Wear and Tear in Early Iron Age Europe

An experimental approach to use-wear analysis on selected assemblages of household ware pottery from the settlements Mont Lassois and the Heuneburg

Master Thesis by Nicole de Koning

Universiteit Leiden

BEFIM
Bedeutungen und Funktionen mediterraner Importe im früheisenzeitlichen Mitteleuropa

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Vessels: Photographs of experimental vessels by the author
House: https://www.researchgate.net/figure/Idealised-reconstruction-of-the-large-apsidal-building-on-Mont-Lassois-after-Chaume-et_fig7_305307085

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University of Leiden
Bedeutungen und Funktionen Mediterraner Importe im Früheisenzeitlichen Mitteleuropa (BEFIM)

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An experimental approach to use-wear analysis on selected assemblages of household ware pottery from the settlements Mont Lassois and the Heuneburg

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Introduction

Ceramics are one of the most important artefacts manufactured by ancient societies and are also one of the best preserved archaeological materials. As all everyday objects, pots and bowls were handled, moved around and used for preparing food on a regular basis. In fact, the handling of prehistoric vessels may be considered integral part of their "*chaîne opératoire*".

The ceramic assemblages studied are originating from two hillfort settlement sites located in Central Europe: Heuneburg in south-western Germany and Mont Lassois in northern Burgundy in France. Both sites contain elite graves "Fürstensitze", and are located northern of the Alps, among many other Iron Age sites (see Figure 1). The ceramic assemblages from these sites can both be dated to the Early Iron Age (Hallstat D2/D3 c. 550 – 450 BC, see Table: 1). the ceramics studied in this research are intended for domestic activities, which entail storing, food preparation and cooking.

Research outline

Actions such as stacking, moving or stirring have left damage on different areas of the pot. Some of these vessels were used to prepare or consume cold food, others to cook and consume hot meals. In order to study the development of such traces, experiments with different type of tools have been carried out to replicate the type of wear that these daily gestures leave on the pottery. Recreating wear traces on pottery aims ultimately to create a reference collection of use-alteration traces on pottery.

Use-wear analysis has been applied on sherds and pots from the Heuneburg and Mont Lassois in order to obtain more information about the function of specific ceramic vessels. This study will add to the conventional study of the typological aspects of the pottery, providing new insights into the actual use of the vessels. Microscopic use-wear analysis on pottery is a relatively new method of research, although macroscopic use-wear was first carried out in the late 1970's on pottery from an excavation in the United States (Skibo 2015, 6). Since then, an analytical framework for the analysis of use-wear has been further developed by researchers. However, few use-wear studies have been carried out on archaeological pottery on a microscopic scale over the past two decades (Vieugué 2013, 622). Thus, an adequate systematic reference collection is hitherto lacking.

To this end, pottery replicas were created in the Laboratory for Material Culture Studies at Leiden and experiments have been carried out on them in order to reproduce the use-wear traces visible on the ancient originals. The aim of the comparison between use-wear traces on experimental and archaeological ceramics is to relate specific traces to specific actions.

This research is part of the international project BEFIM (Bedeutungen und Funcktionen Mediterraner früheisenzeitlichen Mitteleuropa), which involves researchers from several Universities and research centers based in Germany and France[1]. The project started already with a focus on the usage and consumption of liquids; to this end experiments on permeability and fermentation processes have been carried out. The BEFIM project seeks to understand the role and function of Central European, Early Iron Age vessels from amongst others Heuneburg and Mont Lassois. The integral aim of the project is to conduct an interdisciplinary study on the pottery, in which issues related to technological aspects of ceramic manufacture, residue analysis, fermentation and consumption of alcoholic beverages have already been studied by other project members (Maxime 2015, Jacobs 2016, Nick Groat 2016).

[1] http://www.befim.de

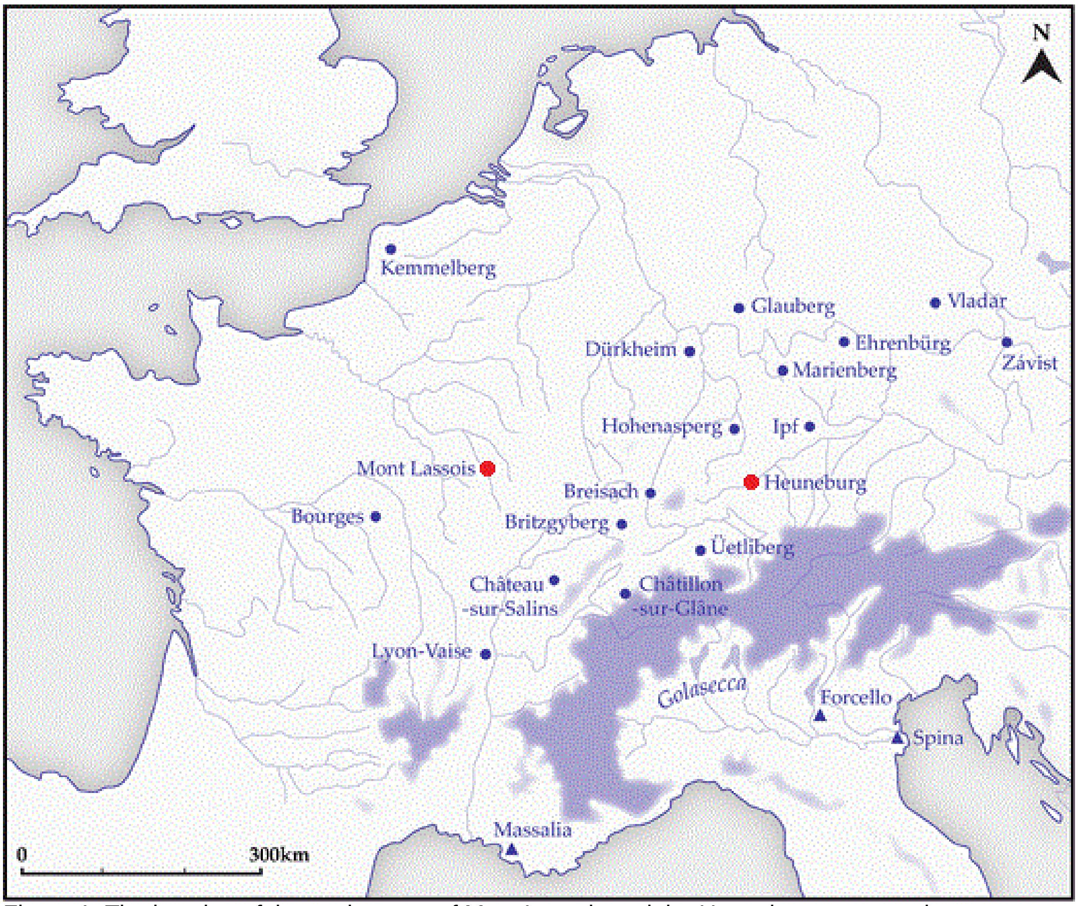

Figure 1. The location of the settlements of Mont Lassois and the Heuneburg among other Fürstensitze sites dating from the 7th – 5th century BC (https://link.springer.com/article/10.1007/s10963-017-9108-5)

Research questions

The main objective of this experimental research is to establish a reference collection for use-wear traces on ceramics, and to determine the function (actual use) of the pottery from Mont Lassois and Heuneburg. An experimental program has been designed in order to answer both methodological and archaeological research questions.

Methodologically the main research issue revolves around the potential of applying use-wear analysis to the study of archaeological pottery especially as concerns the identification of the function of artefacts. Archaeologically, the final goal of this work is to set up a reference collection for use-wear traces on ceramics. By using as case study the ceramic material retrieved from Mont Lassois and Heuneburg, the following sub-questions have been addressed:

- Which use-wear traces can be observed on the early Iron Age pottery from Mont Lassois and the Heuneburg?
- Which wear traces result from the experiments performed on the replicas of the Early Iron Age pottery?
- Can the use-wear traces observed on the experimental vessels be related to the use-wear traces on the archaeological ceramics?
- Can use-wear analysis be applied to study the function of the vessels from Mont Lassois and the Heuneburg?
- To what degree applying use-wear analysis to ceramics may contribute to pottery studies?

Research methods

At first, experiments have been conducted on pottery replicas reproduced by Loe Jacobs in the laboratory for Material Culture Studies at the University of Leiden. Different types of surface finish have been applied on the experimental replicas. Experiments have been conducted in order to cause damage resulting from handling on the pottery replicas in the form of abrasions or scratches, as previously observed on the archaeological material. Use-wear analysis has been performed on the replicas and the identified traces were compared to those on the pottery from the archaeological context. The experiments, focusing on the replication of the everyday use of pottery in a domestic context, have been mainly directed to food preparation, consumption and storing the pots. The food preparation experiments included cooking a vessel over a fire, and use of spoons made out of various materials, to stir the food or to hang them from the rim. The storing experiments included stacking pots, bumping them into each other and shoving pots on a wooden and clay surface.

The ceramic assemblage from Mont Lassois and the Heuneburg has been analyzed as well. The material consists of 200 objects in total (fragmented). The use-wear traces on the replicas have been compared to the ones on the archaeological pottery, in order to determine the origin of the wear traces. The use traces have first been analyzed under a stereomicroscope (10–160x) with an external source of light in order to obtain a general overview. The use-wear traces have been analyzed and documented. The results have been described according to an existing experimental form, the same used for the other experiments carried out within the BEFIM framework. All visible traces have been photographed.

The methodological framework will be presented in the first chapter, including the "*chaîne opératoire"* approach, experimental archaeology and use-wear analysis. These methods form the theoretical background of the research and are illustrated in the following chapters. Chapter 2 addresses the function and use of pottery, elaborating on specific stages in the *chaîne opératoire* which are highly relevant for the formation of use-ear traces in this research. The case-studies will be introduced in chapter 3, including a comprehensive description of the environmental factors which determined the selection of the materials used in the experiments. The results of the research will be presented in chapter 4, including a detailed description of both the archaeological and experimental material, which have been analyzed together and compared in order to make inferences about function. This chapter includes comprehensive photographic documentation, in order to establish a reference collection. Finally, the potentialities of such an approach and future research paths are addressed in the discussion and concluding remarks closing this work.

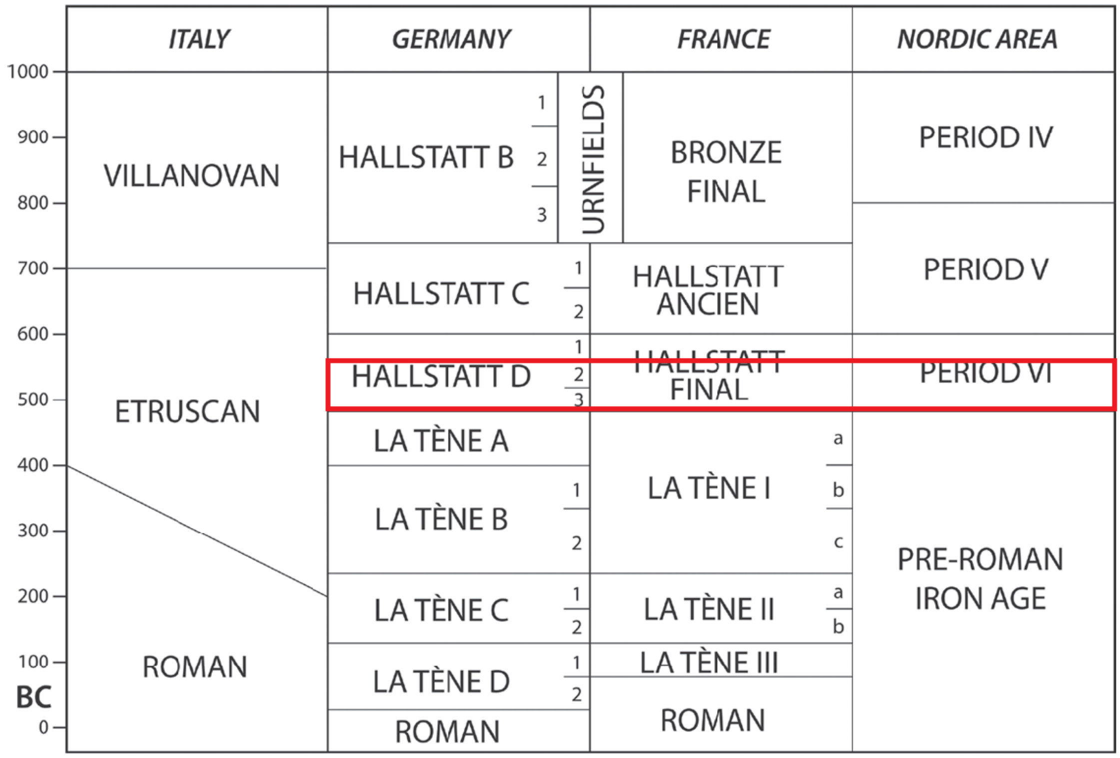

Table: 1. Chronological table for the Iron Age of central Europe (after Harding 2014).

Chapter 1. Methodological Framework

During its lifetime, pottery undergoes several processes, from the moment of manufacture until disposal. All these different stages affect the final shape of the vessels and their possible use-wear traces. Therefore, in order to get a full understanding of the formation of use-wear traces it is essential to trace back all these stages. These processes can be referred to as a *chaîne opératoire*, and its implications for use-wear analysis are described below.

1.1. A chaîne opératoire approach for studying ancient ceramics' function and use

Tracing the "*chaîne opératoire*" of a vessel can be a very meaningful tool for use alteration analysis, as it describes the life history of a vessel, which is the aim of use-wear analysis. A *chaîne opératoire* approach allows to reconstruct the organization of technological activities in the past. Perlès defines such an approach as follows: "a succession of mental operations and technical gestures" (Perlès 1987, 23). The *chaîne opératoire* of a vessel coincides with its own biography, its particular life history. This includes the acquisition of raw materials, manufacture process, interactions, use, reuse, recycling and eventual disposal and archaeological recovery (see Figure 2) (Skibo 2013, 8). The aim of the *chaîne opératoire* method is to describe and reflect all the cultural transformations that a certain raw material had to undergo. "It is a chronological segmentation of the actions and mental processes required in the manufacture of an artefact and in its maintenance into the technical system of a prehistoric group" (Sellet 1993, 106). Collecting the raw material represents the initial stage of the chain, the final stage concerns the disposal of the object (Sellet 1993, 107). Inferences made within this concept are based on experimental or archaeological observations. The term first appeared in French archaeological literature in 1968 (Brézillion 1968, 78). Thence, the concept as currently intended by French archaeologists is also referred to as the "French approach".

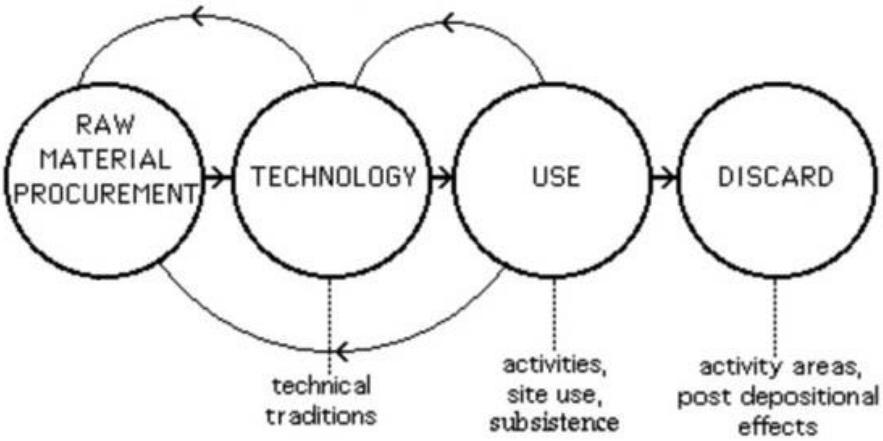

Figure 2. Chaîne opératoire of the pottery manufacturing process (after Gosselain 2008).

Similar approaches have been developed in the United States during the seventies. Especially Schiffer's *behavioral chain* is strongly linked to the principles of the *chaînes opératoires* (Schiffer 1972, Schiffer 1976). Schiffer describes it as follows: "the sequence of activities in the systemic context of any durable element can be grouped in a set of basic processes and represented by a flow model. These processes include procurement, manufacture, use maintenance and discard." (Schiffer 1976, 46).

Although the concepts developed in America and France brought to similar outcomes, there are however slight differences. The *chaîne opératoire* approach evolved from ethnology, while the behavioral chain originates from processual archaeology. In addition, a *chaîne opératoire* study focusses on the analysis of the knowledge and concepts involved in manufacture. This element is lacking from the behavioral chain approach. This has led to a more precise analysis of technical activities within the *chaîne opératoire* approach. Lastly, the research focuses of both approaches diverge (Sellet 1993, 107). The French approach has particularly been aimed at the study of the conceptual level uncovered by a *chaîne opératoire* analysis, while American scholars have been more interested in the organization of the of the manufacture system in general (Nelson 1991).

In the *chaîne opératoire* of pottery production, various technological choices are possible because this process of production is very flexible (Jeffra 2015, 141). A *chaîne opératoire* approach can be applied to reconstruct the technological decisions made by the potter during the process of manufacture, being therefore a very useful method to apply within experimental archaeology, although experimental archaeology is better suitable to answer technological questions rather than social ones (Jeffra 2015,140). However, when both methods are combined, social aspects can be studied as well. As is shown by the pioneering work of O. Gosselain, a *chaîne opératoire* approach can be used to define social groups based on technical choices observed in archaeological material (Gosselain 2002). This method is based on social transmission and the learning process, because an individual acquires knowledge about a skill in a social environment, influenced by factors such as culture, identity, gender, and/or ethnological group (Roux 2010, Gosselain 2002). The technical characteristics of the end products will be similar to those of other members of the same social group (Gosselain 2000).

According to the framework outlined above, the manufacture process of pottery has been divided into the following subsystems: collecting raw material, manufacture, use, maintenance and discard (Schiffer 1976 and Collins 1974). However, scholars have different opinions about which subsystems or stages should be incorporated in a *chaîne opératoire* approach. Collins stated that "any model claiming to cover comprehensively the production must account for all steps in manufacture from the acquisition of raw materials to the disposal of complete implements and must be able to account for the alternative procedures which might occur in any particular situation" (Collins 1974, 3). Because the focus of this research lies on the final stages of ceramics' life cycle, especially the use and discard stages within their *chaîne opératoire* will be addressed in the following sections.

1.1.1 Use and discard

Defining the methods of use and discard concerns the final stages of a technological analysis, which makes the reconstruction of a *chaîne opératoire* complete. The aim of this approach is not the reconstruction of the function of each vessel (which is the goal of the study of use-wear), but to improve the data obtained by traditional typological analysis.

Replicating the manufacture process trough experimentation may provide a dynamic view of the vessels life, and offers the ability to determine relevant technological properties to infer about the strategies of use and discard (Sellet 1993, 109).

It is important to consider that many elements of pottery production are invisible to people who do not practice this craft. Therefore, non-potters may distort certain aspects of the production process. Gosselain has related technical elements to identity, by describing particular relationships. Pottery production techniques are shared by a bounded group of individuals, constituting regional or communal traditions (Gosselain 2000, 189).

Gosselain divides the pottery manufacture process into three different stages relating to their social context, technical plasticity and salience of the conducted techniques. The visibility of the manufacture process on an end product is therefore related to the salience of that process in the past. Some stages of the production process are more prone to influences from outside (Gosselain 2000, 191). The preparation of the paste is determined by the technical performance characteristics and the physical characteristics desired by the potter (Bardel 2009, 2).

The first category entails production techniques that are the most subject to change, such as highly visible techniques as paste color, decoration and other post-firing techniques. The second category includes clay extraction, selection, processing and firing. A potter might be influenced by other potters or people that are otherwise involved in the manufacture process (Gosselain 2000, 192). The communal knowledge shared amongst potters is necessary in this manufacture stage. The last category is the most notable and relates to the shaping of the vessel, which is dependent on the motor habits and specialized gestures that a potter learned during their apprenticeship. However, this hardly leaves any traces on end products and is rather related to individual than communal aspects. These preferred technical choices of the potter are the least likely to change (Gosselain 2000, 192). Gosselain, however, states that “while shaping techniques are considered as a form of cultural inheritance, these techniques are not insusceptible to modification” (Gosselain 2008, 170).

Applying a *chaîne opératoire* method requires a detailed study of technical aspects in the manufacture process. Therefore, Roux states that a definition of the *chaîne opératoire* method should include three aspects: methods, techniques and tools (Roux 2003, 9-10). By exploring these aspects in ceramic assemblages, groups can be identified which share the same technical characteristics. Thereby, the relationship between technological traditions and associated social groups can be better defined (Roux 2011).

1.2. Experimental archaeology and pottery studies

Over the last three decades, the field of experimental archaeology has increasingly developed, and the scientific value of the outcome of these experiments is now widely acknowledged. However, there still is a lack of a more articulated framework and a shared methodology (Mathieu 2002, 14).

In the mid- 1980s, a series of pottery experiments was started at the Laboratory of Traditional Technology at the University of Arizona in the United States. These experiments were focused on individual choices of the potter, such as surface treatment and temper, which influence the vessel performance during use (Schiffer 2010, 102-105). For example, one of the experiments was performed to examine how organic temper influenced the performance of the vessel during manufacture and use, as opposed to sand for instance (Skibo *et al*. 1989). It was concluded that organic temper makes the clay more workable during manufacture, but reduces the heat-resistance when placed over a fire. Using sand as temper on the contrary, did not make the clay more workable during manufacture, but increased the heat-resistance during cooking (Skibo 1992a, 32). A series of experiments on the influence of the surface treatment on the performance characteristics of cooking vessels followed (Schiffer 1990). These experiments provided a revised perception of cooking pots, which were initially considered as plainly manufactured crude ware. The research has showed that cooking pots were in fact were made by highly developed techniques, because they entailed important performance characteristics such as thermal shock resistance (Skibo and Schiffer 1995). These experiments share some significant features with the research performed at the Material Culture Studies Laboratory of the University of Leiden in the Netherlands (van As and Jacobs 1995).

Archaeological experiments constitute a major part within this research's framework. Two different stages from the *chaîne opératoire* were simulated: the manufacture process and the use of the vessels. The experimental vessels were manufactured by Lou Jacobs (see chapter 4.2). The use experiments included stirring, moving of vessels, and cooking over a fire (see Figure 3). Experimental archaeology as method is used to assess the suitability of the vessels and tools for particular use-activities, and to replicate use-wear traces. The use-wear traces on the experimental vessels are in turn compared to the traces observed on the archaeological vessels to make inferences about the function of the objects. In order to construct a solid framework, both techniques must be combined to acquire a reference collection to compare to archaeological materials.

Figure 3. Cooking experiment with beef for the BEFIM project (photograph by the author).

Experimental archaeology investigates the relationship between archaeological objects and human actions, in order to reconstruct ancient human behaviors through the lens of material culture. It is important to have a clear methodology for archaeological experiments because the outcome of these experiments can easily become negligible. To achieve valuable results, experiments need to be based on archaeological data. To be scientifically sustained an experiment must test a hypothesis. The aim of the experiments is to simulate a specific process as close as possible to reality. It is assumed that processes can be replicated in the present in the same way as they occurred in the past, assuming that such processes do not change over time. Thus, one makes use of an analogy: archaeological data can be obtained by looking at similarities when comparing the archaeological record to replicated archaeological processes. The aim of this approach is to gain more knowledge about how material culture functioned in the past (Reynolds 1999, 42).

The validity of an analogy can be denoted with the terms uniformity and non-ambiguity. For an analogy to be uniform the process in the past must be identical to the one in present. Unambiguous means that similarities between processes can only be explained by one specific cause (Lammers-Keijsers 2005, 20). In other words: it is impossible that different actions can produce the same archaeological data.

For this research an example would be as follows: stirring with a wooden spoon in a pot would leave behind exactly the same traces in the Iron Age as in the present (uniform) and there are no other activities that leave behind the same traces (unambiguous). This is, however, very hard to prove in practice. Since non-ambiguity is hard to prove in experiments, an analogy should be regarded not as factual proof rather as a model or a testable hypothesis (Lammers-Keijsers 2005, 20).

For experimental results to become scientific a hypothesis based on archaeological data should be formulated and tested. It is also of great importance to consider all the factors that might possibly influence the outcome of the experiments. It is best to carry experiments out in several stages, in which the interpreted results can be used to improve the hypothesis. In this research, the hypothesis forming phase has been already completed: a series of experiments was conducted on handling and cooking. The results from these experiments were used to select appropriate materials for the next set of experiments (Reynolds 1999, 44).

The research questions addressed in this work derived from use marks observed on archaeological ceramic assemblages from Mont Lassois and Heuneburg. What kind of usage may be inferred by observing certain wear traces? Based on archaeological evidence, it is assumed that certain foodstuffs were consumed and certain materials were used. During usage, pottery came in contact with various abrasive materials. A hypothesis was set up according to evidence, then tested during the experiments in order to verify this assumption.

Several pots were replicated for the experiments in different forms and fabrics. Prehistoric tools made out of various materials were used during these experiments. The structure of the experiments was dynamic, meaning that changes could be made after some tests. If a certain experiment does not leave any use traces on the pottery, the experiment was then re-adjusted with different materials.

It is vital to consider the conditions that might influence the tests. These variables should be defined and controlled as much as possible (Lammers-Keijsers 2005, 23). Conditions that can influence the outcome of the experiments during this research are: the replication of the pottery, the appropriateness of the materials and tools to the early Iron Age context, and the level of measurement. The method applied to measure the traces of usage is use-wear analysis, which will be described in the next paragraph.

To conclude, experimental archaeology has the advantage of providing a reference collection for use-wear analysis. The data from the reference collection can be compared to archaeological data in order to obtain information of use-alteration processes (Marreiros *et al.* 2015, 115). This technique may provide practical information of the characteristics of materials and archaeological objects. Specific archaeological questions can be answered by using experimental archaeology, which could not be obtained by other techniques. A disadvantage of this technique is that it can be very difficult to replicate specific processes vey accurately. Experiments are often performed controlled way, often with one motion and a single contact material. Moreover, people in the past had a very advanced level of skill, which often does not correspondent to the skill of researchers who perform experiments. To limit this problem, researches should cooperate with skilled craftsman during future research (Skibo 2013, 33). Once again, it is also of great importance to compose a vast reference collection.

1.3 Use-wear analysis

The functionality of objects has always been a central issue in archaeological research. An emergent approach to study the function of objects is use-wear analysis. This method was introduced into archaeology a couple of decades ago. The Soviet archaeologist Sergei Semenov was the first one to study use-wear analysis. During the 1930's his initial research focused on the analysis of alteration on the working areas of bone and lithic tools used by prehistoric communities, which finally resulted in his Ph.D. dissertation *"Pervobitnoya Tekhnika"* (Prehistoric Technology, Semenov 1957). Semenov's work focused on the technological characterization of archaeological artefacts in order to reconstruct the social and economic organization of past societies. He introduced use-wear analysis to West-European archaeology in 1964 (Semenov 1964).

Use-wear focusses on the analysis of alterations on the active areas of archaeological objects created by human actions. The principles for this method are based on observations from archaeological experiments (Marreiros *et al.* 2015, 2).

1.3.1 Low power and high power method

For the observation of use-wear traces, the main methods and techniques include: macroscopic analysis with a stereomicroscope (low power) and microscopic analysis with a metallurgical microscope (high power). Additionally, Laser Scanning Confocal Microscopy (LSCM) and Scanning Electron Microscopy (SEM) can be used, but these are costly and are usually only applied upon a limited number of artefacts.

The macroscopic approach is conducted with a stereomicroscope with magnifications between 4 and 64x. For this research, the stereomicroscope was coupled with the software of the Leica Application Suite (LAS) to take microscopic pictures with the computer (see Figure 4).

By the use of a stereomicroscope reflective light illuminates the object. The light can be directed in different angles in order to create a shadow effect. When researching the object for use-wear traces, all the surfaces and edges are systematically analyzed to record small features and damages. Macro-wear traces such as chipping or abrasion can be identified. Areas that should be analyzed trough microscopic observation at a higher magnifications will also be selected (Marreiros *et al.* 2015, 10).

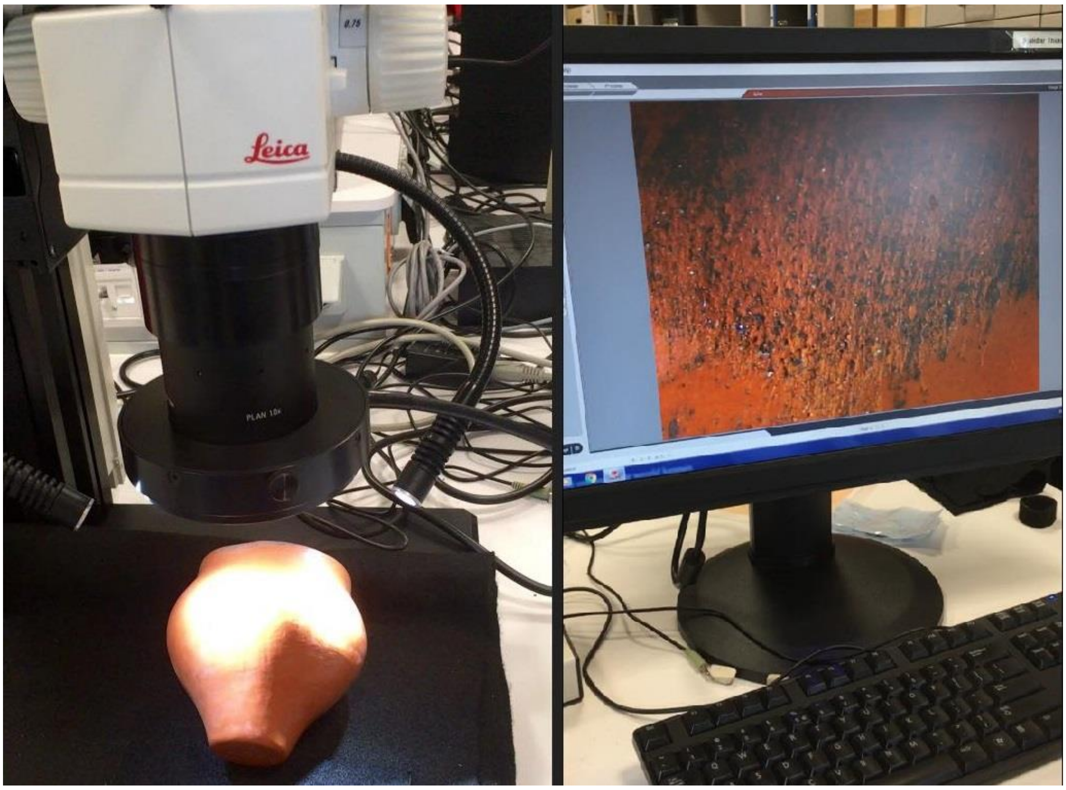

Figure 4. A pot under the stereomicroscope at the laboratory for material culture studies at the University of Leiden. On the right: view of the ceramics trough the LAS program. (Leica Application Suite).

Microscopic analysis is a high power technique which includes analyzing under a metallurgical microscope. This type of microscope works with incident light with an angle of 90° to the surface of the object. High magnification of 50 – 400x are used to record microscopic wear traces such as striations and polish. Specific areas that were selected by means of the low-power method will be analyzed in detail with the metallurgical microscope. It is best to combine the low power and high power magnifications to obtain the most accurate results, because both techniques can complement each other (Marreiros *et al.* 2015, 11, Van Gijn and Lammers-Keijsers, 2010).

1.3.2 Post-depositional processes

One of the biggest concerns within use-wear analysis is the alteration and preservation of wear traces on objects caused by post-depositional processes.

Natural processes could cause abrasion that resemble marks that could be produced by human actions. Processes such as trampling or post-depositional alterations could cause notable damage on the surface or edges of objects such as striations, surface polish and fractures.

Several studies concerning use-wear analysis on pottery have shown that similarities exist between wear traces resulting from human use and post-depositional processes (Skibo 2015, Marreiros *et al*. 2015). Using experimental tests, much research attempted to replicate processes that might cause alterations to objects such as trampling, erosion, soil deposition, movement and transport of objects and to identify the use-wear traces resulting from these processes. Use-wear traces produced by such processes are characterized by a random distribution pattern with dispersed and isolated traces. These traces might destroy or modify the original wear traces resulting from human use. Thus, one of the most important conditions to perform use-wear analysis is the degree of preservation of the archaeological objects. Apart from the post-depositional abrasive processes, the recovery, cleaning, storage and handling of the material during the analytical phases might also cause damage to the objects and thus impede the use-wear analysis. For example, contact with metal trowels, abrasive cleaning materials and contact with other materials or grease from handling can alter the surface or the edges of the material. Thus, in order to maintain all available data it is fundamental to use the correct methods during the recovery of the archaeological materials (Marreiros *et al*. 2015, 17, Van Gijn 2014).

Non-use alteration can be caused by processes such as fluvial abrasion, ploughing, trampling, rodent burrowing and freeze-thaw cycles, in short all processes in which deliberate human activity is not involved. Clearly, non-use alterations may hamper the investigation of use-wear traces, but they can also provide information about the life history of a vessel or sherd. Use alterations can, for instance, inform about the environment in which the object has been deposited such as post-depositional processes. In summary, non-use alteration involves all unintentional interactions between humans and vessels or sherds, in addition to the environmental processes.

When use-wear analysis and experimental archaeology are combined, they can provide a powerful tool to reconstruct the life history and function of archaeological artefacts. These techniques have several advantages. Firstly, it is a non-destructive method which is able to provide detailed information about the alterations on artefacts and their biographies (van Gijn 2014, 166). Use-wear analysis may provide answers for specific and broad archaeological questions. Limitations of this method is that it is a very time-consuming technique. It takes a considerable amount of time to analyze all the micro wear traces under a microscope. The most important drawback of this method is that post-depositional processes such as soil-forming processes and the recovery of the materials during excavation may alter or erase wear-traces, or create new traces. Therefore, it might be difficult to distinguish use traces from post-depositional traces. To overcome this problem, it is important to set up a vast reference collection for post-depositional traces, so that these traces can be distinguished. Like most archaeological methods, use-wear analysis is a subjective technique, based on interpretations. These specialists may use different analyzing or documentation methods. To minimalize this problem, analysis and documentation methods should be unified during future research (Van Gijn 2014, 168). Lastly, some soft contact materials hardly leave any traces. The same applies to materials or objects that were used only for a short amount of time. These kind of deviations may lack in wear traces on materials, and therefore be underrepresented in the result of the research (Skibo 2013, 22).

Chapter 2. The contribution of use-wear analysis to determine ceramic vessels function and use

Vessel use and function may be very informative on certain activities and habits in the past. The application of use-wear analysis may be of great help in determining vessel function and use. Use-alterations on ceramics may inform about use in the past. In this chapter it will be explored what vessel function entails, and how use-wear analysis may contribute to determine function.

2.1 Determine ceramic usage: the contribution of ethnoarchaeology

Ethnoarchaeology offers us the opportunity to study the correlation between objects and people. Ethnoarchaeologists can observe a vessel during manufacture and usage, and can obtain information about the decisions that are involved in these processes (see Figure 5)(Skibo 2013, 1). For quite some time, archaeologists have been aware that traces such as wear, scratches, sooting/carbonization and residues can be evidence for actual pottery function. However how these attritional or accretional processes actually formed was still largely unknown. Ethnoarchaeological and experimental research were performed to explore the complex correlation between pots and people, and to establish models, methods and theory to determine prehistoric pottery use based on alterations (Skibo 2013, 2).

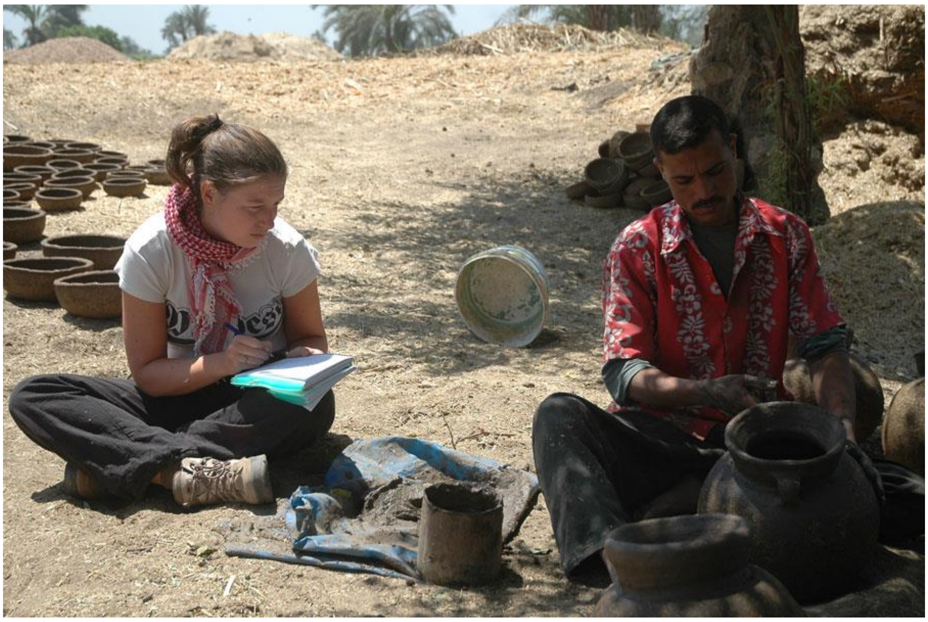

Figure 5: An ethnoarchaeologist documenting the manufacture of pottery in Dayr al-Barsha, Egypt. http://drupal.arts.kuleuven.be/barsha/index.php?q=img_assist/popup/134

A series of ethnoarchaeological studies was carried out (e.g. Arnold 1978; Beck and Hill 2007; Harry *et al*. 2009). Such approaches still continue up till today. This research was performed in order to create models to determine pottery manufacture, use and deposition and to study the relationship between pottery and the prehistoric peoples making and using it (Skibo 2013, 6). Initially, the focus of ceramic studies was mainly on stylistic characterizations, and to discern cultural groups based on observed variation. The technology behind the pottery was neglected at the outset of pottery research (Skibo 1992a, 6).

Pottery plays an important role in everyday life. Although pottery can be involved in activities concerning social, ritual, or religious functions, one of its main function is related to food processing. Likewise, determining food preparation and consumption in the past is one important aspect in studying pottery function. Food consumption has nutritional as well as social elements (Gumerman 1997). Pottery can be used to study activities such as the collection of food preparation, collection and consumption, which can provide insights in the basis of existence of prehistoric communities (Skibo 2013, 2).

2.2 Pottery function

Traditionally, archaeologist divide material culture into functional or stylistic categories. The function of an object is not just strictly related to its utilitarian purpose, but also the social and ideological aspects may influence the morphology of an object.

Research of technological function of pottery can be divided broadly into two different categories: intended function and actual function. (Skibo 1992b, 33). Intended function and actual function can be defined as follows: *intended function* concerns the intention of the potter: the purpose he designed the vessel for. *Actual function* on the other hand, refers to how the vessel was actually used (Skibo 2013, 9). Intended and actual function are not mutually exclusive from each other: objects may have served various functions or were reused over time. In an ideal pottery study, intended and actual function are both analyzed, each of them are vital to obtain a complete picture about pottery techno function (Skibo 1992b, 34). Techno function is influenced by subsistence patterns and settlement systems, thus pottery can be designed to fit an activity that is specific for a certain location. Also, technical choices are dependent on available resources and knowledge (Skibo 2013, 9).

All pots are designed to be used, therefore, each pot has its own function. A potter has at its disposal a number of technical choices when fabricating and designing a pot for an intended function. For example, by adding more temper the thermal shock resistance (which is an important technological capability of cooking pots) will be increased (Skibo 2015, 189). One of the goals of ceramic analyses is to determine the function of the pot by analyzing its specific characteristics. Examples of these characteristics are: size, form, thickness of the wall, firing temperature, temper and surface treatment of the vessel.

2.2.1 Intended function

Ceramic material has a number of advantages in contrast to other materials. For instance, ceramic vessels can be heat-resistant and can be used to contain liquids contents. Vessels can be therefore altered to suit an intended function. During manufacture, specific clay properties might be manipulated in order to do so. Factors concerning the intended function of a vessel such as the state of the contents (either hot or cold, wet or dry) and the duration of usage influence the final characteristics of the vessel. However, also the form of usage is of importance e.g. cooking, processing, serving food or eating (Skibo 1992b, 35).

Generally, a specific relationship exists between vessel form and use. Vessel properties such as rim diameter, openness of the profile and volume of the pot can be indicators of usage. These properties are measurable on vessels and easily quantifiable. Although sherds can sometimes be used to obtain such measurements, complete or nearly complete vessels are required to reconstruct a pot's function in its entirety.

The physical properties of ceramics are important during usage as well as during their manufacture. Physical characteristics of manufacture are fabric shrinkage, clay workability and changes during firing. Characteristics during usage however, include abrasion resistance, heating effectiveness, thermal shock resistance, and evaporative cooling effectiveness. It is important to bear in mind that adaptations in physical properties of a vessel might affect the performance characteristics as well. For instance, certain properties may contribute during the manufacture process, but at the same time entail adverse consequences for the quality of the end product. When researching the performance characteristics of a vessel, it is essential to dispose of knowledge about cooking practices and subsistence (see chapter 4, Material from the Heuneburg and Mont Lassois). However, making assumptions about pottery function based on intended function alone is insufficient. For a complete exploration of function it is required to study the actual use of the vessel as well (Skibo 1992b, 36).

2.2.2 Actual function

Reconstructing actual use is largely based on attributing vessel alterations to specific use activities. It is used to determine how vessels were actually used in the past. By applying this approach it is possible to obtain more specific information about pottery usage. Firstly, vessels could have been used to serve multifunctional purposes. Also, the intended use does not always result in the same actual use. Vessels for particular usage could be substituted by other forms occasionally, when specific pots were not available. Lastly, the function of a pot could change over time, i.e. secondary use or reuse. There are certain examples of fragmented or damaged vessels which were selected for reuse. For example the sherds from Bulgaria and Guadeloupe, which were reused as scraping tools (Vieugué 2015, van Gijn and Hofman 2008; Lopez Varela, Van Gijn and Jacobs 2002). Analysis of pottery through actual function is the only approach to distinguish features as multifunctionality, substitution or secondary use (Skibo 1992b, 38).

2.2.3 Use alteration and function

Wear patterns in the form of abrasions and scratches on specific locations of the vessel may be indicative of usage. An intentional interaction between humans and a vessel or fragment is required for use alteration. Use-alteration of ceramic surfaces can be attributed to attrition or accretion. This research will focus on use-wear analysis of attrition. There are two types of surface accretion: organic residues originating from the content of the vessel, and carbon deposits resulting from cooking on an open fire or organic residues inside the vessel. Organic residue analysis can be applied for example on vegetable oils and animal fats analyzed by gas-chromatography or isotopic analysis (Skibo 1992b, 40). At any rate, organic residue analysis is out of the scope of the research, and therefore will not be discussed further here.

Previous research on ceramic surface attrition has established that particular highly decorated pottery only served non-utilitarian functions (Skibo 1992b, 40). All changes to the ceramic which are caused by chemical or physical processes can be described as ceramic alteration (Skibo 1992b, 42). Ceramic alteration can be created by human or non-human agents, either by use or non-use processes.

In lithic analysis, use-wear traces appear on the working edge of the tool, thus non-use traces often hide or confuse these traces of use. Ceramic use alterations are not confined only to this area, hence they are not necessarily disturbed by non-use alterations. Both traces resulting from the manufacture process as well as depositional processes, can be easily confused with those resulting from use. To get a better understanding of ceramic use alteration, it is important to explore the general processes and principles concerning the causation of use and non-use traces (Skibo 1992b, 43).

2.3 Traces of use: carbonization

The occurrence of soot is often utilized as an indicator of vessel use as cooking pot. Carbonization can be used to infer about the type of cooking, for example indirect or direct heating, cooking mode (dry or wet), or type of hearth (Skibo 2015, 193). There are two types of carbonization: external carbonization in the form of soot resulting from smoke of a fire, and internal carbonization of food remains. Soot is a product that results from the process of pyrolysis of wood, and consists mainly of resins and tars.

2.3.1 External carbonization

There are three different types of soot deposition on the outer part of vessels. The first type of soot is deposited immediately after a vessel is put in a fire, and affects any part of the vessel that came in contact with the rising smoke. This type of soot is characterized by a fluffy and flat black appearance. It can easily be removed by water or rubbing. This vulnerable layer of soot would not be preserved due to the effects of post-depositional processes, and is therefore not very useful for use-wear analysis.

The second type of soot better resistant to decay. This type of soot contains resin drops, which are captured in the rising smoke and deposited on the vessel wall. Once the resin droplets come in contact with a cool surface, they solidify and become affixed to the surface of the vessel. When the resin is cooled down, it produces a solid, waterproof layer, which is quite resistant to breakdown during post-depositional processes (Skibo 2015, 190)

The third type of soot on a vessel exterior deviates clearly from the ones mentioned above. This is in fact the absence of soot, which appears on surfaces with a temperature of 400 °C degrees or higher, because soot cannot form within these temperatures. If soot is deposited during an earlier cooking stage, it will be removed due to such high temperatures. The altered area may vary from light grey to completely oxidized.

The type of external soot deposited is mainly dependent on the temperature of the surface of the vessel. Several factors might influence the temperature of the surface including the presence of water in the ceramic, the distance of the pot from the fire, the type of hearth and the type of wood. The factor which influences the temperature the most is the presence of water, since it keeps the temperature of the surface of the vessel cool enough to be able to deposit soot. In the case of exterior soothing, use-wear traces can accumulate on the deposited soot instead of the ceramic surface (Skibo 2013, 121).

2.3.2 Internal carbonization

The charring of food causes the interior carbonization of ceramics. Charred food remains can be formed as encrustations on the surface, or be carbonized in the ceramic surface itself. Encrustations of charred food are much rarer than internal carbonizations, because they are much more susceptible to deterioration during post-depositional processes. However, encrustations can be used to infer about cooking behavior and the food type that was cooked (Malainey 2011).

Likewise the external carbonization, the temperature of the surface of the vessel is the main factor influencing the internal carbonization, since the vessel must reach a temperature between 300 and 400°C to char food remains. If water is cooked in a vessel (boiling), the temperature of the surface inside the pot will reach far beyond 100°C, therefore carbonization cannot appear below the water. Above the water line however, the temperature will exceed 300°C, so food remains can carbonize on the vessel wall. When a vessel is permeable, because of the porosity of the fabric, food remains can easily be transferred into the walls, in which they will carbonize. This form of carbonization is quite resistant to post-depositional processes since it permeate into the vessel wall. Carbonization in the form of a circle just above the water line is a sign that a vessel was used to boil food. When food is cooked in dry mode, the temperature of the surface in the vessel raise above 300 °C, so that carbonization will occur. However, this type of carbonization will not permeate the vessel wall, as is the case with boiling (Skibo 2015, 191).

Ethnoarchaeological research has shown that on average, cooking pots last variably, ranging from several months to over a year (Arthur 2003). Because of their relatively short use period, they would often serve a secondary function after deterioration (Skibo 2013, 5).

Cooking is not the only activity that causes carbonization on ceramic vessels. The firing process may also cause carbonization on the surface. Particles from fuel or smoke might come in contact with the surface of the vessel and leave behind fire clouds. Also, by smudging an entirely carbonized surface can be created. Smudging is the intentional darkening of the surface of a vessel during firing in a reducing environment. Lastly, carbonization can occur if a pot is exposed to an unintentional fire such as a house fire or post-depositional burning. All these processes might cause patterns that resemble carbonization produced during cooking. However, they can easily be distinguished from carbonization resulting from usage by their patterning. Usually, carbonization by smudging will cover the whole surface of a vessel and the firing process might create randomly distributed fire clouds. However, carbonization resulting from use-related activities will appear in patches in specific areas (see Figure 6)(Skibo 2015, 192).

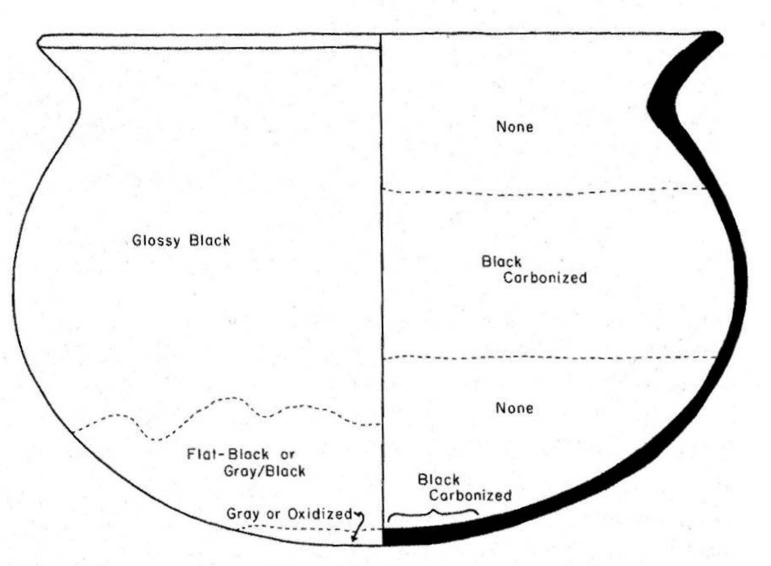

Figure 6: Example of internal and external carbonization deposits on a cooking pot (after Skibo 1992b, p. 150).

2.4 The application of use-wear analysis in ceramic studies

Use-wear analysis usually involves a series of experiments conducted with replicated tools made of materials that are relevant to a specific archaeological case. These types of studies are often restricted geographically because their applicability is limited to a specific study area (Skibo 1992b, 43).

While macroscopic analysis as practiced by Skibo was already established some decades ago, the microscopic use-wear analysis of pottery as applied in this research is relatively new to the discipline. Since use-wear analysis was initially focused on stone materials, consequently, ceramics are a less common material within the field of use-wear analysis and a vast reference collection for pottery in use-wear analysis is still lacking. It is therefore important to set up an observation protocol for archaeological pottery based on a broad experimental reference (Marreiros *et al*. 2015, 2).

As stated above, sometimes it can be difficult to distinguish use-alteration from non-use alteration. Use-wear traces and post-depositional alterations on ceramic can be distinguished by specific location and extent (Vieugué 2015, 92). Several studies have shown that use-wear leaves behind traces accumulated on specific parts of the vessel. Post-depositional alterations in contrast, demonstrate a ubiquitous distribution.

Similar to lithic and bone materials, use-wear traces on ceramics depend on the attributes of the worked material (e.g. wood, bone, iron, ceramic). Use-wear traces can be diagnostic for specific worked materials, use duration and kinematics (motion of objects without considering the mass and force which cause the motion) of ceramics (Vieugué 2015, 89). Use-wear traces can be distinguished based on the following features: the abrasion of the surface, the outline of the traces, the pitting, and the flattening of the temper inclusions, the polish, and the presence of large scratches. (Vieugué 2015, 94). Pitting due to abrasion on the inside of the vessel can be related to contact with a spoon in the form of scraping or stirring (Skibo 1992b, 39). In addition, the nature of the activity carried out affects the use-traces (Skibo 2013, 120).

The position of the worked material in relation to the vessel (oblique or perpendicular) results into distinct use-wear traces. The inclination of these traces and the orientation of wear traces on the worked surface of the vessel may be indicative for the angle between these materials and the type of movement (Vieugué *et al*. 2013).

2.4.1 Attrition

Surface attrition on pottery is the deformation or removal of the ceramic resulting from use and non-use processes during a vessels life history. Processes such as cooking, processing of food, storage, handling and other activities may cause use-attrition traces for its primary function. However, attrition can also inform about a vessels secondary function during its life history, for example recycling. After deposition, post-depositional processes such as erosion or freezing and thawing can be inferred from attritional traces.

Ceramic attrition can be caused either by abrasive or non-abrasive processes. Abrasive processes from traces such as scratches, nicks and gouges. These traces form patches when abrasive activities are repeatedly performed. The principles that determine the attrition of the ceramic are the characteristics of the abrader, the characteristics of the ceramic, and the form of the contact between the ceramic and the abrader. Nonabrasive processes include: vaporization of water, thermal spalling resulting from fermentation, and salt crystallization. Thermal spalling can prevent when fermentation is performed in low-fired permeable pottery, because gasses expend in the vessel wall and affect the interior surface. (Skibo 2015, 193, (Marreioros *et al*. 2015). Spalling can occur during cooking. When cooling down, water in the wall of the vessel turns into stream and leaves through the ceramic surface, creating spalls. Skibo observed this feature during his visits at the communities in the Kalinga, when a cooking pot was taken out of the fire and put next to the fire pit. Spalling can also be used to infer about alcohol production and water storage (Skibo 2013, 123).

Wear traces can be recorded on vessels or sherds. When recorded on vessels, the attritional traces should be sketched on a vessel profile outline. Wear traces on sherds may provide important information about function as well.

Use-attrition can de described by two features: marks and patches (Schiffer and Skibo 1989). Marks result from a single attritional activity, for example a nick, spall, pit, scratch or chip. In many cases, single activities do not cause a visible mark. But when use activities are repeated, marks grow into patches. These patches may have the outside surface removed. Therefore, individual marks resulting from this activity might not be visible in the center anymore, but the often remain visible at the periphery (see Figure 7). When the features of marks and patches are analyzed together, the can provide important information about vessel usage (Skibo 2015, 194).

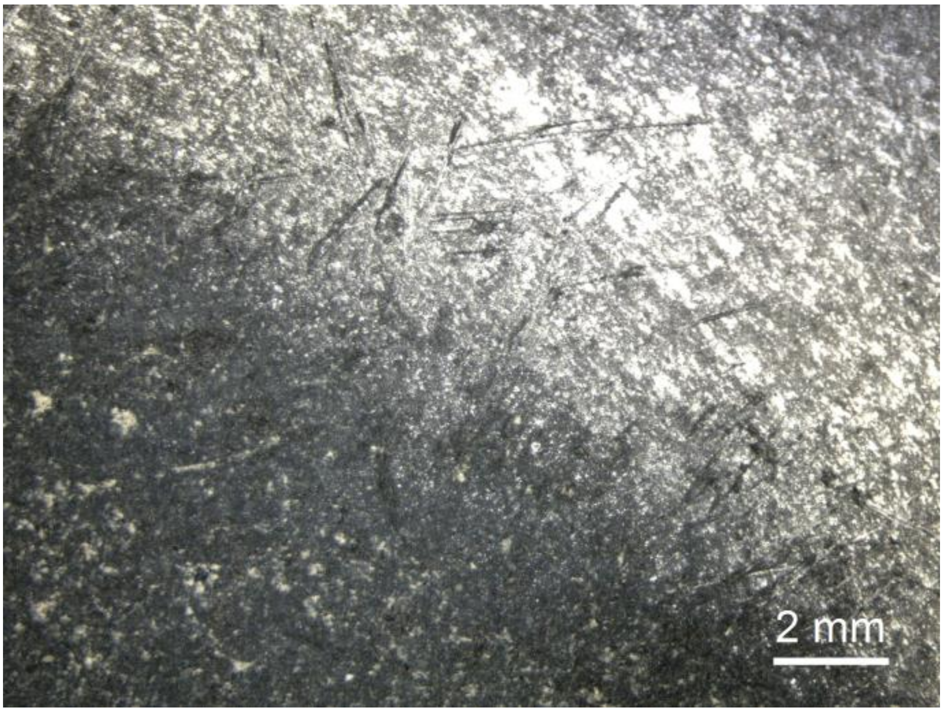

Figure 7: Marks are removed from the center (left) but still remain visible at the corner of the pot (right)(magnification 1.0x)(Photograph by the author).

2.4.2 Abrasion resistance

The resistance to attrition is amongst others dependent on the firing temperature or the application of a polish or slip to the surface. Attrition resistance is perceived as a performance characteristic, which could be increased by the potter (Skibo 2013, 119). Other factors that influence the abrasion resistance are the attributes of the temper, the presence of pores or voids, the surface characteristics and the shape of the ceramic. Properties which affect the hardness of the fired clay include mineralogy and chemistry of the clay and firing atmosphere.

Another factor that can influence the abrasion resistance considerably is the nature of the ceramic surface (Skibo 2013, 120). A smooth surface is more resistant to abrasion than a textured or uneven one. Accordingly, ceramic with a high porosity is more prone to abrasion. In addition, the manufacture process can leave behind cracks or voids in the surface, which are more susceptible to abrasion.

The attributes of the temper particles (size, hardness, distribution, quantity and orientation) can affect the abrasion resistance as well. When the temper is harder than the ceramic, the temper will decrease abrasion. In mineral tempered pottery this is usually the case. However, during a more advanced stage of abrasion, the temper will become outwardly extending, as the clay around the temper will erode away. In contrast, when the temper is softer than the clay, the temper will erode more rapidly (Skibo 2013, 121).

Lastly, the finish of the ceramic surface may affect abrasion resistance. Coatings and resins are commonly applied on pottery. These treatments are used to reduce water permeability, however, they may also influence abrasion resistance.

Another aspect which may affect abrasive activities significantly depends on the properties of the abrader, like shape, hardness, size (Schiffer 1990, 65). Size is one of the most important factors: when an abrader is small, the level of abrasion tends to be greater. The material of the abrader is also an important factor. In food preparation for example, tools from different materials can create different surface abrasions. A spoon made of wood would be far less abrasive than a spoon made of metal. Lastly, the nature of the contact between the ceramic and the abrader is an important element in the formation of use-alteration traces (Schiffer and Skibo 1989, 111-113). The creation of use-traces requires the movement of the abrader, the ceramic, or both. Important aspects are force, rate and directionality of the contact between the abrader and the ceramic. Generally, the greater the force and rate of the contact, the greater the abrasion. Although, when the vessel surface is extremely altered due to abrasion, subsequent contacts might be affected which could reduce the rate of abrasion. One must also bear in mind that in many cases there is not only the ceramic and the abrader but also a substrate, for example water which might increase abrasion (Skibo 2013, 121). The content of the vessel might also influence the abrasion resistance. Some smooth substances such as porridge might impede abrasion because of the reduced friction. Lastly, the duration of the use-activity is another important element in the formation of use-traces. A vessel must have been used long enough to create traces. Some traces will form after a short period of use, such as organic residues. While other use-traces, such as attrition, require a longer use-period to form (Skibo 1992b, 44).

2.5 Concluding remarks

As discussed in this chapter, pottery function can be inferred by studying vessels' technology, carbonization and attrition. These elements are vital to consider when performing use-wear analysis, in order to relate use-alteration to function. Together with the concepts and methodologies addressed in the first chapter, they form the basis of this research. In the next chapter the case studies from the pottery assemblages will be introduced. The subsequent chapter incorporates the practical part of the research, which includes the technology of ceramic manufacture (inclusive the vessel replicas), the performed experiments, the archaeological ceramics, and the analysis of use-wear traces observed on both the replicas and the archaeological sherds. The framework presented in the current and the previous chapter will be used to infer about all the aspects relevant to the interpretation of the ceramic material (both experimental and archaeological).

Chapter 3. Case studies and dataset

In this chapter, the archaeological case studies, the Heuneburg and Mont Lassois, are presented. Both settlements will be briefly introduced together with the ceramic material recovered from the sites, including typological features and paste properties. Lastly, the environmental conditions of the settlements will be discussed, in order to obtain a complete picture about the used materials during the Iron Age in Central Europa. These materials will also formed the basis for the experiments conducted in the laboratory in order to replicate activities performed in the past as close as possible. As a word of caution, it must be noted that there are some inequalities between the archaeological research conducted at the Heuneburg as opposed to Mont Lassois. The latter in fact has mainly been focused on typological studies (of ceramics), while German studies on the Heuneburg assemblage have included a wide range of specialized analysis, including comprehensive botanical analysis. Botanical analysis for Mont Lassois is lacking (Chaume 2001). This has resulted in dissimilarities in the data presented below However, it provides opportunities to fill important gaps for the Mont Lassois assemblage thanks to the application of use-wear analysis.

At the end of the Iron Age (6th and early 5th century BC), the Hallstatt civilization enjoyed a prosperity marked by the presence of a princely elite, who were the leaders of the political and commercial networks and had their influence on aesthetic and cultural conceptions. In Central Europe, the first settlements emerged, and became the headquarters of these elites. During this period, traditional ceramic craft and the introduction of new luxurious vessels fabricated on the potter’s wheel occur. Recent works and new discoveries made on the sites of the Center-East of France, especially on the aristocratic settlement of Mont Lassois, allow us to better understand the organization of regional production. The properties of the ceramics productions evidence the high quality of pottery and the advanced skill pottery craftsmen (Bardel 2009, 1).

The site of Mont Lassois is most commonly compared to the Heuneburg, especially since they date in the same period and are of the same nature (Chaume and Mordant 2011). Both centers north and west of the Alps encompass the emergence of the first towns and early states, which mark the transition between pre- and early history (Krausse *et al*. 2016).

3.1 The Heuneburg

The Heuneburg is located near the Danube River in the state Baden-Württemberg in southwest Germany. The excavated site consists of a fortified Celtic hilltop settlement originating in the Middle Bronze Age. The strategic position allowed to keep the movement of people and goods under control efficiently while crossing the Danube. Archaeological excavation campaigns took place between 1950-1958 and 1963-1979.

The site was divided into three different areas; the citadel, the lower town, and the outer settlement (see Figure 8). The fortified citadel (hilltop settlement) was located on the hilltop plateau on the mountain spur, and measured about 300 by 150 meters. The lower town was surrounded by extensive fortifications consisting of walls and ditches, and a monumental stone gate was erected here as well.

3.1.1 Fortifications

The initial fortifications were constructed following the classis Celtic model, consisting of a wooden framework with a wall made out of stone and earth (*murus gallicus*). Around 650 BC the wall surrounding the city was drastically adapted, and constructed with sun-dried mud bricks, the so-called ”mudbrick wall” system. This technique originates from the Mediterranean world and is unique in temperate Europe, and is only observed at the site of the Heuneburg. The outer settlement consisted of farms and fields. There must have been intensive contact between the Heuneburg and the Mediterranean, which induced the construction of such a Mediterranean model mudbrick fortification. The wall featured lime stone foundations about 10 feet broad and 16 to 32 inches high (3 m broad, 40 to 80 cm high) the total height was about 13 feet (4 m). It was coated with lime plaster and the top was protected against the rain by a wooden walkway. The wall survived for nearly a hundred years and was eventually destroyed in a great fire. After that catastrophe (approximately 500 BC), a *murus gallicus* was constructed once again. This wall, too, was destroyed in a fire, after which the inhabitants of the Heuneburg abandoned the place. During the following centuries, the Heuneburg remained unoccupied until 700 AD, when a new fortified settlement was established again. During the eleventh century AD, the site was definitively abandoned. (Krausse *et al*. 2016, 27).The settlement of Mont Lassois however, as we will see below, ceases to exist until 475 BC.

Figure 8: The citadel, lower town, and outer settlement of the Heuneburg. (https://nl.pinterest.com/pin/37858453094510929/)

Heuneburg was part of the same trade system as Mont Lassois. Imported wine amphorae and Greek black-Figure pottery have been found on the site. The importance of the city's trade network is evidenced by a number of princely graves were located in the immediate vicinity of the settlement, as in the case of Mont Lassois. The fashion of the graves and grave goods, coupled with the presence of indigenous grave goods indicate a distant trade network. The most notorious one is the Hochmichele barrow, which is known for its wagon grave, surrounded by a burial chamber made of wooden planks (Krausse *et al*. 2016, 87).

The Heuneburg is well known for its highly developed ceramics production, and as already mentioned there must have been an intensive commercial network in pottery and iron to make the Heuneburg such an important center of cultural exchange and trade.

3.2 Mont Lassois

The settlement of Mont Lassois is located on a plateau directly next the Seine, near Vix in France. It is one of the famous fortified hilltop settlements in the Celtic world, mostly know for the nearby "grave of Vix". Vix is located near Châtillon-sur-Seine in the department Côte-d'Or in France. The hilltop settlement of Mont Lassois was an important political center with extensive trade relations (see Figure 9)(Chaume 2001, 8).

Imported Greek and Celtic artefacts found at the settlement and the tumulus burials near Vix are indications for widespread network of trade and exchange of gifts within the Celtic world and also between the Greeks and the Celts. Through the port of Massalia (Marseille) goods from the Greek world were imported and transported further into the Celtic regions, especially during the 6th century BC.

Figure 9: Reconstruction of the settlement near Vix, Mont Lassois during the 5th century BC. (https://www.google.nl/search?q=mont+lassois&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjyxtbLpsfTAhWK2xoKHatOBG8Q_AUICygC&biw=1280&bih=635#imgrc=TVg3rHMEy_HDAM)

3.2.1 Grave of Vix

The settlement of Mont Lassois is marked by several burial mounds. The most notorious tumulus encompasses the elaborately furnished grave of the Lady of Vix. The grave was discovered in 1953 and dates from approximately 500 BC.

The burial of a woman along with amongst other things a wagon, rich jewelry and an enormous krater (see Figure 10 and

Figure 11)(Rolley 2003). This krater is 1.63 m high and weights more than 200 kg in total, enabling a capacity of 1100 liters. Its size makes it the largest metal vessel known from the ancient world. The vessel was manufactured in a Greek colony in the south of Italy, and was presumably obtained by the elites of Vix as a gift (Verger 2008b). Archaeologists have argued that the grave belonged to a woman who had an important role as a priestess and/or political leader during her lifetime (Krausse

2003). Two other burials which were interpreted as woman were found in the vicinity of the site of Vix. Based on these finds, it was suggested that a female dynasty ruled the area during the Early Iron Age (Milcent 2003).

In the 1990s a sanctuary was discovered at the site of Mont Lassois, named "*Les Herbues*". This sanctuary is enclosed by a ditch and measures approximately 25x25 m. Two statues of a male warrior and a seated woman made out of limestone were excavated near the entrance of the enclosure. It is argued that the sanctuary functioned as a *heroon*, which is a space where ancestor were worship took place as dedication to the elites (Krausse *et al*. 2016, 172).

Figure 10: Krater of Vix.
(https://i.pinimg.com/originals/ed/f6/14/edf6145be3cc90559f02a6fd4b21bc68.jpg)

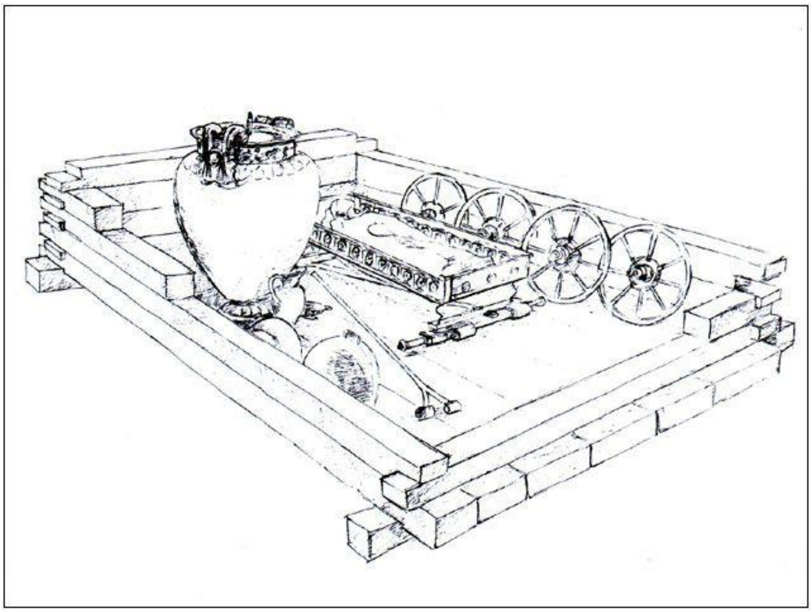

Figure 11: Grave of Vix
(https://i.pinimg.com/736x/10/41/eb/1041eba09805431c1144703656158664.jpg)

3.2.2 Town planning

In 2003 geomagnetic surveys were carried out which created the possibility to obtain an overall picture of the site. It appeared that the settlement structure displayed resemblance to regular town planning. The form of the settlement seemed to be adjusted to the geology of the plateau were it was located on. A passage that runs from north to south divided the settlement plan in different areas which included a complex composition of structures (see Figure 12). Common features of the settlement are sunken houses, pits and ditched enclosures. Buildings occurred in different sizes and shapes. The overall layout of the site suggests a certain complexity in organization and planning, indicating town planning (Chaume and Mondant 2011). The most remarking features of the settlement were a number of large apsidal buildings, of which the largest one measured 20x33 m. This building was excavated in its entirety. The walls of the building were elaborately decorated with paintings. Inside the structure, imports of Attic pottery and wine amphorae from Massalia were found. The extraordinary size of the building, the paintings and the particular finds suggest that a prestigious function was attached to the building. Perhaps this location had a function for gathering and feasting, during which cult rituals took place and in which the political elite was involved (Chaume *et al*. 2013).

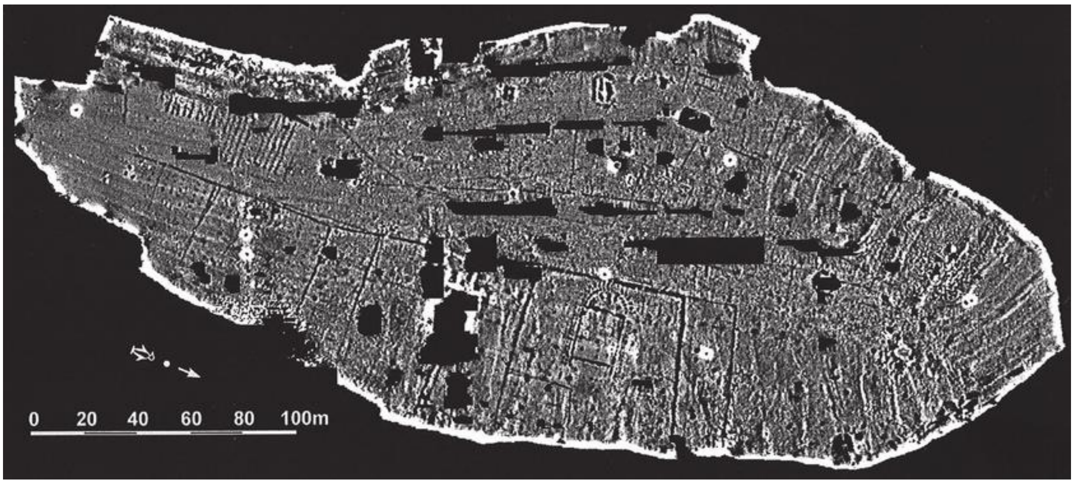

Figure 12: Geomagnetic plan of the settlement, showing a well-organized structure (after Chaume and Mordant 2011).

3.3 The ceramic material from Heuneburg and Mont Lassois

3.3.1 The Heuneburg

A large amount of ceramic material was recovered from excavations near the Heuneburg. Many of these vessels were produced locally, however, wheel thrown pottery was produced in large amounts at the Heuneburg as well. From the 6th century onwards, Mediterranean pottery was imported through the port of Marseille (van den Boom 1989, 167).

White ground, painted vessels with ornamental decoration are some of the most important groups amongst the pottery assemblage of the Heuneburg (Dämmer 1978).The painted pottery from the period Hallstatt D1 can be subdivided into three different types: red and white painted pottery and *Alb-Hegau* ware. The latter type is characterized by geometrical patterns and ornaments. These ornaments can be stamped, incised or carved (*kerbschnitt*) on the surface of the vessels. Graphite, white and red colors were used to decorate the pottery. White incrustation paste was used to fill in engraved ornaments on the vessels (van den Boom 1989, 28-33). From period D2 on, thin-walled pottery, which gave the impression that it was wheel-turned, replaced the white ground wares. The high quality of the pottery indicated that pottery production was a specialized workmanship. This type of pottery can be interpreted as a reaction to the emerge of imported pottery from south of the Alps from the 6th century onwards (van den Boom 1989, 29).

3.3.1.1 Forms

The ceramic assemblage from the Heuneburg is characterized by typical form types, which are known from other Iron Age sites from Central-Europe as well. Bowls, goblets and dishes occur most frequently under the types known from the Heuneburg.

Characteristic for material among the Heuneburg are vessels with an S-profile and/or a (severely) bulging profile (see Figure 13, 1). Closed and open forms both occur. In some cases, bowls have inwardly curved edges (see Figure 13, 4). Some bowls are characterized by parallel ridges just below the edge (see Figure 13, 3; see experimental vessel Z71). Another typical form is a bowl with a small out curving rim ((see Figure 13, 2) experimental vessel HB-AS-036). In some cases, at the center of the base a small convex bulge is pointing inwards (see Figure 13, 4)(see experimental vessel Z71). Lastly, vessels with a small base or stand foot are typical within the assemblage, as well as other Early Iron Age contexts from North- and Central Europe (van den Boom 1989, 34).

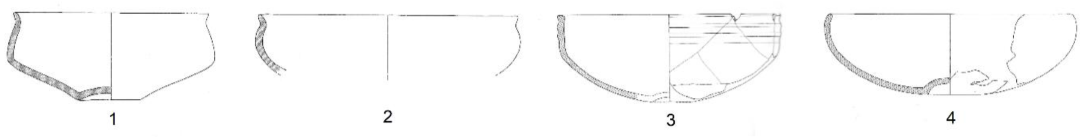

Figure 13: Pottery types from the Heuneburg (van den Boom 1989).

3.3.1.2 Ceramic properties

The largest part of the ceramic assemblage from the Heuneburg is fired in a reducing atmosphere, while oxidized fired pottery occurs to a lesser extent. The most frequently added temper include chalk, feldspar and muscovite. The surface of the vessels is mostly smoothed or polished. Decorations may consist of paint and/or stamped or incised geometric patterns.

3.3.1.3 Graphitized pottery

A particular type of pottery recovered from the sites near Heuneburg is graphitized ware. Graphitizing was performed to provide a higher durability and to create an extraordinary, metal-like, shiny surface. This type of pottery is regularly recovered from archaeological contexts east of the Alps in southern Germany and east France. This type of pottery has a long tradition originating from the Neolithic. The graphitized pottery from the Heuneburg descends directly from the Hallstat Horákov culture (van den Boom 1989, 56, 157).

3.3.2 Mont Lassois

As mentioned for the Heuneburg, the ceramics from Mont Lassois also date from Hallstat D2/D3 (c. 550 – 450 BC). The hand formed, as well as the wheel-thrown pottery from Mont-Lassois will be described in this paragraph.

3.3.2.1 Hand formed fine ceramics

Ceramics that are hand formed using traditional techniques without the use of a potter’s wheel, are the most commonly found in the assemblage of the settlement. The walls of these vessels are commonly relatively thin. The size of the inclusions are more or less fine or coarse and their distribution is rather homogenous. Two major categories of production can be distinguished. Firstly fine-paste ceramics, which are used for the production of fine table wares, used serving of food or drinks, or the preparation of it. They have a carefully smoothed surface which may be decorated. Their firing is generally rather homogeneous. A dark color (brown to black) is obtained by reductive firing is applied for its aesthetic and technical aspects. Only painted ceramics with a red component require clear oxidized firing at the surface (Bardel 2009, 2). There are also coarse and thick walled ceramics used for cooking and storing solid foodstuffs (cereals, salted meat). They have significantly coarser surfaces.

3.3.2.2 Technological innovation: wheel-thrown ceramics

A new form of ceramic production was introduced with the adoption of the potter's wheel. These ceramics are characterized by a very fine paste, splined decorations, or a finish applied by a rotation system, appears in parallel with traditional productions. It has a function as tableware of exceptional technical and aesthetic quality, whose distribution is linked to privileged residential and artisanal contexts. (Bardel 2009, 4).

3.3.2.3 Typology

Dominant ceramic forms encountered at Mont Lassois consist of low forms of frustoconical (type 11000), cylindrical (type 13000), or marli, which can be provided with a high foot (type 21000); or square jars which may also have a foot (type 24000), jumpers bowls (type 25000), keel-shaped bowls (type 32100), sinuous (type 33000) or with a shoulder (type 34000). Finally, among the tall forms are bottles with a sinuous profile (type 73000) or with a shoulder (type 74000). The high type with hollow feet (type 82000), which are not always attributable to a shape, are numerous and are characteristic for the ceramic assemblage of Mont Lassois (see Figure 14)(Dubreucq and Bardel 2012, 33).

3.3.2.4 Decoration

The pottery is often associated with painted decoration, which can be applied by one of the three techniques (Bardel 2005): red paint could simply be applied in on the flat surface, geometric patterns applied by slip (barbotine) within the relief, or the combination of both a red painted flat surface and the application of geometric patterns by slip. This figurative painted decoration, which can be described as "Vixean" type, is present among all large assemblages, at a percentage generally between 5 and 15% of the NMI (minimum number of individuals). The characteristics of this type appears be broadly common to an area reaching from west to east between the valley of the Yonne and Gâtinais, the Bassée and Plateaux Briards (Bardel 2009, Dubreucq and Bardel 2012, 78).

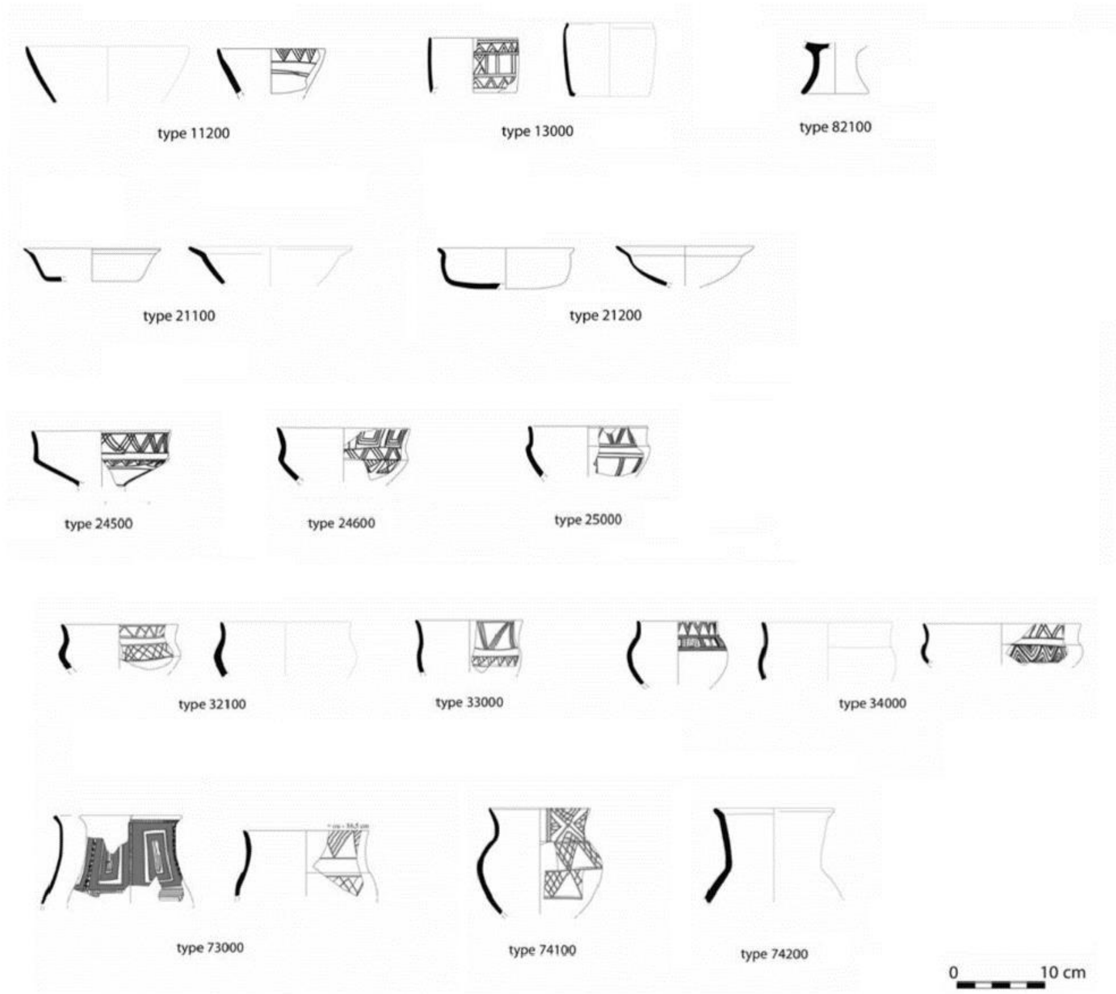

Figure 14: Characteristic forms Mont Lassois ceramic assemblage during Ha D2/D3 (after Bardel 2009, 33).

3.4 Environment and nutrition in Iron Age Central Europe

Besides pottery, botanical remains also provide important insights into the life of ancient communities. In the following paragraph, the archaeological evidence from botanical remains will be discussed. These materials are included in the experiments as well. Since there is a lack of botanical studies from Mont Lassois, the evidence will be mainly based on studies from the Heuneburg, for which a comprehensive paleobothanical research has been performed.

Based on botanical analysis it was possible to reconstruct the environment of the site and the diet of its inhabitants. Evidence for this is mainly derived from (un)charred plant macro-remains and pollen retrieved from excavations on the hilltop area, the lower town and the outer settlement, and the surrounding burial mounds the Speckhau und Hohmichele (Fischer *et al*. 2010, 54.)

3.4.1 Cereals

During the Iron Age, cereal cultivation was practiced extensively in the surrounding areas of the Heuneburg. The most common cultivated cereals were spelt (*Triticum spelta* L.) and barley (*Hordeum vulgare* L.). Spelt was cultivated during the winter and barley during the summer. In addition, various cereal types that were domesticated at that time were grown as well, which include: einkorn wheat, naked wheat, rivet wheat, emmer and millet. Rye and oats were already present in the wild, but were not cultivated yet. A wide variety of species were cultivated for various reasons, the first being that such a diversity reduces the risk of failed harvest. Secondly, the amount of labor that had to be invested in agriculture could be divided.

Various species of beans were cultivated as well: broad beans, peas, pulses, lentils, bitter vetch and chickpeas played an important role in the diet of the inhabitants of the Heuneburg. Flax was grown to provide fiber to produce fabrics. False flax and opium poppy were used as oil crops (Rösch and Fischer 2016, 72).

3.4.2 Pasturage and meadows

A large part of the land was in use as widespread meadows for keeping livestock. Especially the areas that were not suitable for agriculture served this purpose. Ever since the Bronze Age, extensive grazing occurred in the area around the Heuneburg. The Juniper heats near the Swabian Alb are a result of this extensive land use. During the Iron Age, the area was less extensively forested as today, as could be indicated by pollen analysis. Due to human intervention with the landscape, the area had been widely deforested (Fischer *et al*. 2010, 45). The remaining forest had a fairly open character. A large part of the vegetation consisted of scrubland and heath like landscape, in which trees such as hazel, elder, willow, trembling poplar and grew. Trees such as hornbeam and birch were used as firewood. Wildlife was hunted, and fruit, honey and mushrooms were collected in the wild. The higher parts of the landscape were dominated by trees such as common beech, sessile oak, lime, elm and sycamore. Alder and ash grew in the lower, wetter areas. Coniferous trees such as pine and silver fir were less extensively distributed through the area, although they occurred in fairly open environments.

3.4.3 Herbs

Various herbs were grown in gardens, presumably close to the houses. Celery, parsley, dill and rue were used to at this time in prehistory, although a large variety of spices as were know from the Roman period were yet unknown. Orchards with apple trees were located in the direct vicinity of the settlement. Fruits and nuts (hazelnuts) were also still gathered in the wild (Rösch and Fischer 2016, 73).

The agriculture did not produce enough yields for the settlement to be self-sufficient. Therefore, it was necessary to import certain goods. In order to secure the production of bread, gruel and beer, spelt wheat and barley were imported. Import of foodstuffs took place exclusively in central places (Stika 2010, 75).

As presented in this chapter, Mont Lassois and the Heuneburg were both important trading settlements in Iron Age Central Europe. Both settlements were located on a hilltop, with rich elite burials in the direct surroundings. The ceramic assemblages are comparable as well; consisting of locally produced and imported ceramics, with similar forms and characteristics. In both settlement a variety of cereals and herbs were grown. The areas around the settlement were used as pasturage for cattle, which also played an important role in these communities.

Chapter 4. Use-wear analysis on experimental and archaeological pottery

As mentioned earlier, the used materials and applied manufacture techniques affect the formation of use-wear traces significantly. In additions, traces resulting from manufacture can also be easily mistaken for use-wear traces. In order to perform a reliable use-wear analysis, it is therefore essential to consider the manufacture techniques of the ceramics. In this chapter, the manufacture techniques and materials will be addressed first. Subsequently, the applied techniques and materials specifically for the experimental vessels will be discussed.

4.1 Manufacturing performance characteristics

A comprehensive pottery study should consider both intended vessel function and actual function. Intended function includes the technical choices made by the potter, which relate to the performance during the manufacture process and usage of a vessel to suit an intended purpose.

Potters are able to control various technical choices during ceramic manufacture, which include the morphology (form), size, paste composition, temper type, firing conditions and treatment of the surface (Tite 2008). The performance characteristics can be linked to intended function and the technical choices made by the potter will be discussed in this chapter (Skibo 2013, 27).

Potters make certain decisions in performance characteristics to manufacture vessels which suit to a particular purpose. Therefore, a cooking pot (processing) could have a round base to provide strength during cooking, and an open orifice to allow easy access to the interior of the vessel. Vessels can be for example made specifically to process particular liquids or foods. Therefore, the performance characteristics such as form, temper etc. could indicate what type of content a vessel contained (hot or cold, dry or wet) (Skibo 2013, 28).

4.1.1 Morphology

The shape of a vessel may be indicative of its function. In addition, the purpose of a vessel can inform about the customs of the communities which used it. For instance, for a cooking pot to be efficient, the orifice must be wide enough to prevent from spilling excessive boiling and to allow stirring of the contents. Also, the vessel must have a size relative to its heating surface and capacity, to prevent from premature boiling dry due to complete evaporation of the water (Skibo 2013, 29).

Researchers at the Laboratory for Ceramic Studies at the University of Leiden have been very active in combining experimental and ethnoarchaeological research, manufacturing techniques and the analysis of materials, in order to increase the understanding of the *chaîne opératoire* of pottery (van As. 2008) Such an holistic approach to study pottery has been conducted in Leiden for several decades with success (van As and Jacobs 1995). Much of the relevant studies are published in the *Leiden Journal of Pottery Studies.*

Properties of a vessel influenced by their morphology include *stability*, *accessibility* and *heating effectiveness*. *Stability* refers to the ability of a vessel to remain stable to stand upright. The shape, breath of the base, and the distribution of the weight determine the stability of a vessel. Flat bottomed pots have a high stability. Round bottomed vessels have a relatively lower stability, given that they are able to stand upright when on a flat surface, but will wobble easily if nudged. A round base increases strength but has a lower stability (Skibo 2013, 31).

The *accessibility* of a vessel is a functional characteristic that indicates how easily it is to access the contents of the vessel. The diameter of the orifice and the form of the neck determine accessibility for the most part. Thus, storage jars often have a limited orifice and therefore a restricted accessibility to protect its contents. Complete accessibility on the other hand, as often observed in cooking pots, so that the contents can be stirred and easily removed with a spoon. Vessels which stay on the fire for a longer period of time (such as beef stew) tend to have a very open form to provide maximal accessibility, because during cooking the vessel is accessed many times to prevent burning and to stir (Skibo 2013, 32).

Heating effectiveness is a performance characteristic pertaining to the ability of a vessel to heat their contents. Heating effectiveness is determined by various technical choices, such as temper type, thickness, and surface treatment (see chapter 4.1). It will also be increased when a pot is covered when on the fire. Some foodstuffs require a lower cooking temperature and are thus left uncovered while on the fire. For example, beef stew requires a simmering temperature without boiling. So in some cases a lower heating effectiveness is desirable, because the vessel will be able to remain on the fire for a longer period of time without burning the food or boiling over (Skibo 2013, 36).

Many vessels spend a large part of their life history on the ground or on a shelf and are refilled occasionally (Skibo 2013, 33). Some pots are designed so that they can be nested and stacked (see Figure 15)(Experiments including stacking see paragraph 5.3.2). Potters may need to pile up the vessels for a more efficient transport, or to store them for selling or when actually used to preserve foodstuffs (Skibo 2013, 34). Both pre-manufacture and post-manufacture activities can cause use-alteration traces on the pottery surface.

Figure 15: Stacking of vessels during the handling experiments (exp. no. 3626/3629).

Gordon Bronitsky's visit to the Laboratory of Ceramic Studies at the University of Leiden formed the basis for the initial research at the Laboratory of Traditional Technology at the University of Arizona. Replicative experiments were conducted to increase the knowledge about the correlation between temper, firing process, surface treatment, and performance during manufacture and use (Bronitsky and Hamer 1986). In the following paragraph, the relationship between these variables will be discussed, including the effect they have on the properties of a vessel.

4.1.2 Paste and temper

Replication is an important procedure to obtain a better understanding of traditional pottery manufacture (Rye 1976).

Analysis of chemical and mineralogical attributes can inform about the provenance of the ceramics (Carter *et al*. 2011). Intended function can also be inferred from paste and temper variation. It is assumed that potters usually select clay and temper relatively close to the location of manufacture. Ethnoarchaeological data does support this assumption (Arthur 2006). Because it is difficult to transport clay and temper, there is a strong relationship between sources and the site of manufacture. However, potters do still have options among the close sources.

The paste consists of clay and temper, which affects performance characteristics both during manufacture and use. The manufacturing stage concerns the workability and ease of manufacture.

Workability is the ability of the clay to be formed. The workability is determined by the mineralogy, temper, presence of organics and water content of the clay. Generally, increasing mineral temper makes the clay less workable. The workability concerns the ability to bend the clay without cracking (for example as in a coil). The condition of clay can vary from soft to stiff, in which soft means that the clay is easy to form and stiff that the clay is hard to form (Skibo 2013, 39).

Ease of manufacture concerns the time and effort that need to be invested in the construction of a pot. The manufacture of some vessels requires several stages, various tools, or particular skills. Temper influences the ease of manufacture, adding coarse temper for example reduces shrinkage and impedes workability, but at the same time may influence the performance characteristics of a cooking pot during use.

Some performance characteristics on which paste may effects during use are thermal shock resistance, permeability and abrasion resistance. Thermal shock resistance is the level of resistance against physical shocks caused by the repeated heating of a vessel. When the ceramic surface reaches high temperatures, tensile stress can cause damage in the form of micro cracks. If pore spaces or temper interrupt micro cracks, thermal shock resistance increases. Therefore, cooking pots often have a high percentage of temper (Skibo 2013, 40). Mineral (rock) temper increases the permeability of a ceramic surface (Skibo 2013, 40). Abrasion resistance is concerned the ability of the ceramic to resist against alteration of the surface. The type of temper and quantity can affect the abrasion resistance of a vessel significantly (Skibo 2013, 41).

4.1.3 Firing temperature

Traditional handmade pottery is either fired in an open fire, or in a kiln. A kiln usually reaches a higher temperature and has longer firing times. The firing temperature in a kiln can be extremely variable. Potters may have a limited control over the firing conditions in the kiln during the firing process. However, they can control the firing time. Kiln fires slowly reach their maximum temperatures and hold on to it considerably longer than an open fire (Gosselain 2000). Firing temperatures are an effect of duration and atmosphere, which potters can influence by selecting fuels, or the chosen way of stacking etc. (Tite 1995). In a kiln, the firing temperature usually range between 750°C and 950°C, but temperatures between 600°C and 1000°C are possible as well. The firing temperature is based on variation in mineralogy and microstructure of the pottery (Skibo 2013, 45). Mineralogical changes during firing include the decomposition of calcite and the breakdown of clay minerals (Tite 1995, 37).

The firing temperature influences performance characteristics such as strength, permeability and thermal shock resistance. As the firing temperature increases, the strength of a vessel (as in impact resistance) increases as well. Ceramics most often break due to impacts. On the other hand, when the firing temperature increases, the thermal shock resistance usually decreases. This is because of the fact that the sintering process reduces the space between pores, therefore impeding the formation of micro cracks. Low-fired pottery has a higher thermal shock resistance because their structure has more pore space (Harry *et al*. 2009). Also, pore space and thus permeability decrease as the firing temperature raises (Skibo 2013, 47).

4.1.4 Surface treatment

Vessel performance is highly affected by surface treatments. Surface treatments on vessels can be applied before as well as after firing. Surface treatments which are applied prior to firing (when the clay is still moldable) include: smoothing, texturing and incising. Treatments applied before firing when the paste is almost completely dry include amongst others: polishing, slipping, and painting. Treatments applied after firing may consist of painting, smudging, and organic surface treatments. Organic treatments are likely to be overlooked, as they usually do not remain preserved due to post-depositional processes (Skibo *et al*. 1997). Organic treatments are generally applied to reduce the permeability of low-fired pottery. The surface treatment also effects abrasion resistance, and therefore the formation of use-alteration traces to be observed during use-wear analysis.

Several performance characteristics are affected by surface treatments, including permeability, thermal shock resistance, heating effectiveness, and abrasion resistance. Decoration such as painting or incisions may be applied to perform social or ideological functions related to political of ritual activities. Thermal shock resistance of cooking vessels is one of the most important performance characteristics which is influenced by surface treatments, especially roughing. (Skibo 2013, 48).

The presence of water in the vessel wall reduces thermal stress, thus impermeable vessels are often more vulnerable to thermal shock. Textured surface treatments however, may improve the thermal shock resistance of a vessel. As texturing is found on cooking pots regularly, it is assumed therefore that a roughened surface is a primary performance characteristic which served in many cases to enhance thermal shock resistance. By increasing the thermal shock resistance, the use-life of a vessel is also extended, improving its usability. Cooking effectiveness is also reduced by permeability.

Surface treatments also affect heating and cooling effectiveness of a vessel considerably (Harry *et al*. 2009). The permeability of a vessel can be controlled by applying surface treatments. Permeability also influences heating and cooling effectiveness. After testing various surface treatments during experiments performed at the Laboratory of Traditional Technology at the University of Arizona, Mike Schiffer pointed out that the greatest heating effectiveness was found in vessels with the least permeable surfaces (Schiffer 1988, 1990).

Lastly, the strength of a vessel can be influenced by surface treatments, which can be assessed through abrasion resistance, tensile strength or flexural strength (Schiffer and Skibo 1989). Experiments have shown that abrasion resistance is greatly affected by surface treatments (Skibo *et al*. 1997). The greatest abrasion resistance is provided by resin coatings and smudging, while polished, textured and slipped surfaces performed the worst. The properties of abrasion resistance by surface treatments have consequences for use-wear analysis, vessel performance, and the effect of post-depositional processes on the pottery (Skibo 2013, 49).

4.2 Chaîne opératoire in the lab: ceramic replicas

The replications presented in this work are mostly based on observations of the archaeological material retrieved from the Heuneburg, because this material was initially analyzed in Leiden in September 2015. The material was set at the disposal of the university by providing a loan of the museum collection. L.H.F.C. Jacobs manufactured the experimental vessels using the facilities of the Material Culture Studies laboratory at the University of Leiden. After careful analysis of the manufacturing traces, replicas were created by using the same traditional production techniques and comparable materials. Their fabric, shape, surface finish and size properties have been thoroughly documented. The surface of the original vessels has been analyzed for traces of manufacture. The ceramic assemblage was classified based on technological characteristics. Generally, traces of manufacture are poorly visible because their surfaces were finished intensively by smoothing and polishing. As a result, the traces of manufacture are often erased (Jacobs 2017, 1). The unaltered surfaces of the replicas form an ideal basis for archaeological use-wear experiments because they –unlike archaeological material- can be damaged. The experiments are conducted to create a reference collection for ceramics, in order to contribute to use-wear analysis in the future. In the following paragraph, the techniques applied to manufacture the replicas are discussed.

To achieve the best results in replicating the material from the Heuneburg, we focused mainly on large fragments or complete vessels, because from these objects the shaping techniques can be most easily inferred. However, the material from the Heuneburg is highly fragmented, which complicates the analysis. Ideally the fabric properties are best analyzed when the studied fragments are clean and have a fresh break so that the clay body is well visible. Fabric analysis requires only a small amount of the ceramic material (circa 1 square centimeter). Through re-firing the paste properties can be determined. Unfortunately, such samples could not be taken because permission from the owner of the museum collection was not granted.

4.2.1 Materials

Grainy tempers such as calcite and grog were often added to the paste to improve the workability of the clay, but may also have been used to enhance performance characteristics during use (Jacobs 2017, 4). Fine muscovite[2] particles naturally occur in the sediments in the direct environment of the site, and thus commonly occur in many fabrics of the pottery (van den Boom 1989, 45).

It was impossible to acquire clay for the replicas directly from the site. Basic potters-clays were modified to replicate pastes from the archaeological material. Fine river clays with no grains were used, to which different tempers have been added to fit particular paste properties. Many types of fabrics had to be fabricated because the archaeological ceramic collection was extensive and rather varied. The manufacture of the replicas was based on three main fabric compositions based on clay and temper. The first fabric consisted of clay mixed with 25% fine sand with particles with a grain size smaller than 250 microns. This type of temper is comparable to the cover sands, which occur in a large part of the soil from the Netherlands and Germany. This fabric was mainly used for replicating wheel-made pottery. For the fine handmade pottery a coarser fabric with a grain size of maximal 0.5 mm was used. Lastly, the coarse pottery contained 25% coarse sand, mainly consisting of grains of maximal 1 mm in size (Jacobs 2017, 3). The used temper consisted of quartz, muscovite and calcite.

The mentioned pastes were adapted to each particular vessel, by adjusting the composition or by adding specific tempers such as calcite, quarts or basalt. The addition of calcite to the paste was probably intentional. In the Mediterranean area this mineral was often used in pottery that could be related to food preparation (van den Boom 1989, 23).

4.2.2 Shaping techniques

Two different shaping methods could be derived from technological traces observed on the archaeological pottery. A small part of the pottery was fabricated by using a rotating potter’s wheel. However, the majority of the ceramics are handmade. It is striking that in some cases, handmade pottery seems intended to imitate wheel-thrown pottery. A high appreciation of wheel-thrown pottery may have contributed to this preference. This refined finish was possibly performed because of a form of competition between potters or pottery production places

[2] Silver-grey type of mica

(Ruckl and Jacobs 2015, Jacobs 2017, 5). Generally, the surface of the vessel is accurately finished by smoothing by hand, mainly performed in a horizontal direction. Sometimes, vessels reveal traces of slow rotation consistent with the use of a *tournette*, or slow wheel.[3]

Part of the wheel-made pottery was probably imported from the Mediterranean, their counterparts were manufactured locally. It was therefore very informative to perform a provenance study.[4]

The larger part of the ceramic assemblage consists of vessels created with the coiling technique, which is the most common shaping method in handmade pottery. Only for the creation of goblets and small pots the pinching technique has been used. The molding technique is very suitable to fabricate the lower part of vessels, while the upper part is coiled. Often possible traces of manufacture are erased by the finishing of the vessel. A mold or support-form was often used to create the lower part for coiled pottery. This shaping technique is very suitable to form open vessel shapes such as bowls. This is a quick manufacture method that provides control over the uniformity of shape. Existing ceramic vessels could be used as support form or mold. By applying this technique, the lower vessel part has the same shape as the inner shape of the mold and the other created vessels, while the morphology of the upper part may differ.

Following the shaping technique mentioned above, Clay coils were pressed in an external mold, on which the wall was built by adding more clay coils. These coils were fixed to each other by smearing and pinching. When the clay had stiffened a bit, the vessel was shaped by the use of scraping tools (Jacobs 20017, 6). Scraping is performed to connect the coils firmly to each other, and to shape the form of the wall by applying pressure. By this action, the wall eventually becomes thinner and thus lighter and stronger. After that the clay had stiffened further, the form was removed from the mold. In some cases, a foot in the form of a stand ring could be attached to the base, which was formed by pinching and smearing (see Figure 16). Lastly, the surface of the vessel was smoothed by hand or with a soft material such as leather or a sponge.

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[3] A slow wheel often made out of a single stone which was put on the ground or in a socket.

[4] The provenance of the pottery from the Heuneburg was studied by dr. Maxime Rageot through analysis of thin sections as part of the BEFIM project in 2016.

Figure 16. Forming a vessel by coiling. On the picture below a ring-base is added by pinching (photographs by Lou Jacobs).

These manufacture techniques are comparable to the production of the related Iron Age "Marne pottery", which was initially produced in the eponymous department in Northern France. This type of pottery is also known from the Netherlands (van den Broeke 2012, 202-206). The application of these techniques accounts for the typical S-shaped profile on the lower part of many Celtic vessels. Since coiling is not the simplest or the quickest method to create such an S-shaped lower wall, the combination of coiling and molding seems to have been the preferred method (Jacobs 2017, 6).

4.2.3 Surface finish

The surface treatments are of great importance in this research because they concern the outer part of the vessel, which usually bears some of the most significant traces of use. As mentioned earlier the surface finish strongly affects the accumulation of use-wear traces.

After the vessel is completely formed, a surface finish is often applied. The replicas have been finished by smoothing, roughening, polishing, burnishing and graphitizing. Graphitizing is sometimes performed as surface treatment on the replicas because this is also observed in the ceramic assemblage from the Heuneburg (see chapter 3.3.1.3. and Figure 17). This technique is applied as follows. After drying and smoothing the vessel is burnished. Subsequently the still slightly moist surface is covered with fine graphite powder. The powder is smeared on the surface by hand, which is then polished with a smoothing tool (e.g. a polishing stone) in order to consolidate the graphite into the surface. After the vessel has dried further, it is fired in a reducing environment. By graphitizing a shiny surface is created with a black-silver gloss, providing the treated vessels with a metallic appearance (Kreiter *et al.* 2014).

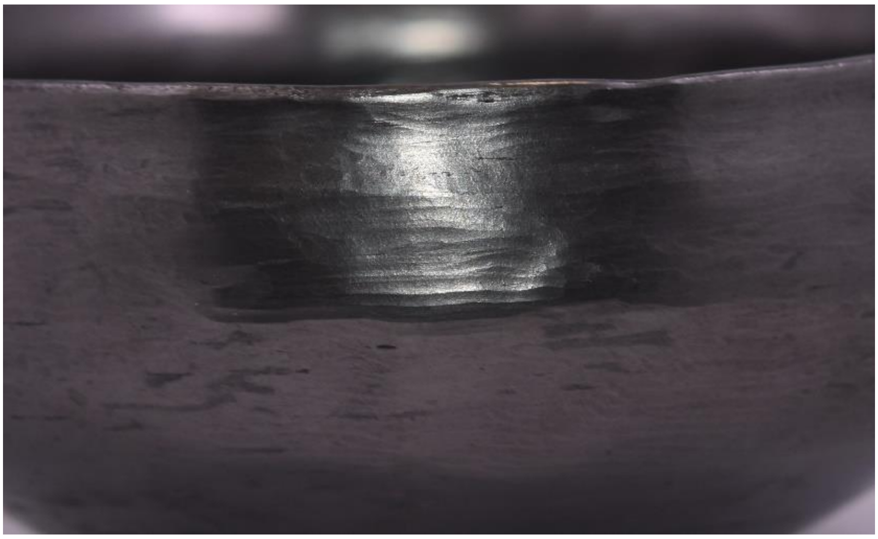

Figure 17: Pottery with a graphite surface finish (vessel no. 3620)(photograph by the author).

4.2.4 Firing

As mentioned earlier, the firing conditions also affect performance characteristics of pottery, as well as the abrasion resistance of the ceramic surface, and thus are essential to our analysis.

Before being fired, pots need to be dried thoroughly. Depending on the environmental conditions, this process can take from a few days up until a few weeks. The firing conditions are generally distinguished as oxidized and reduced, depending on the amount of oxygen circulating during the firing process. In an oxidized environment there is relatively much oxygen at disposal, while in a reduced environment only a very small amount of oxygen is allowed in the kiln's firing chamber. The latter conditions result mainly in dark black/grey colors while an oxidized environment on the contrary results in orange/red colors.

As mentioned earlier, the firing environment also influences other properties of the vessel, such as strength, hardness and porosity. Pottery fired under reducing conditions tends to be somewhat harder than pottery which is fired in an oxidized environment. This is due to the fact that carbon is formed in reducing conditions, which creates a higher density in the ceramic material. Pottery fired in oxidizing conditions might be more susceptible to abrasion than the reduced fired variant. The firing process also affect certain fabric properties, such as the behavior of minerals and rock fragments. Temper and paste inclusions of mineral origin such as mica's, quartz and crystalline calcite. The presence of the latter in the paste does not result in lime spalling while fired under reduced conditions. Reduced firing conditions are also required when the surface is finished with a coating of graphite, because only under these conditions the graphite powder, being pure carbon, adheres to the surface during firing. It is therefore assumed that objects with a graphite coating were fired in a reduced environment intentionally.

The pottery replicas were fired in kilns in the Laboratory for Material Culture Studies at the University of Leiden. The vessels which were fired in a reduced environment were nested in a pile, surrounded by combustible organic material such as wood chips, straw and small branches. The vessels were fired in a closed pot in order to prevent oxygen from reaching the vessels during firing (see Figure 18). The smaller part of the pottery were fired under open oxidizing conditions in which oxygen could easily reach the vessels.

Figure 18: A pot fired in reducing atmosphere just coming out from the kiln, surrounded by burnt organic material (photograph by the author).

For this research it is essential to be able to differentiate well between traces of manufacture and traces resulting from use. In order to do this, it is vital to observe and record traces of production as first. This is done by documenting the vessels by (microscopic) photography, drawing and describing. Both traces resulting from technology and use-wear analysis are essential because they contribute to a complete picture of the formation of these traces. Through such a holistic approach it is possible to replicate the archaeological objects as close as possible, and to prevent that traces resulting from the manufacture process are mistaken for traces resulting from use. By the high precision applied to manufacture pottery, we may already infer that the Iron Age potters in the Heuneburg were highly skilled crafts people.

Chapter 5. Use-wear analysis on experimental and archaeological pottery

5.1 Using pots in the past: analyzing use-wear traces on archaeological ceramics

5.1.1 Heuneburg

The ceramic assemblage from the Heuneburg was analyzed at the Material Culture Studies in Leiden in December 2016 by prof. Annelou van Gijn and drs. Annemieke Verbaas. The traces seen on the vessels and sherds were meticulously documented by (microscopic) photographs, drawings and detailed description. Because the ceramics were returned to the museum shortly after they were analyzed, they were not at my disposal for direct use-wear analysis anymore. Thus, for the observation of the Heuneburg material I had to rely on the existing documentation, consisting of photographs, drawings, and photographs. Therefore, the documentation of the Heuneburg material was primarily used as an example to get familiar with the type of use-wear traces, and as a starting point for further use-wear analysis of the Mont Lassois repertoire. For this reason, the material is described less extensively than the Mont Lassois assemblage. Areas of use-wear were analyzed and described below, including microscopic pictures. The pictures of the complete sherds/vessels and drawings with indications of locations of use-wear can be found in appendix 4.

The ceramic material is recovered from three different sites near the Heuneburg: Heuneburg Vorburg (citadel) (HB-VB), Plateau (HB-PL) and the outer settlement (HB-AS). The largest part of the material can be dated in period Hallstat D3.

5.1.1.1 Description of use-wear traces

In this paragraph, the use-wear traces observed on the ceramics from the Heuneburg will be described. Microscopic pictures are taken of the use-wear traces, which are indicated by loc1, loc2 etc. These locations refer to the locations on the vessels from which the pictures were taken. These locations are indicated on drawings, which can be found at appendix 5. A detailed description of the locations and nature of the traces will be discussed in Appendix 2. The interpretation of these traces will be discussed below.

On the inside of a bowl (HB-VB-002), small scratches could be observed. The surface also appeared to be abraded in a pitted nature. The center of the vessel seemed to be affected most by abrasion (see Figure 19, loc1). Further to the outside, the abrasion gradually decreased (see Figure 19, loc2). One would expect that such a pattern could be related to stirring or scooping, which is centered on the middle of the vessel.

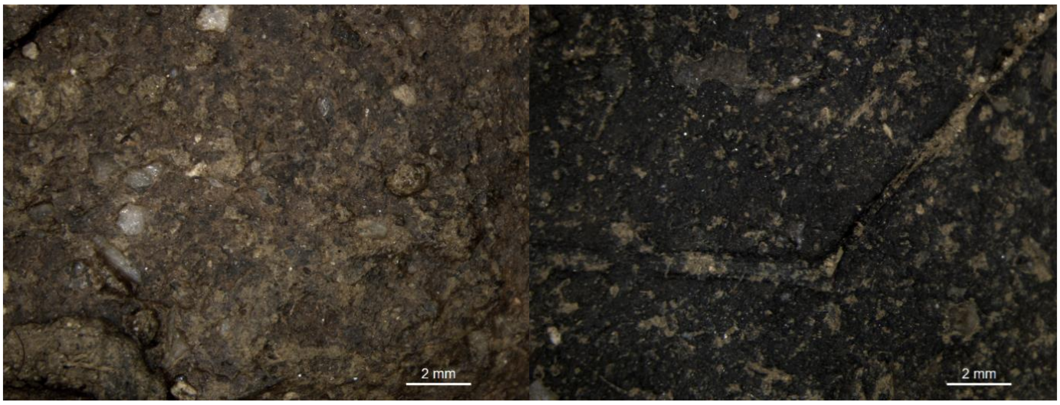

Figure 19: Vessel HB-VB-002. Left: loc1, right: loc2 (magnification 0.75x).

The edge of the center inside a partially complete bowl (HB-VB-005) showed some deep scratches (see Figure 20, loc7). The scratches were relatively wide and widely distributed over the surface. Their direction was random and intersected. The surface near the edge was completely eroded (see Figure 20, loc3), and had a rough, pitted nature. Because the abrasions appeared on some random patches under the rim only, it is expected that these alterations were caused by post-depositional processes.

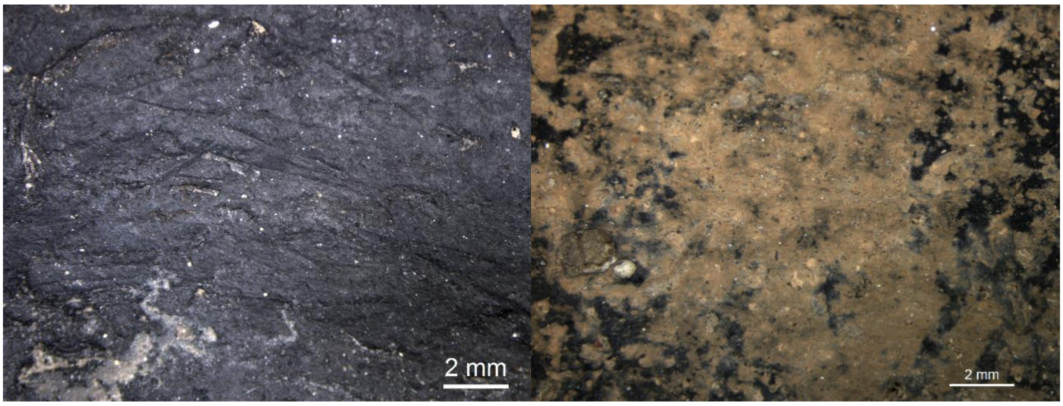

Figure 20: Vessel HB-VB-005. Left: loc7 (magnification 1.0x), right: loc3 (magnification 0.75x).

The rim and the inside of a low bowl (HB-VB-010) exhibited abrasions. The surface of the rim was eroded, rounded and smooth in nature (see Figure 21, loc1). The temper became flatly abraded to the level of the surface as well. Just below the rim, some abrasions were observed as well (see Figure 21, loc6). The surface was lightly pitted in nature, and the temper was exposed and eroded as well.

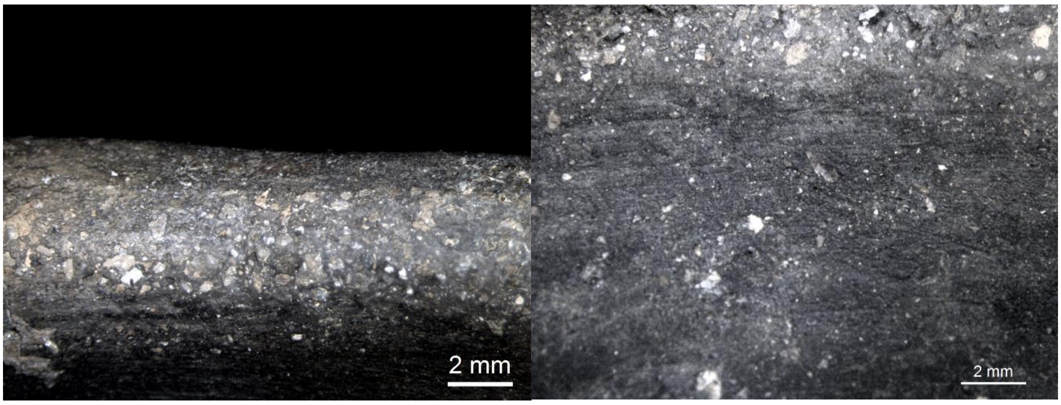

Figure 21: Vessel HB-VB-010. Left: loc1 (magnification 1.0x), right: loc6 (magnification 0.75x).

The inside and top of a rim of a bowl (HB-VB-048) evidenced some alteration as well. Polish was observed on the inside of the rim (see Figure 22, loc5). Since the polish is formed on the inside of the rim only it could be suggested that the wear was caused due to contact with a spoon. Another surface of the rim was rounded, smooth and showed small pitting's (see Figure 22, loc10).

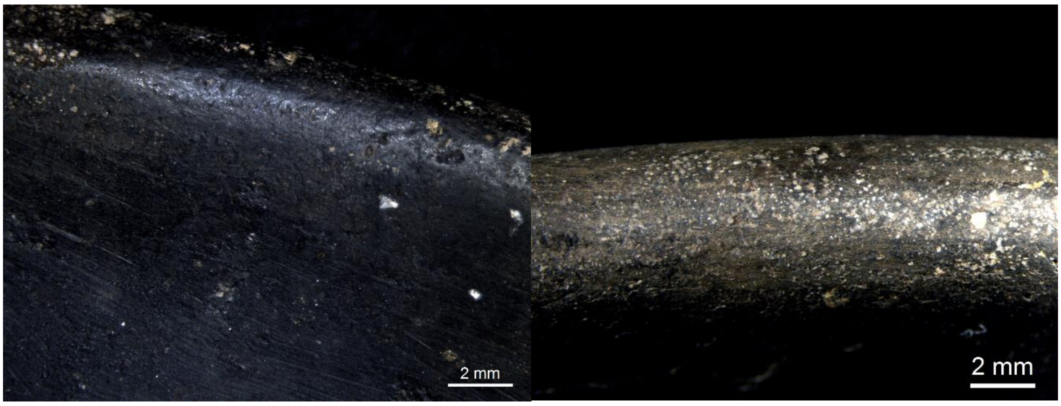

Figure 22: Vessel HB-VB-048. Left: loc5 (magnification 0.75x), right: loc10 (magnification 1.0x).

Scratches and abrasions were observed on the outside of a vessel (HB-VB-050)(see Figure 23, loc3). The scathes were directed in parallel groups. On some locations the surface became entirely abraded. The alterations are evidenced on the widest part of the belly of the vessel, the area on which you would expect abrasions due to contact with other vessels or objects. The rim appeared rounded and smooth in nature (see Figure 23, loc1).

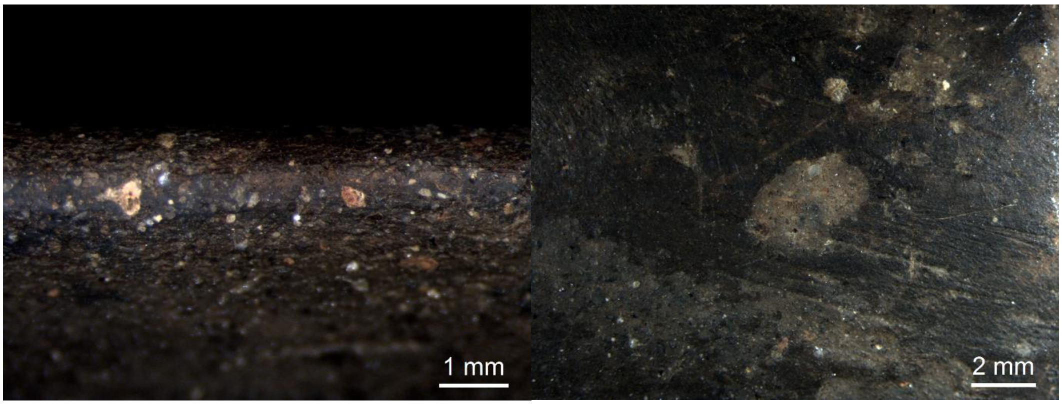

Figure 23: Vessel HB-VB-050, Left: loc1 (magnification 1.8x), right: loc3 (magnification 1.0x).

Similarly to sherd HB-VB-048, polish was observed on the inside of the rim of sherd HB-VB-059 as well (see Figure 24, loc1). It is interesting to see that polish is observed on the inside of the rim multiple times. During analysis of the vessels that were subjected to contact with a spoon, this are should be attentively monitored.

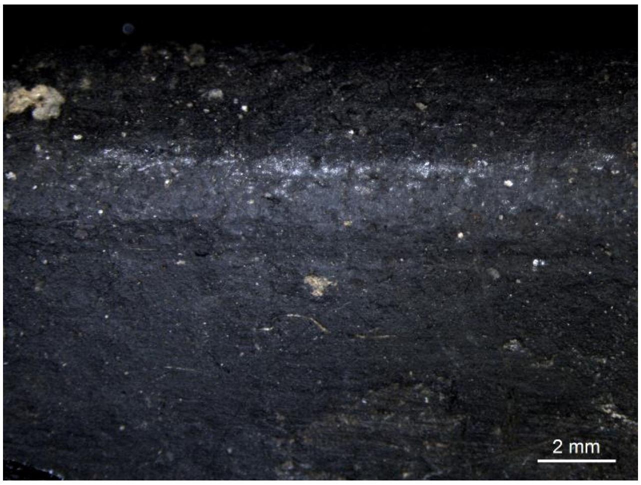

Figure 24: Vessel HB-VB-048, loc1 (Magnification 1.0x).

The inside of a small bowl (HB-VB-063) was lightly affected by some polished spots (see Figure 25, loc2). The inside of the rim was once again covered with polish (see Figure 25, loc1). Some light polished spots were evidenced just below the rim as well.

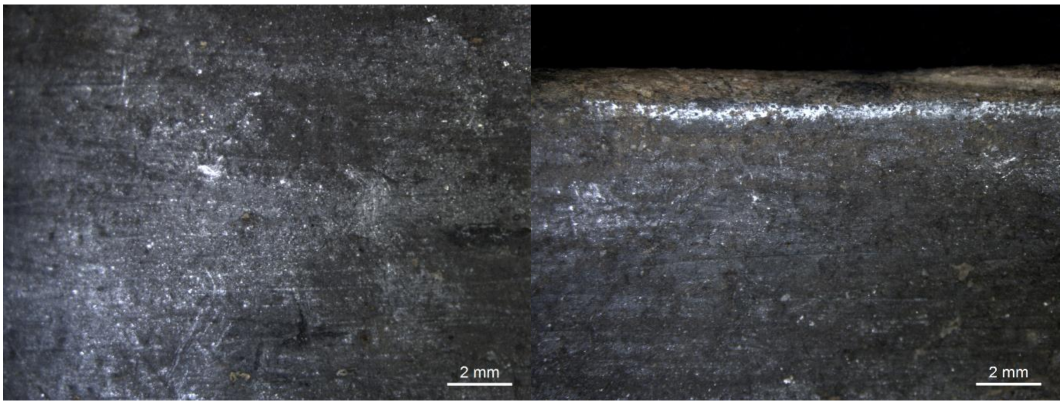

Figure 25: Vessel HB-VB-063, left: loc2, right: loc1 (both magnification 0.75x)

The base of a graphitized bowl (HB-AS-017) evidenced bottom wear. The areas that came in contact with the surface the vessel was standing on were heavily abraded (see Figure 26, loc3). The surface appeared to be strongly pitted in nature (see Figure 26, loc1). Such severe abrasions presumably result from contact with a rough surface.

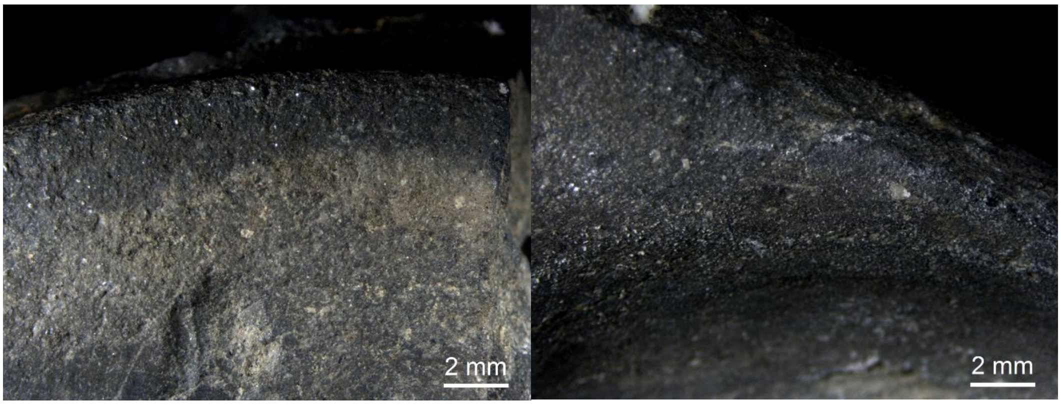

Figure 26: Vessel HB-AS-017. Left: loc1, right: loc3 (both magnification 1.0x).

Some distinct scratches were observed on the lower base of the inside of a bowl (HB-AS-036). The scratches were rather small and randomly distributed (see Figure 27, loc2). The scratches were formed on a smooth surface. The analyzed area concerned is the lower part of the inside of vessel, an area on which you would expect traces resulting from stirring or scraping with a spoon.

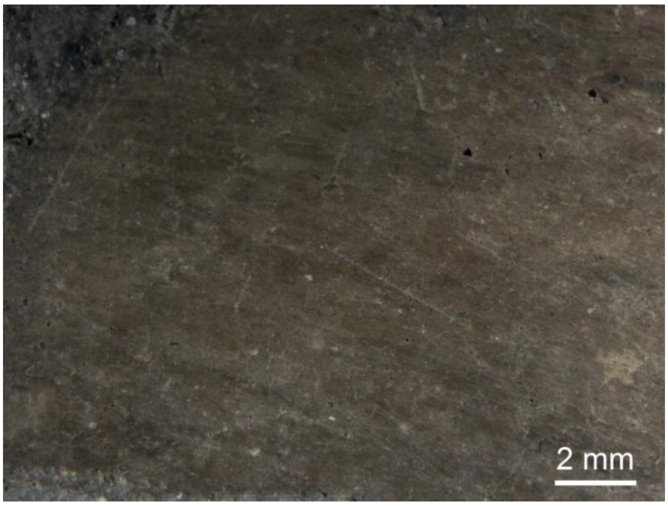

Figure 27: HB-AS-036, loc2 (magnification 1.0x).

5.1.2 Mont Lassois

The ceramic assemblage from Mont Lassois consists mainly of fine tableware such as goblets and bowl-shaped pottery. A considerable amount of material from the ceramic assemblage included coarse ware, presumably intended mainly for the function of storage of liquids or foodstuffs. This type of pottery is characterized by a coarse temper often containing organic material, and a rough finish. This category of pottery has not being analyzed within his research and thus will not be discussed further.

5.1.2.1 Post-depositional alterations

Unfortunately, some of the ceramic assemblage appeared to be poorly preserved due to damage caused by post-depositional processes. Especially post-excavation handling and post-depositional soil processes have played a major role in the formation of post-depositional alteration traces. Since the excavation of the ceramics already took place decennia ago, they remained in the collection of museums for a rather long period of time. Therefore, sherds have been subjected to a fair amount of post-depositional handling. The archaeological material was carefully handled to prevent further damage.

5.1.2.2 Selection

For the purpose of organic residue analysis [5], sherds have been sampled destructively.[6] The sample required an amount of circa 5x1,5x0,3 cm (see Figure 28) from the inside of the vessel. However, an advantage of this sampling technique is that determining the paste and temper is facilitated because the

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[5] Performed by dr. Maxime Rageot.

[6] This type of sample permanently alters or destructs the ceramic material.

sample provides a clear intersection of the material. As is shown in Figure 28 the temper has become highly visible.

Additionally, inventory codes written with pen or pencil, adhesive tape and glue residues impede use-wear analysis. Some of the sherds bear numbers written on the ceramic surface and/or are have been refit together with glue and/or adhesive tape.

Post-excavation activities such as cleaning, transport, packaging and holding during analysis are also factors which could have caused damage use-wear traces on the surface. The sherds were packed in plastic zip lock bags, stored as well as exhibited in the museum. In some cases, multiple sherds were packed in the same bag, which could have caused damage due to friction between sherds. These sherds were packed individually to prevent further damage to the sherds.

Lastly, post-depositional alterations due to soil-forming processes have significantly affected the preservation of the sherds. After deposition, sediment came in contact with the sherds, which is often very abrasive. Due to transport of sand and from the post-depositional environment has eroded the surfaces and the edges of the ceramics. Especially the edges have been subjected to rounding. Also, abrasion of the use alteration traces on the surface impede the use-wear analysis.

Figure 28: Sample taken from the base of a vessel.

5.1.2.3 Methodology

The most informative sherds from the Mont Lassois assemblage were selected for further analysis (14 in total), including: rims, bottoms and the largest circumference of the belly of the vessel. These vessel parts were specifically chosen because they are most likely to accumulate use alteration traces because they come in contact with surfaces or other objects most often (e.g. the surface it stands on or another vessel). For the experiments these parts of the vessel were also selected as contact surface. Sherds that were either too small to determine their initial position on the vessel, abraded, damaged or were lacking clear use-alteration traces were not researched further.

Despite the fact that the pottery from Mont Lassois was affected by post-depositional alterations, some use-alteration traces seemed to remain observable on the ceramic surface. In the following paragraph, all the observed traces (both use-alteration and post-depositional) traces will be discussed for each selected sherd individually.

A description of the vessel properties, including photographs and drawings are shown in appendix 4: Mont Lassois pottery catalogue. The locations of use-alteration traces are indicated on the drawings, as it is done with traces observed on the experimental vessel (loc1, loc2 etc.). Microscopic pictures are taken of these locations. A detailed description of the locations and nature of the traces will be discussed in Appendix 2. The interpretation of these traces will be discussed below.

5.1.3 Interpretation of the traces

A comprehensive interpretation of the traces observed on the Mont Lassois ceramics will be presented below. To keep the interpretation organized and comprehensible, the traces are classified per vessel part and related use-activity.

5.1.3.1 Rim

(Sherd numbers: 88.7323.1, C1-S7, 89.583.1, C1-S5, CA-S5, C1-S12)

In several cases, the rim of the sherds appeared to be abraded. Three different locations on the rim were analyzed and documented: the inside, the top and the outside of the rim. This was done in order to determine the contact areas.

The surface of the rim was in most of the cases rounded and smoothed on all the observed sides, but in some cases the rim was pitted on the outside, while smooth on the top (88.7323.1, 89.583.1). On the latter sherd small transversal grooves could be observed on the top of the rim as well. The rim of sherd CA-S5 was slightly pitted.

In many cases, the surface became abraded and the paste and temper were exposed. The temper particles were abraded as well, so that the whole rim appeared to be smooth in nature.

A striking case is the rim of sherd C1-S12; the inner side of the rim became abraded (see Figure 29, loc4). This is possibly the result of contact with spoon.

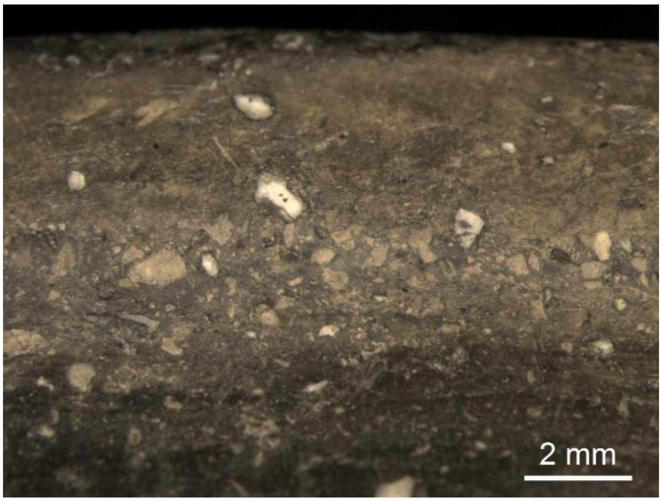

Figure 29: C1-S12, loc4 (magnification 1.0x).

5.1.3.2 Outer wall

(Sherd numbers: 88.9163.1, 88.7323.1, C1-S7, 89.583.1, C1-S5, CA-S5, CA-S16, C1-S12)

The outer wall of the vessel profile is analyzed, because this part of the vessel most likely came in contact with other vessels or objects, thus accumulating use-alteration traces. The abrasions that could be observed on the outer surface are strongly pitted in nature (see Figure 30).

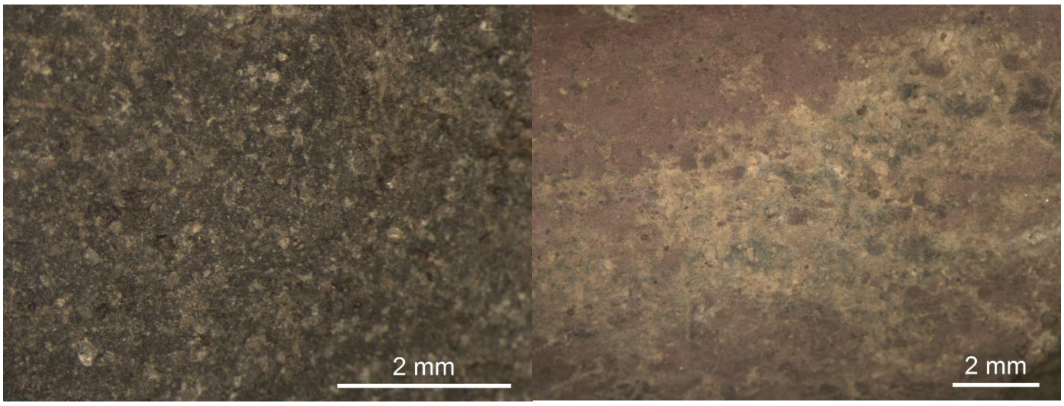

Figure 30: left: strongly pitted surfaces of: left: sherd 88.9163.1 (magnification 2.0x), right: CA-S16 loc1 (magnification 1.0x).

In some cases, the use-alterations are specifically focused on the widest part of the vessel only (CA-S5), (C1-S12), (CA-S16). It is plausible that such alterations were formed because they came in contact with other surfaces.

5.1.3.3 Inner wall

(Sherd numbers: 88.9163.1, C1-S14, C1-S5, C1-S8, C1-S12)

The lower side of the inside of the vessel is an area on which one would expect alteration due to scraping or stirring with a spoon. Alterations on the inner wall are rarer than on the other vessel parts, possibly (partly) due to the fact that samples are taken on this area. Additionally, other post-depositional alteration traces are observed on the inside of the vessel (C1-S8) and (C1-S14). In a few cases distinct alterations could be observed on the inside of the vessel in the form of abrasions. However, it is not possible to say with certainty whether these traces can be attributed to use.

5.1.3.3 Base

(Sherd numbers: 88.6685.1, 88.6690.1, 89.203.1, VI31 92, C1-S8)

Bottoms of sherds were selected to study wear resulting from movement on a surface. Wear was commonly observed on these sherds. In most cases, the base of the stand-ring was smoothly abraded, while the remaining surface of the ring was pitted in nature (see Figure 31) The stand-foot of sherd VI31 92 however, is strongly pitted all over the surface of the rim, possibly due to contact with a surface different from the other base sherds.

Possibly, the base of vessels was polished by contact with the surface, and therefore acquired a smooth nature. Therefore the below surface could have acquired a resistant layer, while the remaining part of the base became abraded. Another explanation could be that contact with different surfaces resulted in different types of bottom-wear.

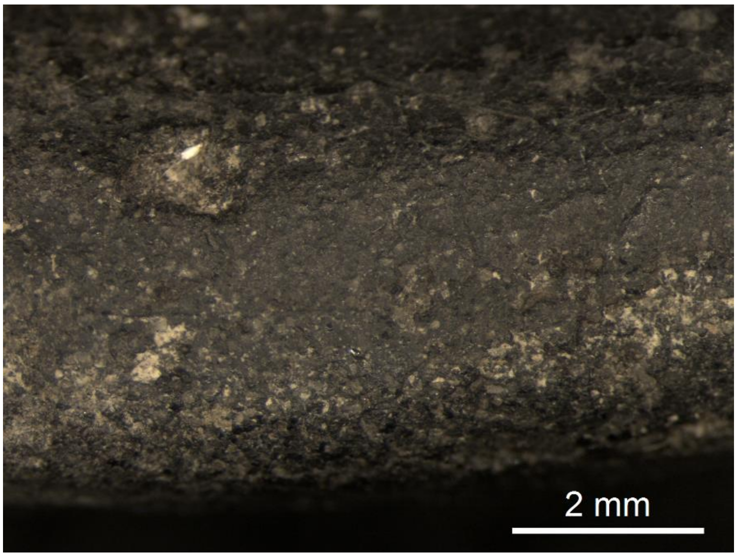

Figure 31. 88.6690.1, loc1 (magnification 1.6x) Smoothly abraded stand ring with

On several sherds widely dispersed or randomly distributed traces could be observed, for example on sherd C1-S7 (see Figure 32). Such traces are often the result of post-depositional processes such as weathering (Skibo 2015, 43).

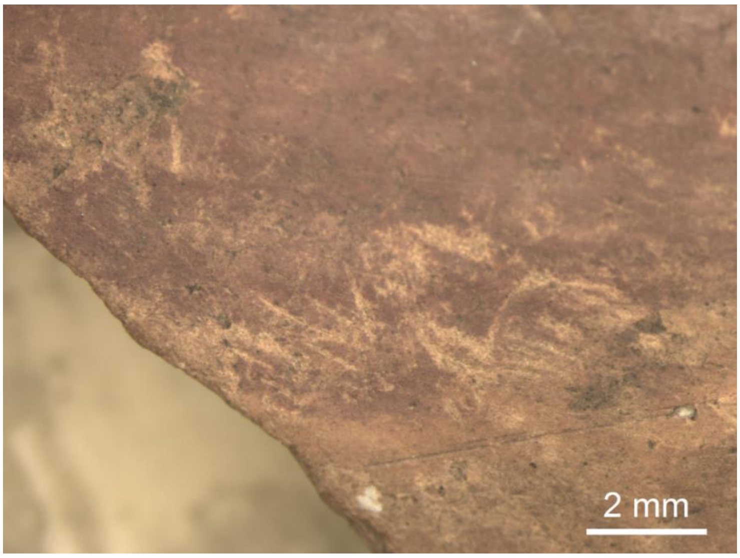

Figure 32: C1-S7 loc3, Post-depositional traces.

5.2 Using the pots in the lab: Performing experiments on pottery replicas

The performed experiments included the handling of pottery, such as food processing, storage and cooking and were performed mostly in the Laboratory for Material Culture Studies at the University of Leiden, only in some cases at other locations; experiments related to cooking, for example, were not conducted at the lab for safety reasons (see Table: 2).

When the experiments included processing of foodstuffs, the material was measured and documented. After these experiments the vessels were cleaned with lukewarm water. Various tools made out of different materials were used in the experiments (see Appendix 3.2). Use-traces that could be observed after the experiments were documented. The effectiveness and deterioration of these tools were also recorded. Every experiment was performed for 60 minutes in total.

A more detailed description of each individual experiment can be found on the experiment forms (Appendix 1).

Exp. no.	Vessel no.	Type	Activity	Material
3590	1145	Small bowl	Eating porridge	Wooden spoon
3591	Z71	Bowl	Whisking milk cream	Pine whisk
3592	HB-AS-036	Pot	Shoving on prehistoric floor	Loam
3593	HB-AS-036	Pot	Showing on prehistoric floor	Oak
3594	HB-AS-036	Pot	Hanging spoon from rim	Copper spoon
3595	HB-AS-036	Pot	Hanging spoon from rim	Horn spoon
3596	HB-AS-036	Pot	Hanging spoon from rim	Wooden spoon
3597	HB-AS-036	Pot	Hanging spoon from rim	Wooden spoon
3598	1620	Small bowl	Eating porridge	Bone spoon
3599	3220	Cooking pot	pounding	Herbs
3626/29	HB-AS-036	Pot	Stacking	-
3600	1612	Small pot	bumping	-
3601	3200	Cooking pot	Cooking beef stew	Iron spoon

Table: 2: Overview performed experiments.

The first experiment of the series included eating porridge with a wooden spoon from a bowl fired in oxidizing conditions. The performed motion was scraping and scooping on the base of the vessel. Unfortunately no use-wear traces could be observed on the vessel after use. Possible explanations for the lack of use-traces could be that the porridge may has worked as a lubricant between the base of the vessel and the spoon or that the wooden material from the spoon was too soft to cause use-traces.

The subsequent experiment consisted of whisking whipped cream/butter in a low bowl using a whisk made out of pinewood. The ingredients were whisked with a stirring, whisking, but also a rotating motion (by rotating the whisk between the hand palms). Because of the small twigs on the end of the tool the milk cream could be whisked easily. After use scratches were visible on the base of the inside of the vessel.

The next set of experiments include the shoving of pots on a surface inside the house. Both experiments are performed on a bowl with a slightly closed profile and a flat base. (HB-AS-036). A floor made out of loam and wood was replicated to resemble the floor of a prehistoric house. It has to be assumed that pots were placed on the floor on a regular basis. For the creation of the loam floor, a mixture of fine cover sand and clay was used. After shoving the pot on the surface the whole base area became excessively abraded, resulting in a pitting pattern. For the second experiment a floor made of oak wood was used. Oak was specifically chosen as material because this type of wood was also used for the burial chamber of the grave of Vix (Kreusse 2017). In contrast to the previous experiment, the oak floor only seemed to cause light abrasion to the base of the pot, presumably because the wooden floor is made out of smoother, les abrasive material.

The following type of experiments consisted in hanging a curved spoon made out of various materials (copper, horn, iron and wood) on the rim. Again, vessel HB-AS-036 was used because with this vessel it is easy to hang the spoon from the rim. The spoons were hanged from the rim repeatedly. Depending on the form of the spoon was either placed outside or inside the vessel. The contact area on the rim is dependent of the form of the hook of the spoon, which can concern the inside, top or outside of the rim. The spoons made out of horn and wood did not seem to leave any traces on a macroscopic scale. The spoons made out of metal however did seem to leave traces on the rim. The copper spoon left very small abrasion behind, while the iron spoon created severe abrasions which were clearly visible on the surface of the rim.

A bone spoon was used to eat porridge from a bowl fired in oxidizing/reducing conditions with a stand-foot (exp. 3620). The performed motion was scraping and scooping on the bottom on the inside. Unlike the vessel fired in oxidizing conditions (vessel no. 1145, exp. no. 3590), abrasions and small scratches could be observed on the base of the vessel.

A birch wooden pounder was used to pound herbs (dill, celery) in a vessel (exp. 3220). The motion performed is pounding and grinding. The herbs were grinded until they were completely processed. However much pressure was performed during grinding, after the experiment no macroscopic traces could be observed on the base of the pot.

The following experiments concern the contact between ceramic surfaces. Two pots (HB-AS-036) were stacked on top of each other repeatedly. The inside of the rim was the contact area of the lower pot, while the upper vessel was affected around the base. Small scratches were visible on the rim of the lower pot and the base of the upper pot. Subsequently, two vessels (1612) were bumped into each other. In both pots, the widest parts of the profile were continuously moved past each other. This specific area was selected because it is the most likely to come in contact with another vessels while moved. Both vessels were subjected to clear abrasion. Both surfaces were extensively abraded, the surface became pitted and the temper appeared visible in the surface.

The last experiment of the sequence consisted in preparing stewed beef (blade steak) in a cooking pot (3200). The cooking pit was dug into the soil. Birch wood was used to light the fire, after the flames reduced and coals were formed, the cooking pot was placed in the pit. Butter and water were added prior to adding the meat. While cooking, the vessel was stirred with an iron spoon regularly (same spoon that was used for the rim experiment). The vessel was very efficient to use as a cooking pot, a high temperature was reached quickly inside the vessel. As a result of the burning coals, the base of the pot was completely soothed on the outside. On the inside of the vessel, the butter was caked onto the bottom, as well as some burned meat particles. Small scratches due to scraping with the iron spoon were visible on the base as well. The vessel was taken out of the fire after 20 and 60 minutes to take photographs with an infra-red camera to measure the distribution of the heat. When these photographs were compared, it was obvious that after 60 minutes the heat was more evenly distributed over the surface of the vessel (see Figure 33).

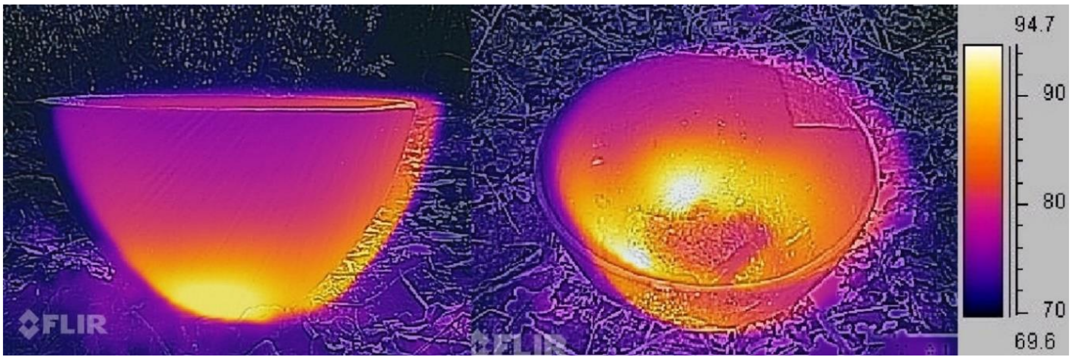

Figure 33: Heat distribution in a cooking bot directly after cooking beef stew for 20 minutes. Experiment number: Vessel number: 3200. Scale in degrees Celsius (°C). Picture by Mark de Koning.

5.3 Use-wear traces on pottery replicas

During the experiments previously described, use-alteration traces accumulated on the surface of the replica vessels. These traces were documented by (microscopic) photographs and detailed description of their form and distribution (see appendix for description of the use-alteration traces). These traces will be discussed, compared and interpreted per group of experiment below, to keep the interpretation clear and structured. The experiments are divided based on the type of activity performed.

This research was concentrated specifically on replicating activities typical of the daily handling of pottery, including stirring, moving and cooking. In order to maintain a clear overview during analysis, the use-wear traces were divided into respective vessel parts: the bottom, inner wall, outer wall, and rim. In this manner, it was easier to compare traces on specific locations to each other, and to link these to specific vessel functions.

5.3.1 "Rim" experiments

The rim experiments included the placement of a spoon made out of various materials on the rim (copper, horn, wood and bone). These materials have resulted in different distinctive use-alterations (see Figure 34). The iron (exp. 3597) seemed to be the most abrasive material, which left behind a completely abraded, smooth surface, in which the temper particles became exposed. The outer edge is sharply abraded, because of the form of the spoon area which determined the contact area between the spoon and the rim.

The copper spoon however (exp. 3594) seemed to cause deviant traces. Transversal striations/abrasions were observed on the top of the rim, while the edges were polished. The edges were also the areas which came in contact with the spoon most intensively.

The use traces resulting from contact with the horn spoon (exp. 3595) appear to be similar in nature as those from the copper spoon: striations and polished edges. The difference is that the striations and abrasions seem to be less apparent.

Lastly, the wooden spoon (3596) seems to have caused the least perceptible use-alterations. The surface appears to be slightly abraded, and few striations can be observed as well.

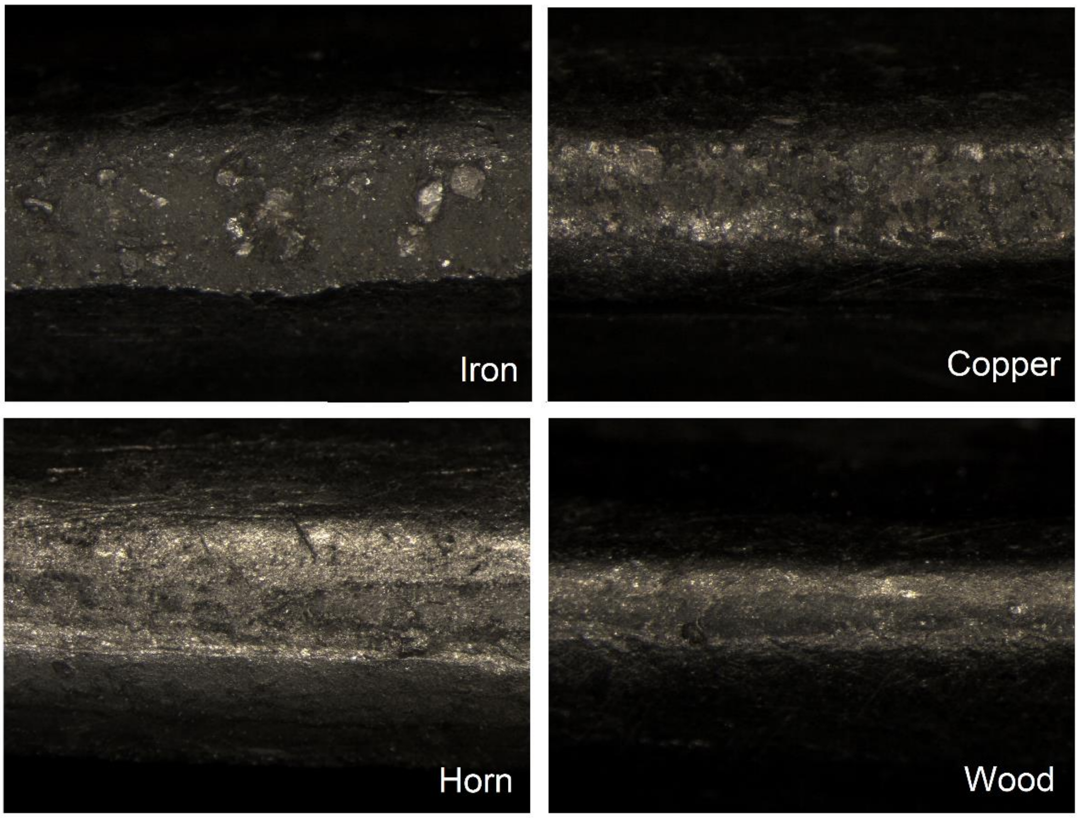

Figure 34: Use-wear traces resulting from contact between an iron, copper, horn and wood spoon and a rim (all magnification 1.6x)

When comparing all the mentioned traces, it is evident that the metal spoons caused the most discernible marks, while the spoons made out of organic material caused the least alteration. All spoons caused, to a greater or lesser extent, stations or abrasions. Also, the spoons with a smooth surface (copper, horn) appeared to have caused polish. Finally, the form of the spoon and the nature of the surface of the spoon (smooth or rough) appear to have affected the type of use-wear. It must be noted that there is an obvious difference between the surfaces of the metal spoons: the iron spoon has a very rough surface (structured cast iron) while the copper spoon is very smooth in nature. The rough nature of the iron spoon had logically facilitated abrasion. The last important factor is the form of the spoon, which determined the contact area between spoon and rim. The area that came in contact with the spoon is naturally the area that accumulated use-alteration traces. This is particularly visible on the rim that came in contact with the iron spoon: the rim became sharply abraded due to the form of the spoon. The area that accumulated traces during use can therefore be used to determine the position of the spoon to the rim. Similarly, the degree of abrasion can inform about the type of material used to make the spoon.

5.3.2 "Handling vessels" experiments

The experiments concerning the movement of vessels include stacking, bumping vessels against each other and shoving them on a wooden or loam surface. The first two entail contact between two vessels itself (ceramic-to-ceramic), while the latter entails contact with a prehistoric floor made out of wood or loam. It must be noted that for the ceramic-to-ceramic experiments two distinct type of ceramic materials were used in order to discern the different effects: the stacking experiment included two fired in reducing conditions, graphitized vessels, the bumping experiments on the contrary concerned two oxidized fired, smoothed vessels.

A striking difference could be observed in use-wear traces on both vessels. The stacking of the vessels resulted in patches of dull polish and polished areas, on both the rim of the lower vessel and the base of the upper vessel. The use-alteration traces appeared in patches because the rim and base of both handmade vessels came in contact only on specific areas, because of the slightly irregular surfaces. The experiment considering the bumping of the oxidized fired vessels, however, left behind more evident traces: the entire contact areas became heavily abraded. During the experiments, abrasions already became evident after a few minutes. The whole surface became abraded, resulting in a slightly pitted surface in which the temper particles were exposed.

The shoving of vessels on a wooden (oak) and a loam surface resulted in very distinct traces as well. The vessel that was shoved on the wooden surface demonstrated an entirely polished area at the center of the base and heavy scratches on the periphery, while the base of the vessel on the loam surface became heavily abraded with a pitted surface.

It can be concluded that the contact between the hard, smooth surfaces of the vessels had a polishing effect, which resulted in (dull) polished patches. The relatively softer oxidized fired vessels on the other hand, were affected by much greater abrasion.

The wooden surface also had a polishing effect on the vessel fired in reducing conditions. Scratches accumulated on the periphery because this area only occasionally came in contact with the wood. As mentioned earlier, this feature was also observed by Skibo (Skibo 2015, 55) the base of the other vessel became heavily abraded due to the rough surface of the loam floor. The uneven surface with small stone particles appeared to result in a strongly pitted ceramic surface.

5.3.3 "Consumption and food preparing" experiments

Unfortunately, the experiment of eating porridge with a wooden spoon (3590) from an oxidized fired bowl did not leave behind any traces. For this reason, the experiment has been repeated with a bone spoon and a bowl (3598). It must be noted that the edges of this spoon were rather sharp. This experiment did leave behind apparent traces. The surface of the inner base part became abraded, whereby the temper became visible. The surface appeared to be relatively smooth, accidently showing some light parallel grooves or ridges in various directions (see Figure 35). On the sloped side of the inside of the bottom, the surface of the bulging edges became abraded in a slightly pitted manner, and some patches showed loss of definition. Loss of definition is the initial, slightest abrasion of the ceramic surface.

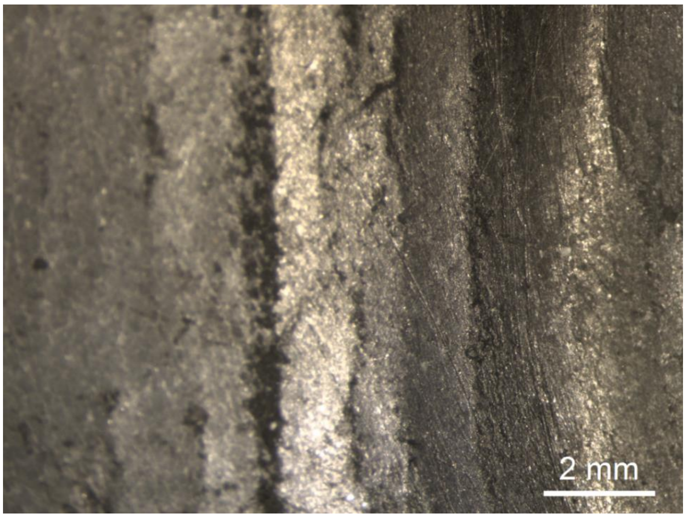

Figure 35: Experiment 3598, Loc3 (magnification 1.0x)

Additionally, Annemieke Verbaas performed an experiment with a wooden spoon and the same type of bowl fired in reducing conditions (number 3622). This experiment appeared to leave behind traces, but they were much less apparent than those resulting from the bone spoon experiment. Scratches were present but they occurred less frequently and were thicker in nature. Some dull polished areas could also be observed.

The whisking of milk cream with a pine whisk (3591) resulted in loss of definition and evident scratches. It must be noted that the contact area of the whisk consisted of sticking out twigs with a small contact surface. Especially on the middle bulb, where production traces are clearly visible (circular), loss of definition is apparent (see Figure 37). The scratches appear on some random locations, but are not widely distributed. The scratches are rather large and firm in nature (see Figure 36). Some of the shiny surfaces have become dull as well.

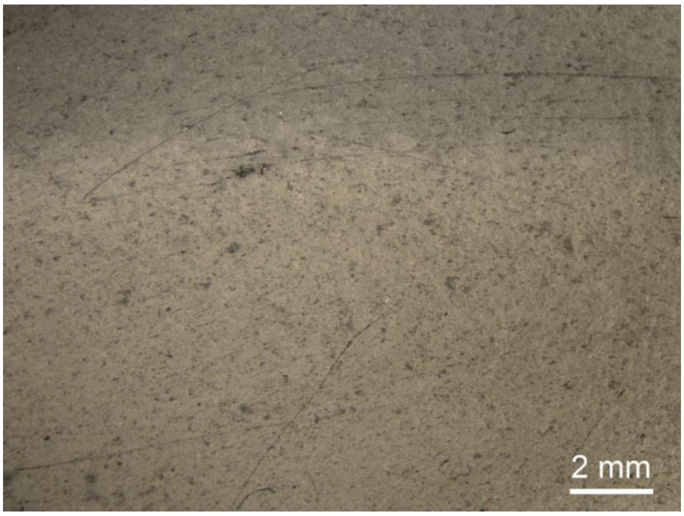

Figure 36: Exp. 3591 Scratches in various directions, Loc10 (magnification 1.0x)

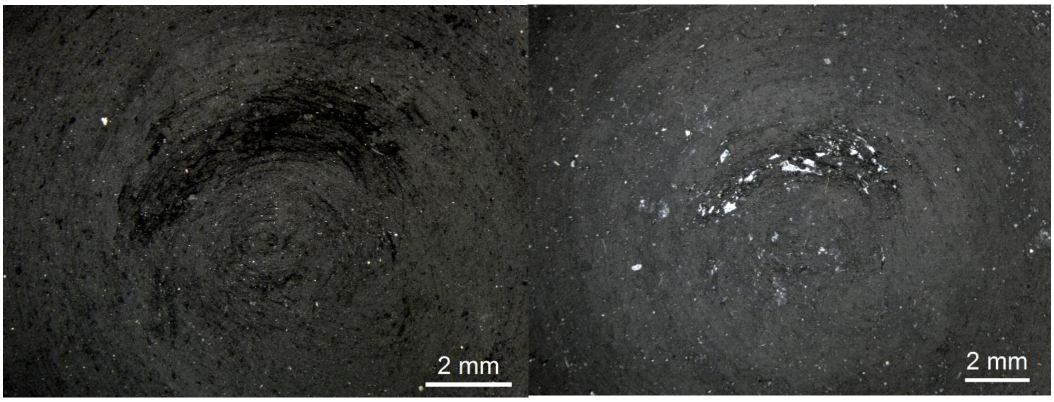

Figure 37: Experiment 3591, loc3. Left prior to experimenting (magnification 1.0x), right after experimenting (magnification 0.75x) (loss of definition).

Contrary to all expectations, except for loss of definition, the pounding of herbs experiment 3599 did not leave behind any traces (see Figure 38). Presumably, because the herbs worked as a lubricant between the pounder and the vessel. In our experience, it could be advisable to repeat this experiment with a harder, rougher material such as cereals, to increase friction between the ceramic and the pounder to check what type of use-alterations are formed.

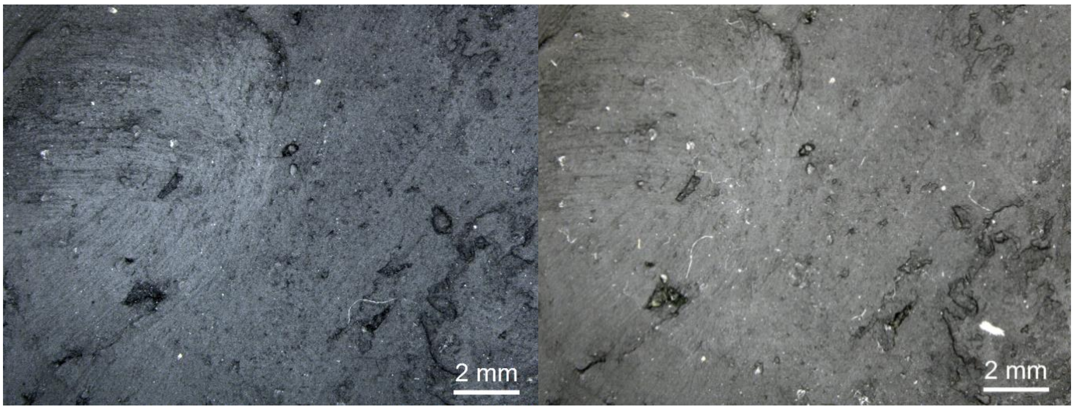

Figure 38: Experiment 3599, loc6. Left before experimenting, right after experimenting (loss of definition)(both magnification 0.75x)

Stewing beef in a cooking pot (exp. 3601) left behind charred food remains on the inside, and soot on the outside. The charred remains originated from butter that was used to cook the meat. These remains formed hard layer with a pattern of small holes (see, Figure 39, loc16). A similar feature was observed on sherd/vessel HB-AS-022-K5 from the Heuneburg assemblage (see Figure 39).

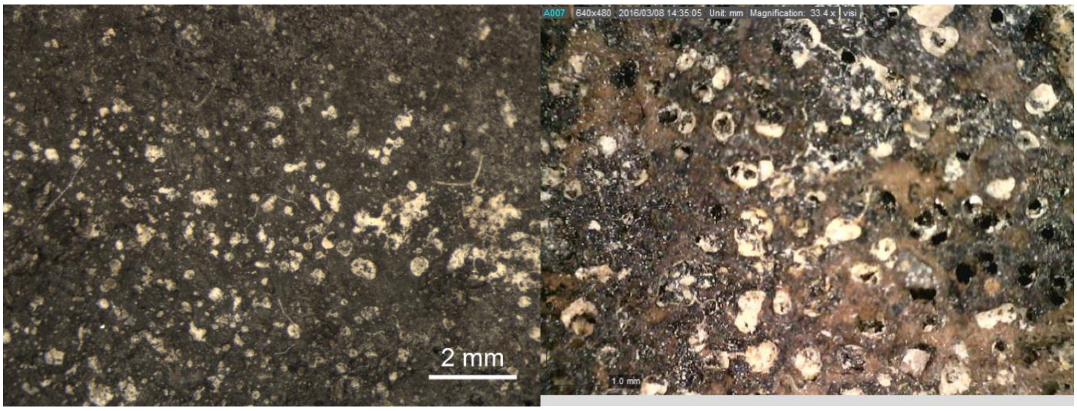

Figure 39: left: loc16, Experiment 3601, right: Heuneburg HB-AS-022-K5, similar charred food residues (both magnification 1.0x).

Because the charred layer covered a large part of the ceramic surface of the vessel, it was not possible to observe any use-alteration traces resulting from the contact with the iron spoon.

The alterations on the outside consisted of different types: flat black soot, soot consisting of resin drops and oxidized patches (see Figure 40). All these traces are comprehensively described in appendix 3.3. The flat black smoke was deposited all over the outer surface, excluding the oxidized patches. Soot formed by the deposition of resin drops from the smoke is present on a large part of the outer surface. This relatively resistant layer is waterproof and could therefore remain preserved on ceramics from archaeological contexts (Skibo 2015, 190).

Oxidized patches are formed on the base and the lower side. The color of these patches vary from brown-grey to completely oxidized. These surfaces have reached a temperature above 400 °C, because soot cannot form under these temperatures. Oxidizing occurred on the reduced fired surface because of the so called carbon’s dissolving effect (Jacobs, 2017).

Production traces in the form of small edges and lines are prone to loss of definition by soft materials in during the initial stage of use-alteration.

The use-wear traces observed on the archaeological ceramics will be compared to the traces on the experimental vessels in paragraph 6.2. Subsequently, the conclusions of the research will be discussed.

Figure 40: The base of the cooking pot: soothing and oxidation patches (vessel no. 3200).

Chapter 6. Discussion of the results

The last chapter contains the conclusion and an evaluation of the results. There will be reflected on the aim of the research and the research questions as presented in the introduction of this research. The research questions will be shortly restated below.

- Which use-wear traces can be observed on the early Iron Age pottery from Mont Lassois and the Heuneburg?
- Which wear traces result from the experiments performed on the replicas of the Early Iron Age pottery?
- Can the use-wear traces observed on the experimental vessels be related to the use-wear traces on the archaeological ceramics?
- Can use-wear analysis be applied to study the function of the vessels from Mont Lassois and the Heuneburg?
- To what degree applying use-wear analysis to ceramics may contribute to pottery studies?

In order to ensure the reliability of this work, it is important to evaluate the applied methods and techniques and the limitations that were encountered during this research. Indications for distinct activities could be inferred from the wear left behind by the experiments on the vessel replicas. Therefore, in this paragraph it will be discussed how the results from the experiments can be used to infer about distinct activities concerning the use of Iron Age ceramics, and to critically reflect on the application of use-wear methodology in this context. Finally, some ideas for future research will be presented.

6.1 Comparing traces on experimental and archaeological material

Since use-wear analysis applied on ceramic materials remains a relatively new and underexplored discipline, a systematic reference collection for ceramic materials (Skibo 2013, 23) and an experimental framework are still lacking (Van Gijn *et al.* in press). Therefore, this research was partly conducted in order to extend the existing reference collection for use-wear traces on ceramic materials currently available at the laboratory for Material Culture Studies at the Leiden Faculty of Archaeology. The performed experiments left behind various distinctive traces, caused by different types of materials. Together with the experiments performed by the other members of the BEFIM project, these traces can be used as solid basis for developing a more consistent reference collection. However, considering the wide range of applied materials and performed activities in the past, it is recommended to extend the experimental program during future research in order to get a complete understanding of the formation of use-wear traces.

A number of practical issues emerged during the experimental phase, which will be described below.

While carrying out the experiments, not all the required types of vessel replicas were available. Therefore, in some cases it was necessary to use alternative vessel types. As a result, the used vessels were not always optimal, and the use of various types of vessels was restricted in some cases.

A wide range of possible use-wear traces were reproduced which could be linked to certain materials. It must be noted however, that not every use-trace can be unambiguously linked to a specific material; different actions can for example produce similar use-wear traces. As on the other hand, the same actions do not always result in the same diagnostic traces. Therefore, one cannot apply experimental data directly to interpreted archaeological materials (see Van Gijn 2014). Experimenting with different materials in fact has provided more insights into the behavior of different tools used with ceramics.

In addition, replicated traces could be used as an analogy for traces observed on archaeological ceramics. However, not all the use-wear traces observed on the archaeological ceramics could be related to performed experiments. It was however impossible to replicate all the possible use-wear traces. Other activities than used the performed experiments could have caused traces observed on the archaeological material. A very important point to take into account is the effect of post-depositional processes. Experiments on post-depositional process should be performed to complement the analysis, in order to get a complete understanding of the formation of wear traces. Within the scope of this research, it was impossible to explore all the possible combinations of materials and ceramics. However, the BEFIM project can function as a basis and starting point for further use-wear analysis on ceramic material.

As noted in section 5.3, this work concentrated specifically on replicating activities typical of the daily handling of pottery, including stirring, moving and cooking. In order to maintain a clear overview during analysis, the use-wear traces were divided into respective vessel parts: the bottom, inner wall, outer wall, and rim. In this manner, it was easier to compare traces on specific locations to each other, and to link these to specific vessel functions.

Another important factor to consider is the time allotted for each experiment. Each session lasted a total of 60 minutes max. Clearly, archaeological ceramics have been used much more frequently and longer during their lifetime. Therefore, archaeological ceramics accumulated more traces which could diverge from those observed on the experimental ware. In addition, the controlled activities during the experiments could have resulted in traces that differ from pottery handling in the past. For example, influences such as experience of the user and environmental factors may have affected the formation of certain use-wear traces. Lastly, during the experiments only one specific activity was carried out, therefore providing a simplistic view on use trace accumulation. It has to be expected that in the past, different activities were performed with a vessel, which would have resulted in a much more complicated distribution of the traces. This impeded the comparison between traces accumulated on both the experimental and the archaeological vessels.

Recording use-wear traces with the stereomicroscope appeared to be difficult in some cases, especially when the surface was irregular or extremely shiny (as in the graphitized ware) due to the reflection of light. However, this effect could be reduced by using different settings and light sources. Complementary analysis under a metallic light microscope is preferred in comprehensive use-wear analysis, but it was decided to skip this step, because it would not be possible to get the ceramic surface at the required exact angle of 90° degrees to the light source (van Gijn 2014, 167).

6.2 Use-wear as result of ceramic activities

In this paragraph, some of the most significant traces on the experimental vessels are compared to similar traces observed on the archaeological ceramics from the Heuneburg and Mont Lassois assemblages. Some similarities between use-alteration traces on archaeological and experimental ceramics could be observed.

It is important to consider that homogeneity between traces cannot be straightforwardly linked to the specific activities performed during the experiments, because particular traces can be caused by distinct actions (Skibo 2013). However, the observed use-wear traces can provide insights on ceramic alteration and the type of actions. Photographs of both archaeological and experimental ceramics are displayed below to show some distinct similarities.

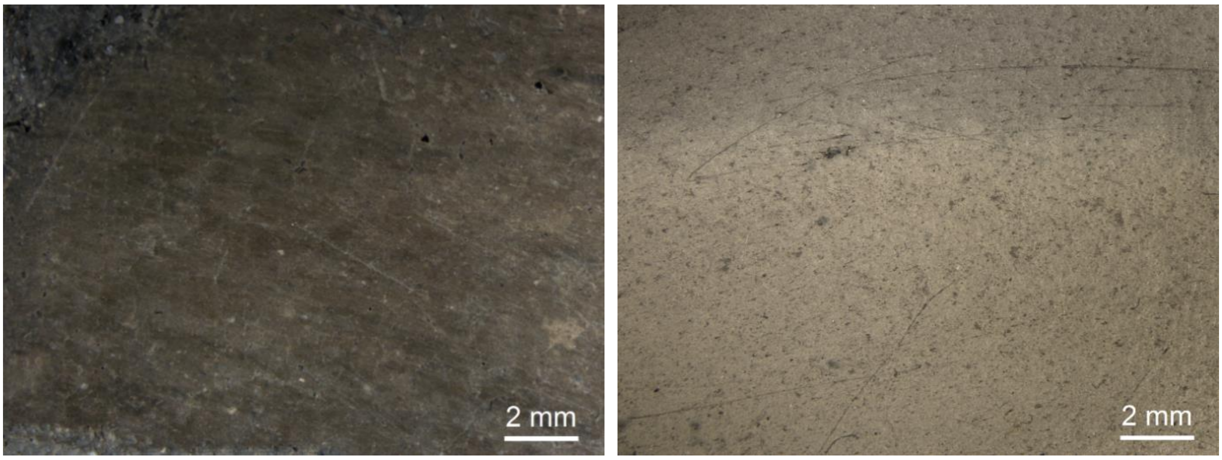

Figure 41: left: scratches on inner wall of HB-AS-036, loc1 and experiment 3591, loc10 (Whisking milk cream with pine whisk)(both magnification 1.0x).

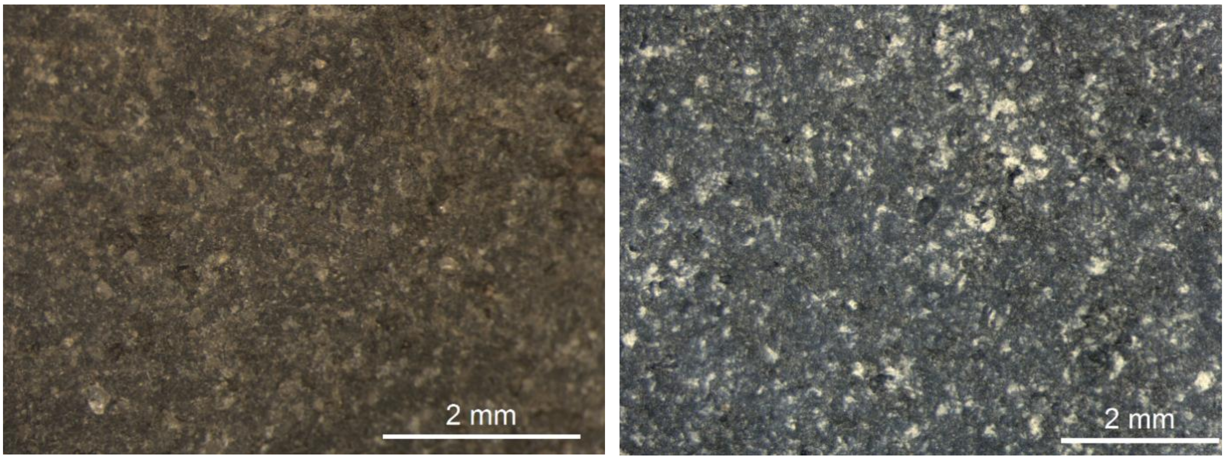

Figure 42: left: 88.9163.1 loc1 (magnification 2.0x) and experiment 3592, loc1 (magnification 1.6x) heavily abraded (shoving on loam surface)

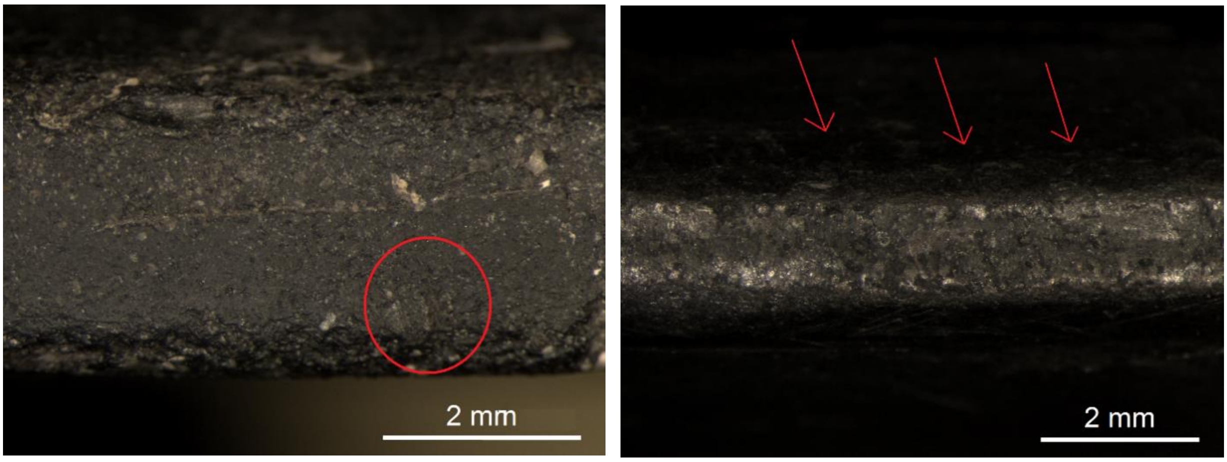

Figure 43: Left: 89.583.1, loc2 (magnification 2.0x) Right: striations, experiment 3594, loc26 (magnification 1.6x) (hanging copper spoon from rim).

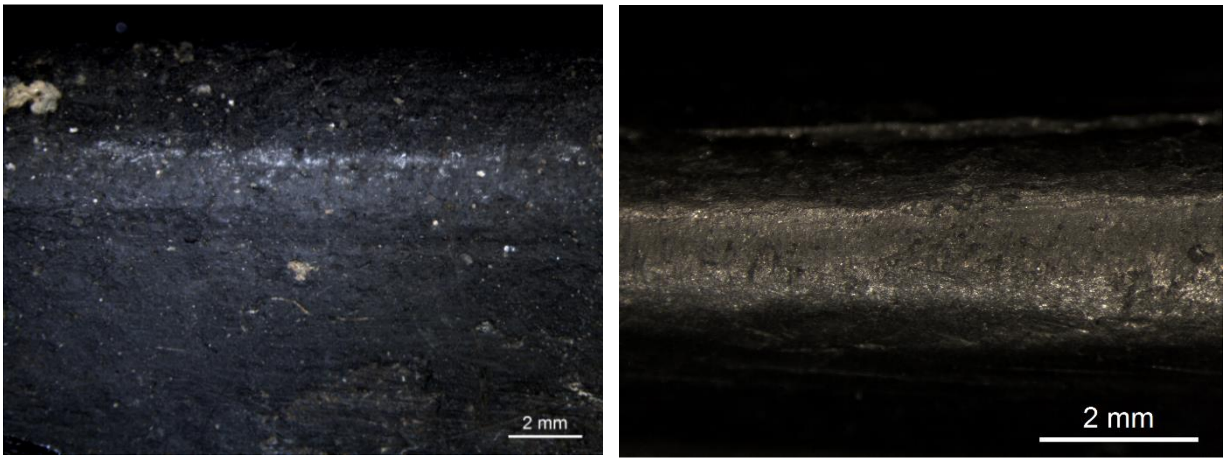

Figure 44: left: HB-VB-59, loc2 (magnification 0.75x) rim, right: experiment 3595, loc1 (magnification 1.6x) (hanging horn spoon from rim) polished rim.

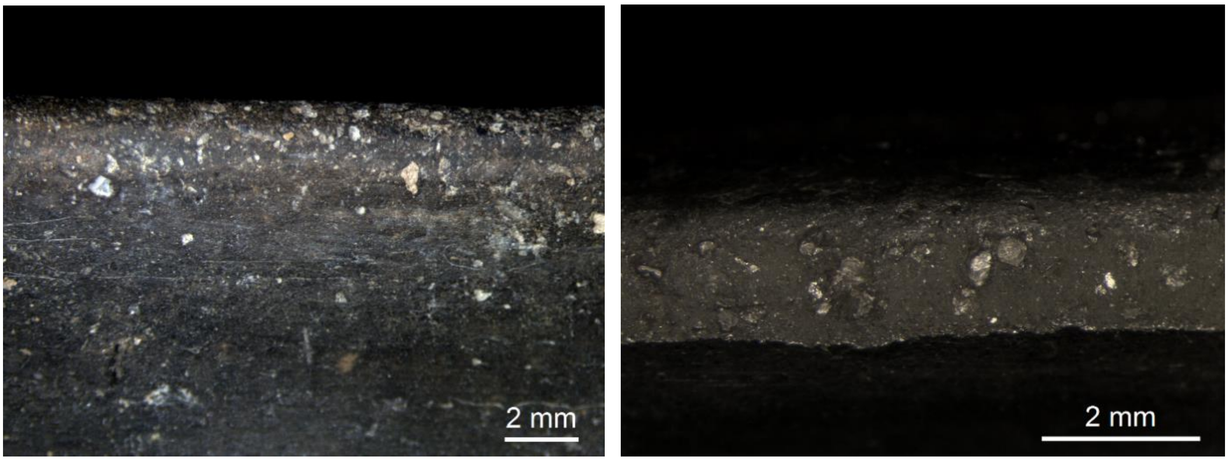

Figure 45: left HB-PL-002, loc2 (magnification 1.0x), abraded rim: right: experiment 3597, loc13 (magnification 1.6x) (hanging iron spoon from the rim).

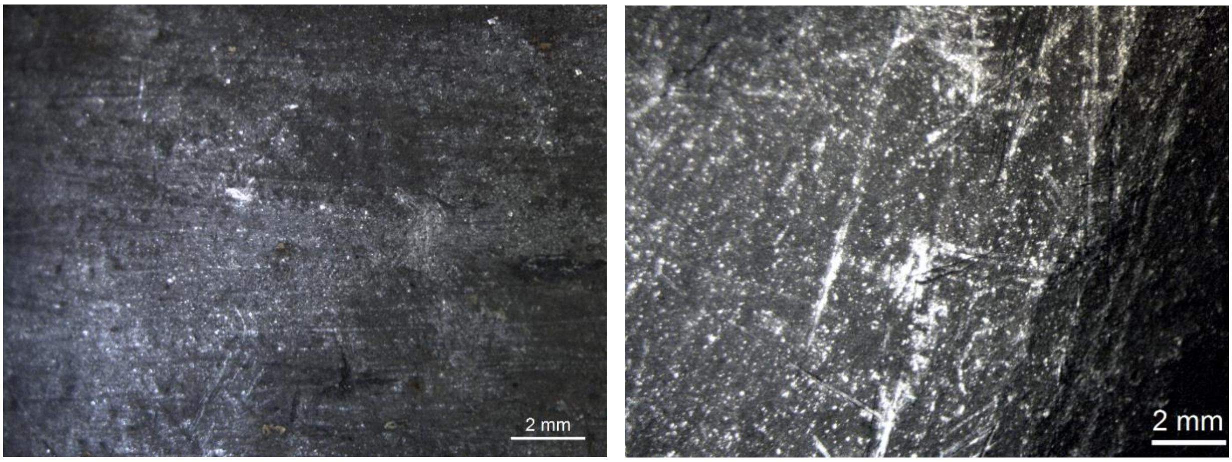

Figure 46: Left: HB-VB-063, loc1 (magnification 0.75x) outer wall of vessel, right: experiment 3629, loc5 (magnification 0.75x)(base of stacked vessel).

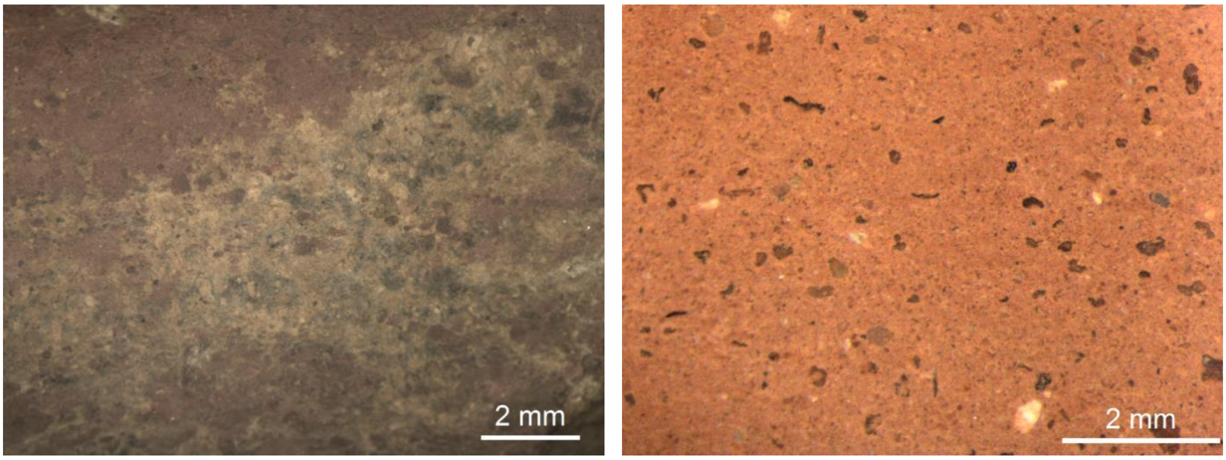

Figure 47: left: CA-S16, loc1 (magnification 1.0x) right: experiment 3600, loc4 (magnification 1.6x)(bumping pots against each other).

It appeared that previous use-wear research on the material of the Heuneburg was mainly focused on the inner wall and the rim of the vessel. Bases are also included although they do not occur frequently in the assemblage. The outer wall of the vessels appear to have been included in the analysis clearly less frequently. In my opinion, it is a good idea to incorporate systematically the analysis of the outer wall because this area is expected to accumulate wear very quickly. Experiments focusing on the outer wall wear are for this reason also incorporated in the experimental program.

When concerning spoons or whisks, it appeared that the bone material clearly left behind more evident traces than wood, presumably because bone is harder in nature. Another factor that seemed to play a role in the creation of traces is the form and size of the contact area on the spoon/whisk. Although wood is a relatively soft material, the pine whisk with a small and sharp contact area caused apparent traces (see Figure 41). These features have also been observed in the rim experiments. The pounding experiments did not leave any traces, although could be observed that contact with soft materials could lead to loss of definition. Finally, the cooking experiment showed that the outer surface was subject to varying temperatures, resulting in soot deposition. Some area’s exceeded 400°C, and became oxidized.

Similarities between use-alteration traces on archaeological vessels and experimental vessels could be observed in the form of scratches, striations (see Figure 43), abrasions (see Figure 45) and polish. During the experiments, polish was formed when the ceramic surface came in contact with relatively soft materials (see Figure 44, Figure 46). It appears that polish also remained preserved on archaeological ceramics. Severe abrasions on ceramics were often observed on the widest part of the wall. The experiments involving the shoving of vessels on a loam surface and the bumping of pots against each other resulted in similar abrasions (see Figure 42, Figure 47).

It is possible that some use-wear traces could have been missed out or incorrectly interpreted because the analyst is not experienced in performing use-wear analysis. In order to minimize this problem, a more experienced analyst (Annemieke Verbaas) has been consulted prior to publishing the results of this research. A large amount of the (microscopic) photographs have been published in this thesis as a reference to keep the analysis reliable. Additionally, all the observed traces were meticulously described to be able to discern miniscule differences.

Unfortunately, some experiments did (hardly) leave behind any traces (exp. 3590 and exp. 3599). Where possible, these experiments were reiterated using different materials. Experiment 3590 (eating porridge with wooden spoon) was repeated using a bone spoon (exp. 3598). This experiment did leave behind significant traces in the form of abrasions and scratches. Experiment 3599 (pounding herbs) was not replicated because it did not fit in the time scope of the research. It would be advisable however, to replicate this experiment using more abrasive materials, for example cereals.

Given the abundance of the material, it was necessary to sample the ceramic assemblages (both experimental and archaeological) to fit the scope of this research. In order to acquire as much information about the use-wear traces as possible, sherds showing the most distinctive use-wear traces were selected for further research. The limited size of the sample could have impact on the validity of the results of the research. However, since the purpose of this research is to provide an explanatory basis for use-wear analysis, this serves the aim of the research well enough.

Due to the frailty of some use-wear traces observed after experimentation, it is questionable whether the smallest traces (such as striations) remain preserved on the ceramic material after been subjected to taphonomic processes in the post-depositional environment. Although striations have not been observed on the archaeological ceramics, other seemingly fragile traces such as polish appear to be identifiable on archaeological ceramics.

6.3 Critical evaluation of post-depositional processes

One of the most important implications for use-wear analysis are the effects of post-depositional alterations (Skibo 2013, 46). This is certainly applicable to the analysis of ceramic materials, which readily accumulate traces, either use-related or the result of post-depositional processes.

Post-depositional alterations formed a major disadvantage during this research, because knowledge on these traces is currently lacking. It is therefore well advisable to set up an experimental program for post-depositional processes, in order to obtain more insights into the nature of these traces. Therefore, additional research on post-depositional processes will be conducted as a final stage in the BEFIM project and is currently on the way (Van Gijn *et al*. in press). Knowledge on the formation of use-wear traces due to post-depositional processes is of great importance in order confidently interpret the function of vessels.

6.4 Concluding remarks and future research paths

The aim of the research was to contribute towards the development of a more consistent experimental reference collection of use-wear traces ceramics and to explore whether use-wear could answer questions on pottery functions, or household activities. It was investigated whether experimental traces could be related to use-wear traces observed on archaeological ceramics. It was researched how various contact materials affected the formation of use-wear traces. Lastly, the traces on the experimental ceramics were compared to the archaeological ceramics to infer about undergone activities.

Use-wear analysis can provide insights into what type of actions cause certain use-traces. Traditional methods such as ceramic typologies and organic residue analysis can be complemented with use-wear analysis as analytical tool, contributing to a multidisciplinary research.

It is suggested that subsequent research would incorporate an experimental program including more materials and repeat the performed experiments in order to increase the validity and scientific value. In doings so, it could be built further on data obtained from the current research.

Abstract

Ceramics are among the most commonly found materials recovered from the archaeological record. Ceramic objects can provide a variety of information about the life of people in the past. Therefore, archaeologists have at their disposal a variety of (traditional) techniques to study pottery, in order to make inferences about the communities that used the pottery. Recently, analytical methods in the field of ceramic studies, such as residue analysis and microscopic use-wear analysis have developed. In this research, the applicability of use-wear analysis for ceramics is addressed.

The methodology applied to this research integrates both use-wear analysis and experimental archaeology. The archaeological dataset consisted of ceramics from the Iron Age settlements of Mont Lassois and the Heuneburg and experimental vessels. The aim of this study was to create a reference collection for use-wear traces on ceramics and to study whether use-wear observed on the experimental vessels could be related to traces on the archaeological ceramics, in order to infer about ceramic function in the past. Unlike other archaeological materials, use-wear analyses on ceramics has not been widely applied yet (Skibo 2015). Replicas of vessels from Mont Lassois and the Heuneburg have been created at the Material Culture Studies Laboratory at the University of Leiden. A series of experiments was carried out in order to replicate various domestic activities such as food preparation, the storing of pots and cooking. The use-wear traces created during the experiments as well as observed on the archaeological ceramics were analyzed by means of a stereomicroscope. Microscopic pictures were taken of the use-wear traces, and the vessels have been drawn to record the traces, in order to establish a vast reference collection.

In order to get a better understanding of pottery use and the accumulation of wear on vessels, the use-wear traces on the experimental vessels were compared to the archaeological material from Mont Lassois and the Heuneburg. It was determined that similar use-wear traces could be observed both on the experimental as well as on the archaeological material.

Use-wear analysis can provide more detailed information about the actual use of pottery in the past. Therefore, an important step in the *chaîne opératoire, or* life biography, of pottery can be studied. To conclude, in a multidisciplinary research use-wear analysis can greatly add to existing analytical methods, providing specific information on the handling of vessels and their corresponding gestures.

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Appendices

Appendix 1: Experiment forms

Experiment number: 3590
Vessel number: 1145
User name: Nicole de Koning
Date: 02-07-2017
Grain size: fine

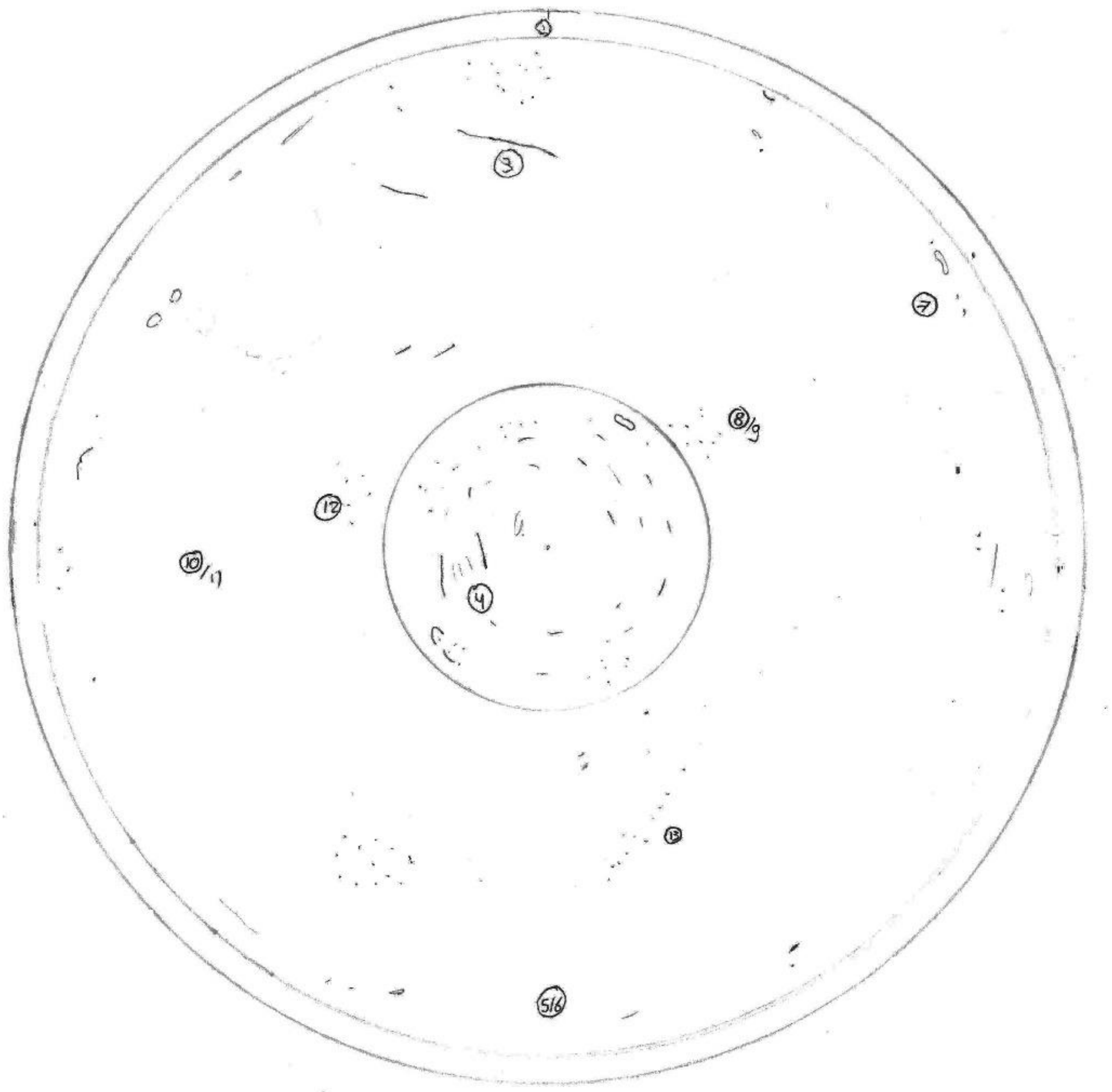
Tool type: wooden spoon
Raw material: pottery

Material: porridge, (oats and milk)
State: wet
Hardness: soft
Type of surface worked on: base of the bowl (inside)
Motion: eating, scraping, scooping
Duration: 60 min
Liquid level: 4 cm
Description of experimental procedure:

The first experiment consisted of eating porridge with a wooden spoon. The eating was conducted by means of scraping and scooping. The bowl was placed on the lap and moved to the mouth regularly to reconstruct the handling as close as possible. The porridge was made out of biological oat flakes and raw milk (unpasteurized and unprocessed). The porridge was put in the bowl directly after it was cooked, and was replaced with (hot) new porridge every 15 minutes. Measurements material: milk: 200 ml oats: 50 g.

Tool effectiveness (and deterioration): A wooden spoon is an effective tool to eat porridge, it was easy to scrape the substance. No use-wear traces were observed on the bowl or the tool. A possible explanation for this is that the porridge worked as a lubricant between the bowl and the spoon, and therefore no traces were left on the bowl. No deterioration on the tool.

Cleaning procedures: water



Experiment number: 3591
Vessel number: Z71
User name: Nicole de Koning
Date: 14-07-2017
Grain size: fine

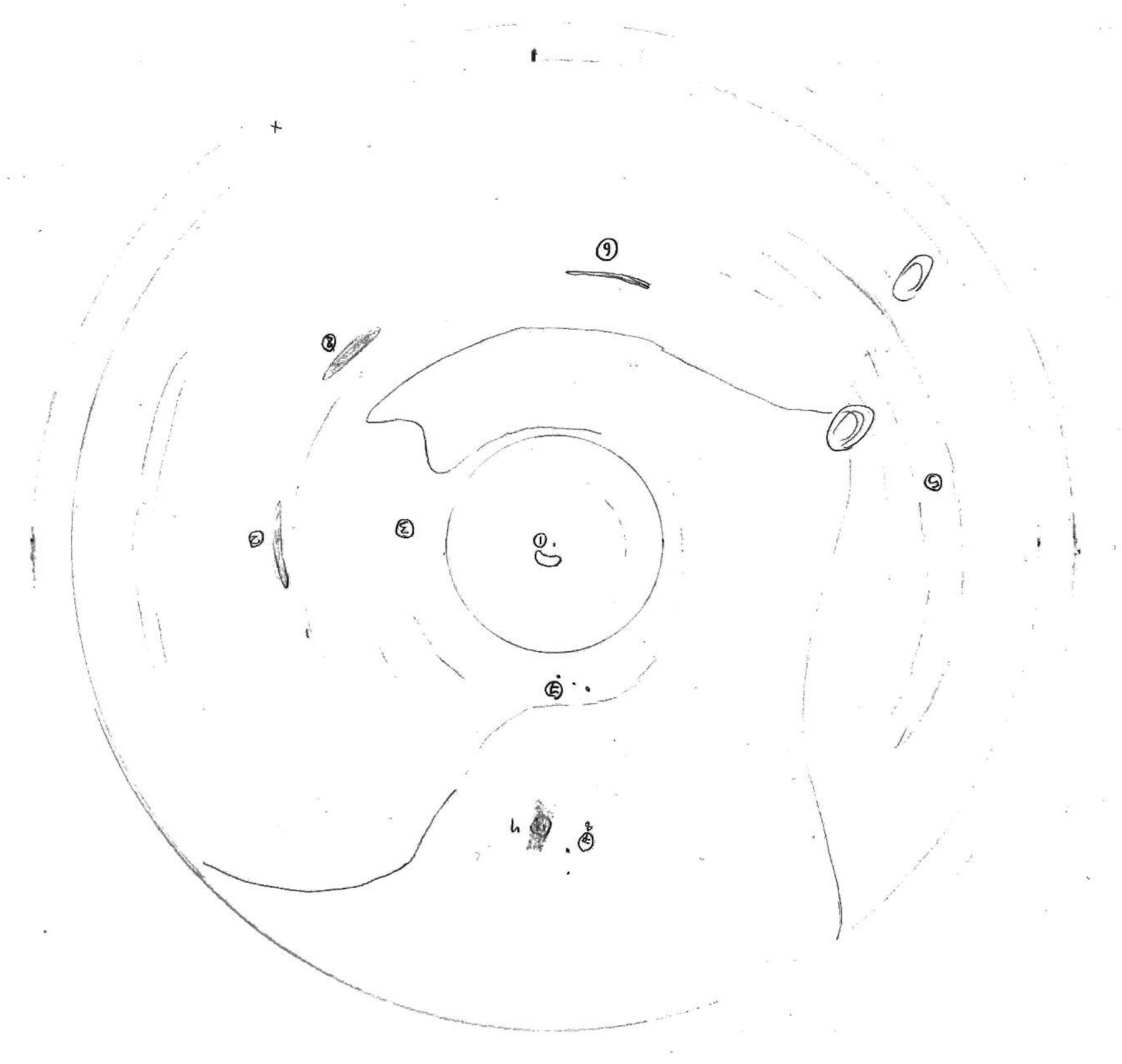
Tool type: wooden whisk (pine)
Raw material: pottery

Material: Milk cream (whipped cream/butter) 250 g butter, 400 ml raw milk, 2 egg yolks
State: wet
Hardness: medium
Type of surface worked on: base of the bowl (inside)
Motion: whisking, stirring
Duration: 60 min
Liquid level: 5 cm

Description of experimental procedure: A wooden whisk was used to whipped cream/butter. After the ingredients were put in the bowl they were whisked to create a smooth substance. After +/- 30 minutes the substance started to segregate. After this occurred the whisking was continued. The motion performed for was stirring, whisking, but also rotating the whisk between the hand palms. Ingredients: 250 g butter, 400 ml raw milk, 2 egg yolks

Tool effectiveness (and deterioration): Quite effective. It was relatively easy to whisk the milk cream with the tool. The small twigs sticking out caused sufficient friction to use the tool as a whisk. No deterioration on the tool. Small scratches visible on the pottery surface.

Cleaning procedures: water



Experiment number: 3592
Vessel number: HB-AS-036
User name: Nicole de Koning
Date: 20-07-2017
Grain size: fine

Tool type: loam surface
Raw material: pottery

Material: -
State: dry
Hardness: medium (but abrasive)
Type of surface worked on: base of the pot (outside)
Motion: shoving
Duration: 60 min
Liquid level: -
Description of experimental procedure:

In the prehistory loam was used to construct the floor of a prehistoric house. The aim of the experiment was to replicate the process of moving a pot on a prehistoric loam floor. It has to be assumed that pots were placed on the floor on a regular basis. In order to complement this experiment, a floor made out of wood was used in the subsequent experiment (experiment number 3593).

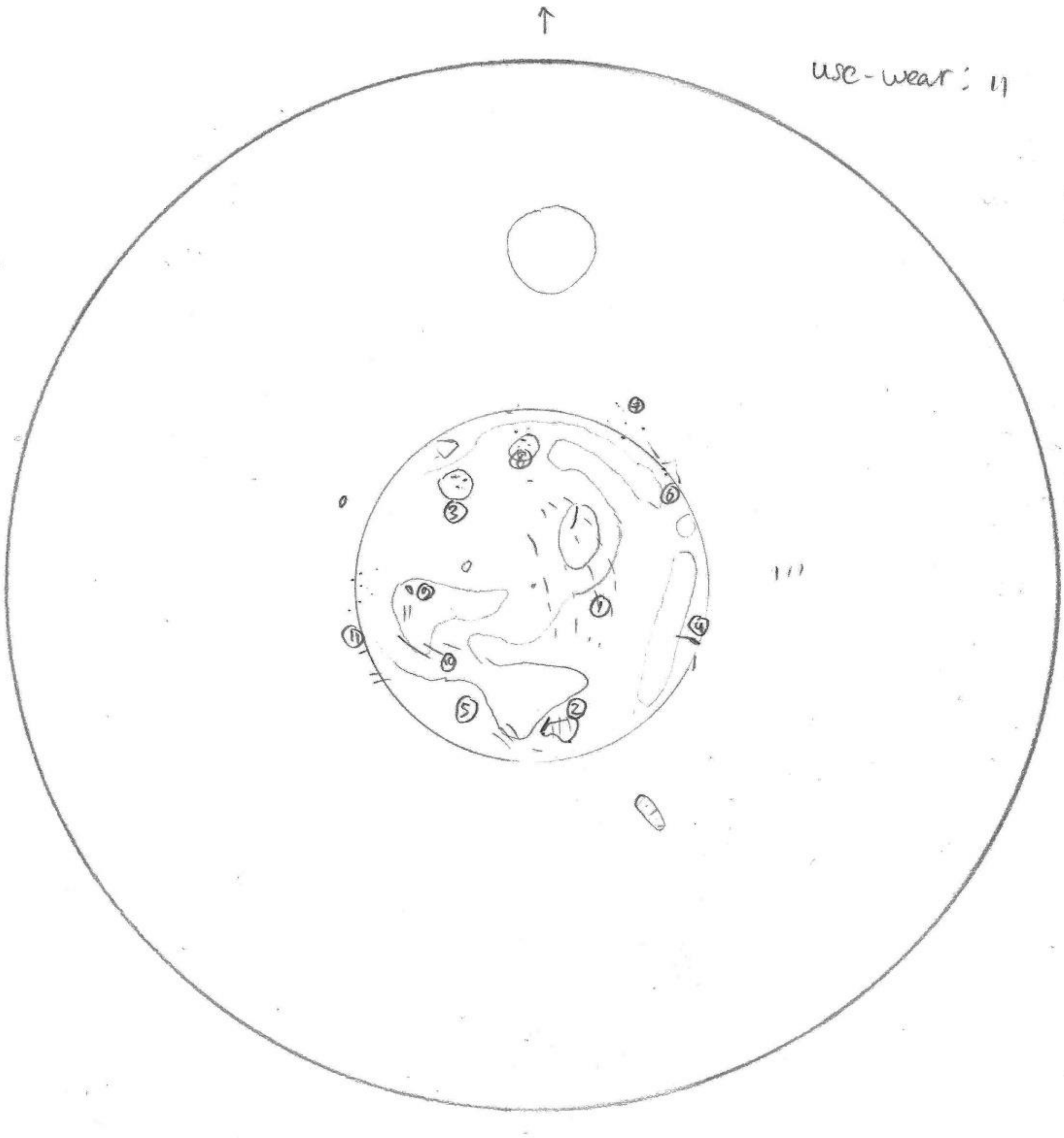
A mixture of sand (1/3) and clay (2/3) was used to replicate a loam floor. The sand used is cover sand obtained from windblown sands at the Veluwe (Harderwijk), in which cover sand is exposed to the surface due to wind deposits. This yellowish sand is contains rather fine rounded grains with a diameter of 105-210 μM and includes small grit particles. This type of sand was chosen because it resembles the soil of the area of Mont Lassois the most (reference).

The loam floor was created in a wooden box that measures 30x50 cm (inch). The thickness of the floor is approximately 5 cm (inch). The surface is rather uneven and some sand grit grains are partially visible in this area.

During the experiment the pot (HB-AS-036) was moved on the surface by shoving. This type of pot was chosen because of its form. The base of this pot is partially flat, which facilitates the contact with the floor. Because the contact surface is larger than a pot witch a stand ring, it has to be assumed that wear traces are easier to be determined on this type of pot.

Tool effectiveness (and deterioration): During the length of the experiment it was observed that a portion of the loam floor came lose (small particles of sand and clay). At the beginning of the experiment it was also notable that some of the wall of de pot left traces on the loam floor (grey scratches) after contact, as it came loose from the pot. This is probably due to the rough, abrasive nature of the loam floor. After a while this process stopped. Tool effectiveness: not applicable.

Cleaning procedures: water



Experiment number: 3593
Vessel number: HB-AS-036
User name: Nicole de Koning
Date: 15-10-2017
Grain size: fine

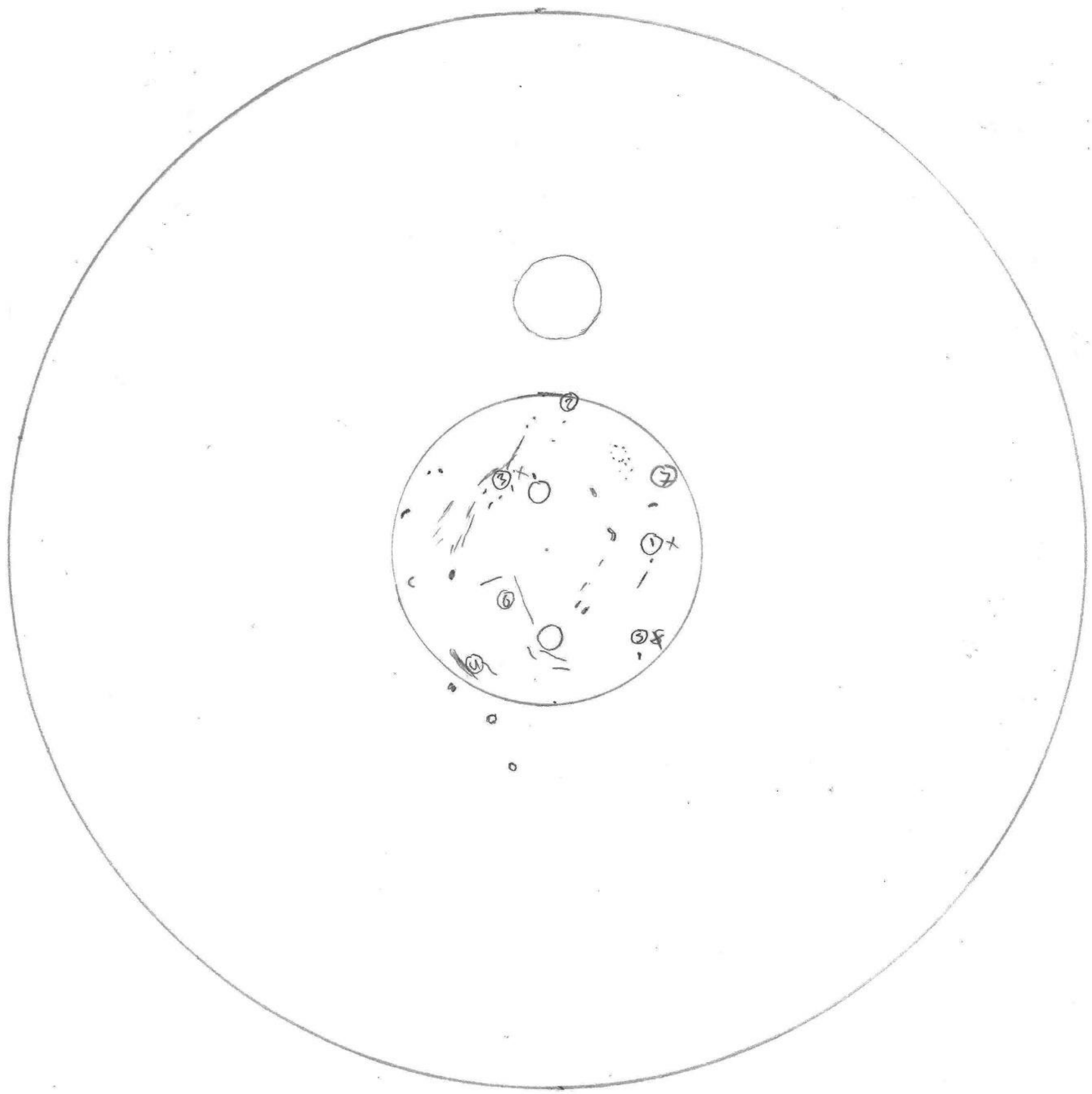
Tool type: wooden surface (oak)
Raw material: pottery

Material: -
State: dry
Hardness: soft
Type of surface worked on: base of the pot (outside)
Motion: shoving

Duration: 60 min
Liquid level: -
Description of experimental procedure: A pot was put on a wooden surface made out of oak, and was moved around. Oak was chosen because it resembles the wood that was used in the burial chamber of Mont Lassois (reference).

A wooden log was used to create an appropriate surface. Firstly, the log was chopped up in halves. Subsequently, the surface was flattened with a knife. A log was used to resemble the roughness of a prehistoric floor as close as possible.

Tool effectiveness (and deterioration): Some of the surface of the pot gave of on the wooden surface. A very light abrasion of the pottery surface could be observed. Tool effectiveness: not applicable.
Cleaning procedures: water



Experiment number: 3594
Vessel number: HB-AS-036
User name: Nicole de Koning
Date: 20-08-2017
Grain size: fine

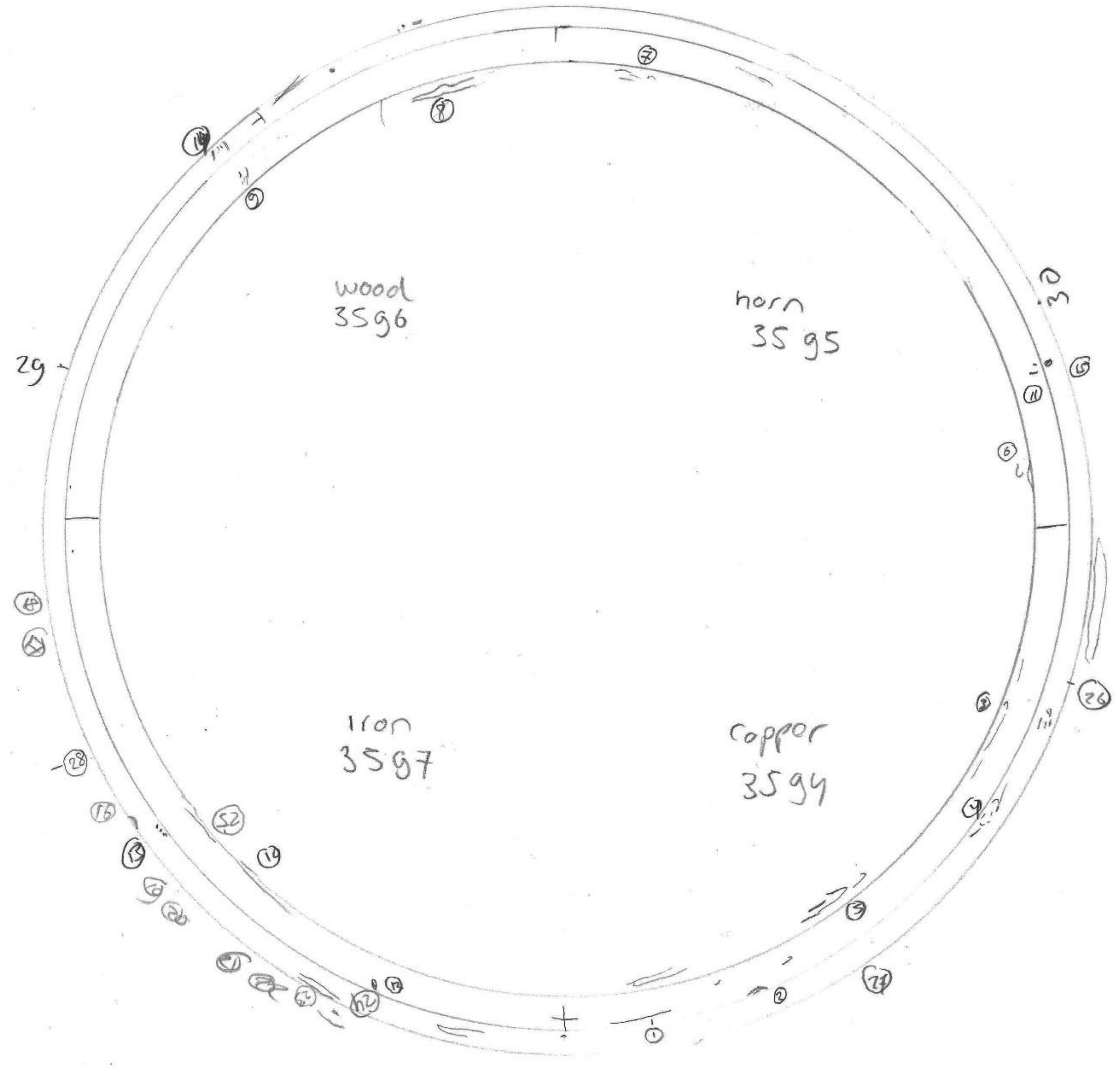
Tool type: curved copper spoon
Raw material: pottery

Material: -
State: dry
Hardness: medium
Type of surface worked on: rim of the pot
Motion: hanging from the rim
Duration: 60 min
Liquid level: -

Description of experimental procedure: A curved copper spoon was hanged from the rim repeatedly. The spoon was hanged outside of the pot. The contact area was the inside and the top of the rim.

Tool effectiveness (and deterioration): It was relatively easy to hang the spoon from the rim. Tool effectiveness: not applicable. Very small traces visible on the pottery surface

Cleaning procedures: none



Experiment number: 3595
Vessel number: HB-AS-036
User name: Nicole de Koning
Date: 22-08-2017
Grain size: fine

Tool type: curved horn spoon
Raw material: pottery

Material: -
State: dry
Hardness: medium
Type of surface worked on: rim of the pot
Motion: hanging from the rim
Duration: 60 min

Liquid level: -

Description of experimental procedure: A curved horn spoon was hanged from the rim. Because of the wide size of the handle of the spoon, it was not possible to hang the spoon outwards of the pot, thus the spoon was hanged inwards. The contact area was the upper part and the outside of the rim.

Tool effectiveness (and deterioration): No deterioration on the tool, and no visible use-wear on the pottery surface

Cleaning procedures: water

Experiment number: 3596
Vessel number: HB-AS-036
User name: Nicole de Koning
Date: 25-08-2017
Grain size: fine

Tool type: curved wooden spoon
Raw material: pottery

Material: -
State: dry
Hardness: soft
Type of surface worked on: rim of the pot
Motion: hanging spoon from the rim
Duration: 60 min
Liquid level: -

Description of experimental procedure: A curved wooden spoon was hanged from the rim, it was hanged outside of the pot. The hook of the spoon was adjusted with a knife, to make it fit exactly on the rim. This is why the contact area entails the inside, as well as the top and the outside of the rim.

Tool effectiveness (and deterioration): surface of the pot came off on the contact area on the spoon, no visible deterioration on the pottery surface.

Cleaning procedures: none

Experiment number: 3597
Vessel number: HB-AS-036
User name: Nicole de Koning
Date: 27-08-2017
Grain size: fine

Tool type: curved iron spoon
Raw material: pottery

Material: -
State: dry
Hardness: hard
Type of surface worked on: rim of the pot
Motion: hanging spoon from the rim
Duration: 60 min
Liquid level: -

Description of experimental procedure: A curved iron spoon was hanged from the outside of the rim, because the spoon is rather large (+/- 30 cm). The iron seemed to be very abrasive on the surface of the pot. The contact area was the top and the outside of the rim.
Tool effectiveness (and deterioration): no deterioration on the tool. Abrasions were clearly visible on the rim of the pot.

Cleaning procedures: none

Experiment number: 3598
Vessel number:
User name: Nicole de Koning
Date: 05-10-2017
Grain size: fine

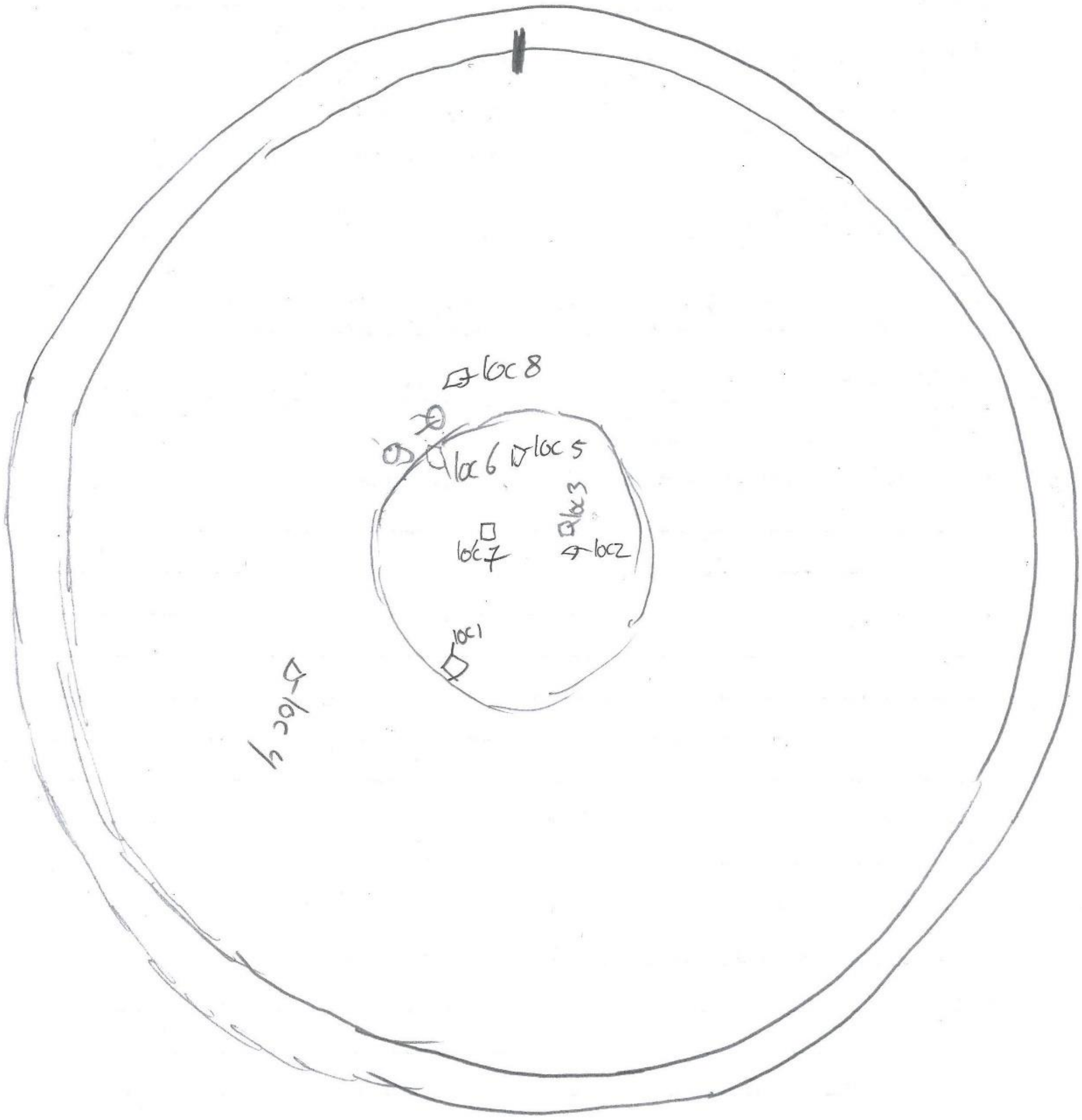
Tool type: bone spoon
Raw material: pottery

Material: porridge (oats and milk)
State: wet
Hardness: medium
Type of surface worked on: base of the pot (inside)
Motion: scraping, scooping
Duration: 60 min
Liquid level: 4 cm

Description of experimental procedure: A bone spoon was used to eat porridge from a bowl. The spoon was used to scoop and scrape the porridge from the pot. The porridge was replaced every 15 minutes, to prevent the cooling down of the substance to much. The pot was placed on a table while eating. Ingredients: 200 ml raw milk and 50 g oats.

Tool effectiveness (and deterioration): bone spoon was effective to use. No deterioration on the tool, scratches on the surface of the pottery.

Cleaning procedures: water


loc 8
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loc 4

Experiment number: 3599
Vessel number: 3200
User name: Nicole de Koning
Date: 5-11-2017
Grain size: fine

Tool type: wooden pounder
Raw material: pottery

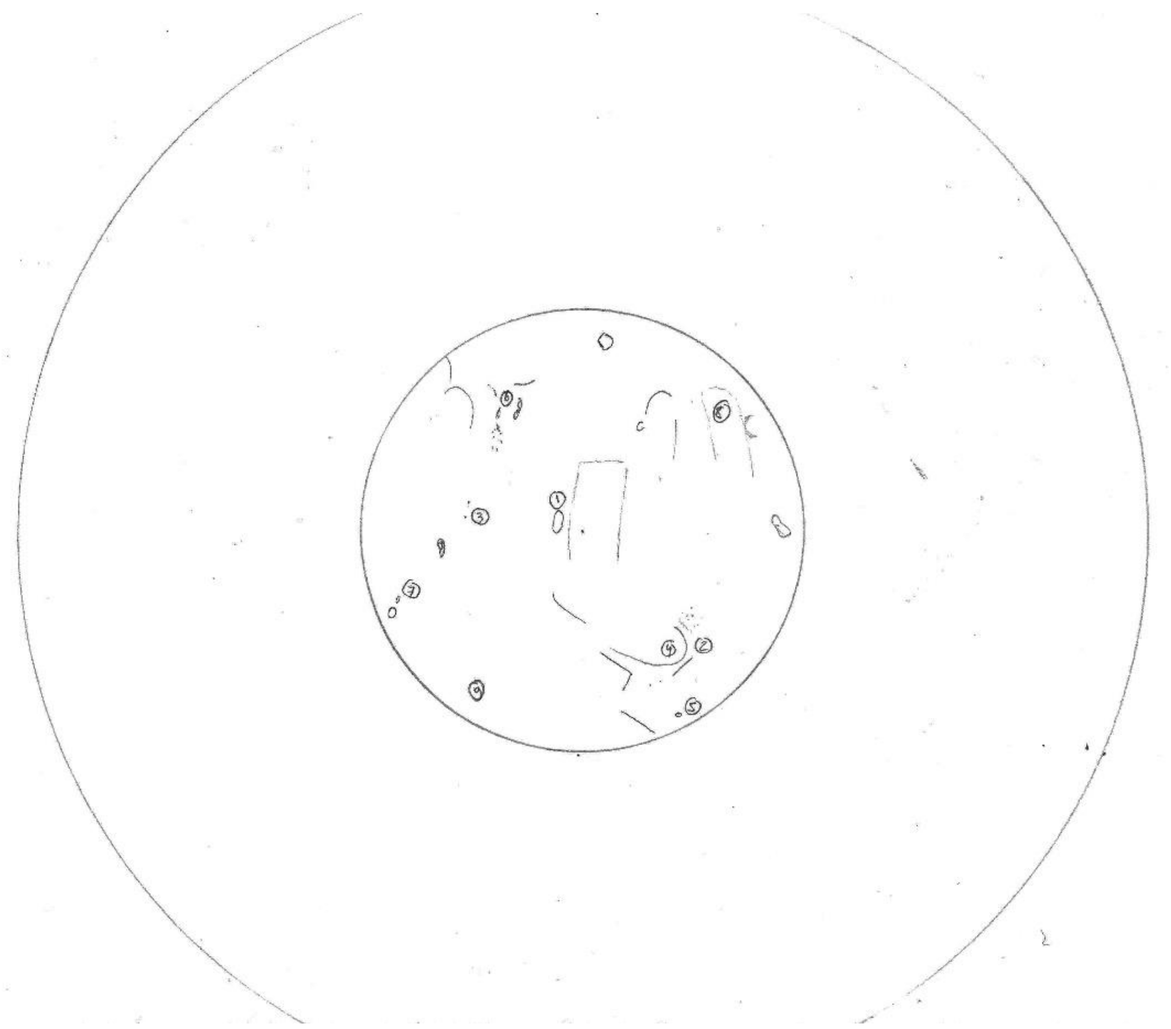
Material: dill, celery
State: dry
Hardness: medium
Type of surface worked on: base of the pot (inside)
Motion: pounding, grinding
Duration: 60 min
Liquid level: -

Description of experimental procedure: A wooden pounder (birch) was used to pound herbs (dill and celery) in a pot. A pot with a rather thick wall was used because this is the most appropriate for grinding. The herbs were replaced every 10 minutes when they were completely grinded. The motion used was pounding and grinding. The pot was placed on a table when grinding.

The pounder tool was made by hand with a knife. Birch was used because this type of three grew in the area of Mont Lassois and because the material is relatively easy workable.

Tool effectiveness (and deterioration): The tool was rather effective to grind to herbs. There was no deterioration on the tool, but the color of the herbs gave off on it.

Cleaning procedures: water



Experiment number: 3626/3629
Vessel number: HB-AS-036
User name: Nicole de Koning
Date: 16-11-2017
Grain size: fine

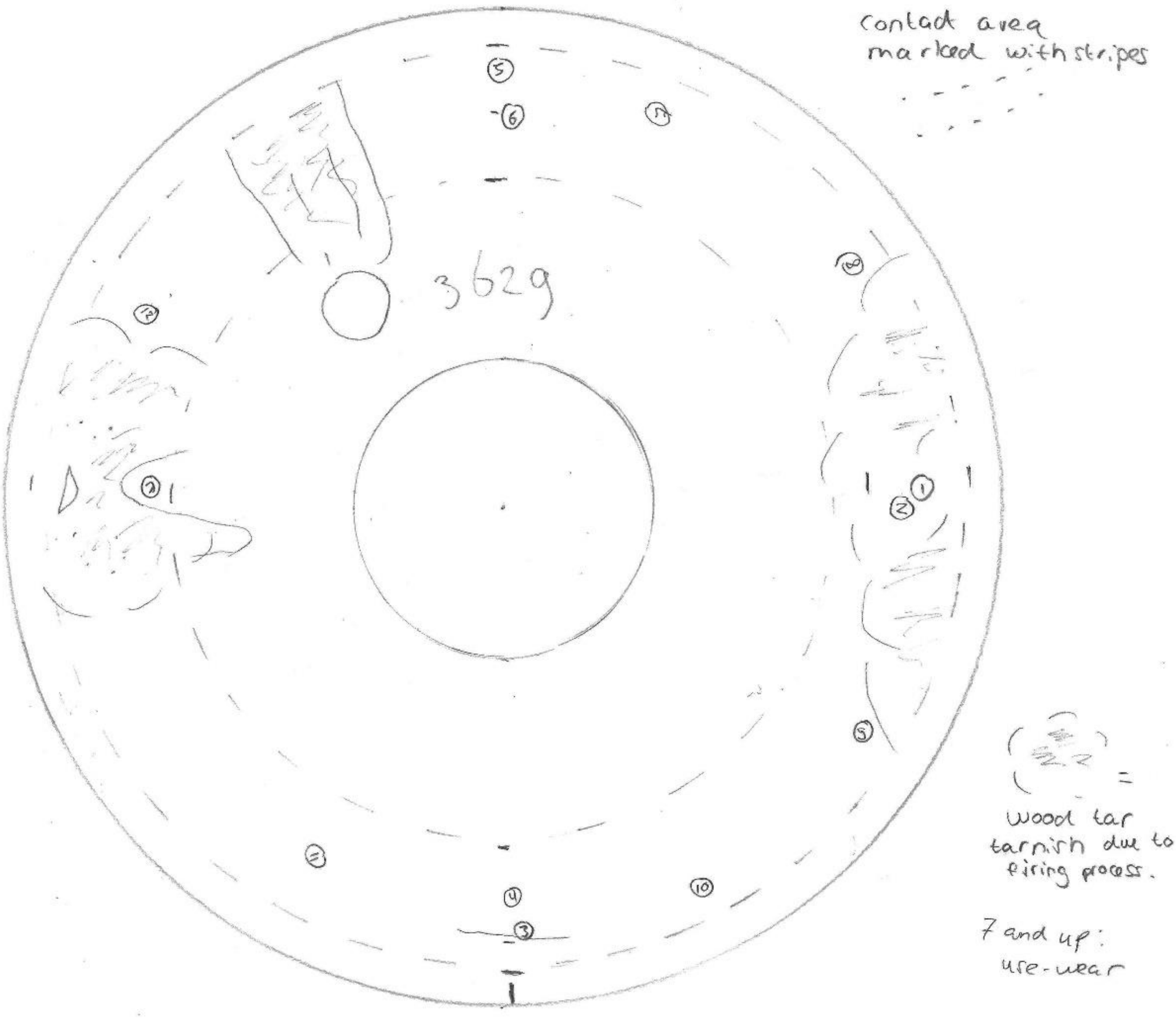
Tool type: -
Raw material: Pottery (reduced fired)

Material:
State: dry
Hardness: medium
Type of surface worked on: Inside of the rim of one pot, base of the other
Motion: Putting on top of each other
Duration: 60 min
Liquid level: -

Description of experimental procedure: Two pots were stacked on top of each other repeatedly. The pot with experiment number 3626 was used as the lower pot (contact area rim) and 3629 as the upper pot (contact area bottom). The inside of the rim of the lower pot was documented, and the base of the upper pot, these were the contact areas. For the upper pot, a circle around the base was documented because this area was in contact with the rim. During the experiment, the lower pot was rotated over the course of time, so that the use-wear traces would be evenly distributed over the contact areas between both pots.

Tool effectiveness (and deterioration): Tool effectiveness: n.a. Small scratches were visible on the rim of the lower pot and the base of the upper pot. Small particles of the surface of both pots came off.

Cleaning procedures: none



Experiment number: 3600
Vessel number: 1612
User name: Nicole de Koning
Date: 14-11-2017
Grain size: fine

Tool type: -
Raw material: Pottery (oxidized fired)

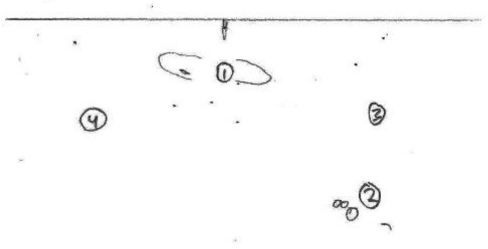
Material: -
State: dry
Hardness: medium
Type of surface worked on: upper part of both walls of the pots
Motion: bumping pots onto each other
Duration: 60 min
Liquid level: -

Description of experimental procedure: Two pots were bumped onto each other repeatedly, whereby they were moved past each other. At both of the pots, a specific area was documented at the upper area of the walls. This area was chosen because it concerned the contact area, at this height the pots touched when they were bumped into each other. One side of each pot was bumped into each other repeatedly to increase the friction on the surface, and to be able to focus on a specific area during the use-wear analysis.

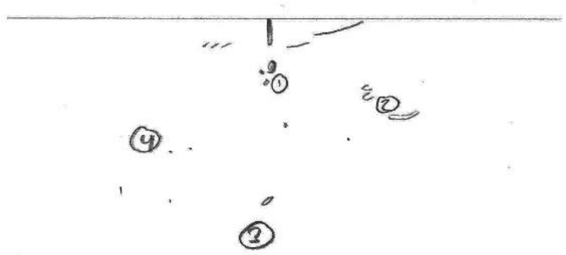
Tool effectiveness (and deterioration): Tool effectiveness: n.a. Both pots were subjected to clear abrasion. Some of the surface of the oxidized surface of the pot came loose in the form of fine powder. Abrasion was already observed after a few minutes.

Cleaning procedures: none

1612 exp. 3600 a



3600b



Experiment number: 3601
Vessel number: 3200
User name: Nicole de Koning
Date: 19-11-2017
Grain size: fine

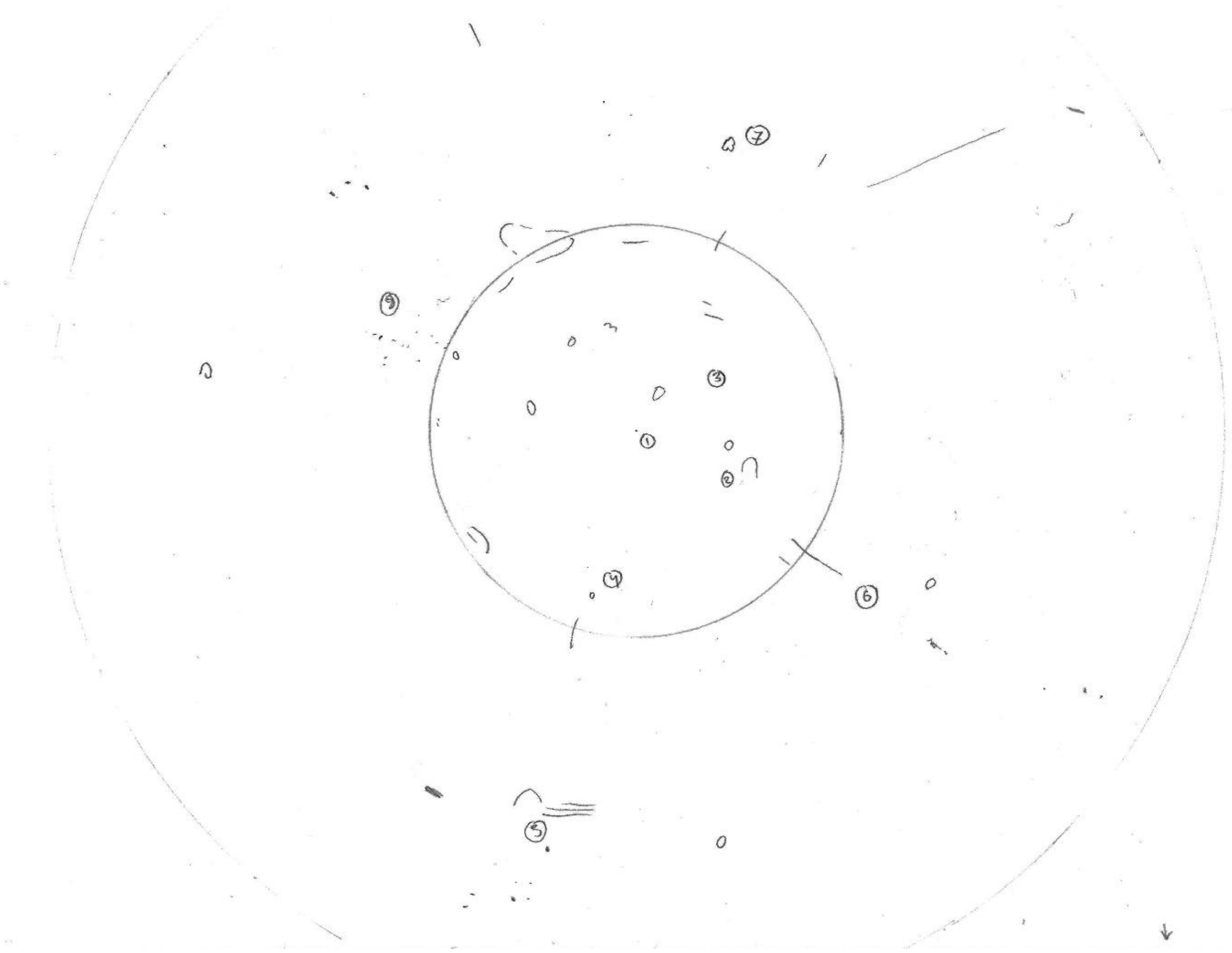
Tool type: Iron spoon
Raw material: pottery

Material: Pottery (reduced fired) butter and beef meat (blade steak)
State: wet
Hardness: hard
Type of surface worked on: Inside pot, base and walls of the pot
Motion: cooking: stirring
Duration: 60 min
Liquid level: -

Description of experimental procedure: Beef stew (blade steak) was cooked inside the pot. A cooking pit was dug into the soil. Birch wood was used to make a fire in the pit. When the fire got smaller, and coals were formed from the wood, the cooking pot was placed on the burning coals. Butter (50 gram) made from animal fats was used to roast the meat (200 gram). A little bit of water was added during cooking. The meat was regularly turned. After 40 minutes the meat got burned and was replaced by a new piece of meat. During cooking the pot was stirred with an iron spoon regularly (same spoon as used during the hanging spoon from the rim experiment). The cooking pot was covered with a steel lid for most of the time. The pot was taken out of the fire after 20 minutes to take pictures with an infrared-camera to measure the heat. Infrared pictures were taken after the cooking of 60 minutes as well to determine the difference in temperature. The heat was clearly more evenly distributed through the pot over 60 minutes.

Tool effectiveness (and deterioration): The cooking pot was very effective to cook the meat. A high temperature was reached inside the pot very easily. The meat did not stick to the surface of the bottom. Due to the fire, the base of the pot was completely sooted. The butter was caked to the inside of the base of the pot, as well as burned particles of the meat. Small scratches were also visible at the base of the inside of the pot.

Cleaning procedures: lukewarm water



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Appendix 2: Description of use-alteration traces experimental vessels

The use-alteration traces on the pottery resulting from the performed experiments have been documented and analyses. Before the experiments started, traces resulting from the production process and handling on the experimental vessels have been documented by drawings and (microscopic) pictures. Distinctive traces were recorded by indications of their location on a drawing, afterwards, microscopic pictures were taken of these locations, which were numbered. Pictures of the compete vessels were taken as well to give a complete overview of the traces. After the experiments were performed on the vessels, (microscopic) pictures were also taken of the use-alteration traces resulting from usage. They were indicated on the drawings as well. When possible, microscopic pictures of traces were taken before and after usage on the exact same location. In some cases pictures of use-alteration traces on new locations were taken as well, which received a new number on the same drawing that was used to record the pre-use traces. A description of all observed use-alteration traces together was given as well, which were linked to specific locations on the vessels (loc1, loc2 etc.).

Vessel number: 1145

Experiment number: 3590

Experiment: eating porridge with wooden spoon

Contact area: base of the inside of the pot

Tool: wooden spoon

Description of use-alteration traces: No use-alteration traces were observed on the contact area after usage.

Vessel number: Z71

Experiment number: 3591

Experiment: whisking butter/whipped cream

Contact area: base of the inside of the pot

Tool: pine whisk

Description of use-alteration traces: Use-alteration traces in the form of small scratches could be observed on the contact area on the base of the inside of the pot (loc2, loc6). Small scratches could be observed on the bulge in the center of the base as well (loc1).

Vessel number: HB-AS-036

Experiment number: 3592

Experiment: Shoving pot on clay surface

Contact area: base of the pot

Tool: clay surface

Description of use-alteration traces: After moving the pot on the clay surface, the whole surface of the base was removed. What remained was a heavily abraded, sanded surface with a rough, irregular character. Temper particles became visible and exposed on the surface (Loc1, Loc3). Therefore, the clay surface appeared to be very abrasive in nature, likely mainly due to the sharp sand that was used as a temper for the clay floor.

Vessel number: HB-AS-036

Experiment number: 3593

Experiment: Shoving pot on wooden surface

Contact area: Base of the pot

Tool: -

Description of use-alteration traces: Compared to the clay surface, the wooden surface seemed to be less abrasive in nature (loc3, loc6). A light polish was observed all over the surface of the bottom. What was remarkable, was that many scratches were observed along the outer edges of the bottom. The distribution of these scratches was random (loc7).

Vessel number: HB-AS-036

Experiment number: 3594

Experiment: Placing spoon on the rim

Contact area: rim of the pot

Tool: copper spoon

Description of use-alteration traces: The use-alteration traces resulting from usage were minimal. Only very slight abrasions and scratches could be observed on the contact area. The direction of the scratches was vertical to the rim, similar (loc26, loc27).

Vessel number: HB-AS-036

Experiment number: 3595

Experiment: placing spoon o the rim

Contact area: rim of the pot

Tool: horn spoon

Description of use-alteration traces: Slight abrasions and small scratches could be observed on the contact area. The direction of the scratches was downwards, similar to the motion of the spoon (loc30).

Vessel number: HB-AS-036

Experiment number: 3596

Experiment: placing spoon on the rim

Contact area: rim of the pot

Tool: wooden spoon

Description of use-alteration traces: The contact area was slightly abraded (loc29).

Vessel number: HB-AS-036

Experiment number: 3597

Experiment: placing spoon on the rim

Contact area: outer part of the rim

Tool: iron spoon

Description of use-alteration traces: The iron spoon appeared to be very abrasive and left behind major use-alteration traces. The surface of the contact area on the rim was completely removed and the temper particles were extremely eroded as well (loc13, loc16 and loc28.

Vessel number: 3620

Experiment number: 3598

Experiment: Eating porridge with bone spoon

Contact area: inside base of the pot

Tool: bone spoon

Description of use-alteration traces: The use-alteration traces consist of a dull polish all over the contact area and the temper particles are flattened (loc2, loc8).

Vessel number: 3200

Experiment number: 3599

Experiment: pounding herbs

Contact area: inside base of the pot

Tool: pounder

Description of use-alteration traces: Contrary to the expectations, there do not seem to be major use-alterations from this relatively abrasive activity. The base of the spot is only slightly abraded, and particles of temper were removed or flattened (loc9).

Vessel number: 1612

Experiment number: 3600a and 3600b

Experiment: bumping pots to each other

Contact area: wall of the pots

Tool: -

Description of use-alteration traces: Two pots were used for this experiment (3600a and 3600b). On both pots, the same use-alteration traces could be observed. These traces consisted of a severe abrasion of the contact areas, similar to those of experiment 3592 (shoving on a loam surface), but this time, oxidized fired pottery was used instead of reduced fired pottery, which is fired on a lower temperature. Near the contact areas, the surfaces were completely abraded and rough in nature. The temper was exposed due to (loc1).

Vessel number: 3200

Experiment number: 3601

Experiment: Cooking beef

Contact area: outside of the pot, inside of the pot

Tool: iron spoon

Description of use-alteration traces: -

Vessel number: HB-AS-036

Experiment number: 3626

Experiment: stacking pots on top of each other

Contact area: rim of the pot

Tool: -

Description of use-alteration traces: Only very small scratches could be observed on the contact area of the rim. The direction of these scratches was downwards (similar to the motion of stacking the upper pot). The rim doesn’t seem to be abraded (loc5).

Vessel number: HB-AS-036

Experiment number: 3629

Experiment: stacking pots on top of each other

Contact area: base of the pot

Tool: -

Description of use-alteration traces: Similarly to the rim of the lower pot (3629) the use-alteration traces on the base of the upper pot upper pot were minimal. There are small scratches of calcite on the contact area, resulting from the finish of the pottery. Similar to the lower pot (3629) there don’t seem to be any abrasions on the contact area (loc7, loc10, loc11).

Appendix 3: Replica catalogue

3.1 Vessels

Number: 1145
Used in experiment: 3590
Form: small bowl
Oxidized/reduced: oxidized
Temper: fine
Surface treatment: smoothed
Orifice diameter: 18 cm

Number: Z71
Used in experiment: 3591
Form: small bowl
Oxidized/reduced: reduced
Temper: fine
Surface treatment: smoothed
Orifice diameter: 25 cm

Number: HB-AS-036
Used in experiment: 3592, 3593, 3594, 3595, 3596, 3597
Form: small bowl
Oxidized/reduced: reduced
Temper: fine
Surface treatment: graphitized
Orifice diameter: 20 cm

Number: 3620
Used in experiment: 5898
Form: small bowl
Oxidized/reduced: reduced
Temper: fine
Surface treatment: graphitized
Orifice diameter: 18 cm

Number: 3200
Used in experiment: 3601
Form: small bowl
Oxidized/reduced: reduced
Temper: fine
Surface treatment: smoothed
Orifice diameter: 30 cm

Number: 3220
Used in experiment: 3599
Form: small bowl
Oxidized/reduced: reduced
Temper: fine
Surface treatment: smoothed
Orifice diameter: 28 cm

Number: 1612
Used in experiment: 3600
Form: small bowl
Oxidized/reduced: oxidized
Temper: fine
Surface treatment: smoothed
Orifice diameter: 16 cm

3.2 Tools

Number: 001
Tool type: spoon
Material: wood
Length: 24 cm
Used for experiment: 3590
Used on vessel: 1145

Number: 002
Tool type: spoon
Material: bone
Length: 16 cm
Used for experiment: 3598
Used on vessel: 3620

Number: 003
Tool type: curved spoon
Material: copper
Length: 10 cm
Used for experiment: 3594
Used on vessel: HB-AS-036

Number: 004
Tool type: curved spoon
Material: horn
Length: 8 cm
Used for experiment: 3595
Used on vessel: HB-AS-036

Number: 005
Tool type: spoon with hook
Material: wood (maple)
Length: 21 cm
Used for experiment: 3596
Used on vessel: HB-AS-036

Number: 006
Tool type: Curved spoon
Material: cast iron
Length: 30 cm
Used for experiment: 3597
Used on vessel: HB-AS-036

Number: 007
Tool type: whisk
Material: wood (pine)
Length: 23 cm
Used for experiment: 3591
Used on vessel: Z71

Number: 008
Tool type: pounder
Material: wood (birch)
Length: 13 cm
Used for experiment: 3599
Used on vessel: 3200

Appendix 4: Description of use-alteration traces Mont Lassois assemblage

The first sherd that was observed during further analysis of use-alteration traces is a rim fragment of an oxidized fired bowl (C1-S5). Locations on the outer side, rim and inside were analyzed and documented. At the outside of the vessel, some abrasions were observed (loc1). After observation under the stereomicroscope, these abrasion appeared to be of post-depositional nature because of their random distribution. The surfaces on the inside (loc2) (loc3) however, seemed to be more abraded. Traces of clearer use-alteration appeared to be present on the rim of the sherd. Both the inside of the rim (loc4), and the outside of the rim (loc5) were analyzed and photographed. The rim appeared to be rounded and smooth in nature.

The subsequent sherd is a rim sherd as well (C1-S7). The rim and outer wall of this sherd have been analyzed. The rim appeared to be abraded (loc1), similar in nature to the rim of C1-S5. On the outer wall of the vessel, clear abrasions could be observed (loc2, loc3). These abrasions seemed to be related to post-depositional processes, since they appeared to be "fresh" in nature, referring to the deep cut (loc2), and the light appearance of the smaller scratches (loc2).

The following sherd related to a base part of the vessel (C1-S8). The base of the vessel and the inside of the vessel have been searched for use-wear traces. Obvious abrasions were observed on the base of the vessel (loc1), which were slightly pitted in nature. These traces seem to relate to use activities of moving of the vessels on a surface because only the part of the vessel that came in contact with the surface is abraded. Abrasions were observed on the inside of the vessel as well (loc2). Unfortunaly, the trace was intersected by the sample taken for the purpose of residue analysis. It is also conceivable that this trace was caused by the post-depositional activity of sampling.

The outer wall, rim and inside wall have been selected for analysis in sherd C1-S12. The inner wall appeared to be very abraded (loc1), unfortunately, this trace was again intersected by a sample. Some light scratches/abrasions were observed on the upper side of the inside on the wall (loc3). The rim (loc5) also showed abrasions which were rounded and smoothed in nature. Lastly, the outer wall showed some abrasions (loc6). The visibility of these traces is however impeded by the decoration.

On sherd C1-S14, a wall sherd of which the rim is missing, only one area showed some abrasions. These abrasions are located on the lower side of the inside of the vessel. The ceramic surface appears to be slightly abraded.

From a rather large rim/wall fragment with a strong nod (CA-S5), the outer wall and the rim were analyzed. The outer wall was documented at the height of the nod, which also considers the widest part of the vessel profile. The traces are exclusively centered on this area, and are abraded and pitted in nature. On the rim fragment three different locations were analyzed: the outside, top and inside of the rim. All the mentioned rim areas evidenced clear abrasion, which are rounded and smoothed in nature. The outer side of the rim is slightly pitted.

A small rim/wall sherd (CA-S16) was selected because clear abrasion was evidenced on the outer side (loc1, loc2). It is striking that the abrasion covered only the widest part of the vessel, which was almost abraded totally. The form of these traces is mostly pitted. The rim was not analyzed because the remained part was very small.

The base of a vessel with a stand-foot (88.6685.1) was analyzed, as well as the inside. The inside of the vessel was abraded (loc1).The stand-foot appeared to be abraded as well. The below surface was abraded in a smooth manner (flattened)(loc2) while the edges of the rim were pitted in nature (loc3). Base wear could also be observed on a fragment with a small stand-ring (88.6690.1). The same features were observed: the base below side (loc1) was flattened, smoothly abraded, while the edge showed clearly more pitting.

A small rim/wall sherd (88.7323.1) showed abrasions on the rim and the wall. The wall showed a pitting structure (loc1, loc2), as with the other rim sherds, the outer side (loc3), top (loc4) and inside (loc5) of the of the rim were analyzed. The feature that was observed on stand-foots of vessels, is applicable for this rim as well: the top of the rim is smoothly abraded (loc4), while the edges of the rim (loc3, loc5) are more pitted in nature. It is also striking that on this rim pitting is much more apparent than on the other observed rim fragments.

The wall sherd 88.9163.1 was selected because both the outer and inner surface appeared to show distinct traces. After further analysis under the stereomicroscope, these alterations seemed to be of post-depositional nature. The traces on the outside (loc1) because of their bubbly structure, and on the inside (loc2) because they are dispersed.

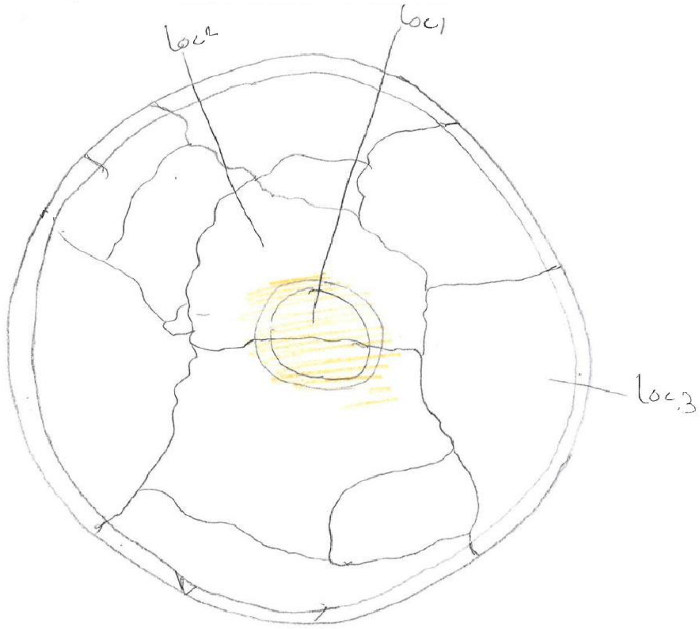
The base of a bowl-like vessel (88.203.1) showed some distinct abrasions. The whole area that came in contact with the surface showed abrasions (circle form). The surface appears to be abraded in a smooth, slightly pitted manner, the temper became clearly visible and was abraded to the level of the surface as well. (loc1, loc2)

A very thin wall sherd (89.583.1) was selected because clear abrasions were observed on the rim. The outer side, top and inside of the rim were documented. On the outside of the rim, the abrasions were strongly pitted in nature (loc1), while the top of the rim was flattened in a smooth manner (loc2). The inside of the rim showed some striations (loc3). The wall of the sherd was analyzed as well (loc4), on which light abrasions could be observed.

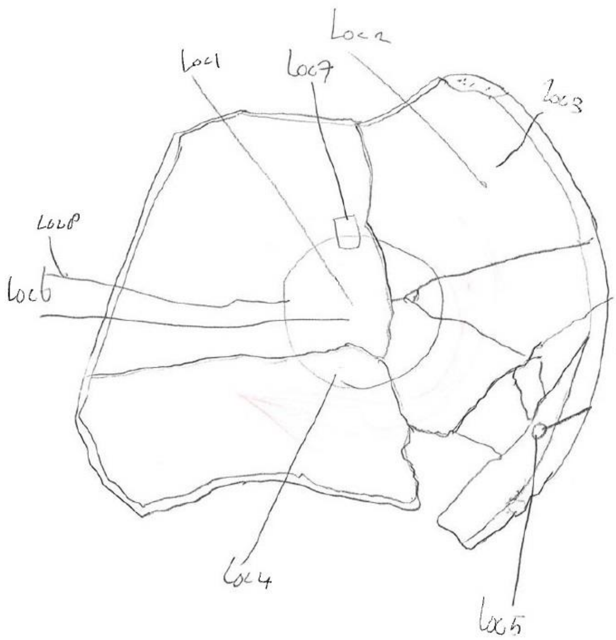
On a small base sherd with a stand-foot (VI31 92), abrasions could be observed on the base of the stand-foot (loc1). The ceramic surface was extremely pitted on the below surface (in contrast to the other base sherds, which are smoothly abraded).

Appendix 5: Heuneburg pottery catalogue

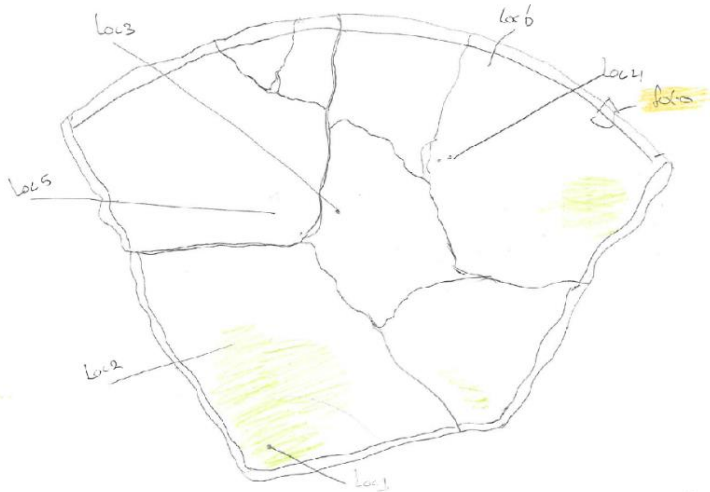
Number: HB-VB-002 (1145)
Form: bowl with stand foot
Use-wear: scratches inside
Part: complete vessel
Hand formed



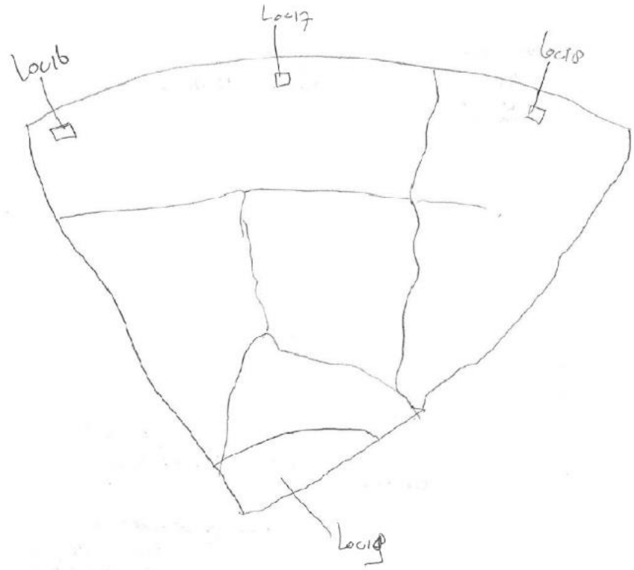
Number: HB-VB-005 (2106)
Form: bowl
Use-wear: scratches inside
Part: Archaeologically complete
Hand formed



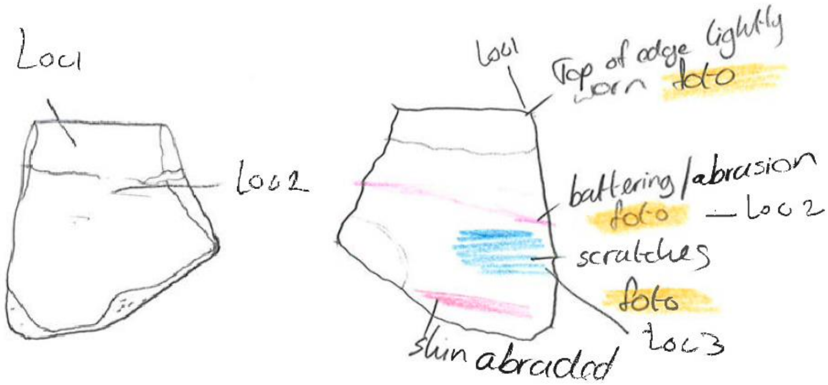
Number: HB-VB-010
Form: bowl
Use-wear: scratches inside, abrasions on rim
Part: rim and wall
Hand formed



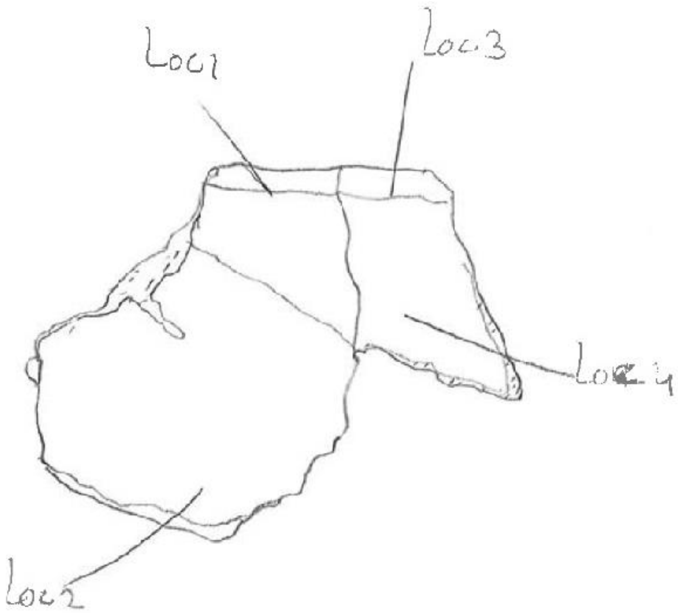
Number: HB-VB-048
Form: bowl
Use-wear: scratches and abrasions on outside near rim and bottom
Part: rim and wall
Hand formed



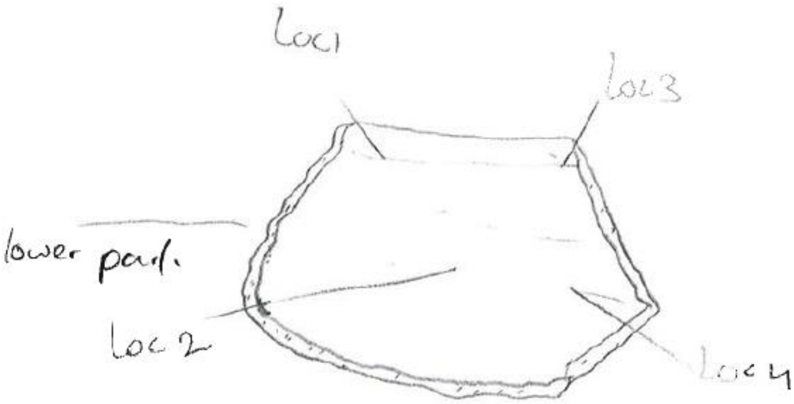
Number: HB-VB-050
Form: bowl
Use-wear: rim abraded, scratches and abrasions on outside and inside
Part: rim
Hand formed



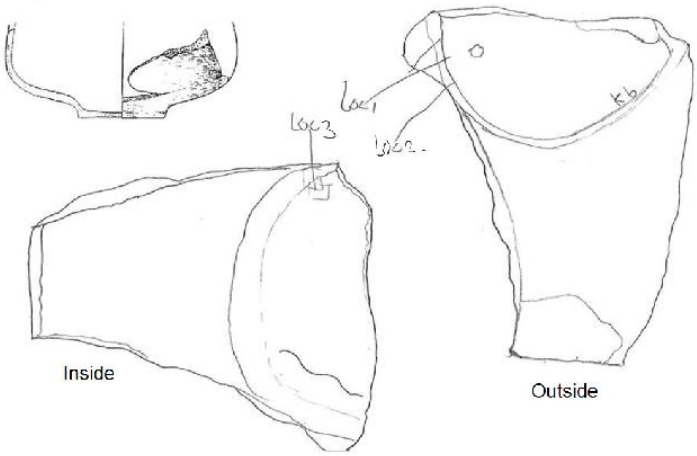
Number: HB-VB-059
Form: bowl
Use-wear: polish on rim
Part: rim and wall
Hand formed



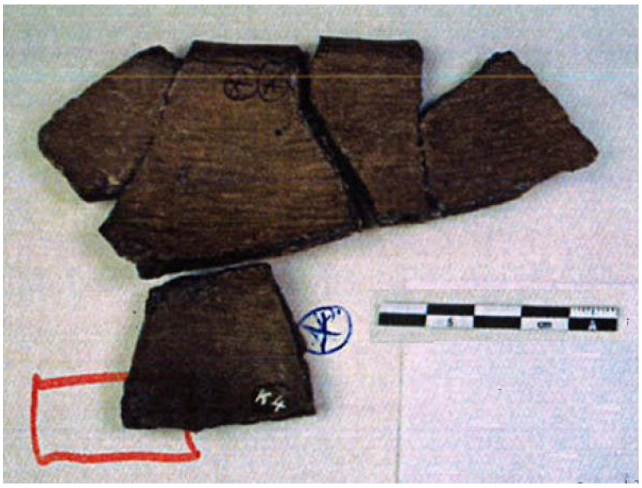
Number: HB-VB-063
Form: bowl
Use-wear: polish on rim
Part: rim
Hand formed

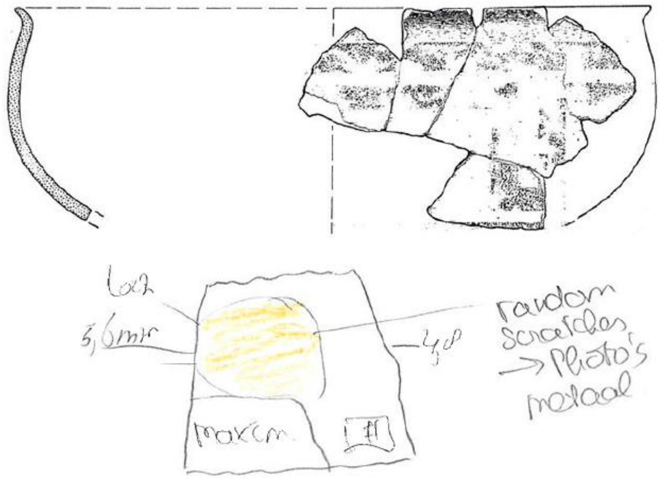


Number: HB-AS-017
Form: graphitized bowl
Use-wear: base wear
Part: bottom
Hand formed



Number: HB-AS-036
Form: bowl
Use-wear: scratches on the lower inside
Part: rim and wall
Hand formed

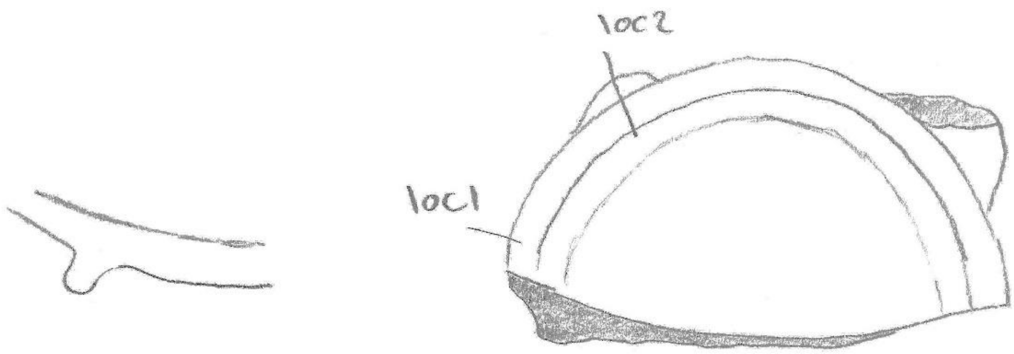




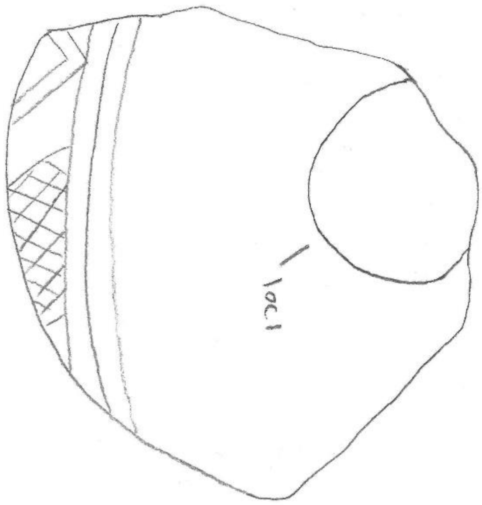
Appendix 6: Mont Lassois pottery catalogue

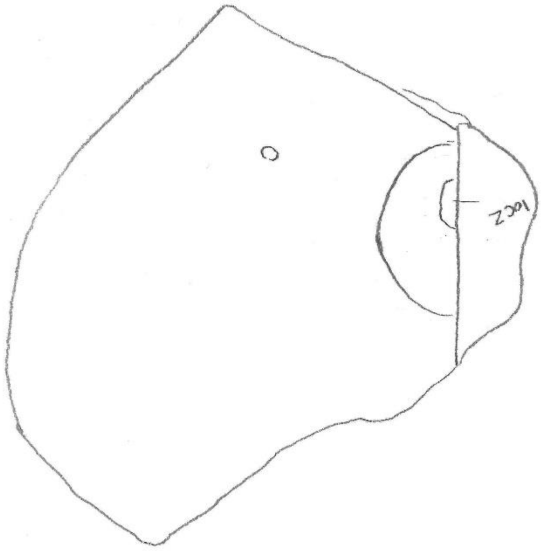
Performance characteristics Ceramic material Mont Lassois

Number: 88.6690.1
Vessel part: base
Form: form wit stand ring
Oxidised/reduced: reduced
Hand formed/ wheel-thrown: hand formed
Paste: rather fine
Temper: fine sand, calcite
Surface finish: smoothed
Post-depositional traces: sampling

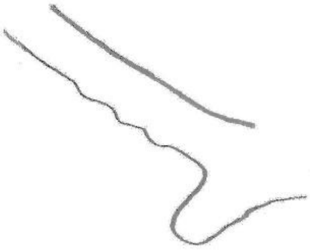


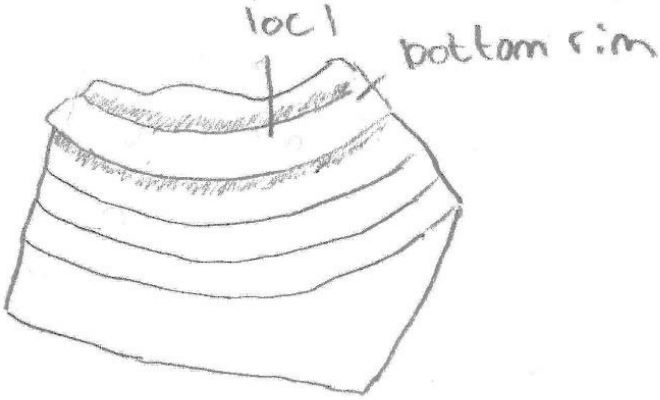
Number: C1-S8
Vessel part: bottom
Form: bowl?
Oxidised/reduced: reduced
Hand formed/ wheel-thrown: hand-formed
Paste: rather coarse
Temper: coarse sand, calcite
Surface finish: polished, decoration: lines and checked pattern
Post-depositional traces: sample



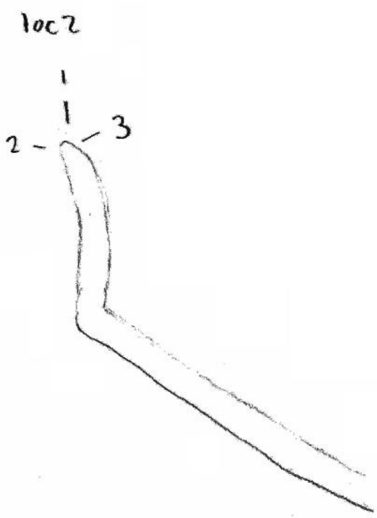


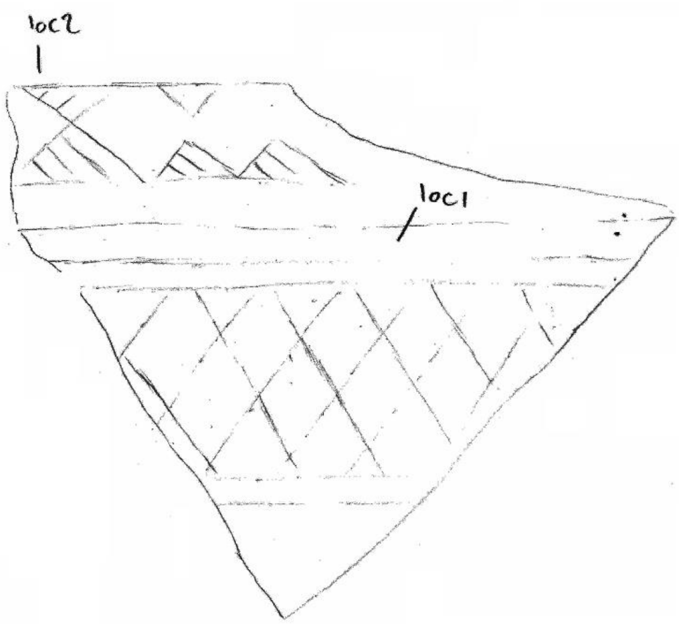
Number: VI31
Vessel part: bottom
Form: stand ring of very wide form
Oxidised/reduced: reduced
Hand formed/ wheel-thrown: wheel-thrown
Paste: rather fine
Temper: fine sand
Surface finish: smoothed
Post-depositional traces: Sample, glue, writings on transparent nail polish



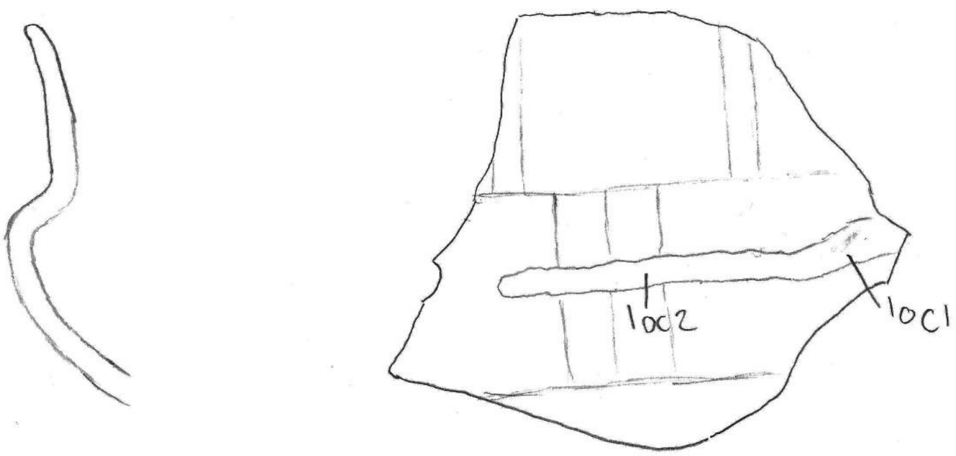


Number: CA-S5
Vessel part: rim
Form: bowl
Oxidised/reduced: reduced
Hand formed/ wheel-thrown: hand-formed
Paste: rather coarse
Temper: calcite and silt stone
Surface finish: smoothed
Post-depositional traces: glue, sample

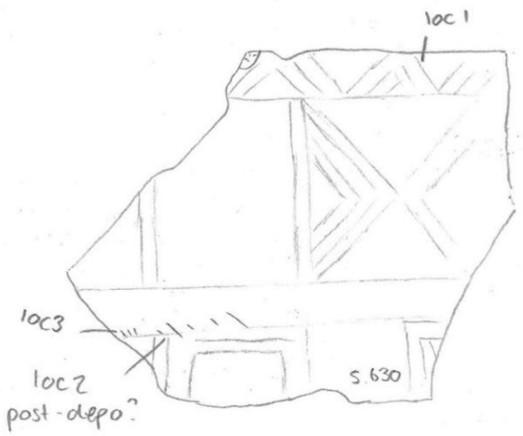


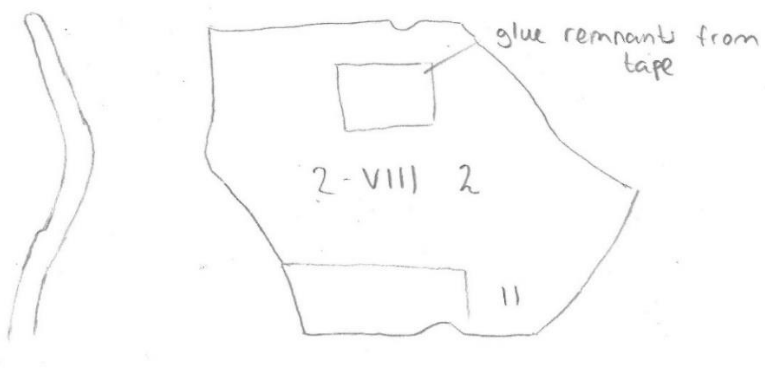


Number: CA-S16
Vessel part: rim
Form: bowl
Oxidised/reduced: reduced (surface oxidized)
Hand formed/ wheel-thrown: hand-formed
Paste: rather coarse
Temper: coarse sand calcite
Surface finish: painted? Decoration: horizontal and vertical lines
Post-depositional traces: sample and tape

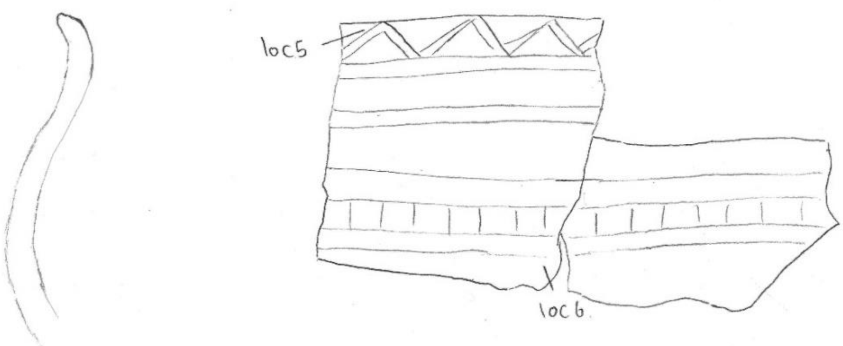


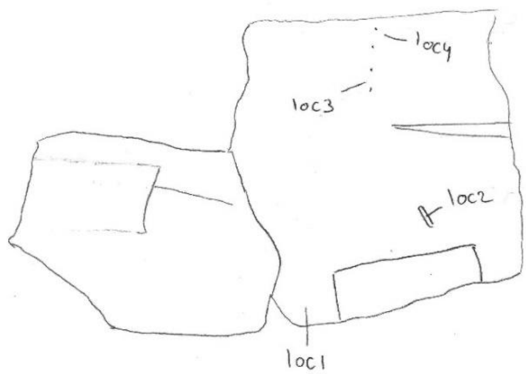
Number: C1-S7
Vessel part: rim
Form: S-profile
Oxidised/reduced: reduced (surface oxidised)
Hand formed/ wheel-thrown: hand-formed
Paste: coarse
Temper: calcite and silt stone
Surface finish: smoothed and painted Decoration: lines, squares and triangles
Post-depositional traces: glue, transparent nail polish with writings, pencil writings and sample



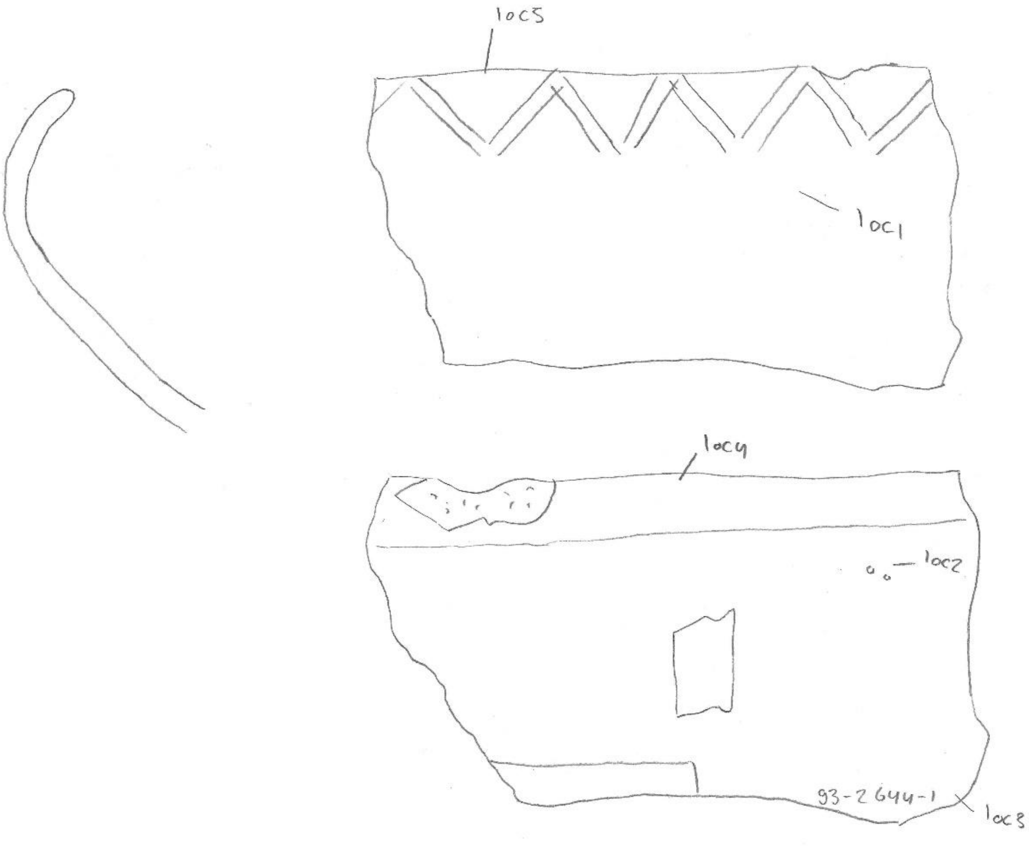


Number: C1-S12
Vessel part: rim, belly
Form: bowl
Oxidised/reduced: reduced
Hand formed/ wheel-thrown: hand-formed
Paste: rather coarse
Temper: sand and quarts
Surface finish: polished and decoration, horizontal lines and zigzag
Post-depositional traces: glue, tape, sample, pencil writings

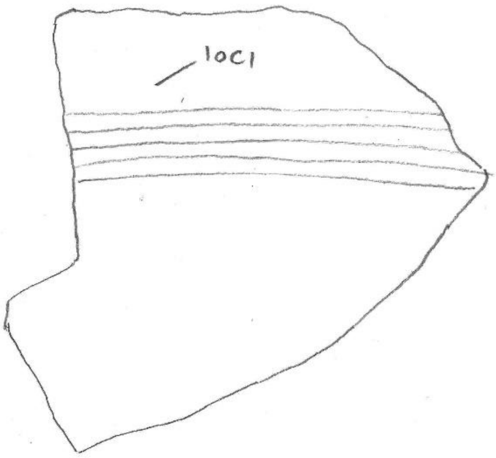


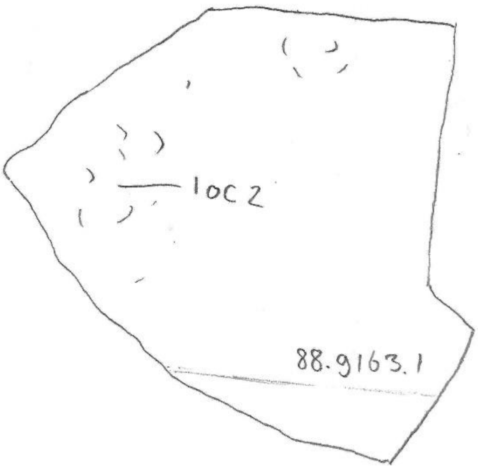


Number: C1-S5
Vessel part: rim
Form: bowl
Oxidised/reduced: oxidised
Hand formed/ wheel-thrown: hand formed
Paste: rather coarse
Temper: quarts and silt stone
Surface finish: polished, Zigzag decoration
Post-depositional traces: sample, glue from tape, pen writing, nick on the outside, inner rim abraded

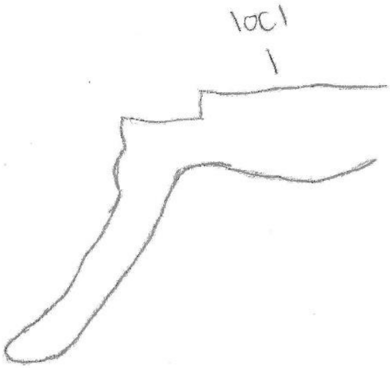


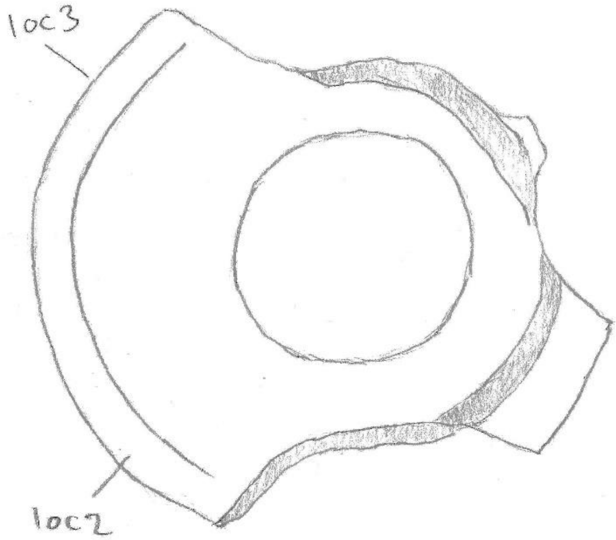
Number: 88.9163.1
Vessel part: wall
Form: wall of a closed form
Oxidised/reduced: reduced
Hand formed/ wheel-thrown: wheel-thrown
Paste: very fine
Temper: fine sand, calcite
Surface finish: polished
Post-depositional traces: sample, pen writing, break is abraded, breakage (piece of ceramic broke off)



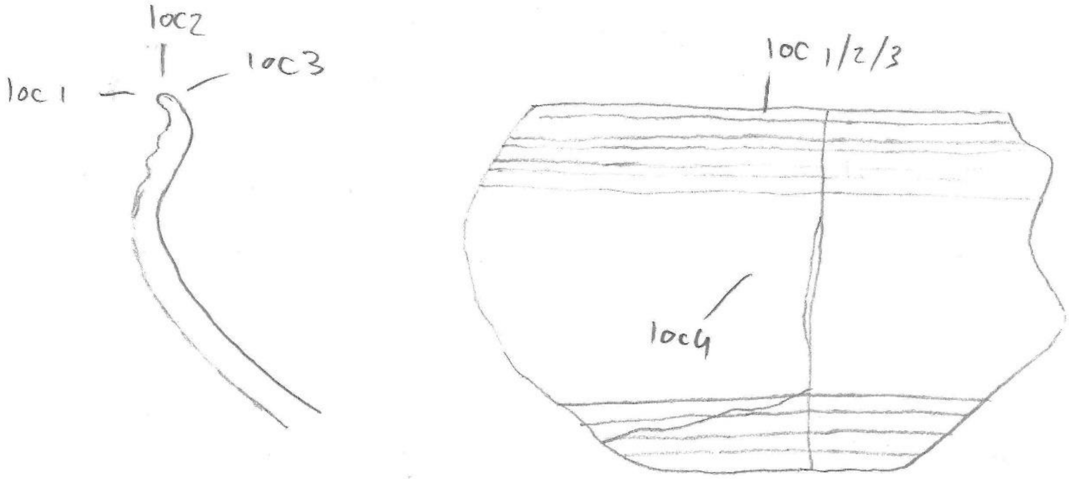


Number: 88.6685.1
Vessel part: bottom
Form: stand foot
Oxidised/reduced: reduced
Hand formed/ wheel-thrown: wheel-thrown
Paste: fine, hard, calcareous
Temper: calcite, silt stone
Surface finish: fine clay slib added, polished (similar to surface finish of 88.7320.1)
Post-depositional traces: sample, pieces broke of, writings

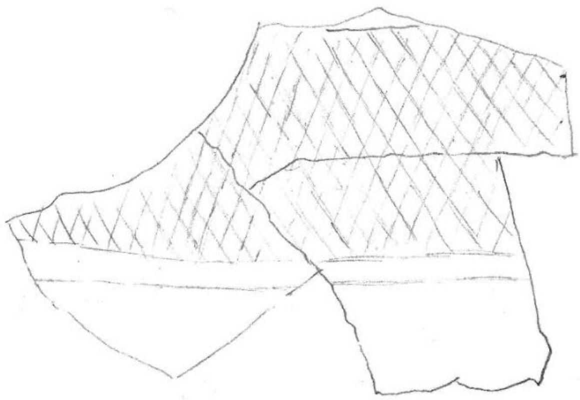


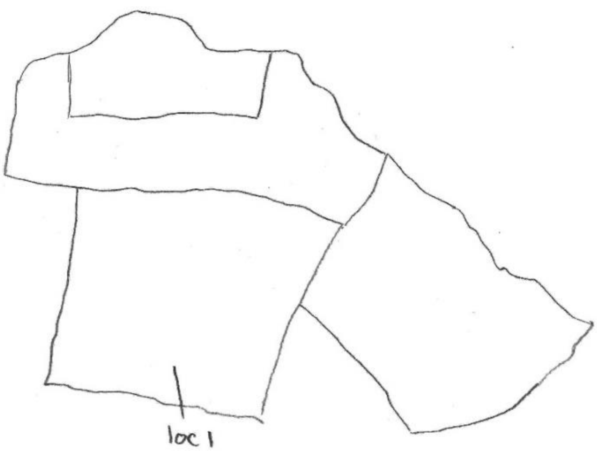


Number: 89.583.1
Vessel part: rim
Form: bowl
Oxidized/reduced: reduced
Hand formed/ wheel-thrown: wheel-thrown
Paste: fine, soft light grey, calcareous (similar to 88.7320.1)
Temper: calcite and quarts
Surface finish: thin layer of fine clay slib, polished
Post-depositional traces: glue, sample

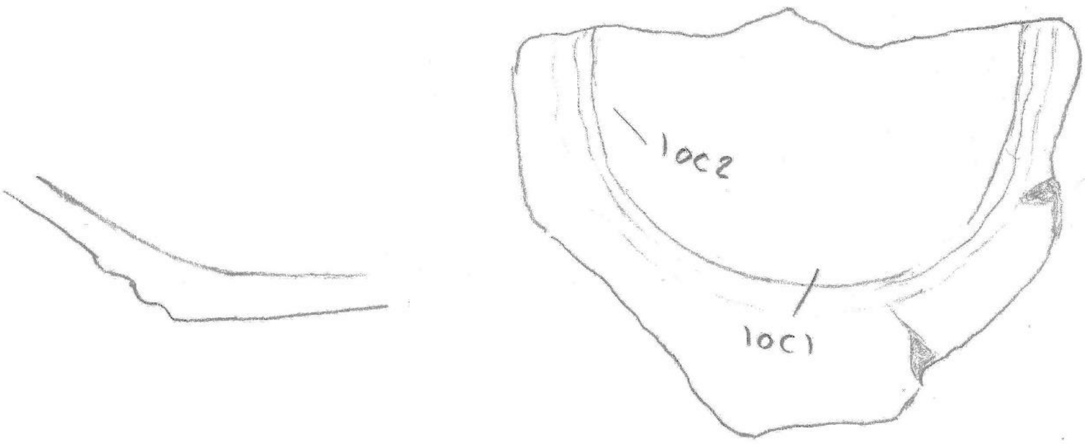


Number: 88.9263.1 (C1 – S14) F
Vessel part: wall
Form: closed small bowl
Oxidized/reduced: reduced
Hand formed/ wheel-thrown: hand-formed
Paste: rather coarse
Temper: fine basalt incidental calcite, organic material from the clay
Surface finish: polished, decoration of horizontal lines and checked
Post-depositional traces: sample, pencil writings, tape, glue





Number: 89.203.1
Vessel part: bottom
Form: ?
Oxidized/reduced: reduced
Hand formed/ wheel-thrown: wheel-thrown
Paste: fine, soft, calcareous
Temper: many calcite particles
Surface finish: smoothed
Post-depositional traces: sample, pencil writings, glue



Number: 88.7323.1
Vessel part: rim
Form: bowl
Oxidized/reduced: reduced
Hand formed/ wheel-thrown: wheel-thrown?
Paste: fine, calcareous
Temper: very fine sand, calcite
Surface finish: polished
Post-depositional traces: sample, writings, abrasions