Beeswax Preserved in Archaeological Ceramics: Function and Use

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Abstract

This paper discusses the occurrence of beeswax residue in various archaeological ceramic vessels. Beeswax residue was detected in ceramics, from different sites in Europe, Near East and Far East, using analytical organic chemical techniques. The detection, preservation and degradation of beeswax residue in archaeological ceramics are discussed in this paper. Up to date, the preservation of beeswax in ceramics is dated back to the Neolithic period. Beeswax residue was not correlated with specific type of ceramics, it was found in different vessels regardless to their forms, sizes, fabrics, decorations and other physical properties. Vessels containing beeswax were used in the past for preparing, processing, storing and serving honey or beeswax, in addition to their use as beehives. Beeswax, however, was exploited in the past as a sealing (or coating) and waterproofing agent, a fuel for illumination, a plasticizer in adhesive production, an insect repellent, a one of the main ingredient used in the preparation of medicines and a substance for casting metal objects in the lost wax technique involved in metallurgy.

Keywords: Archaeological Vessel, Ceramic, Organic Residue, Lipid, Beeswax, Beehive, Biomarker, Gas Chromatography - Mass Spectrometry.

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حفظ شمع النحل في قطع السيراميك الأثرية:
الوظيفة والأستخدام

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الملخص

يناقش هذا البحث احد الموضوعات العلمية الحديثة التي تتعلق بماهية وجود شمع النحل في الأواني الفخارية الأثرية؛ فقد تم العثور على مثل تلك الأواني، التي تحمل أثاراً لشمع النحل، في عدد من المواقع الأثرية في أوروبا وجنوبي شرق وغرب آسيا. ويركز هذا البحث على مناقشة جميع الدراسات التي بحثت في إحدى أهم وأحدث الطرق العلمية التي أستعملت في الكشف عن بقايا الشمع، وذلك باستخدام تقنية التحليل الكيميائي العضوي. وتشير الأدلة الأثرية على أن أقدم وجود للشمع في الفخار يعود إلى العصر الحجري الحديث. كما تشير الدراسات إلى أن وجود الشمع في الأواني الفخارية الأثرية، لم يقتصر على نوع أو شكل أو حجم معين، وإنما تواجد في أشكال وأنواع مختلفة من الفخار. ونتيجة للدراسة التحليلية للأواني الفخارية التي إحتوت على بقايا شمع النحل، فقد تبين أنها كانت تستخدم لأغراض إعداد وتخزين عسل النحل، بالإضافة إلى استخدامها كخلايا لتربية النحل. أما بالنسبة لإستخدام شمع النحل نفسه، فقد خلصت الدراسة إلى أنه كان يستخدم لإغراض عزل جدران الأواني الفخارية، وذلك لمنع تسرب السوائل منها، ومادة حرق خاصة للمصابيح، ولدائن لتصنيع المواد اللاصقة، ومادة طاردة للحشرات، وفي تصنيع القوالب التي تستخدم في تشكيل الأدوات المعدنية، إضافة إلى استخدامه في تحضير بعض المستحضرات الطبية.

INTRODUCTION

Beeswax is one of the organic residues that have been reported in several archaeological ceramics found in different regions and dated to different periods. The occurrence of beeswax in these ceramics has been attributed to different uses. This paper however, presents a review concerning the occurrence of beeswax in archaeological ceramics. It will commence with a general review on characteristics of beeswax and honey, their uses in the past and their occurrence in archaeological ceramics. Then it will discuss the characterisation and identification of beeswax residues preserved in archaeological ceramics, as well as the preservation, degradation and alteration of beeswax in archaeological ceramics during use and burial. Finally, the paper will focus on the function and use of both beeswax and archaeological vessels containing beeswax based on significant observations and data available in the literature.

Beeswax and Honey in Archaeological Contexts

General Properties and Uses of Beeswax and Honey in Archaeological Contexts

Beeswax and honey are produced naturally by bees from the nectars of flowers. Beeswax is one of the organic (and more specific, lipid) components and the earliest waxy material commonly exploited in the past for different purposes. These purposes include: body care and medicines1, symbolic and artistic roles2 and technological purposes3 in addition to the use of beeswax as a fuel for illumination and a waterproofing agent (Regert et al. 2001; Baeten et al. 2010). These uses however, can be attributed to the facts that beeswax: first, is one of the natural products available since millions of years, second, has natural and very fragrant aroma, third, burns very slowly, and fourth, is characterized by its hydrophobicity, plasticity/flexibility and therapeutic properties. Honey, however is "a natural sweet substance produced by honey bees from nectar of blossoms or from secretions of living parts of plants or excretions of plant sucking insects on the living part of plants" (Mendes et al. 1998). It has been used in ethnomedicine since ancient time as it contains about 200 substances; therefore, it is considered an important ingredient of traditional medicine (Küçük et al. 2007). In terms of the chemical analysis of organic residues preserved in archaeological sites, biomarkers of honey have rarely been reported in archaeological contexts and this can be attributed to their high susceptibility to degradation under most environmental conditions (Regert et al. 2003b). Contrarily, biomarkers of beeswax are more stable and resistant to degradative processes; therefore, they have been detected in many archaeological and art historical contexts (Heron et al. 1994; Mills and White 1994: 49; Regert et al. 2001, 2003a and 2005; Bonaduce and Colombini 2004; Lattuati-Derieux et al. 2009). In archaeological ceramic vessels, beeswax was used for different purposes, such as a sealant, an adhesive or a plasticizer in the production of adhesives, a fuel for illumination, a waterproofing agent, an insect repellent, ingredient in the production of medicinal ointments and in lost wax technique used in copper industry (Needham and Evans 1987; Heron et al. 1994; Charters et al. 1995; Panagiotakopulu et al. 1995; Evershed et al. 1997; Aveling and Heron 1999; Garnier et al. 2002; Regert et al. 2003a; Regert 2004; Copley et al. 2005a; Mayyas 2007: 359-360; Namdar et al. 2009; Baeten et al. 2010). However, the presence of beeswax usually implies the availability of honey of bees in that time (Heron et al. 1994; McGovern et al. 2004; Copley et al. 2005a-c).

THE OCCURRENCE OF BEESWAX IN ARCHAEOLOGICAL CERAMIC VESSELS

Beeswax is produced only by honeybees as a white color, but it darkens when contaminants are present. These contaminants include materials carried by bees4 and other materials from bee's body parts5 in addition to certain metals6 from other sources that have been in contact with beeswax (MAAREC 2005; Namdar et al. 2009). However, beeswax has been found as invisible residue absorbed into porous fabrics of archaeological ceramics. Also it has been found as discolored deposit of brown to black color and carbonized residue on the surfaces of archaeological ceramics (Needham and Evan 1987; Heron et al. 1994; Regert et al. 2001; Anderson-Stojanović and Jones 2002; Evershed et al. 2003; Mayyas 2007: 191-195). Beeswax has been found in archaeological ceramics either alone or mixed with other natural materials of animal and/or botanical origin (Heron et al. 1994; Charters et al. 1995; Evershed et al. 1997, 1999 and 2003; Garnier et al. 2002; Regert et al. 2003a-b; Copley et al. 2005a and c; Mayyas 2007: 191-195; Mazar et al. 2008; Namdar et al. 2009). The occurrence of beeswax, either alone or mixed with other materials, in archaeological ceramic vessels is attributed to the fact that vessels were exploited in the past for different uses, such as cooking, preparing, processing, storage, transport and consumption of natural organic materials. Some particular ceramic vessels were exploited in beekeeping as the main way to obtain honey and beeswax (Crane 1983: 45-47; Evershed 1993; Anderson-Stojanović and Jones 2002; Evershed et al. 2003; Mazar and Panitz-Cohen 2007; Mazar et al. 2008). All these uses can result in organic residues being present as amorphous or invisible on the interior or exterior surfaces of the ceramic vessel or absorbed into the ceramic fabric of the vessel. The long preservation of organic residues in ceramics however is attributed to their stability under environmental conditions and to that fired clay can act as a molecular sieve or trap for organic biomolecules during vessel use and burial over a long period of time (Evershed et al. 1999).

CHARACTERISATION AND IDENTIFICATION OF BEESWAX PRESERVED IN ARCHAEOLOGICAL CERAMICS

Organic residues, such as beeswax, are found amorphous, invisible or absorbed in archaeological ceramic vessels and usually present with low levels of concentrations7; therefore, analytical organic chemical techniques are used to analyse the composition of these residues and to identify their nature and origins. Chromatographic separation and spectrometric identification techniques, such as gas chromatography – mass spectrometry (GC-MS), are the most efficient method for analysing organic residues. However, determining the origin of organic residues depends on the detection and distribution of diagnostic components, called biomarkers, components of organic materials of natural origin associated with archaeological materials at archaeological sites (Eglinton and Logan 1991; Evershed et al. 1999; Evershed 2008). In addition, determining the origin depends on drawing comparisons between the relative proportions of these biomarkers of the ancient sample and those of a modern reference material of a natural origin, such as beeswax.

Chemically, modern beeswax is composed of a wide range of chemical components including saturated and unsaturated n-alkanes, long-chain wax monoesters, diesters, hydroxyesters, fatty acids, and other minor constituents, such as flavonoids (Garnier et al. 2002). The composition of modern beeswax, however, is mainly dominated by wax esters8, WE (Patel et al. 2001). Saturated monoesters are the most important compounds of modern beeswax lipids (Patel et al. 2001) and these consist of long-chain saturated alcohols composed of even numbers of carbon atoms ranging from 24 to 36 (AL24 - AL36) esterified to palmitic acid (hexadecanoic acid; F16:09). Other significant constituents, such as even-numbered monoesters derived from palmitoleic (F16:1, cis-9-hexadecenoic) and oleic (F18:1, cis-9-octadecenoic) fatty acids and hydroxyl monoesters derived from 15-hydroxypalmitic acid, are also present in modern beeswax (Garnier et al. 2002).

The chemical composition organic residues, such as beeswax, in archaeological ceramics could be complex and their chemistry could have been either intact or altered compared to their original chemical composition (Evershed 1993; Dudd et al. 1998; Regert et al. 2003b). The alteration however, could happen during vessel use and/or burial (Evershed et al.1995 and 1999; Dudd et al. 1998; Evershed et al. 2001: 331-332). Therefore, modern and ethnographic reference materials, including natural organic materials and ceramics, are used for laboratory simulation experiments. This enables researchers to identify organic residues, such as beeswax preserved in archaeological ceramics (Henrickson and McDonald 1983; Dudd et al. 1999; Garnier et al. 2002;

Evershed et al. 2003). Beeswax in archaeological ceramics can be characterized by the presence of first, long-chain saturated wax monoesters with even-numbered carbon atoms ranging from 40 to 52 (WE40 - WE52) derived from the F16:0 fatty acid (Fig. 1), second, long-chain n-alkanes with odd-numbered carbon atoms ranging from 21 to 33 (C21 - C33) and third, long-chain saturated fatty acids with even-numbered carbon atoms ranging from 22 to 34 (F22:0 - F34:0) in the organic extract (Garnier et al. 2002; Regert et al. 2001, 2003a-b; Evershed et al. 2003; Regert 2004; Copley et al. 2005a; Mazar et al. 2008; Namdar et al. 2009). In addition, modern and archaeological beeswax can be discerned by the predominance of WE46 among the wax ester profile, and F24:0 among the fatty acid profile (Heron et al. 1994; Regert et al. 2001; Garnier et al. 2002; Evershed et al. 2003; Mazar et al. 2008; Namdar et al. 2009). Although odd-numbered linear hydrocarbons, C21 - C33, are characteristic of beeswax and epicuticular leaf wax of higher plants; the n-alkane, C27, is the most prominent in beeswax whilst the C29 is the most prominent in epicuticular waxes of higher plants (Heron et al 1994; Copley et al. 2001; Evershed et al. 2001: 334; Regert et al. 2001, 2003a and 2005; Kimpe et al. 2002; Evershed et al. 2003; McGovern et al. 2004; Regert 2004).

Beeswax is also characterized by a lesser extent of degradation compared to lipid constituents present in animal fats and plant oils. This is clear from the relatively stable distribution of wax esters and n-alkanes of beeswax through time (Regert et al. 2001; Mazar et al. 2008). Though, modification of beeswax components including the wax esters is possible during vessel use and burial.

DEGRADATION AND ALTERATION OF BEESWAX DURING VESSEL USE AND BURIAL

Although it is stable compared to other components of lipid beeswax undergo degradation during use and burial. Its constituents can be affected by degradation processes, such as heat, hydrolysis and oxidation during use and burial, in addition to the leach with ground water. However, the type, pathway and extent of degradation however, depend on the environmental conditions in which beeswax undergo degradation.

Hydrolysis of wax esters to even-numbered long-chain alcohols, AL24 - AL34, under burial conditions possibly occurs during diagenetic degradation of waxes of plants and insects (Evershed et al. 1997; Namdar et al. 2009). It has been reported that in addition to the long-chain even-numbered alcohols being produced by hydrolysis, the F16:0 fatty acid and a partially modified and depleted n-alkane profile are also present in partially hydrolysed beeswax (Regert et al. 2001). It is also worth noting that n-alcohols are present in modern beeswax at low levels (parts per million) but become major components in archaeological beeswax exposed to hydrolytic degradations (Garnier et al. 2002). The degree of hydrolysis of wax esters however, increases with heating, but aging or heating process could also affects reversibly on the amount of n-alcohols produced by hydrolysis (Namdar et al. 2009).

Leaching of hydroxy wax esters with groundwater, in addition to oxidation and heating effects on n-alkanes, wax esters, and may be on n-alcohols, n-alkenes and fatty acids present in beeswax, are also main factors affecting the chemical composition of beeswax (Heron et al. 1991; Regert et al. 2001; Garnier et al. 2002; Evershed 2008; Baeten et al. 2010). Hydroxy esters are present in minor quantities in modern beeswax, but they could be found in significant quantities in archaeological extracts due to their formation by oxidation reactions from the wax esters present in the same residue (Lattuati-Derieux et al. 2009). However, the presence of these oxidative products, i.e. hydroxy esters, in minor quantities in archaeological beeswax has been attributed to their loss by leaching with groundwater due to their solubility in water (Kimpe et al. 2002).

If the lipid was heated in ancient times, and/or buried in dry and warm environmental conditions over time, the n-alkane profile might be depleted by vaporization. The n-alkane profile, C21 - C33, of beeswax is an example of such degradation. In modern beeswax, odd-numbered n-alkanes are present in large amounts compared to even-numbered n-alkanes, but they diminish with heating. In addition, the presence of phenolic compounds10 in the archaeological extract of beeswax can provide evidence that beeswax was subjected to significant heating at temperatures higher than 60 °C (Regert et al. 2001, 2003a-b). Although they attributed the absence of n-alcohols in extracts of unfired Iron Age beehives to the possibility that these hives could have been exposed to high temperatures, Mazar et al. (2008) did not detect products of thermal transformation of natural flavonoids in these extracts. This may be attributed to the loss of these products from the unfired clay during burial, since the unfired clay has less preservation properties for lipid components than the fired one.

ARCHAEOLOGICAL EVIDENCES OF USING BEESWAX IN CERAMIC VESSELS

It is expected that the earliest time that beeswax was exploited for various purposes, is the end of the Ice Age (Crane 1983: 19-21; Regert et al. 2001). However, the rock shelter paintings of bees and honey-hunting scenes, from the Mesolithic, in eastern Spain provide the first evidence for the collection of products from beehives (Crane 1983: 19-21; Regert et al. 2001 and 2003b). According to the results of the chemical analysis of ceramic vessels from western and Mediterranean Europe, beeswax had been exploited from the Neolithic to the Roman periods for a variety of purposes, such as lighting and waterproofing of porous ceramic vessels (Regert et al. 2003b). Results from ceramics in the Far East showed that biomarkers of beeswax have been preserved in jars from the early Neolithic village of Jiahu in Henan province in China (McGovern et al. 2004). In the Near East, organic residue of beeswax was detected in a Late Chalcolithic bevelled rim bowl from the Tehran Plain, Iran (Mayyas 2007: 191-195). Another example comes from a later period, Late Bronze Age, in which beeswax was detected in red lustrous Wheel-made (RLWm) ware (Knappett et al. 2005). Organic residue of most likely beeswax was also detected in cornets, cone-shaped ceramic vessels, from different sites characteristic of the Chalcolithic period in the southern Levant (Namdar et al. 2009).

During the Bronze and Iron Ages in Europe adhesive production was developing through the addition of plasticizers, for example adding beeswax to birch bark tar to increase its plasticity (Regert and

Rolando 2002; Regert et al. 2003b; Regert 2004). In modern experimentation, beeswax has been used to produce soft adhesive due to its flexibility (Regert et al. 2003a). The presence of beeswax in ceramic vessels with an interior combed surface (Fig. 3) from Isthmia, Greece, and dated back to the Hellenistic and Roman periods, provides an evidence for the use of these vessels as beehives in antiquity (Anderson-Stojanović and Jones 2002; Evershed et al. 2003). Beeswax had been exploited on a large scale until the second half of the 19th century A.D. for different purposes in different fields, such as technology, art, medicine and religious rituals (Garnier et al. 2002; Baeten et al. 2010).

Evidences for the earliest uses of archaeological materials and vessels containing these materials is usually needs robust integration of visible markers at the site with the chemical analysis applied to archaeological materials from the same and/or related site. Analysis of organic residues (e.g. beeswax) preserved in archaeological ceramics, however, is an established discipline and important scientific tool in archaeology for revealing information relating to human activities in the past. These activities include function and use of ceramic vessels, diet, medicines, perfumes such as frankincense, adhesives, sources of subsistence activity and technology of the use of ceramics (Heron et al. 1991; Van Bergen et al. 1997; Dudd et al. 1999; Evershed et al. 1999; Regert et al. 2001 and 2003a; Copley et al. 2003; McGovern et al. 2004; Evershed 2008; Baeten et al. 2010). In this paper however, we will focus on the function and use of both beeswax and archaeological ceramic vessels containing beeswax based on observations drawn from analysing organic residues preserved in archaeological ceramics.

FUNCTION AND USE OF BEESWAX AND VESSELS CONTAINING BEESWAX

Beeswax has been found in various archaeological ceramic vessels and contexts in different regions, regardless the typological or stylistic criteria and/or features of the vessel, such as the form/shape, structure, size, slip, decoration, color, fabric texture and porosity. Therefore, functions and uses of both beeswax and vessels containing beeswax were proposed based on the detection of beeswax in their fabrics, physical properties and archaeological contexts of these vessels and on other criteria. These vessels however, can be categorized into two main groups: The first group is beehives while the second one is represented by other ceramic vessels of different forms.

BEEHIVE VESSELS

This group can be divided into two types, fired and unfired beehives.

Fired beehives

Beeswax was detected in coarse fired ceramic vessels with an interior combed surface, excavated from contexts dating from the Hellenistic and Roman periods at Isthmia, Greece. It provides an evidence for the use of these vessels as beehives in antiquity (Anderson-Stojanović and Jones 2002; Evershed et al. 2003). This kind of vessels was found in two different types. Horizontal hives is the first type (Fig. 2), with 0.60 – 0.65 m length, and tapers to a rounded closed end, and some of them with extension rings. The second type is upright hives (Figs. 3 and 4), has typical sizes with 0.29 – 0.33 m high and 0.34 – 0.40 m interior diameters, with straight sides, flattened bottom, and one small hole at the lower end of the wall (Anderson-Stojanović and Jones 2002; Evershed et al. 2003). These two types of vessels are wider at the mouth than at the base. They were manufactured from a coarse gritty red ware. Their interior surfaces were combed/grooved before firing (Evershed et al. 2003).

In case of the first type of beehive, “it was used in horizontal position, with the combed portion at the top for the attachment of honeycombs that hung parallel to the mouth of the hive in a long series”. This type (Fig. 2) was provided with a small bee entry hole in the lower edge of a lid that covers the mouth of the vessel (Anderson-Stojanović and Jones 2002; Evershed et al. 2003). In case of the second type of beehive however, it was used vertically (upright) with the comb hanging down from either the lid or wooden bars, and in which a small bee entry hole, either of rectangular (0.025 – 0.040 m ×

0.150 – 0.010 m) or round (0.026 – 0.030 m in diameter) shape, is present at the bottom of the wall as shown in Figures 3 and 4 (Anderson-Stojanović and Jones 2002; Evershed et al. 2003).

The evidence of the use of these vessels as beehives was mainly based on chemical analysis, archaeological observations11 and ethnographic examples found in several countries around the Mediterranean; e.g. Crete and Malta (Fig. 5). Egyptian paintings dated from 3000 to 1000 B.C. provide evidences of using horizontally stacked pottery as beehives (Evershed et al. 2003). Beekeeping is known to have been carried out in Egypt as early as the 3rd Millennium B.C. (Needham and Evans 1987; Heron et al. 1994).

UNFIRED BEEHIVES

Unfired clay cylinders (Fig. 6) that are expected to have been used as beehives were found at the Iron Age site of Tel Rehov, located in northwest of the Dead Sea (Mazar et al. 2008). All of the cylinders have the same size, with dimentions of about 0.80 m long × 0.44 m in diameter and walls of about 0.04 m thick. They were found in a closed structure inside the city lying side by side in a densely built area although it is known that beekeeping is supposed to be outside settlements. However, Mazar et al. (2008) expect that the location of these beehives within the settlement complex is attributed to a religious function. This observation represents another archaeological source concerning beekeeping in the ancient Near East.

Two of the beehive cylinders found at Tel Rehov were subjected to lipid analysis using GC-MS. The results indicated that the walls of the beehives contain lipid of beeswax (Mazar et al. 2008). Based on archaeological, pictorial and ethnographic investigations, as well as the scientific analysis, it is believed that these cylindrical vessels were used as beehives for both economic and religious purposes (Mazar et al. 2008).

OTHER CERAMIC VESSELS

This second group includes different forms of vessels, such as lamps, cups, jars, bottles, cooking pots, bowls, strainer or sieve vessels, Gallipot (or albarello) vessel and cornets, in addition to unidentified ceramic vessels.

LAMPS AND CUPS

Beeswax was detected in lamps (Fig. 7) and conical cups (Fig. 8) used as lamps (Evershed et al. 1997), during the Late Minoan I (Neopalatial) period at the settlement of Mochlos (ca. 1600 – 1450 B.C.) on the north coast of east Crete. The occurrence of beeswax in these vessels was attributed to the use of beeswax as an illuminant burned in prehistoric Aegean lamps. This demonstrates that beeswax has desirable burning properties and was being exploited by the inhabitants of the Late Minoan, Crete (Evershed et al. 1997 and 1999).

A Bucchero cup (Fig. 9) from an Etruscan settlement named La Castellina (late eighth – seventh century B.C.) located on the Mediterranean cost of Italy was subjected to lipid analysis. The result showed that beeswax was mixed with animal fats and possibly with plant oils (Garnier et al. 2002). The chemical analysis and archaeological observations suggest that beeswax could have been used as a waterproofing agent or as a fuel for candles (Garnier et al. 2002).

JARS

Biomarkers of beeswax were detected in Neolithic jars (ca. 6600 – 6200 B.C.) from the early Neolithic village of Jiahu in Henan province in China (McGovern et al. 2004). Based on chemical, archaeobotanical and archaeological evidences, it is proposed that these jars were used to prepare, store and serve a mixed fermented beverage of honey, rice and fruit. These storage jars are two-handled with narrow-mouth (Fig. 10).

Researchers conducted analysis of organic residues preserved in prehistoric ceramics from different sites in Britain in order to investigate the widespread of dairying during British prehistory. In ceramic sherd of jars from the Bronze Age site of Potterne, Britain, showed the preservation of beeswax (Copley et al. 2005a). In another case, one ceramic sherd of a jar from the Iron Age site of Yarnton CF, Britain, also showed the presence of biomarkers most likely of degraded beeswax (Copley et al. 2005b). In some cases, beeswax was found mixed with both animal fat and plant lipids. This may imply the "addition of honey to other commodities in order to either sweeten the food, or to utilize the sugar in other ways (e.g. fermentation)". On the other hand, the presence of beeswax alone in some jars simply represents the application of beeswax to ceramic vessels as a sealant/waterproofing agent or that these jars were used for processing honey or beeswax (Copley et al. 2005a-c).

BOTTLES

Red Lustrous Wheel-made (RLWm) ware was found at different sites in east Mediterranean areas such as Turkey, Cyprus and Egypt. The famous form of this kind of vessels is the narrow-necked bottle (Fig. 11). This type of vessel was used to transport, store and/or dispense variable liquids (Knappett et al. 2005). Beeswax residue, however, was detected in the interior surfaces of some of these vessels. It was detected alone and mixed with residue of possibly oil/fat. Knappett et al. (2005) proposed that the occurrence of beeswax in these vessels is most likely as a result of the use of beeswax as a waterproofing agent, as part of a medicine or cosmetic, or as decoration.

COOKING POTS

Kimpe et al. (2002) analyzed organic residues preserved in two late Roman cooking pots found at the site of Sagalassos in south-western Turkey. Both beeswax and ruminant animal fat of the sheep origin were identified in the two cooking pots. However, beeswax was not found in the oil lamps. Lipid analysis revealed that beeswax was processed in the cooking pots to purify it to make candles (Kimpe et al. 2002; Humphrey et al. 1998).

BOWLS

Beeswax was detected in a sherd of inturned rim bowl from the Late Saxon/early medieval hamlet of West Cotton, Raunds, Northamptonshire, UK (Evershed 1993). Also, beeswax, mixed with both animal fats and plant lipids, was found in a sherd belongs to a bowl from the Bronze Age site of Potterne, Britain (Copley et al.

2005a). Further five ceramic sherds belong to bowls from the Neolithic site of Eton Rowing Lake, Britain, were also tested by Copley et al. (2005c). The authors showed that three out of the five sherds contained beeswax alone while the other two sherds contained beeswax mixed with, diary fats in one sherd and ruminant adipose fat in the other. The occurrence of beeswax alone and mixed with animal fats and plant lipids in these vessels was mentioned above.

Beeswax was also detected in a fragment (Fig. 12) of a Late Chalcolithic bevelled rim bowl from the site of Tepe Chougali on the Tehran Plain, Iran (Mayyas 2007: 191-195, 192). The bowl is characterised by its coarse and porous fabric and undecorated surfaces. The occurrence of beeswax in the internal surface of this ceramic fragment was attributed to the use of beeswax as a waterproofing agent or as a material to retain a commodity inside the bowl (Mayyas 2007: 359-360).

STRAINER OR SIEVE VESSELS

Beeswax was identified in ceramic sherds from the Neolithic sites of Bercy, France and Dikili Tash, on the Drama plain, eastern Macedonia – Greece (Regert et al. 2001). The function of beeswax preserved in ceramic vessels from Bercy has not been well understood, but it could have been used to waterproof the porous fabric of ceramic vessels, in medicines for its therapeutic properties or maybe imply the use of honey in culinary preparations (Regert et al. 2001). The surfaces of the Dikili Tash ceramic sherds were free of visible residue. One of these sherds is characterized by the presence of man-made holes of 2-3 mm in diameter and considered to come from a strainer or sieve vessel but the exact size and shape of the sieve vessel is unknown (Regert et al. 2001). Ethnographic evidence from Jumilla-Yecla/Murcia, southern Spain, demonstrates that extracting honey was carried out by pressing the honeycomb over a funnel using a strainer made of esparto grass12 on top of the funnel to filter out honey from beeswax and solid particles (Regert et al. 2001).

CORNETS

Organic residue of most likely beeswax was also detected in typical Chalcolithic cornets (Fig. 13) in southern Levant. Vessels were obtained from different archaeological contexts including a shrine, cave, cemetery and habitation sites. Namdar et al. (2009: 635) expect that beeswax in the cornets was used as candles for illumination, leaving no soot as a result of slow burning of the candles of pure beeswax. The possibility of using beeswax as a sealing agent was also not excluded, however, the absolute use of these vessels is still unknown (Namdar et al. 2009). These cornets could be similar to that one described by Regert et al. (2003a) as a funnel-like bowl from the Iron Age site of Grand Aunay, Sarthe – France.

The observations of Regert et al. (2001) on extracting honey using a funnel and a strainer made of esparto grass may suggest that the Chalcolithic cornets found in southern Levant were used as funnels and may strengthen the consideration that the pierced vessel found at the site of Dikili Tash was used as strainer or sieve. Therefore, the possibility that the cornets had been involved in processing or storing beeswax should not be excluded.

GALLIPOT (OR ALBARELLO) VESSEL

The most recent investigations on materials preserved in ceramic vessels showed that beeswax has been preserved in a 16th century A.D. ceramic vessel. This type of vessel is known as a gallipot or albarello (Fig. 14), which was originally intended to contain salves or ointments (Baeten et al. 2010). It was excavated at the Castle of Middelburg, Belgium. Chemical investigations indicated that the content (greasy material/ointment) of this vessel was a medicinal ointment used for treating wounded soldiers at the castle during the late 16th century A.D (Baeten et al. 2010).

UNIDENTIFIED CERAMIC VESSELS

Ceramic vessels were involved in the production or storage of adhesive materials or beeswax during the Iron Age at the site of Grand Aunay, Sarthe – France (Regert et al. 2003a). The form of these vessels is unknown, except for one vessel, which is a bowl with a shape similar to a funnel.

Analysis of a brownish material present on another ceramic vessel of unspecified form at the same site of Grand Aunay revealed the presence of mixture of birch bark tar and beeswax, where beeswax could have intentionally been added to the tar to increase its plasticity (Regert and Ronaldo 2002). Further analyses of organic residues in Iron Age ceramic vessels of unspecified form were also performed by Regert et al. (2003a-b) and Regert (2004). They revealed the preservation of beeswax alone in one ceramic sample and both beeswax and birch bark tar in another one. They concluded that beeswax could have been stored in some vessels and then was added, as a plasticizer, to birch bark tar in the production of adhesives. Other possibilities: beeswax could have been used in the lost wax process in metallurgy in the Iron Age or processed to separate honey from beeswax combs (Regert et al. 2003a).

Beeswax was also identified in charred surface residues of ceramics (of unidentified form) from a Neolithic lacustrine context at the site of Chalain, Jura – France. The occurrence of this residue was attributed to culinary commodities (Regert et al. 2001). The chemical analysis of a black charred residue on the inner surface of a ceramic sherd excavated from a Middle Neolithic level (3000 – 2650 B.C.) at the site of Runnymede Bridge, England, revealed the presence of beeswax, glucose and resin in this charred deposit (Needham and Evans 1987). The absence of beeswax in the body of this sherd excluded the probability of the use of beeswax as a sealant and suggests that honey was one of residue constituents (Needham and Evans 1987). The vessel form of this sherd was not identified.

Discolored residues were also observed on Neolithic ceramic sherds, from vessels of unknown form, from the waterlogged site of Ergolding Fischergasse, Germany (Heron et al. 1994). The occurrence of beeswax as discolored deposit (layer of shiny black material) adhering onto the inner surface of one of these potsherds suggests that beeswax was possibly heated and applied as a thin layer to the permeable fabric of the vessel, enabling the storage of liquids. The other possibility is that beeswax could have been stored in the vessel to be used afterward (Heron et al. 1994). Analysis of discolored residues on the other ceramic sherds from the same site revealed the presence of tar, which could have functioned as waterproofing agent, sealant, adhesive and chewing gum (Heron et al. 1994).

CONCLUSION

Analysis of organic residue preserved in archaeological ceramics using analytical organic chemical techniques has the ability to identify vessel contents that can be linked with the vessel function or use in antiquity. The function or use of these contents can also be derived. Vessels were exploited in the past for different functions or uses, such as transporting, storing, preparing, processing, lightening and cooking, using one type or more of available natural raw materials. For example, analysis of organic residues preserved in ancient lamps revealed that the fuel of these lamps could be one or mixed of plant oil, animal fat and/or beeswax. Other vessels however, were functioned/used in religious and beekeeping activities, as well as in technological activities, such as metallurgy.

Analysis of organic residue preserved in archaeological ceramics provides information about anthropogenic effects during vessel use and about burial conditions after discarding the vessel. Beeswax, as one of the organic residues found in archaeological ceramics, is vulnerable to degradation and alteration caused by heating, hydrolysis and oxidation during vessel use and burial, as well as by leaching with groundwater during burial. However, the degradation and alteration of beeswax in archaeological ceramics is much lesser than that of lipid constituents present in animal fats and plant oils.

Beeswax can be characterized by the presence of even-numbered long-chain monoesters (WE40 - WE52) derived from palmitic (F16:0) fatty acid, odd-numbered n-alkanes (C21 - C33) and even-numbered free saturated fatty acids (F22:0 - F34:0), in addition to other constituents produced by heating, hydrolysis and oxidation.

The preservation of beeswax has been reported in ceramics from different chronological periods in archaeological sites located in different regions in Europe, Near East and Far East. The presence of organic residue of beeswax in various types of archaeological vessels indicates the diversity of the functions/uses of beeswax. These include a sealant for vessels, an adhesive or plasticizer in the production of adhesives, a fuel for illumination, a waterproofing agent, an insect repellent, ingredient in the production of medicinal ointments and a material used in lost wax technique in copper industry. The occurrence of beeswax in particular vessels, some with interior combed surfaces, has been attributed to the use of these vessels as beehives to collect honey and beeswax in antiquity.

There is no apparent correlation between the form, type, feature or other physical characteristics of the vessel containing beeswax and the vessel use. Up to date, archaeological vessels containing beeswax can be categorized into two groups: The first group is beehives, which were divided into two types, burned and unburned clay cylinders. The second group however, is represented by other ceramic vessels of various forms. It includes lamps, cups, jars, bottles, cooking pots, bowls, strainer or sieve vessels, Gallipot (or albarello) vessel and cornets, in addition to unidentified ceramic vessels.

The occurrence of beeswax in archaeological contexts may strongly reflect the use of honey in the past. Archaeological evidences show that honey was used for different purposes such as pharmacological, culinary13 and ceremonial activities. The existence of honey and/or beeswax in ancient settlements could reflect some paleoeconomic and religious aspects.

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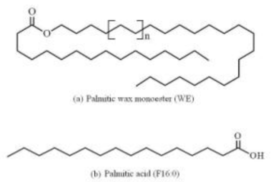

Figure 2. Chemical structures of (a) even-numbered long-chain palmitic wax monoesters (WE40 - WE52) with n = 1, 2, 3, 4, 5, 6 or 7, respectively, and (b) the palmitic acid, F16:0 (Mayyas 2007: 19).

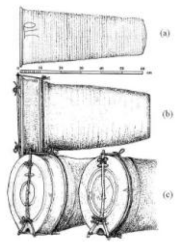

Figure 1. Ancient horizontal hives: (a) Late Roman horizontal hives from Isthmia; and (b-c) Hellenistic hives from Trachones, Attica, shown with and without extension ring (after Anderson-Stojanović and Jones 2002).

Figure 4. (a) A complete combed ware ceramic vessel (upright hive), and (b) and (c) interior combed surfaces of ancient ceramic sherds (each with rim and wall) of vessesls utilized as beehive at Isthmia in ancient Greece during the third century B.C. (Evershed et al. 2003).

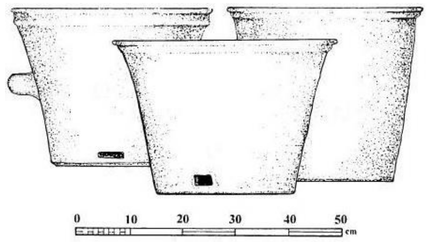

Figure 3. Three Late Roman upright hives from Isthmia (after Anderson-Stojanović and Jones 2002).

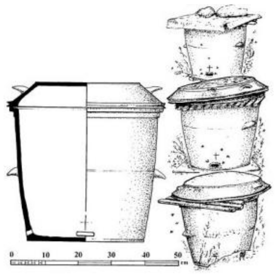

Figure 6. A modern hive at Palaiochorio, Crete, and sketches of three Palaiochorio hives in use (after Anderson-Stojanović and Jones 2002).

Figure 5. Unfired clay cylinders discovered in the 2005 excavations at the Iron Age site of Tel Rehov (Mazar and Panitz-Cohen 2007).

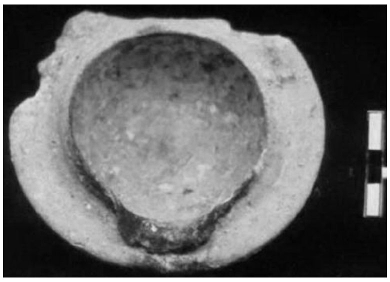

Figure 8. A lamp from the Late Minoan I (Neopalatial) period at the settlement of Mochlos, ca. 1600 – 1450 B.C. (Evershed et al. 1997).

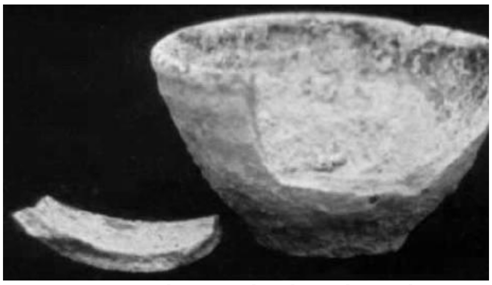

Figure 7. A conical cup used as lamp during the Late Minoan I (Neopalatial) period at the settlement of Mochlos, ca. 1600 – 1450 B.C (Evershed et al. 1997).

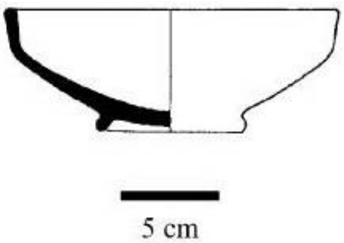

Figure 10. A Bucchero cup from an Etruscan settlement, La Castellina, late eighth - seventh century B.C. (Garnier et al. 2002).

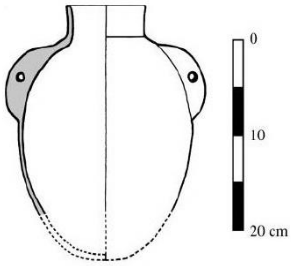

Figure 9. Typical Neolithic storage jar from Jiahu, subperiod II, ca. 6600–6200 B.C. (after McGovern et al. 2004).

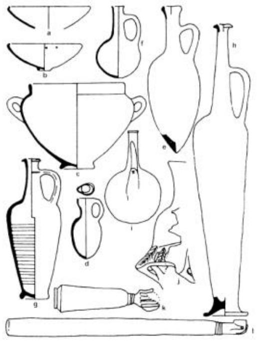

Figure 12. Main shapes of Red Lustrous Wheel-made ware from the Late Bronze Age sites in east Mediteranian (Knappett et al. 2005).

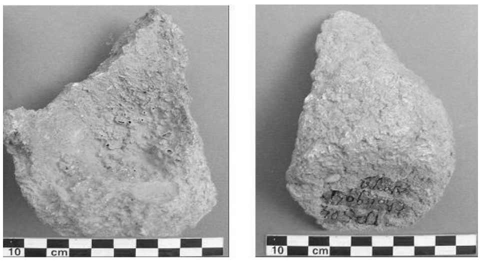

Figure 11. A fragment of a Late Chalcolithic (ca. 3700 - 3000 B.C.) bevelled rim bowl from the site of Tepe Chougali on the Tehran plain, Iran; Left: internal surfaces; Right: external surfaces (Mayyas 2007: 192).

Figure 14. Schematic illustration of the cornet (without scale), characteristic of the Chalcolithic period in the southern Levant (Namdar et al. 2009).

Figure 13. A 16th century ceramic vessel containing a greasy substance found at Middelburg Castle, Belgium at 2.5 m below actual surface in permanent waterlogged conditions (after Baeten et al. 2010).

[1] Such as preparation of cosmetics or medical commodities.
[2] Such as embalming, rituals, paintings and sculptures.
[3] Such as adhesive, sealing, shipbuilding, writing ground, lost wax casting and corrosion protection.
[4] For example, pollen and propolis.
[5] Such as cuticles.
[6] For example iron, aluminum and copper.
[7] Micrograms per gram ceramic powder.
[8] Wax ester (WE) is composed of a long-chain fatty alcohol joined to a fatty acid by an ester bond.
[9] Fx:y means fatty acid with x number of carbon atoms and y number of double bonds.
[10] For example derivatives of benzoic or cinnamic acid that are produced from thermal transformation of natural flavonoids present in beeswax.
[11] For example shape, size and interior roughening or grooving of these vessels.
[12] Spita tenacissima.
[13] As a foodstuff and a source of fermented beverages.