Buttering Up The Dead - An Archaeological Study of the Relationship between Burial Urns and Grave Gifts from the Scandinavian Roman Iron Age from Uppland, Sweden, Using Lipid- and Elemental Analyses

Bachelor Thesis in Archaeological Science
Author: Annika Sundström
Supervisor: Associate Professor Sven Isaksson
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The Archaeological Research Laboratory
Department of Archaeology and Classical studies
Stockholm University

Acknowledgments
First, I would like to thank my supervisor, Associate Professor Sven Isaksson, for his help during this whole process. Since the research project “Broby bro – en plats där världen passerar” is still ongoing, there are no published results concerning the archaeological excavation. The ceramic material that was acquired from the excavation of A7000 is presented in this paper. The help of Lars Anderson from Stockholms Läns Museum and Associate professor Fredrik Fahlander, from Stockholm University, the primary researchers for the project, has been imperative in producing this thesis and they have been a great support, lending me advise when needed and graciously giving me access to their unpublished data. I would like to thank PhD Oscar Verho of the Broad Institute in Boston, MA for his help in explaining the parts of chemistry, which to me seemed unexplainable. I would also like to thank Ragnhildur Árnadóttir for taking the time to advise me through the writing of this paper.
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Cover page: Picture taken by Annika Sundström, 23/10-2015 of grave A7000, Broby, Täby parish, Sweden
1. INTRODUCTION

1.1 AIM
The aim of this study is to explore and hopefully answer several questions concerning grave A7000, which was excavated as part of the research project “Broby Bro en plats där världen passerar” which is an ongoing research project between Stockholm University and Stockholms Länsmuseum. The grave, which to date, has not been fully analyzed. This essay will strive to determine the function and usage of burial urns as well as possible grave gifts found in the grave. Furthermore, this work will attempt to establish if two of the ceramic urn sherds tested come from the same urn because they are closely placed together. This is in contrast to the other urns, which are deposited with equal space between them.

1.2 DEFINITIONS AND ABBREVIATIONS
Layer – Same archaeological context
Level – Height above sea level
SIA – Scandinavian Iron Age
SRIA – Scandinavian Roman Iron Age
BSFTA – 10% chlorotrimethylsilan in bis-(trimethylsilyl)trifluoracetamid
FA – Fatty Acids
TAG - Triacylglycerides
GCMS – Gas Chromatograph - Mass Spectrometer
pXRF - Portable X-ray Fluorescence
FTIR - Fourier Transform Infrared Spectrometry
ND – Not detected

1.3 BACKGROUND AND PREVIOUS RESEARCH

1.3.1 SCANDINAVIAN ROMAN IRON AGE GRAVES AND RITUALS
It is uncommon to find graves dated to the Scandinavian Roman Iron Age (SRIA), not necessarily, because they do not exist, but because when they are found, they are in so unexpected areas (Burenhult 1999:151).

Cremations have, in many cultures, been connected to the belief that the soul leaves the body during the burning processes (Kaliff 1997:58). Many graves found dated to this period have been identified as cremation pit graves (Carlsson 2015:121). This means that the dead were cremated and the remaining bone fragments were assembled to be placed in urns already deposited in the earth. The care of the bone fragments can vary. Some are placed in the urns together with the remains of the pyre as well as with coal soot, bones and miscellaneous objects. Others are carefully cleaned before the deposition takes place. It is hard to determine exactly what the ceramics found in the grave contexts have been used for. Some ceramics have been used to transfer the bones from pyre to grave. Others have contained grave gifts in the form of food for the dead to carry with them to the other side. If the ceramics are surrounded by bone fragments it is an indication that they can have been used for bone storage (Dutra Leivas & Olsson 2005:168).
It is common opinion that no or few grave gifts are found in graves, with the exception of ceramics, from SRIA, giving this period the name “the artefact-less time”. Around the first century before Christ a change concerning this aspect takes place, and grave gifts in the form of metal artefacts become common. It is unusual to find ceramic urns that are intact from this time period as they tend to fragment. When they are found, a great variety in size, shape and decoration can be witnessed. What they all mostly have in common is that the ceramics from this period are expertly made (Hulthén 2013:32).

Many scientists believe that the idea of a life after death was an important part of SRIA culture and extensive rituals took place during burials. Therefore, some ceramics can be found in the grave context that seemed to have been part of the preformed ritual, serving as containers for food or drink. It is not unusual that the still living would bury the dead with the remaining food, even in the same ceramics the food was contained in (Dutra Leivas & Olsson 2005:164).

1.3.2 Preface
Grave A7000 is considered to belong to a larger cemetery found in Broby Bro, (RAÄ36) Täby parish, Sweden, ca 20 km from the center of Stockholm. (Fig 1) It is located right next to a Christian graveyard which has been successfully dated and identified as a late Viking Age graveyard (RAÄ42) The graveyard most likely contains several remains from the the Jarlabake family. This is one of the most famous families during the Late Viking Age – Middle Age in the Mälardalen region (Andersson 2011:8). Jarlabanke is believed to have been a large landowner in what is today Täby parish during the 11th century. Eighteen rune stones have been identified as having been raised by him, and half of them name him as the owner of all of the Viking Age Täby Parish (Wessén & Jansson 1943:13).
The area was first excavated in 1995 when the nearby road Frestavägen needed repairs. The purpose of the excavation was to find the rune stone embellished bridge built to the memory of Östen, husband of Estrid, and the grandfather of Jarlabanke. Instead, what they found was three unmarked graves of a man, a woman and a boy child dated to the late Viking Age (Haas & Karlsson 2014). The results of the excavation were found to be interesting enough to start a research project called “Between Ättebake och gravgård”. Archaeological studies have taken place during the years 2007 until 2015. However, this project is not yet complete and is, to date, on going in the guise of the new project “Broby- en plats där världen passerar” (Andersson 2011:4). The research work presented in this paper will be based on one of these excavated graves, A7000.

1.3.3 Site specifics

The excavation of grave A7000 ran from the year 2013 to 2014 and was originally only meant to last for one year. However, at the end of 2013 when the archeologists were supposed to close the site they found that there was more information to be taken from the site. Therefore, the decision was made to reopen the site in 2014. The complexity of this grave is truly astonishing seeing that it has as many as 28 different contexts and levels and has been used during three different time periods: Modern, Scandinavian Iron Age and Viking age. In total there are presumably six individuals buried in the grave (Aronsson et al. 2014:3). In order to understand this grave one must look at it through the different time periods in which it has been used.

In modern times, the residents of the surrounding area used it as a waste disposal site. Most likely due to the fact that a junkyard exists within a two km radius from the grave, and sometimes it is closed. There is a small parking lot right next to the grave, easing the deposition of trash. Unfortunately, this causes disturbances to all the levels of the grave as the residents in the area buried their trash at the edge of the grave. There were initial worries where that the decomposition rate could have been accelerated from oxidation and biological activity. Furthermore, the close proximity to the road “Frestavägen” was deemed a worrisome source of contamination, for example from heavy metals or Sodium Chloride (NaCl) (Etana & Rydberg 2004:16, Folkeson 2005:10).

During the 2013 excavation season, an inhumation grave was found of a 40-60-year-old woman (Haas & Karlsson 2014). Remains of a wooden coffin were found as well as grave gifts. The skeleton burial was interpreted as a Christian grave. This made sense because there is a larger Christian graveyard in the vicinity with strong connections to several rune stones (Andersson 2011:13). When the archeologists had reached the bottom of the Viking Age context, they noticed burnt areas and bone fragments scattered within the grave which could not be explained and pointed to the existence of another level (Aronsson et al. 2014:3)

In 2014, the grave was re-opened in attempt to conclude and fully understand the grave. There was a hypothesis that at one point there could have stood a rune stone right by the grave and the early focus of the excavation aimed at verifying this theory. However, under the theorized base of the rune stone archaeologists discovered remains believed to be from the 1900s. Since these findings were located under the believed base, the conclusion could be drawn that the rune stone was not raised inside the circle of the grave. Once that was concluded they decided to dig deeper to the next level. They first noticed a stone gasket, in circle form, which later was revealed to reside right on top of the urns yet to be found. The urns were found in sooted black soil, alluding to it being a burnt layer, originating from a burial involving cremation. They were deposited with rather equal space between them as can be seen in figure 2. Bone fragments were also found scattered in the burnt layer (Aronsson et al 2014:5).
1.4 Questions and Hypothesis

The Roman Iron Age is generally referred to as the “artefact-less time”. Scientists have established that during this period of time rituals concerning food and death took place. It was not uncommon that a meal be shared during a burial that was cooked in the burial urn. This lead to the question:

- **Did the urns have a previous function before being used as burial urns?**

Since the burial urns, all have been in the same larger grave, one naturally wonders if they have some connection or relationship to each other. It is fully plausible for this grave to have been traditionally used by one family wanting to be buried together but it is also conceivable that they were all buried there because they all died at approximately the same time. If so, it would help to shed light on the relationship between the urns.

- **Can a conclusion concerning whether the urns are made from similar materials be reached, through an analysis of the elemental composition of what the clay as well as an ocular study.**

By studying the schematic of the layer where the urns were found it is possible to observe that all the urns have been spaced equally within the circle shaped grave with the exception of F16195 and F16263 (fig 2). Due to the extent of the fragmentation of the urn it was hard to establish if the aforementioned urns where two separate or if they were in fact the same urn. If the urns are in fact separate the rational hypothesis would therefore be that the two urns have a connection to one another due to their close proximity.

- **Because the urns designated F16195 and F16263 are so closely placed together, are they in fact the same urn?**
2. MATERIALS

2.1 DATING OF THE URNS

The soot, cremation, bone fragments, urns as well as the stone circle on the ground level all pointed to the grave originating during the Scandinavian Iron Age (SIA). Scandinavian Iron Age encompasses a long time span and is usually divided into five periods: pre-roman Iron Age (500BC-0), Roman Iron Age (0-400 AD), the Migration Period (400 AD-550 AD), Vendel Age (550AD-750AD) as well as Viking Age (750AD-1100AD) (Burenhult 1999:151ff).

Larger raised stones, especially circle formed, usually indicate the presence of a cremation grave from the Scandinavian Iron Age. Cremation pit burials are a characteristic trait for the SIA period with deposited urn graves, found in a burnt layer of earth with bone fragments indicating a pyre having taken place. The cremated bones are also found with elements of the pyres grave goods. They are often deposited in flat land areas and thereafter covered by strategically placed stones (Carlsson 2014:121). The topography of Broby bro however, does not follow this standard, seeing as the surrounding area is sloping with elements of hills.

Unfortunately, no grave goods/gift were found, not unusual for the SIA period, which could be used for identification. However, cremations as a burial format are most commonly found during certain time periods such as late Bronze Age- (1800 BC-500BC) and early Iron Age (500BC-400AD) (Burenhult 1999:252). Bronze Age was ruled out as a time period because the larger stones placed in a circle form pointed more towards the Iron Age than Bronze Age. Also because this form of grave is simply not found during the Bronze Age, nor is there any symbolism associated with Bronze Age graves (Kaliff 1997:86, Kaul 1998:53). The period 500 BC-400 AD is a rather long time span however, so to narrow the relevant Time Period down, the urns were radiocarbon dated to ascertain the correct time period. The radiocarbon dating result showed that the urns were dated to the first century after year zero (table 1).

Radiocarbon dating bones is not unproblematic as there is sometimes cause for misinterpretations. Studies of burned bones show that the carbon in bones is sometimes replaced during the cremation process and carbon from the fuel and atmosphere are inserted instead. If an aged fuel is used (ex. old wood) during the cremation process, the result from the radiocarbon dating provided can be false, showing an age far older that in reality Other contamination factors could be bacteria or fungi that have entered the bone matrix that can affect the radio carbonating. (Engstrand et al. 1967:146). However, since the result of the dating is consistent with the cultural environment the bones were found in, this is not troubling and the results are most likely correct.

Table 1 Radiocarbon dating of bones found in findings F1007 and F16137 sent by Fredrik Fahlander 11/12-2015

<table>
<thead>
<tr>
<th>UBANO</th>
<th>Sample ID</th>
<th>Material Type</th>
<th>14C Age</th>
<th>±</th>
<th>F14C</th>
<th>±</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBA-30460</td>
<td>A7000/F16007</td>
<td>Cremated bone from urn</td>
<td>1968</td>
<td>24</td>
<td>0.7827</td>
<td>0.0023</td>
</tr>
<tr>
<td>UBA-30461</td>
<td>A7000/ F16137</td>
<td>Cremated bone from urn</td>
<td>1932</td>
<td>22</td>
<td>0.7862</td>
<td>0.0022</td>
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</tbody>
</table>
Figure 2 Schematic layout of the urns F16007, F16152, F16195 and F16263 in grave A7000 in red, with the calcified artefact F16137 in blue provided by Lars Andersson from Stockholms Läns Museum, 5/11 2015
2.2 Ceramics

A total of five ceramics will be discussed in this thesis: F16007, F161152, F16195, F16263 and F16137 and their placement in the grave is shown in fig 2. The sherds for the urns F16007, F16137 and F16152 were provided by Sven Isaksson from the Archaeological Research Laboratory at Stockholm University. All of the sherds were kept in a frozen environment, to slow the reduction of lipids from heat and foil wrapped to counteract contamination from plastics. (Seen in chapter 3.1 below)

This practice was followed during the excavation of A7000 with relative success. It failed concerning F16137 and F16362, as the samples chosen from these two urns were far too small to be viable for testing. This could have been prevented by informing the excavators (which consisted inter alia of students) what was required of a sherd meant for testing, concerning size, as well as which sherds forms were preferable for chemical analysis. At the same time, the importance of wearing gloves during the excavation could have been underlined to prevent contamination especially when handling material meant for chemical analysis, perhaps even instituting a practice of wearing previously unused rubber gloves when handling certain materials.

As previously mentioned the original sherds meant as testing pieces for the urns F16137 and F16263 were deemed not usable. Luckily, ceramic sherds could be borrowed from Stockholms läns museum and were lent for the purpose of this research by Lars Anderson at the museum. Unfortunately, these sherds had not been preserved with laboratory uses in mind. Therefore, contaminations from plastics, handling without gloves and fingerprints and a warmed environment were an initial concern during the research presented in this work.

2.2.1 The South East Area

The urn found in the South East of the grave, F16007, was first believed to be a bone stash. However, it was later revealed to be a burial urn with bone fragments with different combustion levels. The upper part of the urn was damaged and brunt bones, carbon and fragments of ceramics were scattered around the urn. There was also a ring of stones placed around the urn. The urn measured 0.24 x 0.23m in diameter. This urn was found on a level slightly higher than the rest resulting in the question whether it could have been deposited later than the rest. The sand like material found in the urn was composed of bone fragments. A basic osteological analysis showed that the bone fragments came from human and animal sources. (Aronsson et al. 2014:6)
2.2.2 The North East Area
F16152 was found in the North East part of the grave, severely damaged, and measured 0.3 m in diameter. Larger bone fragments were found around the edges but in the middle there was mostly bone mass. In the surrounding area where the urn was found there was soot and coal as well as burnt bones. Just like with F16007 a large amount of bone fragments was found outside of the urn as well as a ring of stones. A basic osteological analysis showed that the bone fragments came from a humane source. (Aronsson et al. 2014:7)

2.2.3 The North West Area
The urn found in the North West was measured in as F16195 and was measured 0.25 m in diameter. In addition, here a large amount of burnt bone fragments as well as ceramics, coal and soot were found. The bones were concentrated around the edges of the urn with a larger concentration in the northern part. The orifice of the urn was heavily damaged. A basic osteological analysis showed that the majority of the bones came from a human and that there was a possibility that some of the bones could come from a bovine. (Aronsson et al. 2014:7)

2.2.4 The Other Area in the North West
A bottom of an urn was found in the North Western part of the grave and was defined as F16263. The urn was covered in burnt bone fragments and sand consisting of decomposed bone mass. (Aronsson et al. 2014:7)

2.2.5 The South West Area
F16137 was first believed to be an urn, however when it was analyzed in the archaeological laboratory at Stockholm University, it appeared to be calcified to the point of being made from limestone and was reinterpreted. The artefact was found with carbonized mud and a large amount of burnt bones. The artefact’s function has yet to be determined, however, it is theorized to be some form of bottom or lid, possibly connected to a coffin like construction or superstructure. Even here, there was evidence of bone fragments of both human bones and sheep bones that had been strategically placed. (Aronsson et al. 2014:7)
2.3 MATERIALS

Sherd for urn F16007 – A sherd, 30mm in size, and weighed 4.76g of which 0.62g was extracted for analysis was selected to represent this urn. The sherd was rather dirty, but instead of cleaning it with a brush or water, the tile cutter was used to remove a very thin layer of the sherd. The outside of the sherd was red/yellow in color. (Fig 3) After the tile cutter had drilled ca 0.7 mm below the original surface of the sherd, the color was much darker in the temper, a grey/black (Table 2, V:B). The temper consisted of small parts of quartz.

Sherd for urn F16152 – This sherd, 32mm in size, 7.20g in weight of which 0.84g was extracted for sample use. The sherd was yellow/grey with the slightest hue of red in color. (Fig 4) The sherd, like the previous one, was covered in dirt and a sample was removed by use of a tile cutter. Compared to F16007, F16195 and F16137 the color of the temper was a rather lighter grey once 0.5mm of the ceramic had been removed (Table 2). The sample powder was much harder to extract from this sherd compared to the others. In the temper, a larger size of quartz chips could be observed.

Sherd for urn F16195 – The sherd representing urn F16196 was 25mm in size and weighed 3.83g of which 0.58g was extracted for sample use, and was, unlike the previous presented sherds, a darker grey in the outside color. (Fig 5) This one had a darker color in the temper witnessed after the extraction had taken place, the color of the temper almost black. (Table 2) Shiny sections could be observed where the drill had extracted the samples, indicating that the temper may have had some form of treatment. Even here, quartz chips were found in the temper.
Sherd for urn F16137 – The sherd measured in at 30mm in size and 6.00g of which 0.61g was extracted for testing. The color, like F16007 and F16152 was yellow/red in hue with a darker greyer tone in the temper. (Fig 6) However, compared to the other sherds, with exception of the calcified one, the field spade found in this ceramic composition was much smaller, 1-2mm, compared to the others. (Table 2) Like the previous sherd this one was also rather clean.

Figure 6 Shard for Finding F16137

Sherd for urn F16263 – The sherd used to analyze F16262 was 20mm in size and 3.72g in weight of which 0.61g was extracted to be used as a sample. This sherd was much lighter in color compared to the rest of the sherds, (Fig 7) and leaned more towards a yellow/grey hue than a red, as can be seen in Table 2, V:A-B. The color was more consistent even after scraping the surface of the sherd. The required sample was also much easier to extract from this sherd compared to the others. This sherd was not as dirty compared to the others, and had little or no temper.

Figure 7 Shard for urn F16263
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<th>Temper</th>
<th>Size of temper</th>
<th>Weight</th>
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Table 2: Registry of the ceramics based on ocular study.
3. METHOD

3.1 ARCHAEOLOGICAL LIPIDS

To answer the questions regarding pottery use, a lipid analysis was used to try to analyze the residing lipids, (also known as oils and fats) that can be found in the ceramic sherds taken from grave A7000. Lipids are molecules that contain hydrocarbons, and are highly reduced forms of carbon, and make up the building blocks of the structure and function of living cells. Examples of lipids include fats, oils, waxes, certain vitamins, hormones and most of the non-protein membrane of cells. Lipids can be extracted from plants and animals using nonpolar solvents such as ether, chloroform and acetone (Isaksson 2000:32). Lipid residues are considered to derive primarily from food stored or prepared in the vessels. It is important to point out that lipid analyses are interpretations, much like interpretations of archaeological artefacts. In addition, it is important to keep in mind that just because there is a lot of a certain fat found, it does not necessarily mean that the fat in question was the main component in a recipe. It is simply the compound that contains the most fatty acids (Isaksson 2015:33). It has been much discussed if the lipids found in archaeological pottery by a lipid analysis derives from the last time it was used, or from previous usage. Evershed (2008) argues that the absorbed lipids originate from several different occasions and the results are comprised from these usages (Evershed 2008:10ff). This argument assumes that the pottery has been used previously. However, if an artefact were used but once then the accumulated result would show only evidence of that happening. As Isaksson pointed out the entire life of a pot is unknown to us (Isaksson 2000:37). If the number of uses could be determined, (new vs previously used) the data could be used to try to separate number of times it was used. Perhaps through experimental archaeology, this can be achieved, comparing the digression of ceramic urns, burnt at different temperature and composed of different materials, with times used. This could lead to a deeper understanding of lipid interpretations.

3.1.1 DEGRADATION OF LIPIDS

Lipids, like all organic materials, degrade over time. Preservation of the lipids is both affected by the original chemical compound and condition of the burial environment e.g. temperature, pH, biological activity etc (Evershed 1993:77). Lipids found in a protected environment, such as in ceramic matrix, are far more likely to be preserved than those in unprotected environments, like in the surrounding dirt (Isaksson 2000:36). Lipids are more or less insoluble in water, giving them hydrophobic properties (Evershed 1993:75). Lipids structures can, however, be affected both during deposition and during its usage. This complicated the identification of its origins (Isaksson 2000:33).

3.1.2 INTERPRETATIONS OF LIPIDS

While identifying different compounds can be straightforward, concluding their origin can be problematic (Evershed 1993:75). However, it is possible to determine the origin of the lipids to the point of a broad classification such as land bound animal, aquatic animal and vegetable (Christie 1987:42, Isaksson 2000:32-34, Campell & Farrell 2006:184, Evershead 2008:7).

Fats with longer molecular chains are more resistant to decomposition and are more likely to persist than fats with shorter chains or chains containing double bonds such as the ones found in vegetable oil. This being said the majority of lipids found in the archaeological artefacts consist of free fatty acids (FA) (Christie 1987:13) which are freed from triacylglycerides (TAG) through hydrolysis. If the distribution of TAG is wide (ca 40-52 carbon atoms in the acyl portion compared to ca 46-52) it is usually an indication of the fat being from a milk product such as milk, cheese or butter (Campell & Farrell 2006:186, Isaksson 2015).
Land bound animals have a higher level of stearic acid (C18:0) in relation to the palmitic acid (C16:0). A high C18:0/C16:0 ratio is generally an indication that the fats originate from a land based animal whereas a low ratio points to a marine or vegetable origin (Isaksson 2000:35, Campell & Farrell 2006:190). If the C18:0/C16:0 ratio is high it can be interesting to examine the C17 branched (C17br) in relation to the C18:0. If the resulting ratio is high it can point to the origin of the lipid being a ruminant animal such as bovine (Isaksson 2000:36).

To distinguish animal lipids from plant lipids one must study the sterols that they biosynthesis. The presence or absence of either cholesterol (main component in land bound animals) or physterols (produced by plants through photosynthesis) can point to the lipids origination from the animal kingdom or plant life (Evershed 1993:87, Isaksson 2000:34-35).

Since both marine, plant and animal origins are indicated through a low C18:0/C16:0 ratio, the combination of cholesterol and the low ratio can be used to identify aquatic sources. Cholesterol is also usually the only way to distinguish lean marine animals from plants, as they have similar retention times detected by the GCMS (Olsson & Isaksson 2008).

### 3.1.3 Contamination of Lipids

Contamination is a worrisome factor when studying archaeological lipids. Contamination can be introduced either in the environment or during the excavation process. Environmental contamination can for example be pre-existing lipids in the soil that are introduced to the artefact during the burial process. However, one can compare the result of the lipid analysis with results from soil samples collected in the burial surrounding to exclude any contamination from the lipid analysis results (Heron et al. 1991).

Contamination from the excavation process is quite common, but can be avoided if the artefacts are handled correctly. The later contamination is a rather common problem within the field of archaeological science. The best way to insure no such contamination takes place is to already during the archaeological excavation decide which pieces to use for laboratory studies and handle them accordingly (Isaksson 2012). The presence of squalene in a lipid analysis results most likely point to contamination from fingerprints. Squalene has many double bonds and is subsequently more prone to digression. Therefore, the assumption can be drawn that it was introduced to the artefact in recent times. As such, squalene can be used as a reliability test. If squalene is found in a lipid analysis the results are contaminated to the point of being non-useable, if it is not then the sample is not contaminated and the results are viable. The importance of wearing gloves can therefore not be understated, as the resulting contamination leads to a lot of money and time being wasted (Nakagawa 2007:4-7).

### 3.1.4 Extraction Sample

When fats are heated a part of them are absorbed inside the ceramics or become oxidized. The heat caused by the cooking causes the fats to rise, which makes the orifice of the pot one of the optimal part of the ceramic to analyze (Evershed et al. 2001). However, since no such piece existed amongst the ceramic material found, the inside of a ceramic sherd from the body of the urns, was used instead for the tests described in this work. Extraction of the sample from the ceramic was done by drilling the inside of the ceramic sherds with a tile cutter, resulting in a fine powder. Unfortunately, this process is destructive, but a necessary sacrifice to make to complete the analysis.
3.1.5 **Lipid Extraction**

After adding two parts chloroform (1000 μl) to one-part methanol (500 μl), an ultrasonic bath was used for 30 min as well as a centrifuge (30 min at 3000rpm), in order to separate the lipids from the ceramic powder. After transferring, the resulting liquid to a test tube the remaining chloroform and methanol was slowly evaporated by a stream of nitrogen gas as was well as gentle heat.

3.1.6 **Derivatization**

In the next step, the sample was derivatized by addition of 60-100 μl of regent, 100 μl Bis(trimethylsilyl)-trifluoracetamid with 10 % Chlortrimethylsilan. The resulting mixture was shaken and subsequently heated at 70 degrees C for 20 minutes. After which the remaining liquid was removed by evaporation using a weak stream of nitrogen gas. This concluded the derivatization process and the lipids were dissolved in 400 μl of n-hexan and transferred to vials for the lipid analysis.

3.2 **Gas Chromatograph Mass Spectrometer (GC-MS)**

The Gas Chromatograph (GC) Mass Spectrometer (MS) consists of two different parts (Fig. 8). The GC’s separates the mixtures of chemicals into individual components based on primarily their volatility while the MS fragments the chemicals into unique molecular ions or ion fragments that can be used for identification. The GCMS uses the time it takes for the chemical to travel through the GC column, the retention time (RT), and compares is to known standards to identify the chemical. However, it is important to keep in mind that the GC is a negative evidence technique. It can only prove that two substances are different and not the same, as more than one chemical compound can have the same retention time. A standard can be used to identify the retention times of the relevant compounds. However, to insure a correct identification the MS is used. As the lipids exit the GC column they enter a high vacuum chamber of the MS where they are exposed to an ionization source that breaks apart the chemicals into a number of ionized fragments. By examining, the mass of these ion fragments (spectrum) and correlating the mass spectrum to a reference database it is possible to identify chemical components that were present in the analyzed sample (Christie 1987:7, Kitson et.al 1996:3, Evershead et.al 2001:331).
While the usage of a GCMS is considered the “gold standard” for analyzing and identifying chemical compounds it has its limitation.

1. Frequent maintenance and careful operation, requiring highly trained personnel. For instance, the MS part of the instrument operates under high vacuum and understanding and following the recommendations for the vacuum is critical to ensuring the instrument works properly and that no contamination takes place. Secondly, the range of chemicals that the instrument scans can be limited. Both the GC and MS portion of the instrument needs to be optimized for the types of chemicals one wishes to identify. For example, if the GCMS is configured mainly to detect volatile chemicals it will not detect very high molecular weight. Configuring the instrument is imperative to ensuring reliable and thorough results (Brock 2015)

The GCMS used in this work was a HP 6890 Gas Chromatograph with a SEG BPX5 capillary column (30m x 220μm x 0,25μm) of unpolar character. The injection was made pulsed splitless (pulse pressure 17,6 psi) at 325-degree C via a Agilent 7683B Autoinjector. The oven was programmed for an initial isotherm of two minutes at 50 degrees C after which the temperature was subsequently raised 10 degrees C/10 min until it reached 360 degrees C. This was followed by a final isotherm at 20 min. Helium (He) was used as carrier gas with a constant flow of 2.0 ml per minutes. The Gas Chromatograph was connected to an HP 5973 Mass selective detector through an interface with the temperature of 360 degrees C. Fragmentation of the separated compounds were made by electronic ionization (EI) at 70 eV. The temperature of the ion source was 230 degrees C. the mass filter was set to scan in the range of m / z 50-700, yielding 2.29 scan / sec and its temperature was 150 degrees C. The collection and processing of data was done with the software MSD ChemStation.

2. The pattern of fragmentation in the ion source i.e. what is measured in the mass spectrum is dependent on the mass of the molecule and of its chemical structure. But the interpretation of mass spectra is not always easy. This may be very frustrating when you encounter a new unknown component that is not in your reference library because you know that the mass spectrum contains all the information you need to identify it.

While a Fourier Transform Infrared Spectrometry (FTIR) could be used as a method to analyze the urns presented in this work, it was opted out. By sending IR radiation of which some passes through the sample (transmission), and some is absorbed, it can analyze the resulting spectra of the molecular absorption and transmission. Re result is presented in a spectra and no two compound has the same resulting spectra. (Thermo Nicolet Corporation 2001) It would have been preferable to use the FTIR analysis in the sense that it can analyze both organic and inorganic materials however, it cannot give the specific data, which can derive from a GCMS analyses. While a FTIR can identify what a compound is it cannot identify its origin. (Brock 2015)

Taking the limitation into account it was concluded that the GCMS would be a preferable analytical method as relevant references could be used and it was also optimal due to the low amount of test material that needed to be extracted, 0.5 g, ensuring as little destruction to the artefacts as possible. A GCMS can only examine organic material and so, to study the inorganic material, a pXRF was used to further this research. By combining these two methods, hopefully a full analysis of the material will be achieved.
3.3 Elemental Analysis by pXRF

Portable X-ray Fluorescence (pXRF) is used to analyze the different elements that an artefact consists of. An Olympus Delta Premium portable X-ray Fluorescence was used in this work. By using this method, it is possible to gather further insights concerning the materials comprising the urn. There are many reasons this method of identification has become increasingly popular in recent years. The fact that it is cost-effective, nondestructive, requires minimal preparation, fast and easy to use are just a couple reasons why it is used frequently within archaeology (Shackley 2011:8).

A pXRF works by sending two separate beams with enough energy, 10kV and 40 kV, to affect the electrons in the inner shell of an atom of a test sample. (fig.4) The x-ray beam interacts with the atoms in the sample by displacing the electrons from the inner orbital shell of the atom. This displacement occurs because of the difference in energy between the x-ray beam from the XRF and the binding energy of the electrons with which it interacts. Electrons are fixed at specific energies depending on the element and can thus be identified by measuring the energy of emitted x-rays from a sample. Also the spacing between the orbital shells are unique to the atom of each element, in other words an atom spacing of copper (Cu) and silver (Ag) differ and the separate metals can be identified by the machine, even if they are combined through allegation, through calculating the space between the orbital shells of each element. This identification method is what the fluorescence part of the machine does, it calculates the energy lost (Kalnicky et al. 2001:94–95, Shackley 2011:9, Parsons et al. 2013).

A XRD could have been used to study the artefacts for this research. However, the decision to use the pXRF was made as an XRD specializes in analyzing compounds with crystalline structures (and is a preferable method when such materials need to be analyses) while ceramics contain materials of several structures (Bish et al. 1989, 73–76).
The pXRF was used in this work in an attempt to reveal which different materials the urns in question were composed. Nineteen different elements were used as identification markers as well as light elements. Light elements consist of all the elements which have a lighter atomic weight than magnesium i.e. hydrogen to sodium. In the beginning, three tests were taken for every ceramic sherd. The variation in elements could clearly be observed but for a more definitive conclusion, the decision was made to gather more data. Therefore, three more tests on each sherd were made totaling 6 tests done on each sherd.

4. Results

4.1 Lipid Analysis Results

The lipid analysis results depicted in table 3, shows that there were no detectable amounts of lipids, in F16007, F16137, F16152 and F16263. The only trace findings that could be detected from these test samples were terpenoids that were found in F16007, F16152 and F16195. The existence of terpenoids indicates that the ceramics had been in some contact with either smoke or soot. Terpenoids can either enter the ceramic matrix during the burning of the ceramic itself i.e. during vessel production or after. (Isaksson 2000:35)

This is a reasonable finding considering that these urns have all been defined as burial urns and the deceased deposited in them were cremated. Taking this in to consideration, it is surprising that no terpenoids were found in F16263 as it has been defined as a burial urn as well. In any other case this result could be achieved through dissolution due to either contamination; however, no such evidence was found. Other explanations could be either corrosion or a more rapid decomposition in comparison to the others because of either oxidation or biological activity. However, this is unlikely, seeing as it was closely deposited to urn F16195 and that test resulted in seemingly high lipid findings.

As for the F16195 test, lipids were found. The results showed a high C18:0/16:0 ratio 0.64 (Table 3) indicating that there might be lipids with land bound animal origins. Seeing as a high amount of C17br was found and compared to C18:0, this result points to ruminant origin. The TAGs found in the sample showed a wide distribution, 40-50, which is a strong indication that the lipid residue originated from a milk product. The representative high level of fats found leads to the theory that the lipids could have had the original form of butter (Evershed et al. 2002)

Through the presence of all three isoprenoids, a conclusion can be drawn that there does exist traces of marine lipids, even if there is no evidence of cholesterol, and vegetable lipids, giving F16295 the results TAV, ie. that there are Terrestrial, Aquatic and Vegetable lipids in the urn.
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<th>FA</th>
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<th>LCAL</th>
<th>BR</th>
<th>C17/18 FA(uns)</th>
<th>DA</th>
<th>TAG</th>
<th>Kolesterol</th>
<th>Fytosterol</th>
<th>LCK</th>
<th>Isoprenoid</th>
<th>AFFA</th>
<th>Terpenoid</th>
<th>Interpretation</th>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
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<td>22(26)32</td>
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<td>ND</td>
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</table>
4.2 pXRF RESULTS

The results of the pXRF analysis are presented in Fig. 11 and Table 4 and 5, shown below, was created by using the Statistica 12 software. In all of the analyses, a delimitation of differentials was made at 0.05 or 5 percent because the contradicting findings could be accidental.

What can be seen in Fig. 11 is that F16137 and F16263 are clearly defined and separated from F16007, F16152 and F16195. The divergence concerning the tests taken for F16137 is in fact not surprising, as it was known from previous reports that the composition of the artefact most likely consisted of limestone (Aronsson et al. 2014:4).

However, the results concerning F16007, F16152 and F16195 were unexpected. The results show that while the urns clearly are separate artefacts, they have similar elemental composition, with marginal variation. This finding points toward the three urns originating from approximately the same geological area. To give a clearer result concerning the variation between the urns with similar elemental composition a compare and contrast table was created. The table revealed that the urns F16007 and urn19152 differ in only five elements. (Table 4) - four if you discount the difference in phosphor levels, as the cause for this differential could be explained as phosphor can derive from the burial environment or because it has a slightly overlapping signal with Ca. This strengthens the theory that at the very least these two urns may have originated from the same area.

The divergence of F16162 was, as with F16007, F16152 and F16195, unexpected. Due to F16162s close proximity to F16195 it was first theorized that these could be the same urn, however, this result indicates this theory to be false. To confirm the falsification of the theory a compare and contrast table was made. The results showed that the urns F16162 and F16195 differed in nine different elements, which is a substantial difference (Table 5). Even if one were to exclude magnesium, due to the fact that it is difficult to measure and light elements because it is a combination of many different elements was well as phosphor for previous mentioned reasons, that still leaves a differentia of 6 elements (see Table 5).

The tests appear to have consistent results, with the exception of one of the tests for F16263, which could be a statistical anomaly, confirming the reliability of the results.
Figure 11 Factor plot of the two first factors from a principal component analysis of the pXRF results using Statistica 12 Software
Table 4 Compare and Contrast table for F16007 and 16252 using Statistica 12 Software showing differences in elemental composition in red

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<th>t-value</th>
<th>df</th>
<th>p-Value</th>
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<th>Valid N 2</th>
<th>Std.Dev. 1</th>
<th>Std.Dev. 2</th>
<th>F-ratio</th>
<th>Variances</th>
<th>p-Value</th>
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Table 5 Compare and Contrast table for F16263 and 16195 using Statistica 12 Software, showing differences in elemental composition in red

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5. DISCUSSION

Unfortunately, as there were no lipids found in F16007, F16137, F16152 and F16263, no clear answer can be reached concerning the possible previous function of these artefacts. However, just because no lipids were found in the artefacts does not mean that they did not have a previous function. It is fully probable that there may have been lipids in the ceramics at some point in history, but that they decomposed during the time deposited in the earth.

In F16195, there was an abundance of lipids. Seeing as there could be traces of lipids found originating from terrestrial, aquatic and vegetable, it is within reason that this urn could have been used as a cooking pot at some point. When comparing the amount of residue lipids found, the traces for aquatic residue were on the margin of being present. This leads to the consideration that it could first have been used to either store or prepare an aquatic based meal, before coming into contact with land bound or vegetable lipids. It would be interesting to see if one could compare the marine data to data found in the nearby lake Vallentunasjön, to conclude if the marine material could have originated from there. By comparing the lipids found with an isotope analysis of fish bones from Vallentunasjön dated to the same time period, the theory can either be confirmed or falsified (Szpak 2011).

The results concerning the ruminant lipids from the GCMS can in this case be confirmed. Both through the wide distribution of TAG and C17:br/C18:0 ratio and because there were possible bovine bones found in the urn when it was excavated. The quantity of lipids found with such wide distribution of TAG leads to the conclusion that the milk product lipids could have originally been a form of butter. Butter was considered a precious and expensive product during the SRIA period and was only used during special occasions. To be buried with it shows great respect for the departed (Regionalmuseet.se 8/1-2016).

What can also be concluded from the GCMS analysis is that the urns F16007, F16152 and F16195 have all been in contact with either soot or coal. These findings could have found its way into the ceramics by being used as a cooking pot and the coal/soot originating from the fire used to heat the pots. It is also within the realm of possibility that the coal/soot entered in the ceramics matrix during the production of the urn. However, taking into consideration that all of the aforementioned urns were found in sooted earth, indicating a pyre had once taken place, it is more reasonable to assume that the coal/soot originates from the pyre.

Interestingly enough F16137 and F16263 were also found in the sooted context, however no terpenoids where detected in these artefacts. In the case of F16263, this could indicate that the urn could have been deposited after the pyre had taken place and the bones then deposited in the urn. Unfortunately, as the function of F16137 has not been determined, it remains a conundrum. However, the result from the GCSM could indicate that F16137 has not been in contact with a fire such as a pyre, and could have been deposited there after the pyre had taken place.

The fact that both of the tests that indicated no Terpenoids were provided by Stockholms läns museum, and were not preserved specifically for chemical analyses, has been taken into consideration. It is possible that the museum environment hastened the decomposition of the lipids, however, it has been established that the sherds were not cleaned using water, or any other substance for that matter (Andersson 2016). Thus, early reduction of the lipids due to hydrolysis has been disproved. This leaves the natural decomposition factors of lipids such as heat, oxidation, and biological activity from the earth etc.
As seen in the previous section through the pXRF analysis, three of the urns, F16007, F16152 and F16195 clearly have similar amounts of elements concerning the composition of the clay. However, table 4 shows that they differ only slightly. There are several explanations for how this could come to be. For example, the urns could be locally made, maybe even by the same person. At this stage, one can only theorize due to insufficient data. To truly confirm such a theory, one would have to travel around the surrounding area and take earth samples from several different places, and further pXRF studies performed.

Concerning F16137 and F16263, the former finding has a vastly different composition due to that fact that it mainly is composed of calcified material. Thus, it is hard to draw a conclusion concerning this artefact. To understand the artefact, further studies are warranted, specifically comparison studies to other findings with similar material composition and form comparison. What could simplify these further studies is that the reference artefacts would not have to have the same archaeological context as this one, i.e. burial grave. It is not the cultural aspect that is in focus at this point but the material composition. Therefore, one could compare this urn to any other calcified ceramic artefact, dated to the same time period.

However, F16263 has no clear similarity with any of the other urns leading one to theorize that in this case the urn could have originated elsewhere and been imported to the area. To confirm this theory one would have to further study the material composition of the found ceramics in the area and contrast them to F16263. If, when compared to a larger data set, it still seems to be unrelated to the ceramics in the area it would strengthen the theory that it did not originated in the area but not confirm it. To do so one would have to study other ceramic pieces, with known other origins, to try to find similarities between them. What the field of archaeology really need is a worldwide geological database, which can be used as a reference. Archeologists are already required to catalog and report archaeological findings to the relevant museums. It would not necessarily require too much time to upload results geological analyses to a database with would benefit all archaeologists. For that matter, one could found a cooperation with the geological field study and create the database in cooperation. Of course, confirmation of the original source of the urn would be much simpler if the artefact was unbroken, as one could then compare form, glaze and decoration to try and find its origins. As it is, the urn is in pieces, and there is little to study. While archaeologists can study the width of the wall of the ceramic, the filling of the wall as well as color to try and ascertain burning technique it is only through material composition studies one can give a definite answer to the conundrum that is F16263.

Taking the results presented in this work into consideration, it can be concluded beyond any doubt that F16195 and F16263 are not the same urn. These urns differ in color, size and temper, proven by the ocular study and as the pXRF results showed, they differ in nine elements in their composition.

However, the GCMs results showed some very interesting data. The fact that F16263 has no discernable lipid residue while F16195 has an abundance of it, and because these urns were found deposited in very close proximity to each other, one can theorize that there may be a ritualistic relationship between the two.
As presented in the ocular study, the clay of F16263 was very fine, with no discernable temper. The making of such an urn requires a fair amount of skill. Furthermore, the pXRF result pointed to the urn having been made elsewhere and not local. Imported ceramic goods were considered an extravagance and to be buried in one, especially one in connection with a grave gift urn filled with butter, would suggest a high social standing, one that could afford such an extravagance (regionalmuseet.se 8/1-2016).

6. CONCLUSION

Through the use of the GCMS, it has been established that the urn F16195 had a previous function before being used as a supposed burial urn. It lies within the realm of possibility that it could have been used as a cooking pot for a marine bases meal. A comparison between lipids extracted by using a stable isotope analysis from fish in the nearby lake “Vallentuna Sjön” with the extracted lipids could confirm their origins. Unfortunately, not enough lipids where found in F16007, F16137, F16152, and F16263 to establish a previous function for these urns.

The urns F16007, F16152, and F16195 proved to consist of similar elemental components, leading to the conclusion that they may have been locally produced. However, further studies are warranted to confirm such a theory. To accomplish this pXRF studies need to be done on earth samples from the surrounding area and be compared to the artefacts pXRF results.

F16137 and F16263 showed no relationship to each other, nor to the previously mentioned urns. The divergence of F16137 could be explained due to the fact it is composed of calcified materials and therefore differ from the others. F16263 however, is most likely imported.

F16195 and F16263 have been clearly defined as two separate urns through an ocular study as well as the use of a GCMS- and a pXRF analysis. While these two urns have been separately defined through, this research it has also been concluded that the original theory, that F16195 is a burial urn, is most likely is false. It is far more likely that F16195 was a grave gift filled with butter and maybe bovine meat. This would suggest a high social standing, one that could afford such an extravagance.
SUMMARY
The aim of this study was to explore and answer several questions concerning grave A7000, which was excavated as part of the research project “Broby Bro en plats där världen passerar”. The excavation of grave A7000 ran from the year 2013 to 2014. During the 2014 excavation season, five supposed burial urns where found (F16137, F16007, 16152, F16195 and F16263) and samples were extracted for laboratory analyses.

It is uncommon to find graves dated to the Scandinavian Roman Iron Age (SRIA), not necessarily, because they do not exist, but because when they are found, they are in so unexpected areas. The urns presented in this paper where dated to this period.

The aim was to determine the function and usage of the burial urns as well as possible grave gifts in A7000. This was established through a lipid analysis done of five sherds from the supposed five urns found in the grave. Through the lipid analysis a connection could be made between two of the urns F16263 and F16195. F16195 was redefined as a grave gift in connection to F16263 as it contained a large amount of butter elevating the status of the deceased buried in urn F16263. There were also indications of the presence of aquatic lipids which could indicate that the urn could have been used for meal preparation before functioning as a burial urn.

Through an ocular study the conclusion could be made that three of the urns (f16007, 16152 and 16263) had similar characteristics, a red hue on the outside and a darker grey hue on the inside. However, the temper differed slightly between them. F16195 had both a dark hue on the outside and on the inside and F16137 had a slightly more yellow hue in comparison to the others.

Through the elemental partial analyses, the conclusion was drawn that all of the urns where separate was well as there being a good possibility of F16263 having been imported into the area in contrast to the other urns which appear to have been made locally.
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**World wide web**

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http://kartor.eniro.se/ 22/1-2016

**E-resources**


**Personal communication**

Andersson, Lars (2016) e-mail conversation with Annika Sundström 6/1-2016
Figures and Tables

Figure 1 to the left: satellite image of the excavation area taken from www.eniro.se 22/1-2016 to the right: topographic image of the area with RAÄ number 36 highlighted in blue taken from www.fmis.raa.se 22/1-2016

Figure 2 Schematic layout of the urns F16007, F16152, F16195 and F16263 in grave A7000 in red, with the calcified artefact F16137 in blue provided by Lars Andersson from Stockholms Läns Museum, 2015

Figure 3 Sherd for urn F16007, Picture taken by Annika Sundström 11/11-2015
Figure 4 Sherd for urn F16152, Picture taken by Annika Sundström 11/11-2015
Figure 5 Sherd for urn 16195, Picture taken by Annika Sundström 11/11-2015
Figure 6 Sherd for Finding F16137, Picture taken by Annika Sundström 11/11-2015
Figure 7 Sherd for urn F16263, Picture taken by Annika Sundström 11/11-2015
Figure 8 The GCMS and its components (http://www.kdanalytical.com/instruments/technology/gc-ms.aspx)
Figure 9 pXRF and its components (www.bruker.com)
Figure 10 How the x-ray beams react with the atom shells (www.bruker.com)
Figure 11 Factor plat of the two first factors from a principal component analysis of the pXRF results using Statistisca 12 Software

Table 1 Radiocarbon dating of bones found in findings F1007 and F16137
Table 2 Registry of the ceramics based on ocular study
Table 3 GCMS results
Table 4 Compare and Contrast table for F16007 and 16252 using Statistica 12 Software showing differences in elemental composition in red
Table 5 Compare and Contrast table for F16263 and 16195 using Statistica 12 Software, showing differences in elemental composition in red
# APPENDIX

pXRF spectra

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