oxide</td>
<td>Sonication-—Alkaloid-Scrapping</td>
<td>12.0</td>
<td>40</td>
</tr>
<tr>
<td>7.515</td>
<td>2-Butenoic acid, 2-methyl-, 2-propenyl ester, (E)-</td>
<td>Tiglic acid, allyl ester</td>
<td>Sonication-—Alkaloid-Scrapping</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>7.551</td>
<td>Cyclohexanone, 2-(1-methyl-2-nitroethyl)-/9-Octadecenal</td>
<td>Fragment of menthone?</td>
<td>Sonication-—Alkaloid-Scrapping</td>
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<td>8.603</td>
<td>Cyclohexanemethanol, 4-methyl-, cis</td>
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<td>8.823</td>
<td>Cyclohexanol, 4-ethyl-4-methyl-3-(1-methylethyl)-, (1.alpha.,3.beta.,4.alpha.,)</td>
<td>Menthol isomer?</td>
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<td>9.649</td>
<td>2,3-Dihydrofurano(2,3-b)quinoline</td>
<td>Alkaloid derivative?</td>
<td>Alkaloid-—Alkaloid-Sherd</td>
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<tr>
<td>9.384</td>
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<td>Related to baker’s yeast?</td>
<td>Alkaloid-—Alkaloid-Sherd</td>
<td>12.0</td>
<td>27</td>
</tr>
</tbody>
</table>
Scrapings were extracted using the alkaloid protocol and analyzed using the alkaloid, lipid, and SIM methods with the latter targeting meconic acid and hydrocotarnine. A series of contaminants, alkanes and fatty alcohols were identified that cannot be attributed to a particular source. The sherd was extracted with the alkaloid and lipid protocol and analyzed with the alkaloid and lipid methods.
The sherd extraction was also analyzed in SIM mode targeting codeine and morphine. There were no matches in any of the SIM scans.

Three compounds worth mention were present in the scraping samples. The first of these is the quinoline compound, 2,3-Dihydrofuro(2,3-b)quinoline, that was identified in a series of other samples. As mentioned elsewhere, it may be a fragment of constituents found in Rutaceae species of Haplophyllum from Turkey. Possibilities include: dictamnine (4-Methoxyfuro[2,3-b]quinoline), fagarine (4,8-Dimethoxyfuro[2,3-b]quinoline), pteleine (4,6-Dimethoxyfuro[2,3-b]quinoline), or heliparfifoline (4,6-dimethoxy-9H-furo[2,3-b]quinolin-7-one). If this identification is accurate, it may be noted that Haplophyllum species have a range of other alkaloids, one of which includes scopoletin, a constituent found in psychoactive plants known to have tropane alkaloids (Ulubelen and Öztürk 2008:54-5, 58, 65). However, due to the frequency of this compound, it is possible that this, like the other quinoline compound found in the sherd, Indolo[3,2-b]quinoline, 10-methyl-2-nitro-, may represent artifacts of the analytical process. A similar case may exist for another compound identified in both the scrapings and the sherd. It is however possible, as mentioned elsewhere, that this compound is related to baker’s yeast and therefore indicates a fermented beverage (Fronza et al. 1987). The final compound identified in the scrapings is 3-Octen-2-one, 7-methyl-, which has been reported in liver meat and milk (http://www.thegoodscentstc.com/data/rw151511.html).

In the sherd, a series of fatty acids were identified, the first of which included the short carbon chained butyric acid (C4:0, butanoic acid, heptyl ester). It is possible that this compound further indicates the presence of a fermented beverage since this is one of several acids involved in fermentation (Guth 1997:3027), but like the behenic acid (C22:0, Docosanoic acid, methyl ester) and stearic acid (C18:0, octadecanoic acid, methyl ester), the fatty acid is distributed in a variety of other plant and animal oils.

The final compound was identified at 17.241 minutes in the lipid extraction of the sherd sample with a quality of 74. The compound may either be 5-Methoxy-6H-indolo[3,2,1-de][1,5]naphthyridin-6-one and may represent the fragment of the indole alkaloid, 1-Methoxy-canthin-6-one, or it may be Anthraquinone, 1,2,4-trimethyl, which likely represents a contaminant.
If the former is correct a species in the Rutaceae and Caryophyllaceae families, which are indigenous to Cyprus may be indicated (Ohmoto and Koike 1989:135-144; Tsintides et al. 2002:155-6, 248). However, comparison of the mass spectra puts this identification in question.\(^8\)

Most of the evidence for a preserved residue in this vessel seems suggestive. The presence of a psychoactive substance, whether that be a fermented beverage or other substance containing indole and quinoline alkaloids, is unclear. However, based the presence of a series of fatty acids in conjunction with a compound that has been reported in liver or milk products, a dairy or other animal-derived product may be a more likely identification.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.813</td>
<td>Butanoic acid, heptyl ester</td>
<td>C4:0, Butyric acid</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>40</td>
</tr>
<tr>
<td>6.808</td>
<td>Octadecanoic acid, ethyl ester</td>
<td>C18:0, Stearic acid</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>47</td>
</tr>
<tr>
<td>9.635</td>
<td>2,3-Dihydrofuro(2,3-b)quinoline</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>38</td>
</tr>
<tr>
<td>10.895</td>
<td>1,6;2,3-Dianhydro-4-deoxy-beta-d-ribo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>17</td>
</tr>
<tr>
<td>8.034</td>
<td>Docosanoic acid, ethyl ester/Octadecanoic acid, ethyl ester</td>
<td>C22:0, Behenic acid, C18:0, Stearic acid</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>33/33</td>
<td></td>
</tr>
<tr>
<td>11.085</td>
<td>3-Octen-2-one, 7-methyl</td>
<td>Found in liver/milk?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>36</td>
</tr>
<tr>
<td>11.959</td>
<td>1,6;2,3-Dianhydro-4-deoxy-beta-d-ribo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>47</td>
</tr>
<tr>
<td>17.241</td>
<td>5-Methoxy-6H-indol[3,2,1-de][1,5]naphthyridin-6-one/Anthraquinone, 1,2,4-trimethyl</td>
<td>1-Methoxy-canthin-6-one?</td>
<td>Lipid-Lipid-Sherd</td>
<td>12.0</td>
<td>74/74</td>
</tr>
</tbody>
</table>

\(^8\) If the 2,3-Dihydrofuro(2,3-b)quinoline is in fact associated with a preserved residue, then perhaps the presence of an indole alkaloid in the Rutaceae family could be possible. However, it must be stated that the fabric and shape of the vessel seems perhaps an unlikely container for such a substance.
V.E.5.p 19 W.012.120.69 (Flared Red Polished spout)

Scrapings were extracted by the sonication and alkaloid protocols and analyzed using the lipid and alkaloid methods with no evidence of preserved residue. The sherd was extracted using the sonication protocol and analyzed using the lipid and alkaloid methods, again yielding no results. The sonication sample also underwent analysis by SIM for atropine, codeine, ephedrine, hydrocotamine, morphine, papaverine, harmaline, and thebaine. There was a match for thebaine, but there were discrepancies in the proportions of the molecular ions, which suggests thebaine is not in fact present.

The alkaloid analysis of the sonication extraction did indicate the presence of the baker’s yeast compound that might suggest the presence of a fermented beverage (Fronza et al. 1987). No other compounds were detected in the sample; without further evidence an identification for a fermented beverage should not be retained.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.136</td>
<td>1,6;3,4-Dianhydro-2-deoxy- beta- d-lyxo-hexopyranose</td>
<td>Sonication-Alkaloid-Sherd</td>
<td>12.0</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>
Scrapings were extracted and analyzed using the lipid protocol, in which a number of compounds were identified. The sherd was extracted with the alkaloid and sonication protocols and analyzed using the alkaloid and lipids methods.

The alkaloid extraction was also analyzed in SIM mode, targeting atropine, codeine, ephedrine, hydrocotarnine, morphine, noscapine, papaverine, harmine, and thebaine. While there were matches in the codeine and morphine scans, the proportions of the mass spectra were inconsistent, suggesting those alkaloids were not in fact present.

However, at 16.429 minutes at a quality of 35, 6-Oxo-3-methoxy-N-methyl-4,5,7,8-diepoxy morphine was identified, which may represent a further degradation of a morphinan alkaloid, such as codeine (Morphinan-6-ol, 7,8-didehydro-4,5-epoxy-3-methoxy-17-methyl, (5α,6α)) or morphine (Morphinan-3,6-diol, 7,8-didehydro-4,5-epoxy-17-methyl-(5α,6α)).

A broad range of fatty acids were detected, including C16:0 Palmitic acid (n-hexadecanoic acid), C18:1n9 Oleic acid (9-Octadecenoic acid), C18:2n6 Linoleic acid (9,12-Octadecadien-1-ol, (Z,Z)-), and C24:1n9 Nervonic acid (15-Tetracosenoic acid, methyl ester, (Z)-). Although it is not possible to differentiate olive and plant seed oils based on their fatty acid profiles, several other compounds were detected that help to further narrow the possibilities. One is the fact that olive oil is perhaps the greatest source of oleic acid, which has numerous instances in this sample alongside a number of its decomposition products. Furthermore, Cyclopropaneoctanal, 2-octyl- was identified, which Servili et al. (2003:686) suggest is related to the extraction of virgin olive oil. This certainly cannot be taken as proof that the plant oil was derived from the olive, despite the fact that, in a Mediterranean context, the likelihood is rather high. Another plant oil may also have been utilized or perhaps multiple oils were used in

87 This compound was not identified in the opium degradation study.
conjunction. The presence of nervonic acid may indicate oil from rapeseed or pennycress; species of each genus are documented in Cyprus by Meikle (1977) and both of which have high concentrations of nervonic acid (Fahleson et al. 1994:795-7). An additional oil source may come from members of the Apiaceae (*Umbelliferae*), which may include angelica, anise, caraway, carrot, celery, coriander, cumin, fennel, and others. The seed oils of these plants "are characterized by a high content, over 50%, of petroselinic acid (cis-6-octadecenoic acid)" (Reichling and Galati 2005:92), which was identified at an RT of 16.082.

There are also indications of other plants species. First, a number of known insect pheromones were detected, which may be related to the inclusion of fresh plant material. An example of this may be the presence of 1-Hexyl-2-nitrocyclohexane, which is a minor constituent in extracts of *Ficus capensis* (Muanda et al. 2010:158), as well as a compound identified in a botanical reference sample of *Atropa belladonna*. According to McGovern (2009:93-4), perforated figs were occasionally suspended in fermented beverages in ancient Egyptian funerary vessels. Although sample 19 shows no evidence of wine, beer, or other fermented beverage, the suspension of whole fruits could have been used in Bronze Age Cyprus as well. Perhaps the most important compound identified in this sample is lupinine (2H-Quinolizine-1-methanol, octahydro-, (1R-trans)), a quinolizidine alkaloid found in the seeds, or beans, of *Lupine* species. Prior to consumption, the alkaloid must be leached out by soaking in water. The alkaloid has psychoactive potential in that it has nicotine-like stimulating and biological effects. It also has medicinal potential in its significant antifungal and antibacterial action (Seiple 2006).

The final compound identified in the sample is a labdane diterpene, Labda-8(20)-13-diene-15,19-dioic acid, (E)-. Pollard and Heron (2008:239) state that diterpenoids are common constituents in the resins of conifers, such as members of the Pinaceae, Cupressaceae, Araucanaceae families. The most widely used resins in Mediterranean history are resins from *Pinus* species, which "contain abietane, pimarane, and labdane skeletons" (Pollard and Heron 2008:239, Beeston et al. 2006; Colombini et al. 2009; Romanus et al. 2009; Weitemeyer and

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88 It may be noted that 8-Azabicyclo[3.2.1]octane, 8-acetyl, a tropane alkaloid derivative, was identified in the scrapings, but the mass spectrum for the compound could not be located manually.
A tree resin may be indicated, but no other compounds associated with turpentine or other tree-derived products was identified.

Taken together, the chemical data suggests that this finely made juglet contained a psychoactive or medicinal substance, the primary constituents of which were lupine beans and perhaps included poppy (though not necessarily the cultivated opium poppy) in a plant oil matrix that likely derived from olives (though a series of other plants are possible) with the possible addition of a tree resin.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.736</td>
<td>Dodecanoic acid</td>
<td>C12:0 Lauric acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>27</td>
</tr>
<tr>
<td>11.518</td>
<td>15-Tetracosenoic acid, methyl ester, (Z)-</td>
<td>C24:1n9 Nervonic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>45</td>
</tr>
<tr>
<td>12.439</td>
<td>n-Hexadecanoic acid</td>
<td>C16:0, Palmitic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>94, 93, 95</td>
</tr>
<tr>
<td>12.736</td>
<td>1-Hexyl-2-nitrocyclohexane</td>
<td></td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>49/72/49</td>
</tr>
<tr>
<td>13.765</td>
<td>9-Octadecenoic acid, (E)-</td>
<td>C18:1n9, Oleic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>99</td>
</tr>
<tr>
<td>13.815</td>
<td>Oleic Acid</td>
<td></td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>95/81/62/70/64/62</td>
</tr>
<tr>
<td>13.874</td>
<td>9,12-Octadecadienoic acid (Z,Z)-</td>
<td>C18:2n6 Linoleic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>91</td>
</tr>
<tr>
<td>15.003</td>
<td>9,12-Octadecadien-1-ol, (Z,Z)-</td>
<td>Related to Linoleic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>92</td>
</tr>
<tr>
<td>15.627</td>
<td>9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester</td>
<td>Derivative of oleic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>55/81/46</td>
</tr>
<tr>
<td>16.082</td>
<td>6-Octadecenoic acid, (Z)-</td>
<td>Petroseleinic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>76</td>
</tr>
<tr>
<td>16.429</td>
<td>6-Oxo-3-methoxy-N-methyl-4,5,7,8-diepoxy morphine</td>
<td>Morphinan alkaloid derivative?</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>35</td>
</tr>
<tr>
<td>16.666</td>
<td>2H-Quinolizine-1-methanol, octahydro-, (1R-trans)-</td>
<td>Lupinine</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>58</td>
</tr>
<tr>
<td>16.795</td>
<td>9-Octadecenoic acid (Z)-, 2-hydroxyethyl ester</td>
<td>Derivative of oleic acid or contaminant</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>55</td>
</tr>
<tr>
<td>17.508</td>
<td>9-Octadecenoic acid (Z)-, tetradecyl ester</td>
<td>Derivative of oleic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>58</td>
</tr>
<tr>
<td>17.815</td>
<td>8-Azabicyclo[3.2.1]octane, 8-acetyl- 3-Dodecene, (E)-</td>
<td>Tropane alkaloid?/</td>
<td>Lipid-Lipid-Scraping</td>
<td>15.0</td>
<td>38/38</td>
</tr>
</tbody>
</table>
V.E.5.r 21 W.012.120.111.2 (Footed base of Red Polished vessel)

Scrapings were extracted and analyzed using the lipid protocol. The sherd was extracted with the alkaloid protocol and analyzed with the alkaloid and lipid methods. Three fatty acids were identified in the scrapings: C16:0 Palmitic acid (n-Hexadecanoic acid), C18:1n9 Oleic acid, and C24:1n9 Nervonic acid (15-Tetracosenoic acid, methyl ester, (Z)-).

As noted in the previous sample, it is difficult to differentiate between olive and oil plant seed oils solely on the basis of fatty acid profiles. However, oleic acid occurs in very high concentrations in olive oil.
Such an identification is not a far stretch for a Mediterranean island during this period. Although it is not possible to differentiate olive and plant seed oils based on their fatty acid. Other plant oils may also have been utilized or perhaps multiple oils were used in conjunction. An additional oil source may come from members of the Apiaceae (Umbelliferae), which may include angelica, anise, caraway, carrot, celery, coriander, cumin, fennel, rapeseed or pennycress oils (Meikle 1977; Fahleson et al. 1994:795-7).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.969</td>
<td>2,6,10,14,18,22-Tetra cosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)</td>
<td>Squalene</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>13.0</td>
<td>35</td>
</tr>
<tr>
<td>12.081</td>
<td>n-Hexadecanoic acid</td>
<td>C16:0, Palmitic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>13.0</td>
<td>94</td>
</tr>
<tr>
<td>12.982</td>
<td>Cyclohexanemethanol</td>
<td>Fragment of elemol?</td>
<td>Lipid-Lipid-Scraping</td>
<td>13.0</td>
<td>16</td>
</tr>
<tr>
<td>13.220</td>
<td>Oleic acid</td>
<td>C18:1n9</td>
<td>Lipid-Lipid-Scraping</td>
<td>13.0</td>
<td>91</td>
</tr>
<tr>
<td>13.863</td>
<td>15-Tetracosenoic acid, methyl ester, (Z)</td>
<td>C24:1n9, Nervonic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>13.0</td>
<td>50</td>
</tr>
<tr>
<td>14.863</td>
<td>1,6-Octadiene, 5,7-dimethyl-, (R)</td>
<td>Isocitronellene</td>
<td>Lipid-Lipid-Scraping</td>
<td>13.0</td>
<td>17</td>
</tr>
</tbody>
</table>

Two compounds that may represent essential oil compounds were identified. The first of these, Cyclohexanemethanol, may be a fragment of elemol (Cyclohexanemethanol, 4-ethenyl-α,α,4-trimethyl-3-(1-methylethenyl)-, [1r-(1α,3α,4β)]-), which is related to elemene. If this identification is correct, then a number of plants may be indicated, including: rose, species of torchwood (Amyris balsamifera), wormwood, thyme, wormseed, pine, fir, or yarrow (Grandi et al. 1972; Kordali et al. 2005:1412; Lee et al. 2005:134; Rohmer et al. 1977; Roussis et al. 1994:359; Rusanov et al. 2011:2215; Sáez 1995:822; Smedman et al. 1969:1471, 1474-5). The second compound, isocitronellene, may further narrow the list to rose, since it is a constituent in rose, lemon balm, and valerian (Bowles 2003: 196, 198; Lopez 2011:5). The final compound identified in the vessel, squalene, was the only notable compound present in the sherd. Due to the fact that all the other constituents in that extraction were contaminants, the squalene likely also represents human-introduced contamination.
While the essential oil content of the vessel is rather limited, the small footed vessel may have contained rose oil or petals in a plant oil matrix that likely derived from olives, but the source of which may be a series of other plants.

V.E.5.s  22 V.010.53.12 (Body of Black Polished juglet)

Scrapings were extracted and analyzed using the lipid method. The sherd was extracted with the lipid and sonication protocols and analyzed with the alkaloid and lipid methods. Two fatty acids were identified: C16:0 Palmitic acid (n-Hexadecanoic acid) and C18:1n9 Oleic acid.

There were no results from the analysis of the sherd. The presence of the two fatty acids might suggest the presence of a plant oil, perhaps olive oil, but there is insufficient evidence for a specific identification. It should, however, be noted that this is another case in which fatty acids were only present in the scrapings and did not permeate into the sherd. Such an identification is not a far stretch for a Mediterranean island during this period.
Scrapings were extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. The sample was also analyzed in SIM mode, targeting codeine, hydrocotamine, meconic acid, morphine, and thebaine. Other than two fatty alcohols, the scrapings showed the presence of one compound. Isobutyric acid (Propanoic acid, 2-methyl-, heptyl ester) was identified at 2.906 minutes at a quality of 35.

As noted above, the compound plays a role in fermentation and is present in modern red and white wines and vinegars (Ferriera et al. 2002:4048-50; Guth 1997:3027; Lambert 1997:37; Rocha et al. 2004:257-8). The compound occurs in samples of propolis (Marcucci 1994:83-7).

Like the scraping, the alkaloid extraction of the sherd exhibited contamination and a series of fatty alcohols that could not be associated with a particular source. The sample was also analyzed using the lipid protocol, as well as in SIM mode, targeting hydrocotamine, meconic acid,
morphine, and thebaine. There was no evidence of a preserved residue. While the isobutyric acid may suggest a fermented product, an identification based on a single compound can only be suggestive.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.906</td>
<td>Propanoic acid, 2-methyl-, heptyl ester</td>
<td>Isobutyric acid, heptyl ester</td>
<td>Alkaloid-Alkaloid-Scraping</td>
<td>13.0</td>
<td>35</td>
</tr>
</tbody>
</table>

Scrapings were extracted and analyzed using the lipid protocol. There was no indication of preserved residue. The sherd was not collected for sampling.
V.E.5.v  27 G.003.16.1.4 (Small Red Polished cup)

Scrapings were extracted and analyzed using the lipid protocol. There was no indication of preserved residue. Due to the uniqueness and small size of the vessel, a sherd was not collected for sampling.

V.E.5.w  28 A.005.46.7 (White Pained Jug Neck)

Scrapings were extracted with the alkaloid protocol and analyzed using the alkaloid and lipid methods. Only one compound, Bicyclo[3.1.0]hexan-2-one, 1,5-di-tert-butyl-3,3-dimethyl-, was identified using the former at 3.440 minutes with a quality of 25.

As noted in the discussion of PT15, the compound is likely related to sabina ketone (Bicyclo[3.1.0]hexan-2-one, 5-isopropyl-), sabinyl acetate (sabinene hydrate; 4-thujanol) or another compound related to sabinene (4-methylene-1-(1-methylethyl) bicyclo[3.1.0]hexane). Each of these compounds are widely distributed in species of *Tanacetum*, *Achillea*, and *Artemisia* (Lee et al. 2005:134; Kordali et al. 2005:1411; Teixeira de Silva 2004:707-12). In terms of use, Teixeria de Silva (2004:707-12) highlights that sabinene is used primarily in perfumery, while beta-sabinyl acetate has medicinal applications. Two other compounds were detected in the lipid analysis. The first, Indolo[3,2-b]quinoline, 10-methyl-2-nitro-, may be a degradation compound of one or more alkaloids, but equally may represent an analytical artifact. The second compound is behenic acid (C22:0, Docosanoic acid), which is a fatty acid found in various plant oils ([www.lipomics.com](http://www.lipomics.com)). With only two chemical components, it is difficult to
determine an overall substance, however the jug does seem to have contained a liquid substance that included a species of tansy, yarrow, or wormwood as well as a plant-derived oil.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.440</td>
<td>Bicyclo[3.1.0]hexan-2-one, 1,5-bis(1,1-dimethylethyl)-3,3-dimethyl-</td>
<td>Related to sabina ketone</td>
<td>Alkaloid-Alkaloid-Scraping</td>
<td>11.5</td>
<td>25</td>
</tr>
<tr>
<td>12.538</td>
<td>Indolo[3,2-b]quinoline, 10-methyl-2-nitro-</td>
<td></td>
<td>Alkaloid-Lipid-Scraping</td>
<td>11.5</td>
<td>47</td>
</tr>
<tr>
<td>12.796</td>
<td>Docosanoic acid, ethyl ester</td>
<td>C22:0, Behenic acid</td>
<td>Alkaloid-Lipid-Scrapings</td>
<td>11.5</td>
<td>64</td>
</tr>
</tbody>
</table>

Abundance

Time→

0 3.00 6.00 9.00 12.00

Related to sabina ketone?

Abundance

Time→

0 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00

12.538 Alkaloid degradation?

12.796 C22:0 Behenic acid

Politiko-Troullia
28 A.065.46.7
Alkaloid-Lipid Scrapings

Politiko-Troullia
28 A.065.46.7
Alkaloid-Alkaloid Scrapings
V.E.5.x  29 D.010.64.2 (Neck of small White Painted vessel)

Scrapings were extracted and analyzed with the lipid protocol. A handful of low level alkanes and fatty alcohols were detected. Similar to sample 27, the results were insufficient to identify plant sources and the sample was not submitted for destructive analysis.

V.E.5.y  30 D.010.67.1 (White Painted Small Closed Body)

Scrapings were extracted with the sonication protocol and analyzed using the alkaloid and lipid methods. The sherd was extracted using the sonication and alkaloid protocols and analyzed using the alkaloid and lipid methods. The alkaloid extraction was also analyzed in SIM mode targeting atropine, codeine, harmine, hydrocotamine, morphine, papaverine, and thebaine, none of which showed any matches.

The sample showed several peaks, which included a variety alkanes, alkenes, and fatty alcohols, as well as additional compounds of interest were identified. The first, trans-verbenone (Bicyclo[3.1.1]hept-3-en-2-one,4,6,6-trimethyl-, (1S)-) was identified in the scraping sample at 5.244 minutes with a quality of 23, as well as in a reference sample of Cypriot sage.

It is also a constituent in annual wormwood (Artemisia alba), rosemary, vervain, a species of germander (Teucrium montanum), as well the Lilac Chaste or Monk’s Pepper Tree (Vitex agnus-castus), which is a member of the Verbenaceae family and was used in Ancient Greece in annual festival honoring the goddess Demeter (Ardakani et al. 2003:40; Bowles 2003:35; Radulović and Blagojević 2010:1117-9; Tsintides et al. 2002:350; Vukovic et al. 2007:19). The second compound found in the scraping is 7-Oxabicyclo[4.1.0]heptane, 1,5-
The compound may be related to alpha-bisabolol (4-[(1Z)-1,5-Dimethyl-1,4-hexadienyl]-1-methyl-7-oxabicyclo[4.1.0]heptane), which is a major constituent in chamomile and a minor constituent in sage (Bowles 2003:62, 73; Velickovic et al. 2003:21). The compound is also found in aniseed, fenugreek and germander (Leela and Vipin 2008:333, 335; Leela and Shafeekh 2008:245; Vukovic et al. 2007:19).

Two compounds were identified in the sherd. The first of these, butyric acid (C4:0, butanoic acid), is a short chain lipid that has wide distribution, but quite readily is present in fermented plant and animal products. The second compound, 1,6;3,4-Dianhydro-2-deoxy-β-D-lyxo-hexopyranose, was identified at 10.270 minutes and has elsewhere been suggested to be a baker’s yeast, though the frequency with which the compound occurs in pottery samples may also indicate that it is an artifact of the analysis or perhaps molecular diagenesis of the residue.

If a fermented product is indicated, it does not necessarily have to be an alcoholic beverage. The two essential oils present suggest the presence of an herbal mixture that may or may not have had medicinal qualities. A species of sage or germander is likely the main ingredient as these plants explain the presence of both essential oil compounds.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.898</td>
<td>Butanoic acid, hexyl ester</td>
<td>C4:0, Butyric acid</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>11.5</td>
<td>38</td>
</tr>
<tr>
<td>5.244</td>
<td>Bicyclo[3.1.1]hept-3-en-2-one, 4,6,6-trimethyl-,(1S)-</td>
<td>Verbenone</td>
<td>Sonication-Alkaloid-Scraping</td>
<td>11.5</td>
<td>23</td>
</tr>
<tr>
<td>10.064</td>
<td>7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-</td>
<td>Related to alpha-bisabolol?</td>
<td>Sonication-Alkaloid-Scraping</td>
<td>11.5</td>
<td>27</td>
</tr>
<tr>
<td>10.270</td>
<td>1,6;3,4-Dianhydro-2-deoxy-β-D-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>11.5</td>
<td>13</td>
</tr>
</tbody>
</table>
V.E.5.z  31 U.006.17.1 (Black-topped bowl)

Scrapings were extracted and analyzed using the lipid protocol. The sherd was extracted with the alkaloid protocol and analyzed using the alkaloid and lipid methods. The alkaloid sample was also submitted for SIM analysis for atropine, ephedrine, hydrocotamine, morphine, meconic acid, noscapine, papaverine, and harmaline. No results were generated for any of the analyses, which suggests a residue was not preserved.
Scrapings were extracted and analyzed using the lipid method. The fatty acid, oleic acid (C18:1n9, 9-octadecanoic acid) and one or more of its degradation compounds were identified. Although it is not possible to differentiate olive and plant seed oils based on their fatty acid profiles, olive oil is the greatest source of oleic acid, which has more than one instance in this sample alongside a number of its decomposition products (www.lipomics.com).

Petroselinic acid (6-Octedecanoic acid) was also identified, which at a high concentration (50%) in the seed oils of plants in the Apiaceae (Umbelliferae) family, such as anise, caraway, carrot, celery, coriander, cumin, fennel, and others (Reichling and Galati 2005:92).

Two compounds, farnesyl methyl ester and homofarnesic acid, were also present, which may be derivatives of farnesol. However, according to Leffingwell and Leffingwell (2011:32), show that homofarnesol is an intermediary in the synthesis of ambrox\textsuperscript{89} from beta-dihydroionone, a compound related to the other ionone isomers. This might suggest that a fixative, such as is derived from the pink rockrose in the form of labdanum resin, or an aromatic containing the beta isomer of ionone, such rose or caper flower, may be indicated. The dihydroionone decomposition/transformation may further be suggested by the presence of Tetrahydroactinidiolide (2(3H)-Benzofuranone, hexahydro-4,4,7a-trimethyl) which may be structurally related to sclareolide. This latter compound represents a secondary route in the synthesis of ambrox, has been synthesized in conjunction with Tetrahydroactinidiolide, and is a constituent in Salvia sage species (Leffingwell and Leffingwell 2011:32; Salimpour et al. 2011:1796; Upar et al. 2009:1637)\textsuperscript{90}. If these compounds are instead degradation products of

\textsuperscript{89} A derived compound that is used widely in the perfume industry as fixative.

\textsuperscript{90} It should however be noted that these synthetic formation processes likely differ from natural processes.
farnesol\textsuperscript{91} lemon balm, rose, propolis, honey, or lavender may be indicated. The lavender identification is further suggested by the presence of lavandulol, a major aromatic constituent in lavender flowers (Bowles 2003:195).

The presence of ipsenol (7-Octen-3-ol, 2,6-dimethyl-) may further suggest the presence of a sage species, since it was identified in a reference sample of Cypriot sage, as well as in a sample of pine that originated in Cyprus. Another constituent of sage, camphor, was identified as camphor oxime (Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, oxime, (+/-)-). However, camphor also occurs in annual, white and absinthe wormwood, coriander, lavender, rosemary, oregano, wild fennel and tansy, as well as Taurus cedar in small amounts. It is also found in basil and thyme, though it was not identified in a reference sample of Cypriot thyme. It was however identified in reference samples of lavender and Cypriot sage (Başer and Demirçakmak 1995:17; Bowles 2003:25-6, 34, 71, 85; Daferera et al. 2000:2578; Fasseas et al. 2007:1191; Ferraro et al. ND:1, 3; Lee et al. 2005:134; Nezhadali et al. 2008:557, 559-60; Piccaglia and Marotti 2001:241; Radulović and Blagojević 2010:1117-9; Teixeira da Silva 2004:707-10, 712-3; Veličković et al. 2003:17, 19-20). Thus, it seems likely that both lavender and sage are likely ingredients in this small vessel.

A species of wormwood may also be indicated, based on the presence of the camphor, as well as achillin (Azuleno[4,5-b]furan-2,8(3H,4H)-dione, 3a,5,6,6a,7,9b-hexahydro-6-hydroxy-3,6,9-trimethyl-, [3S-(3.alpha.,3a.alpha.,6.alpha.,6a.alpha.,9b.beta.)-], which was identified in reference sample of wormwood extract. However, the species from which it was derived is uncertain. Menthol, a major constituent in mint species (peppermint, spearmint, pennyroyal) was also identified. It was also present in reference samples of lemon balm and myrtle, the latter originating from Cyprus (Bowles 2003:25-6, 69-71, 85, 88-89). While there is no other indication of a mint species in the sample, the compound may be explained by a species of sage, since Veličković et al. (2003:19) highlight the presence of menthol and its derivatives in various species

\textsuperscript{91} It should be noted that farnesol is structurally similar to squalene, which has a wide distribution but which is particularly present in fish oils and frequently represents human-introduced contaminants. The fact that both farnesol and squalene are present should be noted. However, the fact that a number of other chemical components are also present that derive from the same sources as farnesol, makes the uncertainty less of an issue.
of European sage in the *Salvia* genus. However, menthol was not identified in the botanical reference sample of Cypriot sage.

Three additional compounds were identified in the sample, 1-Hexyl-2-nitrocyclohexane, a derivative of malonic acid, and a compound that may be related to the indole alkaloid, Condylocarpine. While the first two have been identified as minor constituents in various plants and products, none are indicated by the other evidence. The mass spectrum for the final compound could not be located manually, which suggests that it, like the other two, are likely contaminants or misidentifications.

Taken together, the chemical evidence seems to suggest the presence of a perfumed substance that had pink rockrose, rose, lavender, sage, and possible wormwood as ingredients in an oil matrix that may have derived from olives or another seed oil. This identification should however be taken with caution since some of the qualities are rather low.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.075, 20.402</td>
<td>6-Octadecenoic acid, (Z)-/Oleic acid 6-Octadecenoic acid, (Z)-</td>
<td>Petroselinic acid/Lipid-Lipid-Scraping</td>
<td>13.5</td>
<td>16/16/14</td>
<td></td>
</tr>
<tr>
<td>14.640</td>
<td>Azuleno[4,5-b]furan-2,8(3H,4H)-dione, 3a,5,6,6a,7,9b-hexahydro -6-hydroxy-3,6,9-trimethyl-, [3S-(3.alpha.,3a.alpha.,6.alpha.,6a.alpha.,9b.beta.)]-</td>
<td>Related to Achillin/Lipid-Lipid-Scraping</td>
<td>13.5</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>14.986, 31.857, 36.807</td>
<td>Oleic acid</td>
<td>Lipid-Lipid-Scraping</td>
<td>13.5</td>
<td>43/27/64</td>
<td></td>
</tr>
<tr>
<td>16.055</td>
<td>Condyfolan-16-carboxylic acid, 2,14,16,19-tetrahydro-, methyl ester, (14E)</td>
<td>Lipid-Lipid-Scraping</td>
<td>13.5</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>16.432</td>
<td>Malonic acid, isopropyl-, di-(-)-methyl ester</td>
<td>Lipid-Lipid-Scraping</td>
<td>13.5</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>
Scrapings were extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods with no results. The sample was also analyzed using the SIM method, targeting ions associated with atropine, hydrocotarnine, meconic acid, noscapine, papaverine, harmaline, and thebaine.
The sherd was extracted using the alkaloid and sonication protocol and analyzed using the alkaloid and lipid methods. The alkaloid sample was also analyzed using the SIM method for codeine, ephedrine, hydrocotamine, morphine, noscapine, papaverine, and thebaine. There was no indication of preserved residue.

V.E.5.cc 34 U.006.30.2 (Red Polished bowl)

Scrapings were extracted and analyzed using the lipid method. One of two fatty acids was identified at 13.214 minutes at a quality of 72. Tridecanoic acid does not frequently appear in archaeological samples and is not utilized in determining the botanical or faunal source of lipids (Eerkens 2005:92-6; Malainey et al. 1999:102). The same is likely true for undecanoic acid. More informative, is the presence of camphor oxide, which identified in sample 32.

It is related to camphor, which occurs in annual, white and absinthe wormwood, coriander, lavender, rosemary, oregano, wild fennel and tansy, as well as Taurus cedar in small amounts. It is also found in basil and thyme, though it was not identified in a reference sample of Cypriot thyme. It was, however, identified reference samples of lavender and Cypriot sage (Başer and Demirçakmak 1995:17; Bowles 2003:25-6, 34, 71, 85; Daferera et al. 2000:2578; Fasseas et al. 2007:1191; Ferraro et al. ND:1, 3; Lee et al. 2005:134; Nezhadali et al. 2008:557, 559-60; Piccaglia and Marotti 2001:241; Radulović and Blagojević 2010:1117-9; Teixeira da Silva 2004:707-10, 712-3; Veličković et al. 2003:17, 19-20).

Alpha-campholenal was also identified, which might suggest that present in Prickly Juniper (*Juniperus oxycedrus*), a species of Juniper that is indigenous to Cyprus (Tsintides et al. 2002:94). It is also a minor constituent in Sideritis congesta, a Lamiaceae species that is found in
Turkey but which likely has correlates in Cyprus (Gumuscu et al. 2011), and according to Beeston et al. (2006:417) has been reported in a species of thyme (*Thymus funkii*).

The final compound identified in the sample was Cyclohexanemethanol at several peaks. As mentioned elsewhere, this could reflect a fragmentation of elemol (Cyclohexanemethanol, 4-ethenyl-\(\alpha\),\(\alpha\),4-trimethyl-3-(1-methylethenyl)\(-\)), \(\text{[1r-(1\alpha,3\alpha,4\beta)]-}\)), which is related to elemene. If this identification is correct, then a number of plants may be indicated, including: rose, species of torchwood (*Amyris balsamifera*), wormwood, thyme, wormseed, pine, fir, or yarrow (Grandi et al. 1972; Kordali et al. 2005:1412; Lee et al. 2005:134; Rohmer et al. 1977; Roussis et al. 1994:359; Rusanov et al. 2011:2215; Sáez 1995:822; Smedman et al. 1969:1471, 1474-5).

Based on this information, the most likely plant sources are a species of thyme\(^{92}\) and a tree resin, perhaps pine, juniper, or cedar. However, other characteristic constituents of these plants were not identified. Another possibility is that a sufficient residue was not preserved in the bowl or that a food mixture was present that could not be determined using the available data.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.491,</td>
<td>Cyclohexanemethanol</td>
<td>Fragment of elemol?</td>
<td>Lipid-Lipid-Scrapings</td>
<td>13.0</td>
<td>47/32/25/35</td>
</tr>
<tr>
<td>11.550,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.649,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>13.154</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>13.214</td>
<td>Tridecanoic acid, methyl ester/</td>
<td>C13:0</td>
<td>Lipid-Lipid-Scrapings</td>
<td>13.0</td>
<td>72/72</td>
</tr>
<tr>
<td></td>
<td>Undecanoic acid, methyl ester</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.851</td>
<td>1-Cyclohexene-1-acetaldehyde, 2,6, 6-trimethyl-</td>
<td>contaminant</td>
<td>Lipid-Lipid-Scrapings</td>
<td>13.0</td>
<td>17</td>
</tr>
<tr>
<td>16.465</td>
<td>3-Cyclopentene-1-acetaldehyde, 2,2,3-trimethyl-</td>
<td>(\alpha)-Campholenal</td>
<td>Lipid-Lipid-Scrapings</td>
<td>13.0</td>
<td>27</td>
</tr>
<tr>
<td>17.010</td>
<td>2-Bornanone oxime/ Bicyclo[2.2.1]heptan-2-one,</td>
<td>Camphor oxime</td>
<td>Lipid-Lipid-Scrapings</td>
<td>13.0</td>
<td>12/12</td>
</tr>
<tr>
<td></td>
<td>1,7,7-trimethyl(-), oxime, (.(+),-)-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{92}\) But not the species that was collected from Cyprus.
Scrapings were extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. The sample was also analyzed in SIM mode, targeting atropine, codeine, ephedrine, hydrocotamine, morphine, papaverine, and harmaline.

No results were obtained. The sherd was extracted with the alkaloid protocol and analyzed with the alkaloid and lipid methods, as well as in SIM mode targeting atropine, codeine, ephedrine, hydrocotamine, morphine, noscapine, papaverine, harmaline, and thebaine.

Three related compounds, trans-pinane, alpha-pinene, and longipinene were identified in the alkaloid extraction of the sherd. Trans-pinane and its isomer, pinene, are present in the tree resin from a species of pine, cypress, or juniper, in which pinene is the primary constituent. An aromatic herb may be indicated such as sage, rosemary, coriander, savory, fennel, or myrtle. Pinene is also a constituent in white wormwood, nutmeg, everlasting and two species of mountain tea (genus *Sidieritis*) (Adams et al. 1999:167; Amor et al. 2009:183, 188-90; Bowles 2003:35, 58-9, 195-8; Farah et al. 2006: 351-3; Ferraro et al. ND; Gumuscu et al. 2011; Marotti 2001: 239, 238)

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93 Potential local species may include Aleppo pine or Atlas cedar (Yassaa et al. 2000).
Longipinene (2,6,6,9-tetramethyltricyclo[5.4.0.0₂,₈]undec-9-ene), on the other hand, is found in black cumin, which according to Meikle (1977:63) is present in Cyprus (Hajhashemi et al. 2004:195-7). The alpha isomer of the compound occurs as a minor constituent in species of Artemisia, Taurus cedar, as well as two species of hyssop (Cakir et al. 2004:62-5; Kordali et al. 2005:1412-3).

Seven compounds that derive from botanical essential oils were also identified. Levomenthol, which is related to menthol, a species of mint is likely indicated since it is a major constituent in peppermint, spearmint and pennyroyal, though it is also present in lemon balm, myrtle, and sage (Bowles 2003:25-6, 69-71, 85, 88-89; Veličkovič et al. (2003:19). The compound camphenilone, which is also present in the sample, has been reported in labdanum (the resin of rockrose), wormwood, lavender, and a species of thyme from the southern Mediterranean (Imelouane et al. 2009:207; http://www.thegoodscentcompany.com/data/rw1487721.html).

Germacrene-D, a variation of the Germacrene-D-ol present in the sample, is also present in the same species of thyme. While it was not identified in the sample of Cypriot thyme, it was identified in a reference sample of hyssop. It has also been reported in caraway seed, a species of juniper (Juniper oxycedrus), and two species of sage (Phlomis and Clary) though not in the sample of Cypriot sage (Adams et al. 1999; Amor et al. 2009:183, 188-9; Bowles 2003:93; Iacobellis et al. 2005:57, 59; Imelouane et al. 2009:207).

In addition, a compound, 5-Isopropenyl-2-methyl-7-oxabicyclo[4.1.0]heptan-2-ol, that is like related to carvone oxide (5-methyl-2-prop-1-en-2-yl-7-oxabicyclo[4.1.0]heptan-5-ol), was identified, which is present in rosemary, wormwood oil and coriander (Nagella et al. 2012:2951; http://www.thegoodscentcompany.com/data/rw1511401.html). The related compound, carvone, and its derivatives are constituents in a species of rockrose (Cistus ladaniferus), as well as germander, a species of sage, and caraway, with the latter having demonstrated antibacterial activity (Oller-López et al. 2005:554-5; Iacobellis et al 2005:59; Kaya et al. 2009:552; Vukovic et al. 2007:19). Myrtenyl, a compound related to the myrtanal present in the sample, is also a constituent in the same species of rockrose. Other forms of this compound have a variable distribution. Myrtenal acetate is present in myrtle and coriander (Bowles 2003:93; Farah et al.
Myrtenol is in white wormwood (Nezhadali et al. 2008:557, 559-60), while its methyl ester is found in hyssop. Alpha-bisabolene is another compound present in pink rockrose, wormwood, thyme, germander, as well as basil and oregano (De Martino et al. 2009:2737; Lee et al. 2005:134; Vukovic et al. 2007:18-19).

Citronellyl isovalerate, on the other hand, is a constituent in valerian on the other hand, is a known constituent of valerian (Valerian officinalis), a medicinal plant with known sedative effects (Bowles 2003: 196, 198; Lopez 2011:5). However, the compound may represent a degradation of citronellol (6-Octen-1-ol, 3,7-dimethyl-, acetate), which is a constituent in lemon balm and rose. The presence of geranyl linalool (1,6,10,14-Hexadecatetraen-3-ol, 3, 7,11,15-tetramethyl-, (E,E)-), may further corroborate a rose or lemon balm identification. Bertsch et al. (2004:701) identified geranyl linalool as a tertiary alcohol present in the labial gland secretions of the male bumblebee Bombus griseocollis, which may indicate the presence of honey. Elsewhere it has been mentioned that the compound may be an intermediary between geraniol and linalool. If associated with the former, coriander, lemon balm, rose, sage, vervain, myrtle or lavender may be indicated. A related compound, geranyl acetate, is present in fig tree, rose, coriander, vervain, lemon balm, and sage, but was not identified in the Cypriot sample of sage. Linalool, on the other hand, is present in absinthe wormwood, fig tree, lavender, marjoram, basil, oregano, thyme, vervain, as well as reference samples of lavender, sage, and myrtle. Thus, the most likely source of the compound is coriander, rose, sage, myrtle, or lavender.

The last compound identified in the sample was alpha-terpenyl acetate, which was identified in reference samples pine and myrtle from Cyprus. Alpha-terpinen, a related compound, was reported in a species of Moroccan thyme, but not in the reference sample obtained from Cyprus\textsuperscript{94} (Imelouane et al. 2009:207).

Based on this information, a complex mixture is likely represented in this decorated closed vessel was a herbal mixture that composed of a series of ingredients. The following are

\textsuperscript{94} Other varieties may have this compound, but those were not analyzed.
possible ingredients: the resin of pine or juniper, sage, myrtle, thyme, pink rockrose (its resin, labdanum), germander, and/or hyssop.\(^5\)

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.132, 7.176</td>
<td>1,6,3,4-Dianhydro-2-deoxy-beta.-d-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid- Sherd</td>
<td>12.0</td>
<td>50/25</td>
</tr>
<tr>
<td>8.730, 10.236</td>
<td>2,6,6-Trimethyl-bicyclo[3.1.1]hept-3-ylamine</td>
<td>Alpha-Pinene</td>
<td>Alkaloid- Sherd</td>
<td>12.0</td>
<td>25/25</td>
</tr>
<tr>
<td>15.687</td>
<td>Bicyclo[3.1.1]heptane, 2,6,6-trimethyl-, (1.alpha.,2.beta.,5.alpha.)</td>
<td>Trans-Pinane</td>
<td>Alkaloid- Sherd</td>
<td>12.0</td>
<td>28</td>
</tr>
<tr>
<td>17.054, 23.023, 27.875, 28.201</td>
<td>Bicyclo[2.2.1]heptan-2-ol, 3,3-dimethyl-, exo-</td>
<td>Camphenilone</td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>38/38/38/38</td>
</tr>
<tr>
<td>18.162, 18.806</td>
<td>Bicyclo[3.1.1]heptane-2-carboxaldehyde, 6,6-dimethyl-</td>
<td>Myrtanal</td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>47/47</td>
</tr>
<tr>
<td>18.806, 22.142</td>
<td>1,6,10,14-Hexadecatetraen-3-ol, 3,7,11,15-tetramethyl-, (E,E)-</td>
<td>Geranyl linalool</td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>42/38</td>
</tr>
<tr>
<td>18.885, 19.994</td>
<td>6-Octen-1-ol, 3,7-dimethyl-, acetate/ Cyclohexanol, 5-methyl-2-(1-methylethenyl)-, [1R-(1.alpha.,2.beta.,5.alpha.)]-</td>
<td>Citronellol acetate/ Levomenthol</td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>38/38/43</td>
</tr>
<tr>
<td>21.212</td>
<td>Epoxy-alpha.-terpenyl acetate</td>
<td></td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>43</td>
</tr>
<tr>
<td>22.420, 23.083</td>
<td>Butanoic acid, 3-methyl-, 3,7-dimethyl-6-octenyl ester</td>
<td>Citronellyl iso-valerate</td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>32/43</td>
</tr>
<tr>
<td>26.370</td>
<td>1-Hydroxy-1,7-dimethyl-4-isopropyl-2,7-cyclodecadiene</td>
<td>Germacren D-ol</td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>28</td>
</tr>
<tr>
<td>29.241</td>
<td>Longipinene epoxide</td>
<td></td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>37</td>
</tr>
</tbody>
</table>

\(^5\) It should however be noted that several of the compounds are based on rather low qualities.
V.E.5.ee 38 D.030.48.5 (White Painted Small Bowl with Handle)

Scrapings extracted with the alkaloid protocol and analyzed using the alkaloid and lipid methods. The sample was also analyzed in SIM mode, targeting hydrocotarnine, noscapine, and thebaine. A series of contaminants and alkanes that cannot be associated with a particular source were identified. Other than a series of nondescript alkenes and contaminants, the only compound to be identified was the quinoline compound, Indolo[3,2-b]quinoline, 10-methyl-2-nitro-, that has been identified in a variety of other samples.

V.E.5.ff 39/41 P.004.40.1.7 (Small Black-topped bowl found in situ with RPIV jug)

Scrapings were extracted using the lipid protocol and analyzed using both lipid and alkaloid methods. The former returned a number of alkanes. The sherd was extracted and analyzed using the lipid and alkaloid methods.
A number of alkanes were detected again, but unfortunately the sherd sample showed a series of contaminants. However, using the alkaloid method, the compound dl-malic disodium salt was detected at 2.407 at a quality of 25 and is a known compound associated with winemaking, specifically as one of the substances that arises during the fermentation process (Guash-Jané 2006:98; Kunkee 1991; Lambert 1997:137; McGovern 2003:1856-7; Michel et al. 1993:411-2; Wansborough 1974:3-4). The compound, 1,6;3,4-Dianhydro-2-deoxy-.beta.-d-lyxo-hexopyranose, was noted elsewhere as being related to baker’s yeast. Furthermore, this bowl was found in direct association with sample 42, which is the body and base of an RP IV jug with extensive evidence of attribution on one side of the interior. Together, the evidence may suggest the presence of fermented substance, perhaps wine.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.100</td>
<td>1,6;3,4-Dianhydro-2-deoxy-.beta.-d-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>25</td>
</tr>
<tr>
<td>2.407</td>
<td>dl-Malic disodium salt</td>
<td></td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>25</td>
</tr>
</tbody>
</table>
Scrapings were extracted using the lipid and sonication protocols and analyzed using the alkaloid and lipid methods. The sonication method returned a number of peaks, but either matches were either for contaminants, nondescript alkanes, or qualities were too low. One compound, alpha-D-Glucose, was identified in the sonication extraction of the scrapings. The compound was identified in reference samples of everlasting and hyssop, but has a wide distribution in sugary plants and fruits, such as grapes.

The alkaloid extraction of the sherd showed the presence of butanoic acid (C4:0) and lactic acid, butyl ester butyrate, both being derivatives of compounds that play a role in fermentation (Flamini 2005:705, 708; Kunkee 1991; Sahlin 1999:3; Wansbrough 1974:3). However, other sources are also possible, such as the buds of the poplar tree (Black Poplar and Balsam Poplar) (Isidorov and Vinogorova 2003:358), and starflower, a plant native to the Levant (Barcelous 2008:397-8).

Based on the compounds present in the sample, the jug likely contained a fermented beverage, perhaps a grape wine, though the characteristic compound found in grape skins, tartaric acid, was not identified. It has, however, not been identified in any samples that have been analyzed in which the presence of wine is suggested (Guash-Jané 2006:98; McGovern et al. 2003:17596-7; Michel et al. 1993:411-2). However, Mariti (1984:70) maintains that traditional Cypriot wine never makes tartar, which might make the production of wine less visible in the archaeological record from a chemical perspective.

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96 Was found in situ with the small RP bowl, sample 39-41, which suggests the two vessels were used together.
There are two contextual clues that make the identification of a fermented wine more likely and those include the fact that the jug exhibits extensive attrition on one side, an observation that Arthur (2003:522) documented in an ethnoarchaeological study of fermented beverages in Ethiopia. In addition, this jug was found in situ with a small bowl that contains two compounds that are suggestive of a fermented grape beverage. Moreover, the suggestion that jugs and bowls were used together as drinking sets in Cyprus is not a new one and various evidence has been put forth that documents this practice, including representations of jugs and bowls together in genre scenes, as well as in presumably feasting contexts, such as in Building IV at the Middle Bronze Age site of Alambra-Mouttes (Coleman et al. 1996:89; Keswani 2005:109; Knapp 2009:89).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.407</td>
<td>Butanoic acid, hexyl ester</td>
<td></td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>37</td>
</tr>
<tr>
<td>3.670</td>
<td>Butanoic acid, 2-butoxy-1-methyl-2-oxoethyl ester</td>
<td>Lactic acid, butyl ester, butyrate</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>97</td>
</tr>
<tr>
<td>12.106</td>
<td>.alpha.-D-Glucose</td>
<td></td>
<td>Sonication-Lipid-Scraping</td>
<td>12.5</td>
<td>38</td>
</tr>
</tbody>
</table>

\[97\] The quality is rather low, but it is only mentioned here because other related compounds are also present.
Scrapings were extracted and analyzed with the lipid protocol with no results. The sherd was extracted and analyzed with both the alkaloid and lipid methods. There was no indication of a preserved residue with the only compounds identified being contaminants.
The sherd was extracted with the alkaloid and sonication protocols and analyzed using the alkaloid and lipid methods\textsuperscript{98}. The alkaloid analysis of the alkaloid sample showed a series of contaminants and nondescript alkanes, as well as two compounds that may suggest the presence of a residue. At 5.497 minutes, either alpha-limonene diepoxide (7-Oxabicyclo[4.1.0]heptane, 1-methyl-4-(2-methyloxiranyl)-, or carvone oxide (5-Isopropenyl-2-methyl-7-oxabicyclo[4.1.0]heptan-2-ol) was identified. If the former is correct, a series of plants may be indicated.

A related compound, limonene oxide, is a constituent in pistachio (\textit{Pistachia atlantica}) resin (Delazar et al.2004:24) but was also identified in botanical reference samples of wormwood, pink oleander, and everlasting, the latter two being obtained from Cyprus.


If the latter, carvone oxide, is correct, rosemary, wormwood oil or coriander may be indicated (Nagella et al. 2012:2951; \url{http://www.thegoodscentscompany.com/data/})

\textsuperscript{98} While a scraping sample was collected, the size of the sample was deemed too small to obtain results.
A related compound, carvone, and its derivatives are constituents in a species of rockrose (Cistus ladaniferus), as well as germander, a species of sage, and caraway, with the latter having demonstrated antibacterial activity (Oller-López et al. 2005:554-5; Iacobellis et al 2005:59; Kaya et al. 2009:552; Vukovic et al. 2007:19).

The second peak in the alkaloid extraction was hexa-hydro-farnesol (1-Dodecanol, 3,7,11-trimethyl-), which was identified in a species of rockrose (Cistus monspeliensis) (Oller-López, et al. 2005:555). The compound may also be a derivative of farnesol which may suggest the presence of lemon balm, rose, propalis, honey, or lavender (Bowles 2003:195).

The sonication extraction sample showed the presence of alpha-limonene diepoxide, as well as carvone oxide, as separate peaks which suggests that both compounds are represented in the sample. In addition, methyl isovalerate (Butanoic acid, 3-methyl-, methyl ester) was identified, as was 2-Butynedioic acid, di-2-propenyl ester. Neither seems particularly characteristic of a plant source.

Based on this information, the contents of the vessel likely contained a mixture with one or more of the following ingredients: rosemary, sage, wormwood, rockrose, or caraway. A tree resin or oil from juniper, cypress, pine, or pistachio is possible, as are a variety other aromatics.
Scrapings were extracted using the alkaloid protocol and analyzed using both alkaloid and lipid methods. There was no indication that a residue had preserved in the vessel. It may be noted that the fabric of this vessel was very hard and in general these fabric types had poor results. A sherd was not collected for destructive analysis.
V.E.5.kk  49 O.007.77.2 (White Painted base)

Scrapings were extracted using the alkaloid protocol and analyzed using both alkaloid and lipid methods, neither of which yielded results. The sherd was extracted using the alkaloid, lipid and sonication protocols and analyzed using the alkaloid and lipid methods. The alkaloid extraction was also scanned in SIM mode, targeting codeine, hydrocotarnine, meconic acid, noscapine, and papaverine, with no results. In the lipid extraction of the sherd, 1-Dodecanol, 3,7,11-trimethyl- was identified 3.650 minutes with a quality of 59.

As noted in sample 44, this compound is hexa-hydro-farnesol and is found in a species of rockrose (*Cistus monspeliensis*) (Oller-López, et al. 2005:555). The compound may also be a derivative of farnesol which may suggest the presence of lemon balm, rose, propalis, honey, or lavender (Bowles 2003:195).

As noted in sample 14, farnesol is structurally similar to squalene, which has a wide distribution but which is particularly present in fish oils and frequently represents human-introduced contaminants. Thus, the farnesol derivative could represent contamination of some sort. In any case, there is insufficient evidence to suggest the presence of residue.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.650</td>
<td>1-Dodecanol, 3,7,11-trimethyl-</td>
<td>Hexa-hydro-farnesol</td>
<td>Lipid-Lipid-Sherd</td>
<td>12.0</td>
<td>59</td>
</tr>
</tbody>
</table>
V.E.5.ll  50 O.009.85.1 (Black Polished animal shaped vessel)

Scrapings were extracted with the alkaloid protocol and analyzed with the alkaloid and lipid methods. The sherd was extracted and analyzed with the alkaloid and lipid methods, as well as in SIM mode for papaverine and thebaine. There were no reportable data in any of the analyses, which suggests there was no preserved residue.

V.E.5.mm  51 P.003.87.1 (Red Polished amphoriskos)

Scrapings were extracted and analyzed with the lipid method. The sherd was extracted and analyzed with the alkaloid and lipid methods. The alkaloid extraction was also scanned in SIM mode, targeting papaverine. There were no results in the scraping sample. Squalene was identified in both the alkaloid and lipid extraction of the sherd and may represent contamination of some kind.

A faunal source is possible, but with no other data such a differentiation cannot be made.

Farnesol isomer A was also identified in the alkaloid extraction. As noted in sample 49, farnesol is found in a series of products, including lemon balm, rose and honey, but in this case it is probably the result of contamination.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.977</td>
<td>Farnesol isomer a/ Squalene</td>
<td></td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>74/74</td>
</tr>
<tr>
<td>16.983</td>
<td>2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-</td>
<td>Squalene</td>
<td>Alkaloid-Lipid-Sherd</td>
<td>12.0</td>
<td>91</td>
</tr>
</tbody>
</table>
V.E.5.nn  54 O.009.98.1 (Red Polished Juglet Neck)

The scraping was extracted and analyzed with the lipid protocol with no results. The sherd was extracted and analyzed using the alkaloid and lipid protocols with only the latter showing any compound matches. One compound, Butanedioic acid, 2-hydroxy-3-methyl-, dimethyl ester, was identified using the latter method at 3.658 minutes at a quality of 50.

The compound is d-(-)-citramalic acid, an analog of malic acid, which plays a role in wine fermentation (Guash-Jané 2006:98; Kunkee 1991; Lambert 1977:137; McGovern 2003:1856-7; Michel et al. 1993:411-2; Wansborough 1974:3-4). It may be added that malic acid is not one of the compounds that Spinhirne et al. (2003:585) found to be associated with dairy products. However, in the absence of other evidence for a preserved residue, an identification of a substance is unclear.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.658</td>
<td>Butanedioic acid, 2-hydroxy-3-methyl-, dimethyl ester</td>
<td>d-(-)-citramalic acid</td>
<td>Lipid-Lipid-Sherd</td>
<td>12.0</td>
<td>50</td>
</tr>
</tbody>
</table>

V.E.5.oo  55 U.034.232.1 (Red Polished Spout)

Scrapings were extracted and analyzed using the lipid protocol. The sherd was extracted using alkaloid and lipid protocols, with the former being analyzed using both the alkaloid and lipid methods. The sherd was also analyzed in SIM mode, targeting codeine, hydrocotamine, papaverine, and thebaine. There was no indication that a residue had preserved.
V.E.5.pp  57 U.010.173 (Red Polished Black-Topped Bowl Fragments)

Two sherds were selected that likely belonged to the same bowl. Each sherd was extracted and analyzed using the alkaloid protocol. Sherd B was also extracted and analyzed using the lipid protocol. Three compounds were detected in the alkaloid sample using the alkaloid method. Only the alkaloid extraction and analyzes showed results. Isobutyric acid (Propanoic acid, 2-methyl-, hexyl ester), was detected in both sherds of qualities of 47 and 50.

As noted elsewhere, this compound is associated with fermentation, but it is unclear whether it is associated with the production of wine or dairy products (Kunkee 1991; Lambert 1977:137; McGovern 2009; Spinhirne et al. 2003:585). In addition, a compound, 1,6;3,4-Dianhydro-2-deoxy-beta.-d-lyxo-hexopyranose, that may be related to baker’s yeast, was identified in sherd B. In conjunction with the isobutyric acid identification, it seems likely that the decorated bowl was used for the consumption of a fermented product.

A third compound, 2,3-Dihydrofuro(2,3-b)quinoline, was identified in sherd A. While the identity of this compound is somewhat unclear, it is at the very least a fragment of a quinoline alkaloid. According to Michael (2005:223), a series of furo[2,3-b]quinoline alkaloids are present in fringed rue (Ruta chalepensis), a plant that is indigenous to Cyprus with medicinal properties that were known in Classical times. Specifically, the plant was used as an antidote in aconite poisoning (Tsintides et al. 2002:248). These alkaloids have also been identified in Rutaceae plants in the Haplophyllum genus from Turkey. Possible alkaloids from which the fragment may have derived include dictamnine (4-Methoxyfuro[2,3-b]quinoline), fagarine (4,8-Dimethoxyfuro[2,3-b]quinoline), or pteleine (4,6-Dimethoxyfuro[2,3-b]quinoline), heliparvifoline (4,6-dimethoxy-9H-furo[2,3-b]quinolin-7-one) If this identification is accurate, it may be noted that Haplophyllum species have a range of other alkaloids, one of which includes scopoletin, a
constituent found in psychoactive plants known to have tropane alkaloids (Ulubelen and Öztürk 2008:54-5, 58, 65).

The final compound identified in sherd B, Cyclohexanol, 4-ethyl-4-methyl-3-(1-methylethyl)-, (1,alpha.,3.beta.,4.alpha.-), which is likely related to menthone or its isomer in alcohol form, menthol. This compound as well as its derivatives are the primary constituents in species in the Mentha family, including peppermint (Mentha piperita) and pennyroyal (Mentha pulegium) (2003:25-6, 69-71, 85, 88-9). In addition, menthone is a major constituent in caper (Romeo et al. 2007:1277) and species of Ziziphora. The primary constituent of the latter is pulegone, the same compound found in pennyroyal, and in a species indigenous to Turkey (Ziziphora tenuior L.)\(^99\), the compound comprises over 80% of the volatile oil content (Meikle 2000:1258-62, 1286-7; Mehmood, et al. 2010; Sezik et al. 1991; Verdiar-Rivi 2008). Three menthone-related compounds are also present in basil and thyme (Lee et al. 2005:134).

Taken in sum, the vessel likely contained a fermented beverage that contained a species of mint and perhaps a species of rue. Sample 15 also contained these four compounds, though this sample lacked some other constituents. It should also be noted that the alkaloid extraction of sherd B was scanned in SIM mode for thujone with a match at 8.281 minutes. The comparison of the mass spectra, which is illustrated to below, seems to show that most of the ions are in the correct proportions. Thujone and its derivatives are major constituents in Artemisia absinthium, or absinthe wormwood, (Emmert et al.2004:352-4; Ott 1993:389-393; Parry 1922:56-58), Aristolochia clematitis, or birthwort, (Barceloux 2008:383-5; Francisco et al. 2008:171-2), sage, including Salvia officinalis (Daferera et al. 2000:2578), as well as tansy or Tanacetrum vulgare (Teixeira da Silva 2004:707-710). The compound was also identified in a botanical sample of sage obtained from Cyprus. The substance in PT15 also contained a thujone-related compound, sabina ketone, which makes it likely that the two vessels contained the same product.

\(^99\) While the species that was submitted for analysis derived from Turkey, Meikle (2000:1286-7) that the species Ziziphora capitata is indigenous to Cyprus.
<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.899</td>
<td>Propanoic acid, 2-methyl-, butyl ester</td>
<td>Isobutyric acid, butyl ester</td>
<td>Alkaloid-Alkaloid-SherdB</td>
<td>13.0</td>
<td>47</td>
</tr>
<tr>
<td>2.909</td>
<td>Propanoic acid, 2-methyl-, hexyl ester</td>
<td>Isobutyric acid, hexyl ester</td>
<td>Alkaloid-Alkaloid-SherdA</td>
<td>13.0</td>
<td>50</td>
</tr>
<tr>
<td>8.801</td>
<td>Cyclohexanol, 4-ethyl-4-methyl-3-(1-methylethyl)-, (1.alpha.,3.beta.,4.alpha.)-</td>
<td>Menthol isomer?</td>
<td>Alkaloid-Alkaloid-SherdB</td>
<td>13.0</td>
<td>47</td>
</tr>
<tr>
<td>9.620</td>
<td>2,3-Dihydrofuro(2,3-b)quinoline</td>
<td>Quinoline alkaloid derivative?</td>
<td>Alkaloid-Alkaloid-SherdA</td>
<td>13.0</td>
<td>38</td>
</tr>
<tr>
<td>10.255</td>
<td>1,6;3,4-Dianhydro-2-deoxy-.beta.-d-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid-SherdB</td>
<td>13.0</td>
<td>17</td>
</tr>
</tbody>
</table>
Scrapings were extracted using the alkaloid protocol and analyzed using the alkaloid and lipid methods. The alkaloid analysis was run twice and are noted in the datatable as A and B.

The alkaloid extractions were also analyzed in SIM mode, targeting atropine, ephedrine, codeine, harmine, hydrocotarnine, meconic acid, morphine, noscapine, papaverine and thebaine. The sherd was analyzed by the alkaloid and lipid protocols. None of the runs using the lipid method showed any results.

Four compounds were detected, in both the scraping and the sherd, that are likely related to a fermented product. In the scrapings, these include butanoic acid (C4:0) and a compound related to baker’s yeast. In the sherd, include malic acid and its disodium salt in two separate runs of the alkaloid extraction, which has been shown to be associated with wine production (Guash-Jané 2006:98; Kunkee 1991; Lambert 1977:137; McGovern 2003:1856-7; Michel et al. 1993:411-2; Wansborough 1974:3-4).

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100 This is the final sample in which scrapings and sherds were collected and analyzed for comparative purposes.

101 Both sherds likely belonged to the same bowl. Only one sherd underwent destructive analysis.
Two additional compounds were identified in the scrapings. Pristanic acid (Pentadecanoic acid, 2,6,10,14-tetramethyl-, methyl ester) was also identified in both runs of the sample and represents a fatty acid in found in fermented products, such as beer and dairy products (Mobley et al. 2003:775). The second compound, 2,3-Dihydrofuro(2,3-b)quinoline, the derivative of a quinoline alkaloid mentioned elsewhere as indicating the presence of fringed rue (*Ruta chalepensis*), a plant that is indigenous to Cyprus with medicinal properties that was known in Classical times (Michael 2005:223; Tsintides et al. 2002:248), a species in the *Haplophyllum* genus from Turkey (Ulubelen and Öztürk 2008:54-5, 58, 65).

This evidence suggests the presence of a fermented beverage, perhaps a beer or wine, that may included a plant species in the *Rutaceae* family as an additive.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.900</td>
<td>Butanoic acid, hexyl ester</td>
<td>C4:0, Butyric acid</td>
<td>Alkaloid-Alkaloid-Scraping B</td>
<td>12.0</td>
<td>25</td>
</tr>
<tr>
<td>2.901</td>
<td>dl-Malic disodium salt</td>
<td></td>
<td>Alkaloid-Alkaloid-Sherd B</td>
<td>12.0</td>
<td>27</td>
</tr>
<tr>
<td>2.906</td>
<td>Butanedioic acid, hydroxy-, (S)-</td>
<td>D-Malic acid</td>
<td>Alkaloid-Alkaloid-Sherd A</td>
<td>12.0</td>
<td>32</td>
</tr>
<tr>
<td>6.810/6.814</td>
<td>Pentadecanoic acid, 2,6,10,14-tetramethyl-, methyl ester</td>
<td>Pristanic acid</td>
<td>Alkaloid-Alkaloid-Scraping B/Scraping A</td>
<td>12.0</td>
<td>37/28</td>
</tr>
<tr>
<td>9.186</td>
<td>1,6;3,4-Dianhydro-2-deoxy-,beta-d-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid-Scraping B</td>
<td>12.0</td>
<td>36</td>
</tr>
<tr>
<td>9.639</td>
<td>2,3-Dihydrofuro(2,3-b)quinoline</td>
<td>Quinoline alkaloid?</td>
<td>Alkaloid-Alkaloid-Scraping A</td>
<td>12.0</td>
<td>38</td>
</tr>
</tbody>
</table>
The sherd was extracted and analyzed using both the alkaloid and lipid protocols. The latter yielded no results, while the former yielded only a series of alkanols that are widely distributed and therefore cannot easily be attributed to specific sources. There was no other indication of preserved residue.

The sherd was extracted using the alkaloid and sonication protocols and analyzed using the alkaloid and lipid methods. One compound was detected, the quinoline compound, Indolo[3,2-b]quinoline, 10-methyl-2-nitro-, which has been noted in a series of other samples and may represent a degradation compound of one or more alkaloids, but equally may represent an analytical artifact. It may be noted that no fatty acids were detected in the storage vessel, which might indicate the vessel was not used for the storage of olive oil.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
</table>
V.E.5.tt 62 R.007.62.2 (Black Polished Bowl Body)

The sherd was extracted with the alkaloid protocol and analyzed with the alkaloid and lipid methods. There was no indication of a preserved residue.

V.E.5.uu 63 R.007.76.3.2 (Red Polished Bowl Body)

The sherd was extracted and analyzed with the alkaloid and lipid protocols. The alkaloid extraction was run twice and is noted as A or B in the chart below. Both samples had a series of contaminants. One of these may be saccharin, which is an artificial sweeter, and which was identified in the first alkaloid sample. The quinoline alkaloid derivative, Indolo[3,2-b]quinoline, 10-methyl-2-nitro-, was identified in the lipid analysis and, as mentioned elsewhere, may represent an analytical artifact. Two other compounds were identified in the alkaloid extraction.

The first of these is the baker’s yeast compound that Fronza et al. (1987) have stated may be associated with fermentation. The second compound is strawberry furanone (2-Acetoxy-4-phenylhex-2-en-5-one), which has been reported in various substances including meats (beef, ham), malt, and a series of fruits (strawberry, grape, and raspberry) (http://www.thegoodscent.com/data/rw1000931.html). Together, the yeast compound and the furanone compound might suggest the presence of a fermented fruit juice other than grape, but the evidence is too limited to confirm this. It is possible that the saccharin identified at the low quality represents a sugar or carbohydrate compound that was altered in the fermentation process. However, this would need to be demonstrated experimentally.
<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.865</td>
<td>Saccharin</td>
<td>Contaminant?</td>
<td>Alkaloid-</td>
<td>11.0</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alkaloid-Sherd A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.555</td>
<td>2-Acetox-4-phenylhex-2-en-5-one</td>
<td>Strawberry furanone?</td>
<td>Alkaloid-</td>
<td>11.0</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alkaloid-Sherd B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.388</td>
<td>1,6;3,4-Dianhydro-2-deoxy-beta-d-lyxo-hexopyranose</td>
<td>Related to baker's yeast?</td>
<td>Alkaloid-</td>
<td>11.0</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alkaloid-Sherd B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abundance

Time->

48000 44000 40000 36000 32000 28000 24000 20000 16000 12000 8000 4000 2000 1000

2.865 Saccharin

7.388 Related to baker's yeast

Abundance

Time->

20000 19000 18000 17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000

6.555 Strawberry furanone?

Abundance

Time->

20000 19000 18000 17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000

7.388 Related to baker's yeast

Abundance

Time->

20000 19000 18000 17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000

6.555 Strawberry furanone?
V.E.5.vv  64 R.007.76.3.3 (Red Polished Bowl Body)

The sample was analyzed using the lipid protocol. There were numerous contaminants with no indication of preserved residue.

V.E.5.ww  65 R.014.61.3 (Cooking Pot with a Button Base)

The sample was analyzed using the lipid protocol. There was no evidence of preserved residue.

V.E.5.xx  66 R.015.101.3 (Red Polished Bowl Body)

The sample was analyzed using the lipid protocol. There were numerous contaminants with no indication of preserved residue.
V.E.5.\textit{yy} 67 R.015.101.3 (Red Polished Incised Bowl)

The sherd was extracted using the alkaloid protocol and analyzed using both the alkaloid and lipid methods. The only compound present in the sample is the quinoline alkaloid derivative, Indolo[3,2-b]quinoline, 10-methyl-2-nitro-, as mentioned elsewhere, may represent an analytical artifact. Other than a series of contaminants there was no other indication of preserved residue.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
</table>

V.E.5.\textit{zz} 68 R.022.108.6 (Black Polished Decorated Juglet Base)

The sherd was extracted and analyzed using the alkaloid and lipid protocols. As with PT67, the quinoline compound, Indolo[3,2-b]quinoline, 10-methyl-2-nitro, was identified, the source of which is presently unknown. It may be noted that no fatty acids were detected in the storage vessel, which might indicate the vessel was not used for the storage of olive oil.

It should be noted at this stage that the series of vessels from which only sherds were collected had been stored in plastic bags in a storehouse over two years. It may be noteworthy that there is limited or no evidence of a preserved residue in these samples – more so than in the rest of the sample set. Thus, it should be stated potential items of interest should be set aside and stored in a different fashion to avoid contamination and further degradation of ancient residue.
V.E.5.aaa  69 S.011.76.231.2 (Red Polished Coarse Ware Basin)

The sherd was extracted using the sonication protocol and analyzed using the alkaloid and lipid methods. Two compounds were identified that were not contaminants or alkanes and other compounds that have wide distributions and which therefore a source cannot be identified. The first compound, 1-Cyclohexene-1-methanol, was identified at 11.077 minutes with a quality of 50.

The compound is likely a fragment of perillyl alcohol ((4S)-4-(1-methylethenyl)-1-Cyclohexene-1-methanol), which is a minor constituent in thyme and cardamom (Chempakam and Sindhu 2008:44; Lee et al. 2005:135:). A related compound, perillaldehyde, is a constituent in caraway (Iacobellis et al. 2005:59).

The second compound, 2-Butynedioic acid, di-2-propenyl ester, was identified at 11.935 minutes at a quality of 33 and is fumaric acid, which may be the result of a chemical degradation of succinic acid, but may equally be involved in the degradation of adipose fat or simply be a contaminant (Gardner and Flett 2000:180, 187-8). The limited results of organic residue is not surprising since these basins or pans are suggested to have functioned as mealing bins, in which grains and other subsistence products were ground or dried (Webb et al. 2007; Swiny 2003:18). However, the chemical data is insufficient to identify the type of product that would have been processed in or on the basin.
V.E.5.bbb  70 W.011.108.83 (Red Polished Footed Closed Body)

The sherd was extracted using the alkaloid protocol and analyzed using both the alkaloid and lipid methods. Nothing was detected in the lipid analysis. There were, however, eight compounds identified in the alkaloid run. The first of these, Salicylic acid, was identified at 5.697 minutes with a quality of 53.

Aspirin is known as acetylsalicylic acid and therefore potentially a source of contamination, but the compound was originally derived from the bark of the white willow tree (Salix alba), a species that is indigenous to the island of Cyprus (Lopez 2011:5; McCurdy and Scully 2005:477; Parry 1922:297; Tsintides et al. 2002:104). The compound is also found in anise (Pimpinella anisum), royal jelly, and buckwheat (Fagopyrum esculentum) (Janeš and Kreft 2008:293, 295-6; Reichling et al. 2005:92), but there is no other evidence that points to these sources.

The second compound, 7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-, was identified at 8.734 and 9.199 minutes at respective qualities of 25 and 32. It is likely a fragment of alpha-bisabolol (4-[(1Z)-1,5-Dimethyl-1,4-hexadienyl]-1-methyl-7-oxabicyclo[4.1.0]heptane), which was
identified in reference samples of thyme and pink rockrose, which were obtained from Cyprus, as well as reference samples of wormwood (Artemisia) and henbane seeds (Hyoscyamus). In addition, bisabolene was first isolated from the essential oil obtained from sweet or bisabol myrrh from which the compound derives its name (Parry 1922:81-2). The plant from which this resin was obtained, Opopanax opopanax, was described by Pliny (Nat. Hist. 12.57) as being a major ingredient in unguents. Brun (2000:278) in his discussion of the production of ancient perfumes also notes the use of opopanax in scented oils stored in the Assyrian palace at Mari in the 18th century B.C., along with myrtle, cypress, odoriferous reed, galbanum, storax, and labdanum. However, it is unclear whether there would have been a source of this resin available in the Cypriot flora. It may also be noted that both alpha-((1,5-dimethyl-1,4-hexadienyl)-1-methyl cyclohexene) and beta-bisabolene (Cyclohexene, 1-methyl-4-(5-methyl-1-methylene-4-hexenyl))-were identified in germander, basil, thyme and oregano, but the relationship between these two compounds and alpha-bisabolol is unclear (De Martino et al. 2009:2737; Lee et al. 2005:134; Vukovic et al. 2007:18-19).

The compound camphenilone (Bicyclo[2.2.1]heptan-2-ol, 3,3-dimethyl-, exo-,), which is also present in the sample, has been reported in labdanum (the resin of rockrose), wormwood, lavender, and a species of thyme from the southern Mediterranean (Imelouane et al. 2009:207; http://www.thegoodscentcompany.com/data/rw1487721.html). Citronellyl isovalerate was also present in the sample and is a known constituent of valerian (Valerian officinalis), a medicinal plant with known sedative effects (Bowles 2003: 196, 198; Lopez 2011:5). This compound may also represent a degradation variation of citronellol (6-Octen-1-ol, 3,7-dimethyl-, acetate), is a constituent in lemon balm and rose.

Further suggesting the presence of aromatic plants is geranyl linalool (1,6,10,14-Hexadecatetraen-3-ol, 3, 7,11,15-tetramethyl-, (E,E)-), which was detected at a quality of 50. The compound is likely an intermediary compound in the transformation of one of two structurally similar compounds: geraniol and linalool. As noted in the discussion of two small Red Polished spouts (samples 1 and 14) and a Red Polised closed vessel (sample 37) from Politiko Troullia, geranyl linalool may indicate the presence of honey (Bertsch et al. 2004:701). The compound
may also be related to geraniol, geranyl acetate, or linalool, which are found in a wide variety of plants. In this case, he most likely source of the compound is coriander, rose, sage, myrtle, or lavender. The potential presence of coriander, rose or sage in conjunction with a perfume fixative may be intriguing since oils perfumed with the scent of coriander, rose and sage are documented in texts from Pylos and Knossos (Brun 2000:281; Shelmerdine 1985:18, 21-25).

Similar to linalool, caryophyllene oxide (5-Oxatricyclo[8.2.0.0(4,6)]dodecane, 4,12,12-trimethyl-9-methylene-, [1R-(1R*,4R*,6R*,10S*)]–), and its related compounds (alpha- and beta caryophyllene) have a somewhat wide distribution. The compound itself was identified at 9.799 minutes with a quality of 37 and is a major constituent in species of *Artemisia* (*A. spicigera, santonicum, and absintium*), fig leaves, oregano and *Phlomis* sage. It is also a minor constituent in black poplar buds, and white wormwood (*A. herba*) (Alves-Pereira and Fernandes-Ferreira 1998:795-6; Amor et al. 2009:183, 88-9; Isidorov and Vinogorova 2003:357; Kordali et al. 2005:1408, 1410, 1412; Muanda et al. 2010:153; Nezhadali et al. 2008:560; Wesolowska et al. 2011:173). Alpha- or beta-caryophyllene are constituents in everlasting, juniper berries, various species of lavender, germander, peppermint, basil, thyme, savory, sweet marjoram, and a major constituent in Aleppo pine (*Pinus halepensis*) (Bowles 2003:94-98; Daferera et al. 2000:2577-8; de Martino et al. 2009:2737; Roussis et al. 1995:359; Vukovic et al. 2007:17, 19). In addition, one of these three compounds were identified in reference samples of lavender, wormwood, as well as thyme, pink rockrose, and bay leaf from Cyprus. It may also be added that beta-caryophyllene is a known fungitoxin, making plants with this constituent a useful fumigant (Kordali et al. 2005:1408, 1410, 1412).

The final compound identified in the sample was farnesol (2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-), which was identified at 11.915 minutes at a quality of 53 and is a known constituent of rose oil (Bowles 2003:71-2; Rusanov et al. 2011:2212). It is also minor constituent in white wormwood (*Artemisia herba*), and coriander (Nezhadali et al. 2008:560; Wesolowska et al. 2011:173; Zhou et al. 2011). A related compound, farnesene (beta isomer) is a constituent in chamomile, species of *Phlomis* sage, caper flowers, juniper berries, and germander (Amor et al.
2009:183, 88-9; Bowles 2003:57-8, 60-2; Romeo et al. 2007:1277; Tsinites et al. 2002:353, 356; Vukovic et al. 2007:19). The alpha isomer was also identified in a reference sample of wormwood.

Based on the above discussion, the substance contained in this footed vessel seems to be an aromatic substance that likely contained a combination of the following ingredients: thyme, a species of *Artemisia* (perhaps white wormwood), lavender, lemon balm, germander and pink rockrose or its resin (labdanum). The mixture may have included a tree resin (white willow or Aleppo pine). The presence of the pink rockrose in conjunction with various aromatic herbs might indicate that the mixture was a perfume, but it is also possible that if functioned as a medicine.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.697</td>
<td>Salicylic Acid</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>8.734</td>
<td>Cyclopentaneethanol, .beta.,2,3-trimethyl-/7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-</td>
<td>Related to alpha-bisabolol?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>25/25</td>
</tr>
<tr>
<td>9.199</td>
<td>7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-</td>
<td>Related to alpha-bisabolol?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>32</td>
</tr>
<tr>
<td>9.483, 10.925</td>
<td>Bicyclo[2.2.1]heptan-2-ol, 3,3-dimethyl-,exo-</td>
<td>Camphenilone</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>27/35</td>
</tr>
<tr>
<td>9.499</td>
<td>Butanoic acid, 3-methyl-, 3,7-dimethyl-6-octenyl ester</td>
<td>Citronellyl iso-valerate</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>38</td>
</tr>
<tr>
<td>9.623</td>
<td>2,3-Dihydrofuro[2,3-b]quinoline</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>9.779</td>
<td>Caryophyllene oxide</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>11.915</td>
<td>2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-</td>
<td>Trans-farnesol</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>53</td>
</tr>
<tr>
<td>12.480</td>
<td>1,6,10,14-Hexadecatetraen-3-ol, 3, 7,11,15-tetramethyl-, (E,E)-Geranyl linalool</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>

Abundance

```
```

![Graph showing compound identification and abundance]
The sherd was extracted using the alkaloid protocol and analyzed using both the alkaloid and lipid methods. There was only one compound identified in the latter. This compound, Indolo[3,2-b]quinoline, 10-methyl-2-nitro-, has been identified in a series of other samples. It may be an analytical artifact or may represent a derivative of a quinoline alkaloid.

The same is true for the 2,3-Dihydrofuro(2,3-b)quinoline, which may equally be a contaminant or a fragment of alkaloids found in fringed rue or a species of *Haplophyllum* (Tsintides et al. 2002:248; Ulubelen and Öztürk 2008:54-5, 58, 65).

Four additional compounds were identified in the alkaloid analysis. Cyclohexanemethanol was identified at 9.364 minutes at a quality of 12. While the compound was identified in a reference sample of wormwood, it may be a fragment of elemol (Cyclohexanemethanol, 4-ethenyl-α,α,4-trimethyl-3-(1-methylene)-, [1r-(1α,3α,4β)], which was identified in a reference sample of hyssop. A further fragment, Cyclohexanemethanol, 4-methylene-, was identified in henbane seeds. Elemol, a sesquiterpene alcohol (Parry 1922:157), is also a constituent in rose (Rusanov et al. 2011:2215), a species of torchwood (*Amyris balsamifera*) (Rohmer et al. 1977), a minor constituent in thyme (Lee et al. 2005:134; Sáez 1995:822), *Santolina oblongifolia* (Teixeira da Silva 2004:706-7), wormseed (*Artemisia santonicum*) (Kordali et al. 2005:1412), Aleppo and other pine needles (Petakis et al. 1994:359), as well bay leaf (Parthasarathy et al. 2008:428). However, the compound was not identified in the reference sample of Cypriot bay leaf.

As noted in the discussion of the Red Polished Black-Topped bottle (sample 8) from Sotira *Kaminoudhia* and the Red Polished Closed vessel (sample 15) from Politiko *Troullia*, elemol transforms into one of three isomers of elemene (Parry (1922:157). As such, there is a long list of possible plants from which the compound may have derived, including rose, yarrow, a species of wormwood, a species of *Sideritis*, henbane seeds, pink rockrose from Cyprus, myrrh,
black currants, two species of fir, oregano, basil, juniper berries, coriander as well as a species of woundwort that also has beta-ionone (Alves-Pereira and Fernandes-Ferreira 1998:796; Bowles 2003:25-6, 256; De Martino et al. 2009:2738; Dev et al. 2011:203; Grandi et al. 1972; Gumusc et al. 2011; Kordali et al. 2005:141; Le Quere and Latrasse 1990:3; Rusanov et al. 2011:2215; Senatore et al. 2007:135, 137; Smedman et al. 1969:1471, 1474-5; Zhou et al. 2011:32). Two related compounds, citronellol acetate (6-Octen-1-ol, 3,7-dimethyl-, acetate) and citronellyl isovalerate (Butanoic acid, 3-methyl-, 3,7-dimethyl-6-octenyl ester) were identified. They are likely related to the monoterpene citronellol, which is a major constituent in a number of rose varieties and readily transforms into rhodinol, another constituent of rose (Bowles 2003:71; Joffre 1954; Rusanov et al. 2011:2211-3). Other potential sources include basil, thyme, and a reference sample of lemon balm (Lee et al. 2005:134; Sáez 1995:822; Wesolowska et al. 2011:173). Citronellyl isovalerate was also present in the sample and is a known constituent of valerian (Valerian officinalis) (Bowles 2003: 196, 198; Lopez 2011:5).

Like in the last sample, farnesol (2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-), which was identified at 11.915 minutes at a quality of 53 and is a known constituent of rose oil (Bowles 2003:71-2; Rusanov et al. 2011:2212). It is also minor constituent in white wormwood (Artemisia herba), and coriander (Nezhadali et al. 2008:560; Wesolowska et al. 2011:173; Zhou et al. 2011). A related compound, farnesene (beta isomer) is a constituent in chamomile, species of Phlomis sage, caper flowers, juniper berries, and germander (Amor et al. 2009:183, 88-9; Bowles 2003:57-8, 60-2; Romeo et al. 2007:1277; Tsinites et al 2002:353, 356; Vukovic et al. 2007:19). The alpha isomer was also identified in a reference sample of wormwood.

The final compound to be identified in the sample is cis-Z-alpha-Bisabolene epoxide, which occurred at 10.875 minutes with a quality of 25. As noted in PT70, alpha-bisabolene was identified in reference samples of thyme and pink rockrose, which were obtained from Cyprus, as well as reference samples of wormwood (Artemisia) and henbane seeds (Hyoscyamus). Bisabolene was initially isolated from sweet myrrh, the resin of which was used as a major ingredient in the production of unguents in antiquity (Parry 1922:81-2; Pliny Nat. Hist. 12.57). In addition, both alpha-(-(1,5-dimethyl-1,4-hexadienyl)-1-methyl cyclohexene) and beta-bisabolene
(Cyclohexene, 1-methyl-4-(5-methyl-1-methylene-4-hexenyl)-) were identified in germander, basil, thyme and oregano (De Martino et al. 2009:2737; Lee et al. 2005:134; Vukovic et al. 2007:18-19).

Overall it seems that the vessel contained a perfumed substance the primary ingredient of which was likely rose. Additional ingredients may have included thyme, a species of Artemisia, lemon balm, basil or germander. If a species Haplophyllum or fringed rue was included, then the mixture may also have had medicinal applications.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound</th>
<th>Identification</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.364</td>
<td>Cyclohexanemethanol</td>
<td>Fragment of elemol?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>12</td>
</tr>
<tr>
<td>9.625</td>
<td>2,3-Dihydrofuro(2,3-b)quinoline</td>
<td>Quinoline alkaloid derivative?</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>47</td>
</tr>
<tr>
<td>9.741</td>
<td>3-Eicosene, (E) / 6-Octen-1-ol, 3,7-dimethyl-, acetate</td>
<td>Citronellol acetate</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>37/37</td>
</tr>
<tr>
<td>10.875</td>
<td>cis-Z.,alpha.-Bisabolene epoxide</td>
<td></td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>25</td>
</tr>
<tr>
<td>11.600</td>
<td>Butanoic acid, 3-methyl-, 3,7-dimethyl-6-octenyl ester</td>
<td>Citronellyl isovalerate</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>22</td>
</tr>
<tr>
<td>11.924</td>
<td>1,6,10,14-Hexadecatetraen-3-ol, 3,7,11,15-tetramethyl-, (E,E)</td>
<td>Trans-farnesol/</td>
<td>Alkaloid-Alkaloid-Sherd</td>
<td>12.0</td>
<td>23</td>
</tr>
</tbody>
</table>

![Abundance graph](image)
V.E.5.ddd 72 Y.024.156.4 (Red Polished Juglet Base)

The sherd was extracted using the lipid protocol. There was no indication of a preserved residue.

V.E.5.eee 73 Y.024.156.1 (Storage vessel body fragment with attrition)

Three sherds were collected from a storage vessel embedded in a foundation wall. The first sherd was obtained from the body of the vessel which showed some attrition. Arthur (2003:522) observed attrition on the interior of jars used in the beer production. This first sherd was extracted using the alkaloid and lipid protocols and analyzed using the alkaloid and lipid methods. There was no evidence of preserved residue.

V.E.5.fff 73 Y.024.156.2 (Storage vessel body fragment with carbon residue)

The second sherd was collected from a section of the body that exhibited a carbon residue. This sample was extracted and analyzed using the lipid protocol. There were no results from this sherd either.
V.E.5.ggg    73 Y.024.156.3 (Storage vessel base fragment)

The third sherd was collected from the pointed base of the storage vessel. This sample was extracted and analyzed using the lipid protocol. There were no results from this sherd either.
VI.A. MUSEUM SAMPLES

VI.A. Background

In addition to samples from five stratified sites, twelve samples from three museum collections were also analyzed. These samples are from the Jane Barlow and Belcher Collections held at the State University of New York at Albany and the Cypriot and Cesnola Collection held at the Semitic Museum at Harvard University. The samples from the former were analyzed with the permission of Stuart Swiny and the latter with the permission of Joseph Greene, the museum Assistant Director, Adam Aja, the Assistant Curator of Collections, and Helena Wylde Swiny, the Curator of the Cypriot and Cesnola Collection. All samples are from unstratified contexts and, therefore, have limited contextual information regarding their use.

VI.B. SAMPLES

All of the samples from the Jane Barlow Collection and from the Semitic Museum were submitted for destructive analysis and included three Base Ring I sherds, two Base Ring II sherds, and one White Painted sherd. The samples from the Belcher collection were either sherds that underwent destructive analysis or whole vessels from which drillings from the base of these vessels were obtained. The former included two Base Ring II sherd and the latter, two White Painted juglets, one Red Polished juglet, and one Black Polished flask. These samples were selected because they represent known Bronze Age types which are comparable to the material obtained from stratified contexts.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Collection</th>
<th>Fragment Description</th>
<th>Catalog Reference/Proposed Provenience</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC5</td>
<td>Belcher Collection, University at Albany</td>
<td>Red Polished Gourd Juglet with lime-filled incised decoration</td>
<td><a href="http://www.albany.edu/cyprus/catalog/data/bc005.html">http://www.albany.edu/cyprus/catalog/data/bc005.html</a></td>
</tr>
<tr>
<td>BC18</td>
<td>Belcher Collection, University at Albany</td>
<td>White Painted III-IV Stringhole Juglet with painted decoration</td>
<td><a href="http://www.albany.edu/cyprus/catalog/data/bc018.html">http://www.albany.edu/cyprus/catalog/data/bc018.html</a></td>
</tr>
</tbody>
</table>
VI.C. METHODOLOGY

All samples underwent one of two organic extraction procedures followed by analysis by Gas Chromatography/Mass Spectrometry using one of two programs. These procedures were detailed in the previous chapter as the Alkaloid and Lipid protocols. The GC parameters that were used were the alkaloid (12.67 minutes) and the lipid (45.67 minutes) methods. Samples were generally run in SCAN mode. When possible, they were also analyzed in SIM mode, targeting the following compounds: codeine, hydrocotamine, meconic acid, morphine, noscapine, papaverine, and thebaine.

VI.D. SUMMARY OF RESULTS

1) BC 5, Red Polished Gourd Juglet (Belcher Collection)

The vessel contains a single, short-chain fatty acid compound that may be related to fermentation, but this is insufficient to suggest the presence of fermented beverage.
2) **BC11, Black Polished Flask (Belcher Collection)**
   The vessel contains a single compound that is related to fermentation, but this is insufficient to suggest the presence of fermented beverage.

3) **BC18, White Painted III-IV Stringhole Juglet (Belcher Collection)**
   The ornately decorated juglet likely contained a plant oil (other than olive oil) that have derived from or included carob or geranium as ingredients. Due to the lack of other compounds with a more limited distribution, a variety of other products are also possible.

4) **BC20, White Painted V Trough Spouted Juglet (Belcher Collection)**
   A preserved residue was not detected.

5) **BC64, Base Ring II Sherd (Belcher Collection)**
   Both compounds detected in this sample (Phenobarbital and Ribitol, pentaacetate) are likely due to contamination, rather than associated with a preserved residue.

6) **160.EAI.12, Base Ring II Sherd (Belcher Collection)**
   The vessel may have contained a plant oil, perhaps deriving from geranium. Additional chemical data are required to identify the specific plant source.

7) **130.DK.5, Base Ring II sherd (Barlow Collection)**
   Similar to BC18, this vessel likely contained a plant oil that derived from a plant other than olive. In this case, the oil may have derived from caraway.

8) **151.DK.1, Base Ring II sherd (Barlow Collection)**
   The vessel contains a single compound that is related to fermentation, but this is may be insufficient to suggest the presence of fermented beverage due to the fact that the same
compound has been identified in numerous other samples and therefore may represent an analytical artifact.

9) 1995.10.543, Base Ring I Sherd (Semitic Museum)
A preserved residue was not detected.

10) 1995.10.1329a, Base Ring I Sherd (Semitic Museum)
A preserved residue was not detected.

11) 1995.10.1331a, White Painted Sherd (Semitic Museum)
The vessel contains a single compound that is related to fermentation, but this is may be insufficient to suggest the presence of fermented beverage.

12) 1995.10.1329a, Base Ring I Sherd (Semitic Museum)
It is unclear whether or not a preserved residue is indicated.
VI.E. ANALYTICAL DATA

VI.E.1. Belcher Collection

VI.E.1.a. BC 5, Red Polished Gourd Juglet

The sample was extracted with the lipid protocol and analyzed with the lipid method. A series of contaminants were identified with only one compound, Butanoic acid, butyl ester, that may be indicative of a preserved residue. The compound is a small chain fatty acid that has a wide distribution. It may be related to fermentation, but in the absence of any other evidence it may equally be the result of contamination (Hoffmann and Heiden 2000:4-6).

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.674</td>
<td>Butanoic acid, butyl ester</td>
<td>C4:0</td>
<td>Lipid-Lipid</td>
<td>12.0</td>
<td>74</td>
</tr>
</tbody>
</table>

http://www.albany.edu/cyprus/catalog/data/bc005.html.
VI.E.1.b. BC11, Black Polished Flask

The sample was extracted with the alkaloid extraction and analyzed with the alkaloid method. As with the previous sample, there were a number of contaminants and nondescript alkanes present. There was however one peak that may be associated with a preserved residue. This peak may represent one of two compounds: Isobutyric acid, hexyl ester (Propanoic acid, 2-methyl-, hexyl ester) or the same short chain fatty acid identified in the previous sample (C4:0, Butanoic acid). The former may indicate the presence of a fermented beverage. Based on the fact that the compound plays a role in fermentation and is present in modern red and white wines and vinegars (Ferriera et al. 2002:4048-50; Guth 1997:3027; Lambert 1997:37; Rocha et al. 2004:257-8).

Alternatively, the compound has also been identified in samples of propolis, a plant-based resinous substance collected by bees and used to seal their hives (Marcucci 1994:83-7). The latter compound may be related to this compound. However, because it is only indication of preserved residue, the suggestion of a fermented beverage should be taken with caution.

The alkaloid sample was also analyzed in SIM mode, targeting morphine, papaverine and hydrocotamine with no matches. The lipid extraction of the sample likewise indicated no preserved residue.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.491</td>
<td>Propanoic acid, 2-methyl-, hexyl ester/ Butanoic acid, butyl ester/</td>
<td>Isobutyric acid, hexyl ester C4:0/</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>78/78</td>
</tr>
</tbody>
</table>

103 http://www.albany.edu/cyprus/catalog/data/bc009-10-11.html
VI.E.1.c. BC18, White Painted III-IV Stringhole Juglet

The sample was extracted with the alkaloid and lipid protocols and analyzed with the alkaloid and lipid methods. The alkaloid extraction was also analyzed in SIM mode, targeting meconic acid, noscapine, papaverine, hydrocotamine and thebaine. Only the lipid extraction showed any results. Three fatty acids were detected in the sample: stearic acid (C18, octadecanoic acid\(^\text{105}\)), palmitic acid (C16:0, hexadecanoic acid), and pelargonic acid (C9, nonanoic acid). Fatty acids generally have a wide distribution. It may be noted that pelargonic acid is a natural constituent in plants in the genus *Pelargonium*.

The stearic and palmitic acids have a wider distribution, occurring in various vegetable oils and animal fats (Beeston et al. 2006; Lalli 2005:311-2; www.lipomics.com). Palmitic acid was

\(^{104}\) http://www.albany.edu/cyprus/catalog/data/bc018.html

\(^{105}\) It should be noted that methyl isostearate was identified at a slightly higher quality, but the compound is related and therefore the stearic acid identification is retained (http://webbook.nist.gov/cgi/cbook.cgi?ID=C5129613&Units=Sf).
identified in reference samples of carob, olive oil, myrtle, pink and white rockrose, and thyme, all of which were obtained from Cyprus, as well as hyssop and wormwood. Stearic acid was identified in reference samples of carob and olive oil.

No other compounds that could narrow the range were present. However, it should be noted that Oleic acid (9-octadecanoic acid) was absent, as was linoleic acid (9, 12, 15-octadecatrienoic acid). Both of these compounds are found in high concentrations in olive oil, which may eliminate olive derived oil as a constituent. Carob or geranium (Pelargonium) oil is a possibility, but in the absence of additional chemical data, a specific identification cannot be made. It should be noted that a food product is also a possibility.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.185,</td>
<td>Nonanoic acid, methyl ester</td>
<td>C9:0, Pelargonic acid</td>
<td>Lipid-Lipid</td>
<td>12.0</td>
</tr>
<tr>
<td>10.482</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.868</td>
<td>Hexadecanoic acid, methyl ester</td>
<td>C16:0, Palmitic acid</td>
<td>Lipid-Lipid</td>
<td>12.0</td>
</tr>
<tr>
<td>13.145</td>
<td>Heptadecanoic acid, 16-methyl, methyl ester/</td>
<td>Methyl isostearate</td>
<td>Lipid-Lipid</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>Octadecanoic acid, methyl ester</td>
<td>C18:0, Stearic acid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abundance

Belcher Collection
BC18 White Painted III-IV
Stringhole Juglet
Lipid-Lipid
VI.E.1.d. **BC20, White Painted V Trough Spouted Juglet**\(^{106}\)

The sample was extracted using the alkaloid protocol and analyzed using both alkaloid and lipid methods. There was no indication of preserved residue. In addition, the alkaloid sample was analyzed in SIM mode, targeting codeine, hydrocotamine, meconic acid, morphine, noscapine, papaverine, and thebaine, with no matches.

---

VI.E.1.e. **BC64, Base Ring II Sherd**\(^{107}\)

The sample was extracted and analyzed with the alkaloid method, which showed contamination by plastics and inks, as well as the presence of a few nondescript fatty alcohols. Two compounds deserve further discussion. The first is the peak at 5.621, which is either Phenobarbital or what appears to be a derivative of cinnamic acid (2-Propenoic acid, 2-cyano-3-(3-phenylphenyl)-, ethyl) (http://webbook.nist.gov/cgi/cbook.cgi?ID=C103537). Neither of these compounds can be attributed to a natural source that might indicate preserved residue. The same is probably true for the second peak, which indicates the presence of ribitol, pentaacetate at 7.017 minutes.

While the former is intriguing because it is a drug compound, its presence is most readily explained by the fact that the sherd was in a teaching collection that was handled by numerous individuals over a number of years.

---


\(^{107}\) Original image for the samples were lost, but is similar to the other Base Ring II sherds in the sample set.
<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.621</td>
<td>Phenobarbital/2-Propenoic acid, 2-cyano-3-(3-phenylphenyl)-, ethyl ester</td>
<td>Cinnamic acid derivative or contaminant?</td>
<td>Alkaloid-Alkaloid</td>
<td>13.0</td>
<td>30/30</td>
</tr>
<tr>
<td>7.017</td>
<td>Ribitol, pentaacetate</td>
<td>Alkaloid-Alkaloid</td>
<td></td>
<td></td>
<td>23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.481</td>
<td>Nonanoic acid</td>
<td>C9:0, Pelargonic acid</td>
<td>Lipid-Lipid</td>
<td>12.0</td>
<td>64</td>
</tr>
<tr>
<td>11.873</td>
<td>Decanoic acid</td>
<td>C10:0, Capric acid</td>
<td>Lipid-Lipid</td>
<td>12.0</td>
<td>78</td>
</tr>
</tbody>
</table>

VI.E.1.f. 160.EAI.12, Base Ring II Sherd

The sample was extracted with the alkaloid and lipid protocols and analyzed with the alkaloid and lipid methods. Both samples showed extensive contamination with no indication of preserved residue in the alkaloid extraction. The lipid extraction, however, showed the presence of two small-chain fatty acids, both of which have a wide distribution. However, C9:0 (Pelargonic acid) was noted above to be found in plants in the *Pelargonium* genus. C10:0 (Capric acid) (Beeston et al. 2006; Lalli 2005:311-2; www.lipomics.com; Romeo et al. 2007:1272).

While a plant oil is suggested, the source of that oil is uncertain.
VI.E.2. Barlow Collection

VI.E.2.a. 130.DK.5, Base Ring II sherd\textsuperscript{108}

The sample was extracted using the alkaloid and lipid protocols and was analyzed using the alkaloid and lipid methods, respectively. Numerous contaminants were present in the samples, as well as a series of nondescript alkanes and alkanols. No other compounds indicative of a preserved residue were present in the alkaloid extraction. In the lipid extraction, four fatty acids were identified: C8:0 (Octanoic acid), C9:0 Pelargonic acid (Nonanoic acid), C13:0 (Tridecanoic acid), and C16:0 Palmitic acid (Hexadecanoic acid). C8:0 is a short chain fatty acid that has a wide distribution, but which in this case likely represents the fragmentation of another compound. As mentioned above, C9:0 Pelargonic acid is a natural constituent in plants in the genus \textit{Pelargonium}. Tridecanoic acid does not frequently appear in archaeological samples and is not utilized in determining the botanical or faunal source of lipids. The same is likely true for undecanoic acid. C16:0, Palmitic acid has a wider distribution in various vegetable oils and animal fats, but has been identified in a series of reference samples, including carob bean, olive oil, myrtle, pink and white rockrose, thyme, hyssop and wormwood (Eerkens 2005:92-6; Malainey et al. 1999:102). As noted elsewhere, the absence of oleic and

\textsuperscript{108} Original image for both Barlow Collection samples were lost, but were similar to the sherd from Enkomi.
Linoleic acids may suggest that an oil that derived from a plant other than the olive may be indicated. A final compound, trans-tetagetone (5,7-Octadien-4-one, 2,6-dimethyl-(Z)), was identified in the sample at 5.432 minutes. The compound is a constituent in caraway seeds (Iacobellis et al. 2005) and tansy (Tanacetrum vulgare) (Hethelyi et al. 1987). Caraway oil may be indicated in this case due to the presence of octanoic acid and palmitic acid (Azeez 2008a:217-8). While perhaps due to preservation, none of the essential oil compounds typically found in caraway were identified.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.115</td>
<td>Octanoic acid, methyl ester</td>
<td>C8:0</td>
<td>Lipid-Lipid</td>
<td>12.5</td>
<td>83</td>
</tr>
<tr>
<td>5.432</td>
<td>5,7-Octadien-4-one, 2,6-dimethyl-(Z)</td>
<td>Trans-Tagetone</td>
<td>Lipid-Lipid</td>
<td>12.5</td>
<td>37</td>
</tr>
<tr>
<td>6.184</td>
<td>Nonanoic acid, methyl ester/Decanoic acid, 2-methyl/Undecanoic acid, 2-methyl-</td>
<td>C9:0, Pelargonic acid</td>
<td>Lipid-Lipid</td>
<td>12.5</td>
<td>78/78/78</td>
</tr>
<tr>
<td>7.175</td>
<td>Undecanoic acid, 2-methyl-</td>
<td>Lipid-Lipid</td>
<td>12.5</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>10.471</td>
<td>Tridecanoic acid, methyl ester</td>
<td>C13:0</td>
<td>Lipid-Lipid</td>
<td>12.5</td>
<td>74</td>
</tr>
<tr>
<td>11.867</td>
<td>Hexadecanoic acid, methyl ester</td>
<td>C16:0, Palmitic acid</td>
<td>Lipid-Lipid</td>
<td>12.5</td>
<td>90</td>
</tr>
</tbody>
</table>

VI.E.2.b. 151.DK.1, Base Ring II Juglet Sherd

The sample was extracted using the alkaloid and lipid protocols and was analyzed using the alkaloid and lipid methods, respectively. Numerous contaminants were present in the samples, as well as a series of nondescript alkanes and alkanols. No compounds indicative of a preserved
residue were present in the lipid extraction. In the alkaloid extraction, one compound, 1,6;3,4-
Dianhydro-2-deoxy-.beta.-d-lyxo-hexopyranose, that is likely related to baker’s yeast was
identified at four different retention times. These may represent slight variations of the compound
that could not be differentiated by the spectral library. According to Fronza et al. (1987), this
compound is a carbohydrate associated with the fermentation action of baker’s yeast. This might
suggest the presence of beer, but other biomarkers, such as beerstone, were absent (McGovern

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.987, 4.578, 7.240, 9.765</td>
<td>1,6;3,4-Dianhydro-2-deoxy-.beta.-d-lyxo-hexopyranose</td>
<td>Related to baker’s yeast?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>38/38/47/32</td>
</tr>
<tr>
<td>8.138</td>
<td>Maleamic acid</td>
<td>Contaminant?</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>38</td>
</tr>
</tbody>
</table>

Barlow Collection
151.DK.1 Dhal Kalkalia
Base Ring II Juglet
Alkaloid-Alkaloid

Abundance

Time→
VI.E.3.  Semitic Museum

VI.E.3.a.  1995.10.543, Base Ring I Sherd

The sample was extracted using the alkaloid and lipid protocols and analyzed using the alkaloid and lipid methods, respectively. The alkaloid sample was also analyzed in SIM mode, targeting codeine, hydrocotarnine, morphine, papaverine, and thebaine. There was no indication of a preserved residue.

VI.E.3.b.  1995.10.1329a, Base Ring I Sherd

The sample was extracted and analyzed with the alkaloid protocol and method. In addition, the sample was analyzed in SIM mode, in which morphine, papaverine, noscapine and thebaine were targeted. There was no indication of a preserved residue.

VI.E.3.c.  1995.10.1331a, White Painted Sherd

The sample was extracted with the alkaloid method and analyzed with the alkaloid protocol. The sample was also analyzed in SIM mode, targeting morphine, noscapine, papaverine and thebaine.

All analyses showed extensive contamination with only one compound, Isobutyric acid, hexyl ester (Propanoic acid, 2-methyl-, hexyl ester) being detected that may be indicative of a preserved residue. Based on the fact that the compound plays a role in fermentation and is present in modern red and white wines and vinegars, a fermented beverage may be indicated (Ferriera et al. 2002:4048-50; Guth 1997:3027; Lambert 1997:37; Rocha et al. 2004:257-8). Alternatively, the compound has also been identified in samples of propolis (Marcucci 1994:83-7).
However, being the only compound identified in the sample, any suggestion of a fermented beverage should be taken with caution.

<table>
<thead>
<tr>
<th>RT</th>
<th>Compound Identified</th>
<th>Match</th>
<th>Protocol</th>
<th>Integration Threshold</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.496</td>
<td>Propanoic acid, 2-methyl-, hexyl ester</td>
<td>Isobutyric acid, hexyl ester</td>
<td>Alkaloid-Alkaloid</td>
<td>12.0</td>
<td>59</td>
</tr>
</tbody>
</table>

**Abundance**

![Abundance Graph]

**VI.E.3.d. 1995.10.1332, Base Ring I Juglet**

The sample was extracted with the alkaloid method and analyzed with the alkaloid protocol. The sample was also analyzed in SIM mode, targeting codeine, morphine, noscapine, papaverine and thebaine. All analyses showed extensive contamination with no indication of preserved residue.
VII. SUMMATIONS, OBSERVATIONS, AND PROBLEMS

Having detailed the chemical analysis and interpretation of various pottery containers from both museum collections and stratified contexts that span the Cypriot Bronze in Chapters V and VI, I will now summarize my analytical findings according to sample set and product type, highlight any underlying issues or problems, and address the larger goal of my dissertation project to model the development of social complexity in Prehistoric Bronze Age Cyprus through a product-centered approach to feasting.

VII.A. Observations and Conclusions by Sample Set

VII.A.1. Stratified Samples

VII.A.1.a Episkopi Bamboula

The analysis of eight Base Ring vessels from Episkopi Bamboula demonstrated that these vessels certainly served as containers for valuable products. Five out of the seven containers with analytical results suggest the presence of a fermented beverage. If isobutyric acid and its derivatives in these samples are, in fact, associated with red wine fermentation, then the Base Ring juglets may have been utilized as containers for aromatic wines. Regarding Merrillees' (2003[1962]) hypothesis that these vessels were used as containers for opium, the Base Rings from Episkopi Bamboula did not provide any evidence for such an association. The only suggestion of opium is a single compound that could be a degradation product of noscapine but with little analytical evidence to support this claim. The compound may rather represent a contaminant. Either suggestion requires further investigation.

What may be gleaned from these results is the incorporation of locally available aromatic plants and herbs into mixtures that may represent fermented beverages or herbal infusions. In regards to the function of these substances, the fact that these vessels were deposited in tombs speaks to not only to the specialized nature of these drinks, but also raises questions as to their purpose and the party for whom they were intended – as gifts for the individual or individuals interred in the tombs or as part of a funerary feast for the mourners. Final deliberations are, however, not possible until the excavation of the site is more fully published.
An interesting direction for future work would include the analysis of similar types of pottery from a Late Bronze Age domestic context either at Bamboula or another site in southern Cyprus to determine whether the use of these substances were limited to funerary contexts or were consumed in everyday life as well.

VII.A.1.b Alambra Mouttes

Based on the analysis of thirteen juglets from spaces at Alambra Mouttes that seem to have served a special communal function, several observations may be made. The first issue relates to the fact that the majority (eight of thirteen) of the vessels exhibited extensive contamination with no evidence of a preserved residue. In general, the collection and analysis of samples from artifacts stored for decades introduces a high potential for contamination by glues, putties, plastics and other reconstruction and modern storage materials. In addition, relatively few compounds were identified that could securely be attributed to the ancient substance that the vessels would have held. An unanswered question that future work in analytical archaeology may address is the extent of chemical degradation that may occur after excavation.

Despite the poor preservation evident in the juglets, a few different products seem to be represented. Most interesting is the presence of camphor in F391/P11, a vessel for which there does not appear to be any parallels. The substance contained in the vessel likely consisted of the aromatic oil of rosemary, sage or white wormwood. All three are highly fragrant, locally available, and have medicinal benefits. It is interesting that the largest juglet, F87/A69, seems to have contained a similar substance, from at least a chemical perspective. While the chemical evidence is limited, the possibility of beer in F118/P36 and F119/P39 and grape wine in F98/P64 is also intriguing in respect to the feasting activities purported to have occurred in Building IV. An unfortunate reality is that none of the associated bowls could be analyzed. Despite the limitations, there does seem to be enough evidence to suggest that the pottery assemblage of bowls and juglets present in Building IV were utilized in communal feasting activities that may have involved alcoholic beverages, medicinal substances and culinary preparations.
Based on the analysis of eight vessels from three spatial contexts dating to Early Cypriot III at Marki Alonia, several observations may be made. The issue of contamination was detailed in the section on Alambra Mouttes. Similar considerations apply to the Marki Alonia samples. In addition to extensive contamination being present in the artifacts, the preservation of a residue may have been affected by the length of time that elapsed since excavation, which may have resulted in further chemical degradation. Such post-depositional decomposition is not well understood and may constitute an area for future research. What is certain is that the greatest contamination occurred in vessels that were reconstructed, glued, or labeled with acrylic or ink. Best results, in this case three out of the eight analyzed, occurred in closed shapes not in museum collections. The latter point is relevant in that objects in museum collections are often handled by numerous individuals, which increases the likelihood of introducing modern contaminants.

Despite issues of contamination and preservation, a few different products seem to be represented. Most interesting is the presence of what appears to be an aromatic mixture containing wormwood (or a related species in the Artemisia genus), rose or hyssop in a cedar or juniper resin base in the RP pyxis (P15656). An aromatic mixture seems to be consistent with the shape of the vessel. The decorated, closed vessel (P16171) also contained an aromatic substance from similar, locally available plants. However, the substance in this vessel is categorized as an unguent or ointment that would have been applied externally due to the presence of a cytotoxin. The extent of toxicity is unknown and for this reason a comestible function should not be ruled out. The substance in P15381 has been provisionally identified as a red grape wine, which would seem consistent with the juglet shape.

As discussed in the analytical section on Marki Alonia in Chapter V, there were a limited number of samples that could be sampled from the occupational phase that was selected and with fewer chemical results. Thus, the implications for the use of these substances within the context of the site are still unclear. However, it may be noted that similar plant substances have been identified in analyses from the other Bronze Age sites. A more in depth chemical study
would be necessary to more fully document that range of organic products being utilized at this important Early and Middle Bronze Age site. Of particular interest would be a comparison between Philia closed shapes and later RP varieties.

VII.A.1.d Sotira Kaminoudhia

Twelve pottery vessels were analyzed from various stratigraphic contexts at Sotira Kaminoudhia. From Area A, five samples from different contexts were analyzed. Of particular interest was the Red Polished bottle, P74, from Unit 5, which is an irregularly shaped room that would have been built at an earlier phase, pre-dating the construction of Units 7 and 18. The bottle, which was an import from the north coast of the island, was placed in a niche that sat 20 cm above the floor, measured 40 cm in width and 30 cm deep, a context that would suggest that the contents of this vessel were highly valued (Swiny 2003:19-20). The chemical analysis suggests that such a designation was justified.

An aromatic substance with possible medicinal qualities was identified in the Brown Polished bottle sherd from Unit 7 (sample 12), which was a multipurpose room partially covered with a roof and contained various other types of pottery and lithic artifacts, grinding equipment, and a hearth (Swiny 2003:23-4). This space communicated with Unit 18, from which a Drab Polished juglet (sample 9) was obtained (Swiny 2003:27-8). Similar to the bottle in Unit 5, an aromatic oil that was scented with flowers and herbs and which contained one or more medicinal or mildly psychoactive plants was found in a largely domestic context.

The other two samples from this area, a storage jar from Unit 27 and a Drab Polished Blue Core juglet from Unit 44, showed no evidence of a preserved residue. In the case of the storage jar, which was found in what Swiny (2008:45) describes a “true basement”, may have contained dry foodstuffs or other items that do not readily leave residues. The lack of a preserved residue in the sample from Unit 44 (sample 6) is more surprising. However, the fact that the juglet was found strategically placed within a narrow shelf in a room with over a dozen juglets and bowls resting against walls and set on benches and shelves likely indicates that the contents of the vessel had an important function (Swiny 2008:45).
Four samples from Area B were analyzed from two different contexts. As noted in the introduction, the Unit 12 Complex is an enclosed, unroofed structure that was planned on a tripartite arrangement and in which a series of atypical activities, likely ritual and communal in nature, took place. The first sample was a tray from Unit 12b (sample 3\textsuperscript{109}), which based on the presence of a grinding platform and a large stone basin, is a space that may have been associated with the production and storage of items utilized in the activities taking place elsewhere in the Complex (Swiny 2008:48-9; Swiny 2003:34-7). In particular, the courtyard and adjacent room, Unit 12c, could have been used as a communal space in which village inhabitants congregated for leisure or religious activities. This is suggested not only by the range of exotic items found in the adjacent room, which included examples of copper slag and ore, a gaming stone, numerous river pebbles and stone tools, and a cattle scapula, but also the imposing stone and plaster construction at the north wall (in Unit 12a) (Crewe and Hill 2012:212; Swiny 2003:34-7; Swiny 2008:48-50).

Returning to the suggestion of production activity in Area B, Swiny (2008:48) suggests “a scatter of broken milling equipment in the open space 64 as having originated from protracted grinding equipment within the complex”. A similar argument may be extended to the three samples that were found in Unit 13, the broad alleyway or street that measured 10 meters long by 2 wide, and communicated with the presumable ceremonial complex noted above. The rim of a Red Polished Mottled bowl (sample 1), from the base of a Red Polished bowl with a flat base (sample 2), and the body of a Red Polished bowl (sample 11), may represent refuse from or preparation for activities that took place in the ceremonial complex (Swiny 2003:37-8). I point particularly to the residue of sample 1 and highlight the fact that such a bowl is an unlikely container for a perfumed substance. However, if we consider the possibility that activities related to production were occurring in open areas surrounding the complex (i.e., open area 64) or at least the resultant refuse and discard of those activities, a more likely explanation may be that the bowl was utilized in the production of a perfumed substance.

\textsuperscript{109} Unfortunately, there was no evidence of preserved organic residue in the tray.
It is intriguing that the medicinal or mildly psychoactive substance identified in the Drab Polished juglet from Unit 18 (sample 9) has a series of ingredients in common with the substance identified in the flat-based bowl (sample 2) from Unit 13. Both mixtures included a plant that contained thujone, which, as discussed earlier, is a major constituent in absinthe wormwood as well as a species of Cypriot sage. The mixtures differ in that the bowl may have evidence of a fermented grain. However, it is possible that the bowl contained a food product that incorporated a processed grain and aromatic herbs that may have been utilized for multiple purposes and some of which may also have medicinal benefits. I point specifically to the presence of thujone; while it is a mildly psychoactive principle, it does also occur in sage and some other plants that have historically been used as seasonings. It should also be noted that the analysis performed was qualitative in nature, which means that the extent to which the thujone or other ingredient contributed to the mixture is unknown.

Despite these issues, a similar set of substances appears to have been deposited in tombs in Cemetery A, which may further suggest their value. All three were Brown Polished bottles that came from two tombs (T.4 and T.19) in Cemetery A. The contents of P27 (sample 5, T.4) and P105 (sample 7, T.19) seem to be similar to the substance contained in the Red Polished bottle from Unit 5. The final sample, P29 (sample 10, T.4) may be similar to the substance that was identified in the flat based bowl, sample 2, in the street outside of the Unit 12 ceremonial complex, but this identification largely hinges on whether or not the presence of a fermented grain or beer is acceptable. The key issue in the comparison of the chemical data from the settlement and the tombs is that a similarity exists in the types of aromatic substances that were being produced. T.4 is particularly interesting in that the two Brown Polished bottles that were found in the tomb “closely resemble those found in the settlement” (Swiny and Herscher 2003:108-110). The Brown Polished bottle from T.19 was found with two Red Polished bowls in a somewhat smaller tomb that may have contained the remains of a child. Based on the characteristics of the bottle, this tomb likely dates to a later phase of the settlement, EC III (Swiny and Herscher 2003:135-6).
Taking the range of equipment and chemical residue in vessels discarded from the complex in Area B together with the incidence of small, decorated bottles and juglets in seemingly domestic contexts in Area A, it seems possible that one of the functions of the ceremonial complex was the production of fragrant oils that may have been utilized externally as perfumes or internally as aromatic medicines. A fermented grain beer that was flavored with herbs, flowers, and other ingredients may also have been produced. These aromatic substances may have been used in everyday, domestic contexts, but also played an important role in mortuary ritual. If the identification of a flavored beer is accurate, the current evidence suggests that such a drink played a role in mortuary ritual, though it may been speculated that such a substance could have been consumed in communal activities that took place in the Area B complex.

From a methodological perspective, open shapes made of a coarse fabric (e.g., storage jar, coarse ware tray) generally did not indicate the preservation of a residue. The one exception to this was the Red Polished Mottled bowl sherd which may have been utilized in the production of a perfumed substance and discarded in the alleyway (Unit 13) of Area B. The small closed vessels, the Brown Polished bottles in particular, showed the best results.

Contamination is a recurring problem in this kind of analysis. It is likely that the number of contaminants present in these samples represents a combination of storage (plastics, inks) materials, as well as analytical artifacts that may have been introduced during analysis. In the case of the quinoline alkaloid that was present in four samples from Kaminoudhia, it is unclear whether this is related to preserved residue or represents an analytical contaminant.

Despite issues of the preservation of a residue and the introduction of contamination that may reduce the likelihood of detecting an ancient residue, some key observations can be made. First, there seems to be a preference for flowers and aromatic herbs with species of rose, myrtle, sage, wormwood, and mint being represented repeatedly. In two cases, a fermented grain substance may be indicated, but the evidence is too limited to make a conclusive determination. In a few cases, a medicinal or mildly psychoactive substance may be indicated, based on the presence of a thujone-containing plant and the degradation products of quinoline and tetrahydroisoquinoline alkaloids. However, due to the qualitative nature of the analysis, the
concentration of these compounds in the overall mixture is unknown. What does seem apparent is that aromatic mixtures, most likely in liquid form were being produced of locally available plants and utilized both in domestic and funerary contexts and likely served cosmetic, medicinal and perhaps mildly psychoactive functions.

VII.A.1.e Politiko Troullia

In the comparison of the results of the samples from Politiko Troullia that were collected by scraping the interiors of vessels as opposed to destructive analysis of sherds, there were only five with chemical results in both types of samples (14, 15, 30, 42, 58). There is little in the way of fabric or shape that these vessels have in common. A more constructive conclusion can be drawn in comparing vessels that had results either from the scrapings or the sherds. The scrapings showed a slightly higher number of positive results (10: 1, 3, 5, 20, 21, 22, 28, 32, 34) than the sherd (9: 2, 8, 11, 18, 19, 37, 39-41, 44, 49). Overall, the difference seems to come down to shape and porosity of fabric. The harder fabrics showed poor results in the scrapings, but these fabrics showed the best results in the destructive analysis. For the scrapings, the best results were obtained from spouts, necks, and the bodies of closed vessels with soft, chalky fabrics.

More generally, it should be noted for future analytical work of this kind that it is imperative to collect samples in situ to minimize contamination that can be introduced during excavation, as well as during storage. This is particularly evident in the last group of samples which underwent only destructive analysis and which had been stored for a few years.

In terms of broad patterns in the products identified in the analyses, there are similarities in the types of plants being utilized with aromatic plants, such as rose, lavender, mint, rockrose, thyme, sage, and wormwood being represented repeatedly. The products being made from these locally available plants largely seem to be aromatic mixtures that may equally serve medicinal, culinary and cosmetic functions. However, there are a couple of instances in which a culinary

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110 It should be noted that the reason for the brief discussion of Politiko Troullia is that the site is still in the process of excavation, making it necessary to postpone the interpretation of contexts of use.
function seems clear (i.e., pickled caper, possible dairy or liver product). In other cases, a psychoactive or at least a medicinal function can be attributed based on the presence of alkaloids or other compounds that have a physiological effect (i.e., pennyroyal, opium, lupine, some wormwood species). Elsewhere, a perfume may be indicated based on the presence of flowers (i.e., rose, lavender, hyssop), as well as perfume fixatives (rockrose or its resin – labdanum).

Most frequently, aromatic mixtures with various flowers and herbs (i.e., thyme, sage, germander, rosemary, caraway, coriander) were represented, which may equally serve to perfume, feed, clean, or medicate. To a lesser extent, alcoholic beverages made from grain or fermented fruits may also be represented. It must be mentioned that what is identified in those vessels is that fermentation has occurred; however, fermentation is a general process that was utilized in prehistory not only to make alcoholic drinks, but also to make water drinkable by removing pathogens, as well as making other products such as milk and yogurt.

Overall, the analytical results seem to suggest the utilization of local plants to make a series of products that, while having a quotidian use, would have had more specialized functions beyond basic subsistence.

VII.A.2. Museum Samples

Twelve curated pottery samples were analyzed for which the stratigraphic contexts were not known. The samples derived from whole vessels, as well as potsherds from the Jane Barlow and Belcher Collections at the State University of New York at Albany and the Cypriot and Cesnola Collection from the Semitic Museum at Harvard University. Extensive contamination was evident in all of them. The sherds at SUNY at Albany were in teaching collections that would have been handled by numerous individuals. The complete vessels would have been handled to a lesser degree. The sherds from the Semitic Museum were placed in plastic bags and accession numbers written in ink on slips of paper were placed inside. There is no doubt that this packaging contributed to the contamination in the samples.

While there were a few cases in which compounds potentially associated with a fermented product or an aromatic plant oil may be indicated, the preserved residue had likely
degraded or was overshadowed by contaminants to the point that a definite identification could not be made. However, in comparing this information with the large number of stratified samples, it does seem that the White Painted wares seem to absorb and (by extension) preserve ancient residues more readily than the harder fabrics. It is also noteworthy that the same set of compounds that has elsewhere been associated with fermentation (isobutyric acid, derivatives of butanoic acid, a compound related to baker’s yeast) was also identified in several of the curated samples. This might suggest that these set of compounds are, in fact, biomarkers associated with these kinds of ancient products. It is also possible that they are analytical artifacts that arise as a result of the analysis or perhaps by-products of the chemical degradation process. If future analyses are conducted at another lab, it would be useful to compare the incidence of these compounds to determine their ultimate source.

II.B. Observations and Conclusions from a Product-Centered Perspective

From a product-centered approach, all three categories of the prestigious products discussed in Chapter I were represented. These broadly included psychoactive substances containing products like opium, lupine beans, wormwood, and a series of fermented beverages, herbal mixtures containing aromatic plants like rose, thyme, anise, hyssop, mint, lavender, and sage, and perfumes made with resins and well-known fixatives, potentially including cedar and pine resin, sage, labdanum, and ambergris.

The identification of these products was based on the presence of the following constituents:

1) Alkaloids, which are compounds with pharmacological or toxic actions (Hesse 1981:3-4).

   Examples of compounds in this category identified in the sample set include:
   a. Noscapine, dihydrocodeinone, and lupinine

2) Terpenoids, which may have a pharmacological action or medicinal benefit (Bowles 2003:41-63). Examples of compounds in this category identified in the sample set include:

   a. Thujone, isopulegol, artemiseole
3) Compounds associated with fermentation (Kunkee 1991; Lambert 1997:137; McGovern 2003:1856-7; Michel et al. 1993:411-2; Wansborough 1974:3-4), such as:
   a. Malic, succinic, butyric, butanoic acids and their derivatives
   b. Yeast and beerstone derivatives

4) Essential oils, which are aromatic compounds found in plants (Bowles 2003). Examples of compounds in this category include:
   a. Camphor, thymol, and menthol.

In terms of general trends, the use of fermented beverages was probably widespread in Cyprus as it was elsewhere in the Mediterranean. However, based on the evidence presented here, it seems that wine occurs more frequently and in greater abundance in the later part of the Bronze Age. The evidence for beer seems to be limited with a possible identification in a Brown Polished bottle from a tomb at Sotira Kaminoudhia and a suggested presence in a few other contexts based almost entirely on the presence of a compound interpreted as baker's yeast. This evidence should be taken with caution until experimental work can sufficiently demonstrate that those compounds are in fact associated with ancient forms of beer.

More unexpected was the absence of opium in the Base Ring juglets, contra Merrillees’ (2003[1962]) long held and frequently repeated suggestion, and the presence of herbal wines, as represented in the tombs at Episkopi Bamboula. More puzzling was the presence of opium alkaloids or derivatives (noscapine and dihydrocodeinone) in mixtures with a perfume fixative (ambreine) and a toxic lupine alkaloid (lupinine) in a spouted vessel and highly decorated juglet from Politiko Troullia. Overall, there was little evidence that suggests the use of hallucinogenic substances, with the exception of a possible tropane alkaloid identification in highly decorated juglet neck at Politiko Troullia. Also from this site is evidence for the consumption of fermented beverage using a drinking set that included a small decorated bowl and jug, which shows signs of attrition typically associated with fermentation.

Another intriguing result was the identification of potential perfume fixatives, namely the resin of the rockrose (known as labdanum) and a possible identification of ambergris. The latter identification should be taken with caution and must be confirmed by comparative analysis. I
suggested elsewhere that the ambreine, being an aromatic compound, could be related to the broader use of labdanum, for which the island was known both in antiquity and in modern history. The reasoning for this suggestion is that labdanum was said to have the aroma and fixing properties of ambergris, which may suggest that the two substances have a similar range of aromatic compounds (Bolster 2002:42-3; Miller and Miller 1990:38; Plin. Nat. 12.37; Zohary 1982:194). At present, the two Cypriot rockrose species that were collected and analyzed did not corroborate this hypothesis. These aspects should be addressed in future work.

The line between the categories of substances is ambiguous in some cases. In this respect, it is important to mention that the categories of products defined here would not necessarily have been acknowledged by the ancient Cypriots making and consuming them. This is particularly true for the range of herbal mixtures documented in the sample set, which seem to indicate that throughout the Bronze Age, a variety of local plants were being utilized in the production of various aromatic mixtures that may have served culinary, medicinal, and/or cosmetic functions.

Moreover, caution should be exercised in interpreting these findings, particularly in the case of psychoactive substances. While there is sufficient evidence presented here that does suggest that a broad range of prestigious substances were being produced and used in socially significant contexts, care must be taken to not to see intoxication and prestige everywhere. In addition, it should be acknowledged that these substances likely crossed ancient categories and may have filled multiple social, economic and religious roles, both in sacred and more mundane domains.

VII.C. General Methodological and Interpretative Issues

The above summary highlights some key issues in the underlying methodology, data analysis, and archaeological interpretation. Overall the sample set is large, diverse and incorporates a representative relevant chronological periods, a range of contexts that are meaningful to the anthropological questions, and pottery wares and forms typical of the period under discussion. In some instances, the selection of contexts and of samples could have been
more informative, such as in the case of Marki *Alonia*. Initially, I had hoped to incorporate an architectural analysis based on Space Syntactic Analysis (SSA) as the method for identifying spatial and use contexts within Prehistoric Bronze Age villages that may have been conducive to certain types of feasting events\(^\text{111}\). The analysis was meaningful for Alambra *Mouttes*, applied with difficulty to Sotira *Kaminoudhia* due to the fact that the excavated area covers three spatially discrete areas, and Marki *Alonia*. It was only in the final case that the method was actually used for the selection of samples. A more informed approach for Marki *Alonia* material, perhaps collected samples from both Philia and later RP varieties would have been more informative. Despite the imperfect sample selection at this site, interesting data was collected regarding the range of substances and contamination and preservation issues.

Another issue pertains to the difference between samples from active excavations and curated samples. While obtaining samples from active or recent excavations is useful from a chemical methodological perspective, it is somewhat problematic for archaeological interpretation due to the fact that there is a limited published material available. Thus, for Episkopi *Bamboula* and Politiko *Troullia*, acceptable archaeological and anthropological interpretation is limited. Despite this, I feel that the nature of the contexts and the broad range of data from those sites are useful for comparative purposes within this project and also will be increasingly informative once the sites are more fully published.

There are additional issues regarding chemical and botanical interpretation. An underlying assumption for the Prehistoric Bronze Age was that all flora would have been indigenous. Superficially, it may seem that this view is unfounded due to the successive movements of populations from mainland areas to island, but there is a large body of information about Cypriot flora\(^\text{112}\). There was a general attempt to limit the range of possible plant sources to the broader Eastern Mediterranean region. This was partly due to necessity in that there is a limited amount of chemical data from specifically Cypriot plants. I did attempt to address this

\(^{111}\) This approach involved four sites: Marki *Alonia*, Sotira *Kaminoudhia*, Alambra *Mouttes*, and Episkopi *Phaneromeni*. The preliminary results for the analysis were presented at 2010 American Schools of Oriental Research Annual Meeting.

\(^{112}\) In this assessment, I drew heavily on the work of Robert D. Meikle, the foremost expert on the distribution and history of Cypriot flora.
problem with the collection and characterization of fifteen plants and products from the island. It should be added that, in theory, the Protohistoric Bronze Age, during which time there were considerable contacts throughout the region, there is a possibility of plants from other areas being introduced to the island. Limiting the geographic distribution of flora to the Eastern Mediterranean region addresses this problem in relation to changes occurring over the span of the Bronze Age.

A larger issue may derive from the method by which a plant source was determined. The use of alkaloids is an ideal scenario in this regard because of their limited distribution. However, in the case of the essential oil compounds, the amount of data identified in some archaeological samples was limited and the chemical profiles of the plants discussed in Chapters V and VI are complex. The question then arises as to whether the range of preserved chemical constituents in the samples represents the profile of a single or multiple ingredients. This uncertainty derives largely from cursory knowledge of the behavior of these chemical constituents in the long-term. The taphonomic study on opium, wine, beer, and olive oil discussed in Chapter IV addressed some of these issues. Future experimental work should then focus on the preservation potential and specific alterations for common aromatic compounds that may occur in depositional environments over the long term.

To that note, it must be noted that there was an emphasis on plant-derived substances in this research and perhaps insufficient consideration of animal-derived products. This is broadly related to the lipid analysis and the differentiation between animal and plant lipids. This work may still be done using the current dataset, but it must be noted that the necessary range of lipids were not detected in most samples. A related issue pertains to the range of hydrocarbons in some samples and the general question of determining whether some compounds are inherent to a sample or contaminants introduced during deposition, collection or analysis.

\[113\] In this regard, I acknowledge the differences between the analysis presented here and the evidence that Beck et al. (2004) present for a range of subsistence products in White Slip bowl sherds. The absence of subsistence products in my analysis likely stems from the range of vessels that were targeted and the limited attention given to lipids.
For the most part, these issues represent areas of future work and generally speak to the potential of this area of research in archaeology, anthropology and collaborative work in chemistry.

**VII.D. Implications for Feasting as a Model for Complexity in Bronze Age Cyprus**

The goal of this project was to examine the use of prestigious products during the Bronze Age by analyzing organic residues that preserved in finely made and highly decorated serving vessels. It was argued in Chapters I and II that these types of vessels would have been most likely to contain prestigious products, such as psychoactive substances, medicines, and perfumes, which would have played an important role in various types of feasts. Feasts again represent contexts of interaction characterized by the presentation and sharing of various food and non-food items and serve as settings in which a diverse range of strategies are enacted. The nature and extent of these strategies vary depending on the social scale, expectations and goals of the individuals involved, and the location and circumstances of the feast. In particular, feasting events have been tied to the emergence of social complexity in that they serve as settings in which the social, economic, political and religious aspects of society intersect (Appadurai 2003:3; Bray 2003; Brun 2000; Dietler 1996, 2006; Dietler and Hayden in Dietler and Hayden 2001; Joffe 1998; Rosenswig 2007; Spielmann 2002).

I highlighted in Chapter III the archaeological evidence from early prehistoric Cyprus that documents the practice of small scale feasting and emergent forms of social differentiation. Proceeding from this view is the acknowledgement of the fact that feasting served the simultaneous aims of promoting social solidarity within a community or social unit and of giving opportunistic individuals occasions to distinguish themselves and to gain power and influence (Twiss 2008, 2007). This dual relationship seems particularly applicable to the Prehistoric Bronze Age on Cyprus, which was a dynamic period during which social complexity began to emerge and which is characterized by a series of social, economic, political and ideological developments. One category of changes centers on the emergence of elite groups that gained their wealth, power and influence through the control of the procurement and trade of copper resources in the
center of the island. It is generally acknowledged that these elite individuals (and their heirs) communicated their position through competitive funerary displays of rich objects and through the ritualized consumption of specialized, prestigious products from an increasingly elaborate complex of serving vessels (Adams 2004:28; Aglaze 2001:206-7; Fisher 2007; Keswani 1989, 2005; Peltenburg 1996).

I argued that these competitive funerary displays only represent one type of feasting being practiced during the Prehistoric Bronze Age and that the prestigious products that played an important role in death, likely also served a purpose in everyday life. It is from this perspective that pottery samples from both mortuary and settlement contexts underwent chemical analysis with the aim of determining the identity of those prestigious products that would have been utilized in the feasting contexts characteristic of the period. The categories of feasting that I argue would have occurred during the Prehistoric Bronze Age include:

1) communal feasts which fostered social solidarity
2) empowering feasts which created opportunities for individuals to create alliances, accumulate social debts, and move into positions of influence, and
3) conspicuous consumption associated with mortuary ritual.

All three seem to be represented in the sample set described in Chapters V and VI.

Episkopi Bamboula likely represents competitive display and conspicuous consumption in a mortuary context that is centered on the use of Base Ring vessels as formalized drinking sets. As noted in the previous chapter, the products that were consumed from these popular vessels included aromatic mixtures and spiced or seasoned fermented beverages. While greater interpretation is limited until excavations at the site are completed and findings published, it may be mentioned that the tombs would have been used for multiple interments, many of which likely reflected a process of increasing familial membership and inter-communal competition with the “juxtaposition of tombs and houses” (Keswani 2004:87) potentially signaling the permanence of social distinction in death and the everyday.
The intersection between the domains of the living and the dead, both in practice and in product, is further documented at Sotira Kaminoudhia. This largely stems from the fact that the samples from this site derived from mortuary contexts, contemporary and in some cases unique settlement spaces, and deposits associated with ceremonial activity (or at least production or discard associated with such activities). The spatial organization of the settlement does not immediately suggest any differentiation in the use of space, with the exception of the Unit 12 Complex, as is represented at Alambra Mouttes. Rather, the arrangement seems more typical of the ad hoc nature of Phase E at Marki Alonia (Keswani 2005:363). Likewise, the variation in burial treatment, especially the presence of single tomb interments, seem to suggest a low level of social differentiation with the contents of the vessels interred with the dead suggesting commonalities in the types of products being used in contemporary areas of the settlement. However, there is also evidence of knowledge and perhaps indirect contact with elite groups along the north coast. A case in point is the RP bottle, P74, that was an import from the north coast, in which a medicinal (perhaps mildly psychoactive) mixture that likely contained pennyroyal, rockrose, and a species of wormwood. The fact that similar types of substances are found in other containers at the site could suggest that the development of a repertoire of prestigious substances is an independent, local phenomenon and not necessarily an imported practice from the north.

There is arguably a religious character to the site, centered primarily on Unit 12, the ritual complex in Area B, the architectural layout and internal features of which seem to parallel some details of the Vounous Bowl. The multi-roomed and unroofed structure seem amenable to communal congregation with what Swiny (2008:44-9; 1997:201-4) interprets as a tripartite structure at the rear of the area with a large trough carefully centered in front of the tall whitewashed wall. This arrangement is reminiscent of some other clay models that have a tripartite structure and one or more bowls or other containers at the base (Washbourne 1998:63, 198, 204-5). From the chemical data and archaeological evidence, there is little that seems to suggest social distinction, but there is most certainly a ritual role that may include aspects of production as it may pertain to the making of the prestigious substances that were imbued with
meaning and that held purpose both in the life and in death. While “feasting” in terms of sharing food and drink is not unequivocally demonstrated at the site, the synthesis of the chemical and archaeological data seem to indicate a communal practice centered on gatherings in the ritual complex, the most likely purpose of which was the fostering of social solidarity (Swiny 2008:43-9; 2003:40-6).

This is paralleled to a certain degree at Marki Alonia, where the architectural layout and use of space is clearly oriented towards the household and extended family. In terms of feasting practice as it relates to emergent complexity at the center of the island, there is little in the way of evidence presented here to document it. If it were to be suggested that feasting at some level were to have occurred at Marki, it might be expected to occur in a form that fosters social and economic relationships among social units, namely on the household, rather than, community level. The chemical evidence does, however, contribute to a broader conception of the range of substances that would have been utilized during this period, chief among which is the ointment identified in P16171.

This is contrasted with the evidence from Alambra Mouttes, where the architectural layout, degree of town planning, and specific characteristics from Building IV indicate an empowering feasting strategy centered on a smaller group of individuals engaged in a shared consumption event within a discrete setting (Coleman et al. 1996:89; Keswani 2005:109; Knapp 2009:89). It may also be mentioned that whereas the tripartite structure within a spatially discrete ceremonial area at Sotira Kaminoudhia seems to parallel the scene in the clay model from Vounous, the series of spaces at Alambra seems to parallel the depiction of penned (perhaps, sacrificial) animals within a community space.

A feasting practice centered on negotiation and social distinction may also have occurred at Politiko Troullia, but this assessment is entirely based on the diversity and elaboration in the ceramic repertoire and the large set of samples with chemical evidence. The range of evidence for the consumption of psychoactive substances in various forms suggests, inasmuch as an extensive range of drinking equipment is represented at the site in conjunction with a broad range of prestigious products, that the site may potentially document a series of socially-important
feasting activities. The nature of these activities is only speculative until final interpretations of the site are published. Despite this, there does appear to be an affirmation of a connection between the use of jugs and serving bowls as drinking sets, specifically for the use of fermented beverages during Prehistoric Bronze Age 2 and the Protohistoric Bronze Age.
VIII. CONCLUSIONS

VIII.A. Summary and General Conclusions

In the preceding seven chapters, my goal was to address a series of theoretical, methodological and archaeological assertions pertaining to the development of social complexity on the island of Cyprus during the Prehistoric Bronze Age.

Questions regarding the emergence of social complexity have tended to focus on end results, as opposed to mechanisms for social change and the contexts in which these mechanisms were enacted. A model based on feasting, in all its formulations, provides a generalized basis for approaching the social, economic, political and ideological strategies that would have been negotiated by various parties within a community. Such negotiations would have necessarily involved establishing a sense of communal solidarity, while generating opportunities for self-aggrandizing individuals to exert, gain, and consolidate their influence and power. Over the long-term, such strategies would have resulted in the ultimate emergence of a stratified and urban-oriented society, characteristic of the Protohistoric Bronze Age on Cyprus. The Prehistoric Bronze represents a period during which the relationships that lead to these social changes would have been negotiated.

It is generally acknowledged that a major arena for the enactment of these various strategies occurred in funerary contexts, in which increasingly elaborate drinking sets composed of large and small jugs and bowls were utilized in the ritualized consumption of prestigious substances as a way to signal their social distinction and to legitimate their social, economic, political, and perhaps religious positions. I have argued that the identity of the products that are being consumed and displayed in such significant occasions is as important to such strategies of social distinction as the objects from which they are consumed. Moreover, it is assumed that social positioning and re-positioning likely involved a multifaceted process that occurred in domestic and ritual aspects of everyday life as readily as in funerary commemoration.

Based on these assertions and in connection to the large body of material evidence that suggests a dynamic interaction between agricultural production, copper exploitation, emerging complexity, and a transforming ideology, I argued that product-centered approach based in
chemical analysis served as an appropriate methodology for the documentation of the range of prestigious substances that were being produced, consumed and displayed and the social contexts and the spatial and chronological patterns of their use.

From this perspective, it is apparent that during the Bronze Age, there was a rich repertoire of specialized organic products being produced from locally available aromatic plants with a potential increase in the use of agricultural products, such as grapes and grains, towards the end of the Prehistoric Bronze Age and into the Protohistoric Bronze Age. While the contexts of the use of these products is unclear in some cases, such as at Marki Alonia, the fact that these products are deposited in tombs such as at Episkopi Bamboula and Sotira Kaminoudhia, and in communal feasting contexts such as Alambra Mouttes, and more generally are stored in finely made and highly decorated vessels further corroborates the prestige associated with these substances.

There are similarities in the types of plants being utilized with aromatic plants, such as rose, lavender, mint, rockrose, thyme, sage, and wormwood being represented repeatedly. The products being made from these locally available plants largely seem to be aromatic mixtures that may equally serve medicinal, culinary and cosmetic functions. However, all three categories of prestigious products – psychoactive substances, herbal mixtures with medicinal benefits, and perfumes and ointments of cosmetic value – are represented.

In this avenue of research, one should exercise caution in interpreting such findings and heed a similar warning that once was given to Wasson, to not see intoxicants, and in this case, prestigious substances, everywhere! Moreover, these substances likely crossed ancient categories and may not have been viewed as prestigious, but filled multiple social, economic and religious roles. And finally, we do not know the extent of the intoxication produced by these substances due to the fact that they are often in complex herbal mixtures in which the psychoactive ingredients may play only a minor role.
VIII.B. Future Directions

The research presented in this dissertation, in many ways, covers new ground in Cypriot archaeology. As such, the conclusions presented here should be viewed as a first step with potential for future research in several areas. One of these in which there is much work to be done pertains to methodology and data interpretation. Some areas may include:

1) creating a spectral database of the chemical profiles for plants and other products indigenous to Cyprus and the Mediterranean Basin;

2) compiling a list of contaminants from surrounding archaeological contexts, conservation materials, and lab procedures;

3) conducting taphonomic and diagenetic experimental studies as they pertain to chemical constituents found in aromatic substances and post-depositional decay of preserved residues; and

4) incorporating quantitative chemical analyses to determine to what extent chemical constituents contribute to a substance.

In order to more fully understand the developments occurring in Prehistoric Bronze Age Cyprus from a product-centered perspective, future work should:

1) place more emphasis on associating specific products to vessel types;

2) incorporate Philia material and compare results to later RP varieties; and

3) address regional, chronological and contextual patterns more fully.
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YMBD-: Yeast Metabolome Database


Zohary, Michael