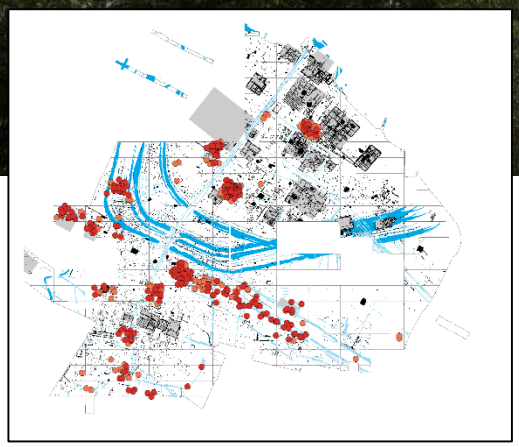
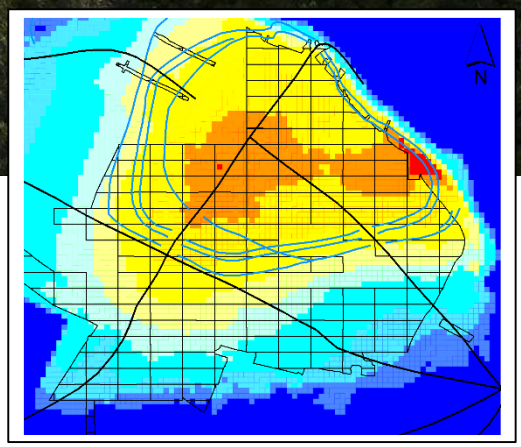
The Roman Fort on the Kops Plateau

A chronological and spatial analysis of its contexts





Frank Stephan Beijaard

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Front cover: a view from the Kops Plateau (image from Wikimedia Commons).

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Preface

Seven months ago I started this research project as the final part of my master's program and now that journey has come to an end. Before I will present my results I wish to thank the people that have helped and supported me throughout my study. Without them this final product of that study would not be the same.

First of all I would like to thank Rien Polak, the supervisor of this thesis. I owe him a lot for the stimulating discussions, critical thoughts and pointing me in the right direction. I am deeply indebted to him for his encouragement and thorough reading of everything I wrote. Not only during this project but throughout my study I have learned from him as a student. For that I am very grateful.

I also owe much gratitude to Caesar Carreras and his team of experts. Their detailed revisit of the amphoras found on the Kops Plateau has proven to be crucial for this thesis. I hope that my results will aid them in their ongoing research.

Next, I would like to thank the staff of the Mapping the Via Appia project and in particular Stephan Mols, Jeremia Pelgrom and Maurice de Kleijn. Being able to participate in this project for four years gave me the change to explore my personal interests in archaeology. Many of the experiences I got from the Via Appia project proved to be helpful during this research and I am grateful for the opportunities that were given to me.

A very special word of thanks goes out to Harry van Enckevort, Gianmarco Alberti, Ryan Niemeijer and René Kloosterman who helped me on several occasions with my research. I also thank Marenne Zandstra for inviting me to give a presentation during the Nijmegen Aardewerkdag of 2015. It was a great experience.

Switching from archaeologists to family and friends, I would first of all like to thank my parents and sister. My whole life you three have supported me with all your love and care. For that I am eternally grateful.

My friends Jasper, Juan and Gijs. Eight years ago, we started our adventure in Nijmegen and never has there been a dull moment. Cheers for that.

Last, Kristel for being there for me these last two years. You probably learned more about my thesis than you ever cared for. Still, you listened, never complained, and continued listening some more when I wouldn't stop talking. You corrected me when I was wrong and believed in me when I could not. Thank you.

1. Introduction

In the years 1986-1995 W. Willems and H. van Enckevort were tasked by the Cultural Heritage Agency of the Netherlands (ROB) with excavating the remains of a pre-Flavian Roman fortification on the Kops Plateau, situated in the eastern part of Nijmegen. Described by Willems as the "*Nachtwacht van de Nederlandse Archeologie*" (The Night Watch of the Dutch Archaeology) [1], the Roman fort is today considered to be one of the richest and most extensively documented archaeological sites of the Lower Rhineland. During the excavations more than 400.000 ceramic sherds were uncovered in a wide variety of contexts. The pottery assemblage of these contexts is the starting point of this thesis.

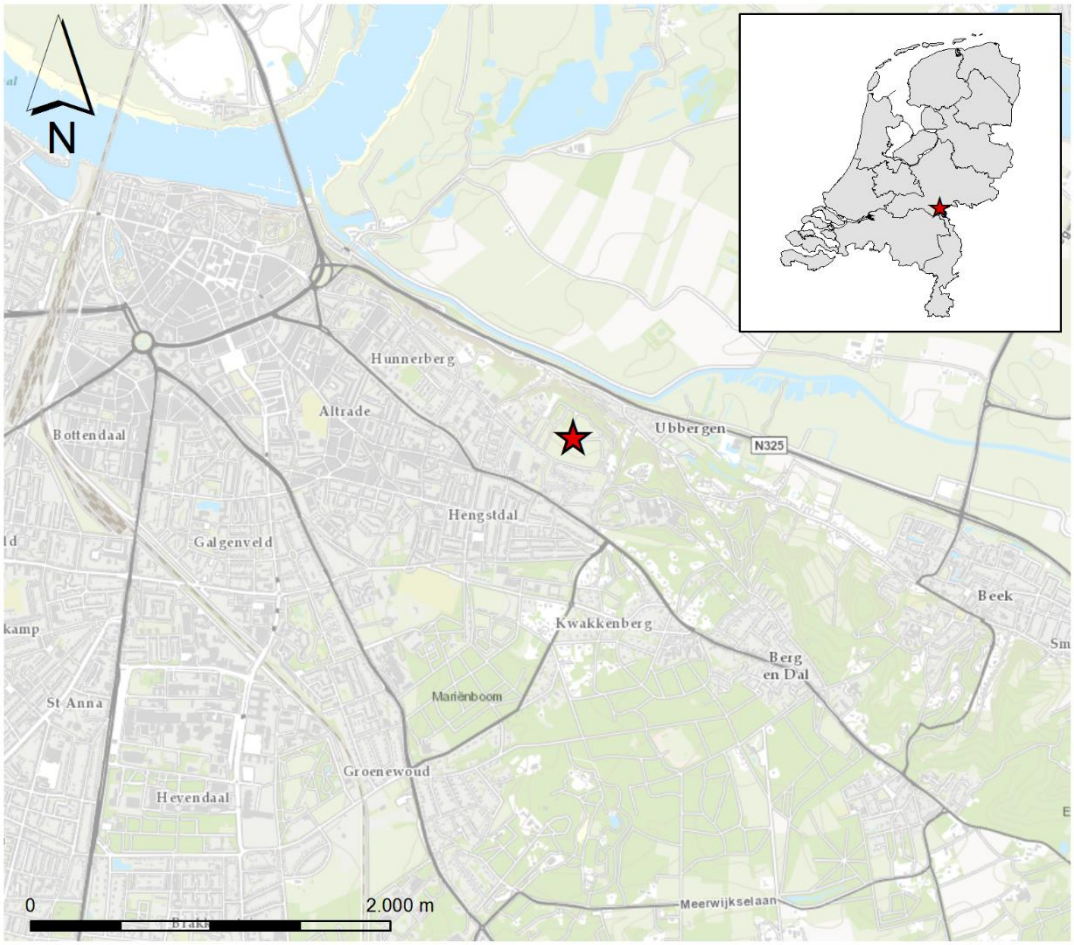

Fig. 1.1. Location of the excavation site on Kops Plateau in Nijmegen. Base layer: ESRI's Topo Basiskaart (in RD).

1.1. Research themes

The results of the 1986-1995 excavations were quickly published in the several excavation reports and an overview work for the general audience. Subsequently, several categories of the artefacts, in particular ceramic pottery, were studied and published.[2] Following the launch of the scientific program "Odyssee" by the Netherlands Organisation for Scientific Research (NWO) in 2008, a new and more elaborate study of the archaeological data became possible.[3] The results so far have been

[1] Toebosch 2003, 166.
[2] Van Enckevort & Zee 1996; for a complete bibliographic overview of the excavations reports and individual artefact studies, see Van Enckevort 2014a, 115-120. Several previous artefact studies will be discussed in more detail later on.
[3] "Nijmegen Kops Plateau: A Roman Fort".

two published bundles and a public accessible database of all the archaeological data obtained during the excavations.[4]

Although we have greatly improved our understanding of the Kops Plateau fortification because of these publications, we still know very little about the spatial developments that occurred on the plateau throughout the Roman occupation. So far no (published) attempt has been made to map the spatial organisation on the Kops Plateau and its development. The goal of this thesis is to do just that by analysing the chronological and spatial developments of contexts and their ceramic assemblage on an intra-site level. To reformulate this goal into a clear-cut question:

"How did the Roman fortification on the Kops Plateau develop during the pre-Flavian period, and in what way was space utilised over time by its occupants?"

To answer this question we have to go beyond the traditional treatment of the archaeological data of the 1986-1995 excavations. In this study we will approach the data "quantitatively", meaning that we will focus on the broader developments found within the archaeological data instead of studying the material and contexts separately as has already been done in previous studies. Archaeological contexts will be compared based on their ceramic assemblage in combination with our existing knowledge that we have obtained from the study of individual ceramic categories. Since the ceramics from the Kops Plateau are from clearly defined archaeological contexts, well studied and large in number, it is expected that using this artefact group in a quantitative approach will reveal the best results in our goal of mapping any form of spatial organisation on the plateau.[5] In turn this approach may even lead to a better understanding of the historical, social, economic and cultural processes that influenced the way Romans lived on the Kops Plateau.

From the start of this project it was the intention to incorporate the data from a new international study led by C. Carreras on the amphora vessels found during the 1986-1995 excavations.[6] Not only did this study redefine the typology of the amphora vessels, it also studied the content and origin of the material in greater detail. It was thought that this new information may provide an additional exploration of the spatial organisation on the Kops Plateau.

1.2. Research approach

Because an analysis of archaeological contexts on an intra-site level is rarely conducted, no standard research strategy currently exists. Therefore a new strategy was developed in this study in order to tackle the vast amount of data that the excavations of 1986-1995 have yielded. During the development the approach used in the recent published study led by R. Polak on the Hunnerberg legionary base in Nijmegen has been very influential.[7] In this study on the Hunnerberg contexts the exploratory statistical technique of the correspondence analysis is used to establish a chronological ordering of the contexts based on their assemblage. In this thesis we use the correspondence analysis but combine its ordering of the contexts with two spatial statistical techniques, namely a cluster and outlier analysis and a hot-spot analysis. This will enable us to both study the possible chronological developments of the Kops Plateau contexts and at the same time analyse their spatial developments over time. Each of these statistics will be discussed in detail in the next chapters.

[4] Van Enckevort 2014a; 2014b. The excavation data is freely accessible from the DANS website: https://easy.dans.knaw.nl/ui/datasets/id/easy-dataset:57281/tab/1;jsessionid=9318A377011595368FE9B0F70E23B9D1.
[5] See chapter 2 for a more expanded argumentation on the advantages of ceramics in a quantitative approach.
[6] Almeide 2014. A new more detailed (English) publication by Carreras and Polak is currently in the making.
[7] Kloosterman, Polak & Zandstra 2014.

1.3. A brief description of the site

The Kops Plateau is one of several plateaus situated on the north-western end of a lateral moraine, which extends from Nijmegen further south-east to Xanten (see figure 1.2). It is the last and highest plateau of significant size that also possesses a good overview of the river Waal and the surrounding lowlands. Because of its relative distant location from the urban centre of Nijmegen, no large-scale human interventions have taken place on the plateau since the Roman occupation. This lack of post-Roman building activities has left the remains of the fort largely undisturbed. Today the Kops Plateau is an open playground and park for the general public.[8]

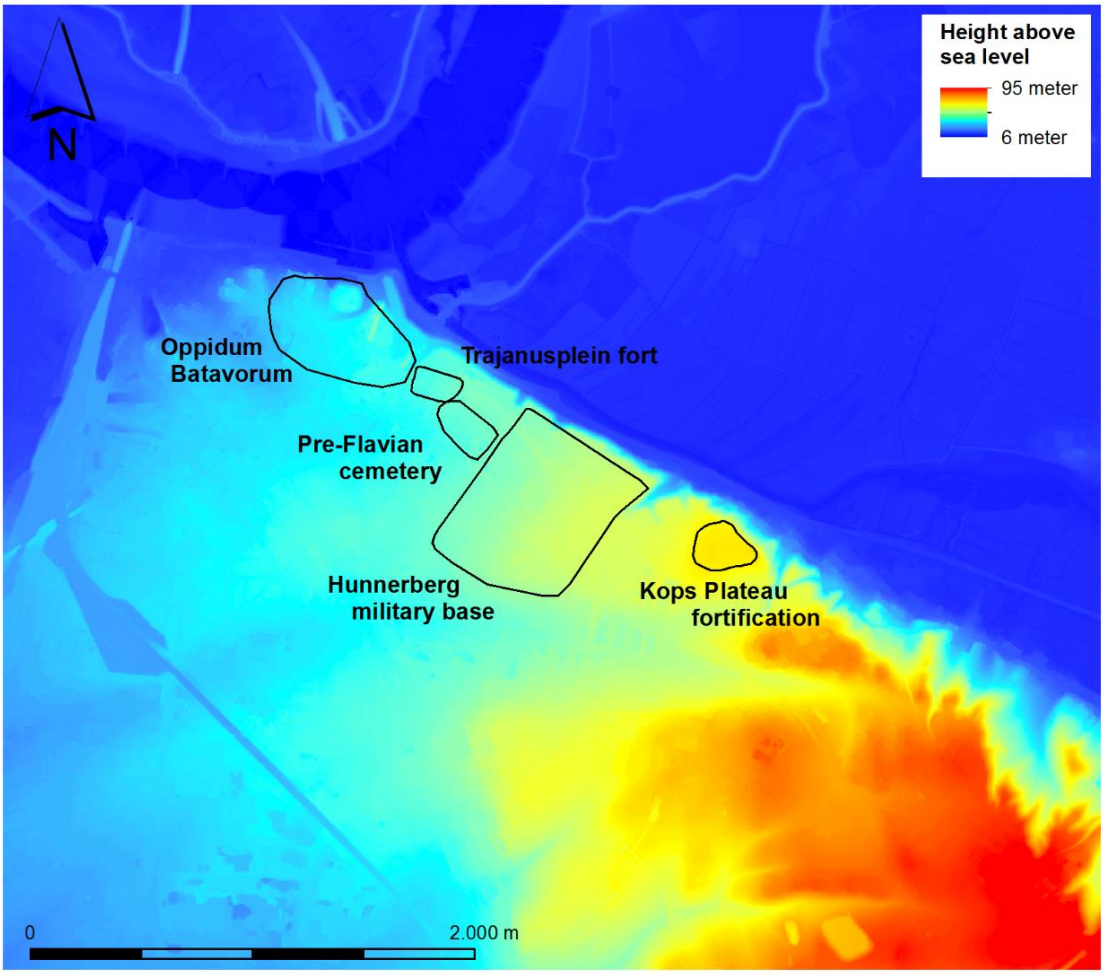

Fig. 1.2. Elevation model of Nijmegen in combination with the locations of pre-Flavian sites. Base map: Lidar-based digital elevation model (AHN – Actueel Hoogtebestand Nederland, www.ahn.nl).

1.3.1. History of excavations

The long history of excavations on the Kops Plateau started with the accidental discovery of several Roman pottery sherds on the northern flank of the plateau in 1914. The early dating of the findings triggered the attention of J. H. Holwerda, one of the leading Dutch archaeologists at that time. He quickly organised the first series of official excavations which lasted between 1915 and 1921.[9] The excavations revealed the remains of a settlement which Holwerda interpreted as the site of Oppidum

[8] For a detailed study of the post-Roman history of Kops Plateau, see Van Enckevort 2014a.
[9] Ibidem, 43-62.

Batavorum, the supposed "capital" of the "native" Batavians.[10] Closely following the ancient writer Tacitus, he argued that a thick layer of ash that was found during the excavations was evidence of the capitals ultimate destruction during the Batavian Revolt.[11]

Holwerda's theory was met with many critical reactions as colleagues doubted the indigenous character of the site.[12] Despite all the criticism it ultimately took two new excavations in 1971 and 1972 by the Radboud University Nijmegen[13] before his theory was conclusively debunked. These excavations, supervised by J. Bogaers and J. K. Haalebos, were conducted on the northern flank of the plateau and focussed on the stratigraphy of the site. According to the excavators, the small amount of hand thrown pottery that was found in the oldest archaeological layers could not, as Holwerda argued, indicate an indigenous Batavian settlement. Instead, Bogaers and Haalebos concluded that based on the artefacts the settlement on the Kops Plateau was probably an early Roman military fortification that was founded somewhere in the last decade of the first century BC.[14] Furthermore, excavations in the centre of the city of Nijmegen in the 1980s showed that Oppidum Batavorum was actually located there on the Valkhof.[15] In addition to the excavations, a palynological study was done by Teunissen en Teunissen-van Oorschot in the 1970s on colluvial deposits on the north-eastern slope of the Kops Plateau. The results show that the area had seen large-scale deforestation around the same time of the settlement's supposed foundation. The researchers also concluded that the remarkable amount of cereal pollen was an indication of a considerable extension of the arable fields.[16]

Archaeological research of the 1970s had shown that the site on the Kops Plateau was no indigenous settlement and probably had its origin during the first period of Roman advancements in the Lower Rhineland. However, it remained unclear exactly what the size or layout of the site was and who lived there. This all changed when in the 1980s plans were made for a housing project on the Kops Plateau. In a response to the possible destruction of the archaeological material that was still buried on the plateau the ROB, with the help of W. Willems and H. van Enckevort, conducted a series of rescue excavations from 1986 to 1995.[17] The excavation area was divided by a grid of 15 by 30 meter trenches and originally covered most of the plateau and some neighbouring areas. However, because of the limited timeframe, the decision was made to leave certain areas unexplored. Eventually the excavations uncovered an area of roughly 11 ha of the plateau and its surroundings (see figure 1.3). Although the housing project was never realised, the rescue excavations finally enabled Dutch archaeologists to get an accurate impression of the layout and size of the site on the Kops Plateau.

[10] Holwerda 1921. Note the quotation marks around the words capital and native. Much ink has been spilled on the origin of the Batavians and their supposed capital Oppidum Batavorum. However, there is no room for us to delve into these discussions. For a detailed overview of the early Roman history of Nijmegen, see Van Enckevort & Heirbaut 2010.
[11] Tacitus *Hist.* 5.19.
[12] Van Enckevort 2014, 63-75.
[13] Until September 2004 known as the Katholieke Universiteit Nijmegen.
[14] Bogaers & Haalebos 1975, 168.
[15] Enckevort & Heirbaut 2010.
[16] Teunissen, Teunissen-van Oorschot 1980, 260f. Cf. Polak & Kooistra 2013, 412 for objections against this conclusion.
[17] Van Enckevort & Zee 1996, 13-16; Van Enckevort 2014a, 107-111.

Fig. 1.3. Map of 1986-1995 ROB excavation trenches combined with those that were made by Holwerda. Base layer: aerial photograph (CycloMedia, Aerodata, ESRI Nederland).

1.3.2. Layout

Already in the first years of the excavations it became clear that the archaeological remains were part of a Roman fortification that occupied most of the highest parts of the plateau. The excavations uncovered approximately three-quarters of the fort with the exception of the north-eastern part which remained unexplored. The fort itself has a triangular plan that was adjusted to the shape of the elevation. Three ditch systems have been identified that encircle the same shaped space but of slightly different sizes: ca. 3.5 ha, 4.5 ha and little under 3.5 ha. This has led the excavators to believe that the ground plan of the fort was probably altered (at least) three times.[18]

The interior of the fort follows the basic principles of a Roman *castrum*.[19] The main divisions inside the fort is formed by its main roads; the *via praetoria* and the *via principalis*, which met in a T-junction at the centre. Remnants of the *via decumana*, the rear road, have not been found since the rear (north-west) of the camp has not been excavated.[20] The identification of buildings inside the fort is, at best, a tentative task. So far, only three buildings have been identified with some form of certainty (see figure 1.4). First, the headquarters building, the *principia*, was situated at the junction

[18] Van Enckevort 2014a, 122; Driessen 2007, 64.
[19] Johnson 1983, 27-35. Ideally Roman fortifications are built with a north-south orientation. This is not the case on Kops Plateau were the camp is tilted towards the west. Thus the north or backside of the camp is actually the west side.
[20] Van Enckevort 2014a, 13.

of the *via principalis* and *via praetoria*, positioned so that it was facing the latter street. Nothing is known about the internal plan of the headquarters and only the outer perimeter of the complex has been reconstructed.[21] Second, a long rectangular structure has been found east of the *principia* on the opposite side of the *via principia*. Although it was initially identified by Holwerda as a possible water basin, the 20 by 10 meter long structure is now commonly described as a storage building or *horreum*.[22] Third, a large-scale complex was uncovered in the north-western part of the fort. This large structure was built in alignment with the north-eastern ridge of the plateau instead of following the grid-like pattern of the roads. A narrow street with a strip of rectangular structures, possibly *insulae*, separated the complex from the *via praetoria.* From the outset, this unusual large structure has been identified as a *praetorium*, the residence and office building of the commander of the fort. In comparison to the two other buildings, the *praetorium* has received much attention since its discovery and plays an important role in the interpretation of the forts original function.[23]

During the excavations an auxiliary camp was discovered just south of the main fort. This small annex of the main fort seems to have clustered around a large stable complex. In addition, a large number of iron and bronze cavalry-related artefacts – including the famous Batavian ceremonial cavalry helmets – were found in contexts spread across the campsite. This has led archaeologists to believe that the annex might have functioned as a station for a Batavian cavalry unit.[24] The before mentioned deforestation of the area has also been attributed to the need for practice space for cavalry training.[25] Two other possible auxiliary camps are located just east and west of the main fort but not much is known about these sites.

[21] Van Enckevort & Zee 1996. Two latrines that are thought to be part of the complex are discussed on p. 59.
[22] Van Enckevort 2014, 59 note 116.
[23] For a detailed study and reconstruction of the complex, see Peterse 2005.
[24] Van Enckevort & Zee 1996, 55-62.
[25] Driessen 2007, 70-71.

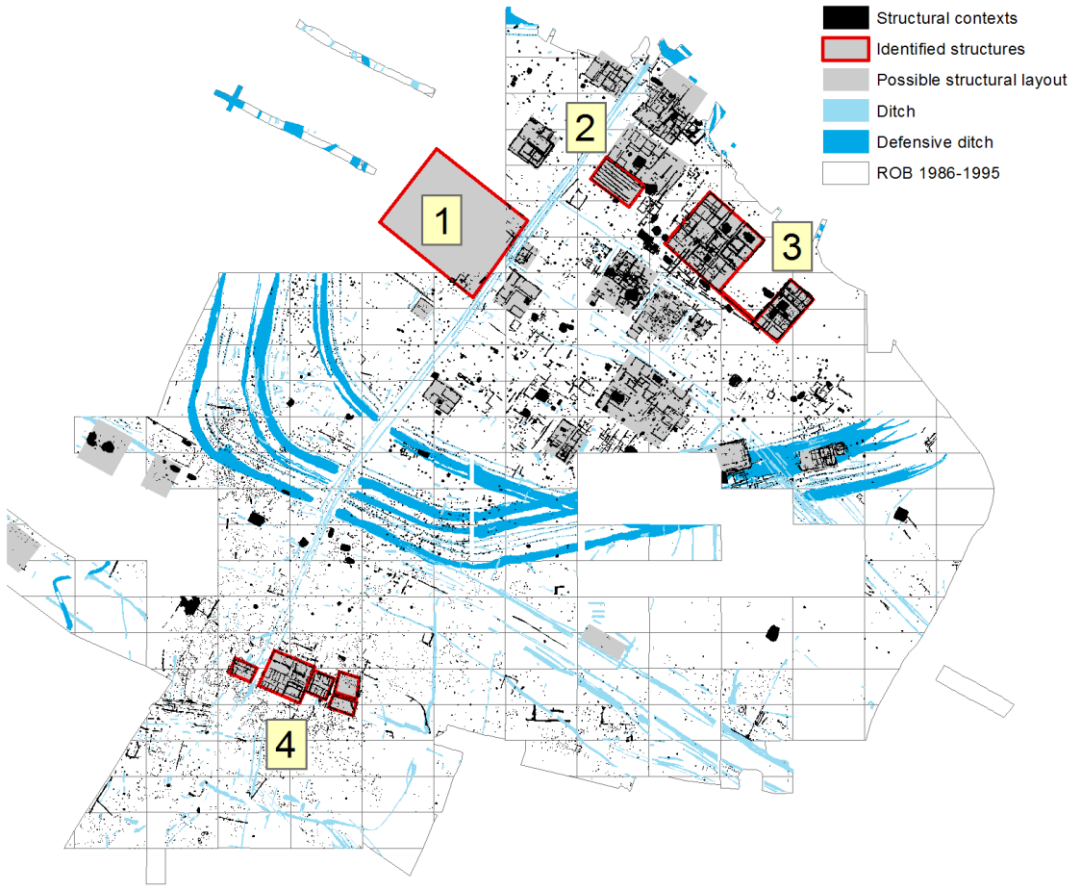

Fig. 1.4. Map of contexts related to structures. 1: Principia. 2: Horreum. 3: Praetorium. 4: Stable complex.

1.3.3. Chronological developments

The exact chronology of the Roman fortification on the Kops Plateau is still uncertain. The coin collection, especially the Nemauses *asses*, found during the excavations of the fort indicate a foundation date of ca. 12 BC.[26] A much earlier date has been proposed by García-Bellido. Based on the presence of several Spanish coins and a great number of *asses* from Vienna, she believes that the Kops Plateau may already have been used as a military base during Agrippa's first governorship.[27] This hypothesis is, however, not widely accepted and has received some critical responses.[28] Although it cannot be ruled out that the plateau was visited by Roman troops before, a majority of the evidence points towards a foundation date of ca. 12 BC.

The early dating of the fort, its relative small size and the presence of the disproportioned large *praetorium* has led to much speculation about the original function of the fort. The excavators have argued that the fort in its initial phase may have served as a command post for the Roman army during the military expeditions of Drusus.[29] In 12 BC Drusus' expeditions were initially focused on Germanic tribes west of the river Rhine. This made it possible for the Romans to rely on existing infrastructure that was already in place around the area of modern Nijmegen. The possible function of the fort as a command post for Drusus' expeditions has also led to some speculation on the

[26] Beliën 2008, 181-183.
[27] García-Bellido 2007, 165-168.
[28] Especially Baliën 2008, 181-188.
[29] Van Enckevort & Zee 1996, 32-35; Driessen 2007, 67-80; Willems & Van Enckevort 2009, 35-41.

possibility that Drusus himself might have used the fort as his personal winter quarters.[30] It is possible that the original function of the fort was indeed connected with the activities of Drusus. However, the military focus of the military campaigns already shifted further into eastern Germania from 11 BC onwards. This would have made the location of the command centre most problematic as it quickly became far removed from the frontlines.[31]

An alternative interpretation of the forts first phase was made by Slofstra. The fort might have been used as the seat of a *praefectus gentis* or *civitatis* who oversaw the observance of the treaty that was made between Rome and the Batavians.[32] As pointed out by Polak and Kooistra, the Kops Plateau is located at the fringes of the Batavian territories which would have made the fort ill-suited as a mere watch post. The use of the site as an official seat of regional Roman power is therefore much more probable.[33]

The original fort on the Kops Plateau is believed to have been replaced by a slightly larger fortification of 4.5 ha around 10 AD. The construction of this second fort might have been part of the new military infrastructure overseen by the young general Germanicus. It is also possible that the second phase is connected with the redeployment of Roman troops in AD 9 by Tiberius following the catastrophic defeat of Varus. The enlargement of the fort probably did not lead to any big interior changes. Since the *praetorium* remained in use, it is believed that the function of the site did not change either.[34]

The third rebuilding of the fort took place around AD 35-40. It were the last major adjustments to the site before the Kops Plateau was abandoned around AD 69/70. The size of the fort was reduced to more or less its original plan of ca. 3.5 ha. A possible explanation for all these renewed building activities might have been Claudius' reorganisation of the Lower Rhineland.[35] The original roads remained intact but archaeological evidence indicate that several buildings might have been rebuilt. Also the *praetorium* underwent some changes and it is thought that only the east wing of the complex remained in use.[36] In addition, the stable complex and auxiliary annex just south of the fortification are thought to have been constructed during this last phase. Because the fort was never burned down during the Batavian Revolt – a fate which Oppidum Batavorum did not escape from – it has been suggested that the Batavian *Ala Batavorum* might have been stationed there. Because these local cavalrymen already occupied the Kops Plateau at the outbreak of the revolt, there was no need to destroy its fortifications.[37]

1.3.4. Pre-Flavian Nijmegen

Apart from the fortification on the Kops Plateau, two other pre-Flavian military settlements are known in Nijmegen (see figure 1.2). A few hundred meters east of Kops Plateau, a large legionary fortress was built at the Hunnerberg. This Augustan base was an irregular square of ca. 42 ha and situated on a plateau slightly lower than Kops Plateau. Research done by F. Kemmers on the coin assemblage has pointed out that it is the earliest Roman military site in the Lower Rhineland, dating

[30] Willems & Van Enckevort 2009, 39. It has been pointed out, however, that according to ancient sources Drusus always spent his winters back in Rome (Polak & Kooistra 2013, 408-409).
[31] Polak & Kooistra 2013, 408.
[32] Slofstra 2002, 27f. Cf. Driessen 2007, 65; 69 and 72.
[33] Polak & Kooistra 2013, 409.
[34] Ibidem, 422-426: for an overview of the discussion on the effects cause by military reforms of Germanicus and Tiberius.
[35] Van Enckevort & Zee 1996, 55.
[36] Driessen 2007, 71.
[37] Van Enckevort 1995, 57.

back to the period of Agrippa's military expeditions in 19 BC.[38] The Augustan base remained in use to around 16 BC, thus placing its occupation period before the military campaigns of Drusus.[39] However, it should be noted that the base appears not to have been immediately abandoned, but was probably maintained by a small military detachment for some time.[40]

A second pre-Flavian military settlement was built at the modern Trajanusplein, a few hundred meters west of the Hunnerberg. It was a short-lived irregular fortification of ca. 1.9 ha and its supposed function was to control the ford of the river Waal and the adjacent civilian settlement of Oppidum Batavorum on the Valkhof. Although two building phases have been distinguished, it is believed that this small stronghold was only occupied from AD 10 to 20.[41] The construction date of the Trajanusplein fortification is connected with the same events that triggered the rebuilding of the fort on the Kops Plateau.[42]

1.4. The Roman fort on the Kops Plateau

This study of the contexts on the Kops Plateau based on their ceramics assemblage is divided into two parts. The first consists of two chapters and will focus on the chronological developments of contexts. Chapter 2 contains a statistical analysis of the contexts based on their ceramic assemblage. It discusses the possible phases of the contexts and the chronological developments of various ceramic vessel types. Chapter 3 is devoted to a case-study on the chronological developments of amphoras based on their content and provenance. Our main goal here is to study the changing popularity of different amphora contents and production centres.

The second part of this study is about the spatial distribution of the archaeological contexts and consists of two chapters. Chapter 4 begins by combining the chronological ordering of the contexts with an analysis of their spatial characteristics. An important theme that will be discussed here is whether similar dated contexts also show spatial correlation. The spatial statistics will show where contexts where most concentrated at various stages of the occupation period. Chapter 5 will focus on amphoras and their distribution across the site. By studying possible rubbish dumps of amphoras a number of areas are identified which show a strong association with specific products.

Chapter 6 will recapitulate the results of the previous chapter and incorporate them into an overall answer to our main question.

[38] Kemmers 2005, 13-57.
[39] Ibidem, 44-49. The latest coins found on the Hunnerberg might date back to 15 BC at the latest.
[40] Heirbaut & Van Enckevort 2009, 106.
[41] Van Enckevort 2011, 64-68. Cf. Bloemers 1973, 29.
[42] Polak & Kooistra 2013, 422.

2. Establishing a relative timeline

In this chapter the aim is to establish a relative chronological seriation of the contexts based on their artefact assemblage. The results of the correspondence analysis will be used to explore the chronological developments of individual ceramic artefacts in order to detect possible phases in the ordering of contexts. The goal is to provide a detailed chronology of the fort on the Kops Plateau which can be compared with the existing narrative of the site.

2.1. Chronological seriation

Chronological seriation[43] is a methodological approach in archaeology which may create time-related sequences of archaeological contexts based on their artefact assemblage. The basic assumption with this approach is the changing pattern of artefact usage and their single-peakedness of the distribution over time. This means that artefacts are expected to have a "life cycle" that evolves from non-existence, to an increase in numbers due a rising popularity, to disappearance. The idea is that the assemblage of a context is supposed to be a "sample" of the artefacts that were used during the time in which the context was created and eventually closed off.

The success of chronological seriation primarily depends on the choice of typology used to describe the artefact forms and whether or not this typology possesses a strong chronological component. Artefact types that either had multiple peaks in popularity (multimodal distribution) or no chronological development at all are not suitable for seriation and including these types in an analysis can cause inaccurate results. Chronological seriation does not provide absolute dating but may result in a relative chronological ordering of contexts, thus representing time without a scale.

In order to perform a seriation on a dataset, the data is stored in a contingency table (crosstab), where each of the rows corresponds to a context and each of the columns corresponds to an artefact type present in one or more of the contexts. There are many different methods for chronological seriation but today the most popular one is based on the exploratory technique of correspondence analysis (CA). Over the last several decades the use of this application has steadily increased in all disciplines of social science and also in archaeology it has gained popularity since the 1980s.[44] Archaeologists have used the technique for various purposes including the study of socio-economic patterns, faunal distribution patterns, stratigraphic and formation processes and chronological seriation.[45]

We will not go deeper here into the theoretical and mathematical background of the CA as a chronological seriation method, since these can easily be found in the excellent publications by M. J. Greenacre.[46] Some of the more simple principles are, however, necessary to understand the presentation of the analysis results discussed below. Therefore a brief non-technical introduction to CA will be given before we will continue with the actual results of the CA.[47]

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[43] Seriation is simply put the ordering of things based on certain variables.

[44] For a detailed history, up to 1992, see Baxter 1994, 133-139. Cf. Baxter 2003, 12-13.

[45] Expositions on CA from an archaeological standpoint, see Shennan 1997, 308-341, Baxter 1994, 100-139 and Baxter 2003, 136-146. Detailed examples on the use of CA for seriation can be found in Jensen & Nielsen 1997, 29-61, Nance 2013 and Bayliss *et al.* 2013.

[46] Greenacre 1984 provides a thorough mathematical account, with a more approachable revision in Greenacre 2007.

[47] The computer program that was used for running the CA is "R", a free and open-source program for statistical computing. All graphical results under discussion here are produced with R. For a detailed introduction into R from an archaeological perspective, see Alberti 2013b, Baxter & Cool 2010 and Baxter 2015.

2.2. Correspondence analysis

CA is an exploratory technique developed to graphically represent patterns within contingency tables. This graphical output is what makes the technique such a useful seriation method. Essentially what a CA does is reducing a contingency table to a two-dimensional scatterplot where row and column variables are represented as points.[48] The visual display of data patterns helps the interpretation of large and complicated datasets (as is often produced by excavations).

On the scatterplot map, the distance between row points (i.e. contexts) is related to the degree to which rows have similar "profiles" in terms of their artefact assemblage; points which are very distant from each other correspond to contexts which have very different assemblage profiles. The same goes for the points that represent the column variables (i.e. artefact types). Points which are close together identify artefacts with similar distribution profiles across the contexts. As for the distance between row and column points, it tells us something about the "correspondence" between the contexts and types. The more a row point is closer to a certain column point, the larger the proportion is of that artefact type in the assemblage profile of the context. When the CA is calculating the distance between each profile, not all are equally important. Simply put, profiles that occur infrequently are weighted less to reduce their contribution to the overall distribution of the points on the scatterplot. It is therefore important that the individual contributions of types are taken into account when analysing results from a CA.

Performing a CA is an iterative process, often based on trial-and-error. The first time you run a CA the results can be unpredictable and it might take several reconfigurations of the data input in order for any relative patterns to emerge.[49] After a clear pattern does become visible, the first step is to interpret this ordering and see if it represents a chronological seriation. Often when a strong chronological seriation is present in the dataset, the CA produces a parabola or horse-shoe pattern of row and column points. The presence of such a pattern is called the Guttmann-effect and provides a first clue of the existence of seriation within the dataset.[50] The next step is to interpret in which order we should read the chronological ordering. In most cases it is the first dimension or X axis of the scatterplot that is representing time.[51] Analysing the sequence of artefact types on this axis usually reveals the order in which to read the relative chronology of the seriation. Because the row points are placed on the same axes and their position is based on their assemblage of artefact types, the ordering of row points on the X axis can also be interpreted as revealing a chronological sequence.

2.3. Preparing the data of Kops Plateau

During the excavation on the Kops Plateau, 18 different artefact groups or "material groups" were distinguished, ranging from ceramics like pottery and building material to glass and metal objects.[52] Pottery is by far the most numerous of these material groups and seven can be related to the Roman period on Kops Plateau.[53] For our analysis it was decided to focus on the ceramic assemblage of contexts. There are three reasons for this. First, ceramics are large in number and are present in the majority of contexts; secondly, the typology of ceramic vessels is well documented and thirdly, their

[48] In mathematical terminology, a dataset has as many dimensions as it has column variables. In most cases the total number of "dimensional space" can be reduced to just the first and second most relevant dimensions which are usually represented by the X and Y axis on the scatterplot respectively.
[49] See the next paragraph for more information on the process of preparing data for a CA.
[50] Greenacre 1984, 226-232. For a detailed analysis of the Guttman effect, see Camiz 2005.
[51] Shennan 1997, 343; Lock 2003, 127; Jensen & Nielsen 1997.
[52] Three additional "groups" in the dataset are ignored as they are mistakes or no material category.
[53] Two other possible Roman-related material groups are prehistoric and hand thrown ceramics. They are excluded though because no clear typology was available to them.

typology is clearly rooted in chronology. This artefact group is therefore best suited for chronological seriation.

Almost 400.000 sherds attributed to 484 different ceramic vessel types were found in 7190 contexts during the excavation on the Kops Plateau. When preparing the data for the CA it became apparent that not all of these types and contexts were suited for the analysis. Three basic steps of selection were taken during the preparation phase which reduced the total of types and contexts.[54] First, several types were combined together because of their similar chronological profile. This was done primarily with types that are small in number in order to preserve them during the analysis. Secondly, contexts that proved to be unsuitable for the analysis. An obvious example are the roughly 1100 contexts that were removed because they simply did not possess any ceramic material at all. Third, contexts and types that were identified as "outliers" during the initial testing of the CA. Outliers are profiles that dramatically deviate from the rest because of having very small (or large) numbers. Because of this deviation, outliers are placed far away from the other points, dominating the plot and causing the other points to cluster together. Whether outliers actually disrupt the analysis and should be removed is up for debate as it has been stressed that this problem is only a matter of graphical layout; outliers do not actually affect the relative distance between points but only the scale of the plot.[55] In the context of this study, however, removing the outliers that are time-related can actually benefit the analysis as it narrows down the relative timeframe of the data.[56] In our case, contexts that do not belong to the Roman occupation period on Kops Plateau are relative small in size and usually have a very unique combination of late vessels or too few, in which case their assemblage profile is dominated by one of these late vessel types and causes disruptive behaviour. To counter this problem, a threshold was created, removing all contexts that have less than 3 different vessel types in their assemblage and all types that are present in less than 3 different contexts.[57] Eventually a total of 96 types and 2799 contexts were used for the CA.

For the purpose of assemblage comparison the way vessel types are counted needs to be directly comparable. Fragmented vessels found on the Kops Plateau were recorded by two measures; sherd count and estimated number of individuals. Sadly, both ways of quantifying vessels lack the property of direct comparability. Sherd fragmentation differs per vessel type because certain vessels break easily compared to other more robust forms. The resulting effect would be a disproportional influence of certain types of vessels on the profile of contexts.

The estimated individual count was intended to provide the solution. Based on the amount of fragments, specialists estimated the number of complete vessels to which the sherds belonged to. During the initial testing with the CA, however, it became apparent that the estimated number of individual count was inconsistent due to unknown reasons.[58] As an alternative, the row entries were counted as a way of quantifying vessel types. This is far from ideal as it basically reduces the frequency of vessel types to either zero or one – absent or present – but it is the least biased measuring method to use.

[54] See Appendix 1 for a detailed description of the selection process.
[55] Greenacre 2007, 267-270.
[56] This process, also called "data peeling", is illustrated in Cool & Baxter 1999.
[57] This threshold is rather subjective than based on solid statistics. As stated before, CA can be an iterative process with a high level of trial-and-error. Analyses with different thresholds did not yield any different results.
[58] The problem has largely to do with the way data was added to the database. It seems that the column for the estimated individuals was sometimes also used for other measurements.

Before we continue with the CA results of the Kops Plateau data, a word of caution has to be made about the representativeness of these results. As stated above, not all find contexts were used in the chronological ordering produced by the CA. Material that is present in these unused contexts therefore had no influence on the CA results. Thus, when we analyse the distribution of ceramic material we have to remember that it does not show the complete artefacts assemblage.

2.4. Results

The results from the CA based on the data described above can be seen in figure 2.1. Apart from the horse-shoe pattern a quick glance at the positioning of the vessel types on the X axis reveals a seemingly clear chronological sequence. Reading the axis from left to right we can distinguish an ordering of Augustan to Flavian vessel types. As mentioned before, it is important to identify which of these vessel types contribute most to the ordering on the X axis (first dimension). Figure 2.2 is a bar plot displaying the contributions of all types used in the analysis, ordered by their position on the X axis. The reference line indicates the threshold (average contribution) above which any contribution should be considered important for interpreting that axis.[59] Looking at the distribution of types across the X axis and their contribution, two clusters of highly contributing types can be identified on either side of the axis centre. Starting on the left side, the first cluster of highly contributing types is dominated by the relative early Arretine terra sigillata cup Haltern 7C.[60] Two other important Arretine types are the Haltern 1B/C dish, followed by the Haltern 8 cup. In the first cluster we also find the group "Augustan beakers" (AUG_BEAKER), which includes the so-called ACO beaker Oberaden 34. Other early drinking vessels that show a significant contribution to the left side of the axis are the Haltern 41 beakers and the *Rillenbecher* Oberaden 30 (Haltern 43A).

The second cluster is found on the right side on the axis centre and is primarily composed of the Stuart 149 mortarium, Hofheim 50 jug and the South Gaulish terra sigillata cup Dragendorff 27 – all commonly found from the Claudian period onwards. Other highly contributing South Gaulish sigillata types are the Dragendorff 15/17 dish and Dragendorff 18 dish. Also the colour-coated cup Hofheim 22 should be considered an important type in this cluster.

The strong opposition between Arretine and South Gaulish terra sigillata vessels is obvious. This is no surprise as Arretine vessels were popular in the Augustan and Tiberian periods while those produced in Southern Gaul were introduced during the reign of Tiberius and dominated the market by the time of Claudius.[61] If we look at the timeframe of the Roman occupation on the Kops Plateau, 12 BC – AD 69/70, the transition from Arretine to South Gaulish wares occurred roughly halfway, explaining the clear left-to-right ordering of types belonging to these two groups.

The two clusters of significant contributing types on either side of the axis centre allow us to make a first educated guess on how the "relative timeline" that the X axis is supposed to represent should be read. Because the timeline is dominated by two groups on either side of its axis centre, two distinct time phases can be identified. To the left of the centre, the axis ordering is dominated by relative early types that are strongly connected to the Augustan-Tiberian period. On the right side the ordering is determined by younger vessel types, primarily dating to the Claudio-Neronian period. It can be suggested that the ordering of contexts show some resemblance with the previous discussed theory of the fort's three building phases. Although we should not blindly follow this theory, it is

[59] Greenacre 2007, 82.
[60] When the finds were identified and recorded the typologies from Haltern and Oberaden were used for terra sigillata vessels; the new Conspectus typology (Ettlinger *et al*. 1990) was not yet published at that time. This study upholds the old typology for convenience.
[61] See next section for a general overview of the development of Arretine and South Gaulish terra sigillata.

possible to see the three phases in our relative timeline. Contexts that are placed on the left side of the axis might be related to the first building phase of the Roman fort on the Kops Plateau while the contexts on the right can be identified as belonging to the third building phase. The middle part of the axis, between the two clusters, might actually represent the second building phase of the fort between early Augustan phase of the fort and the later Claudio-Neronian phase.

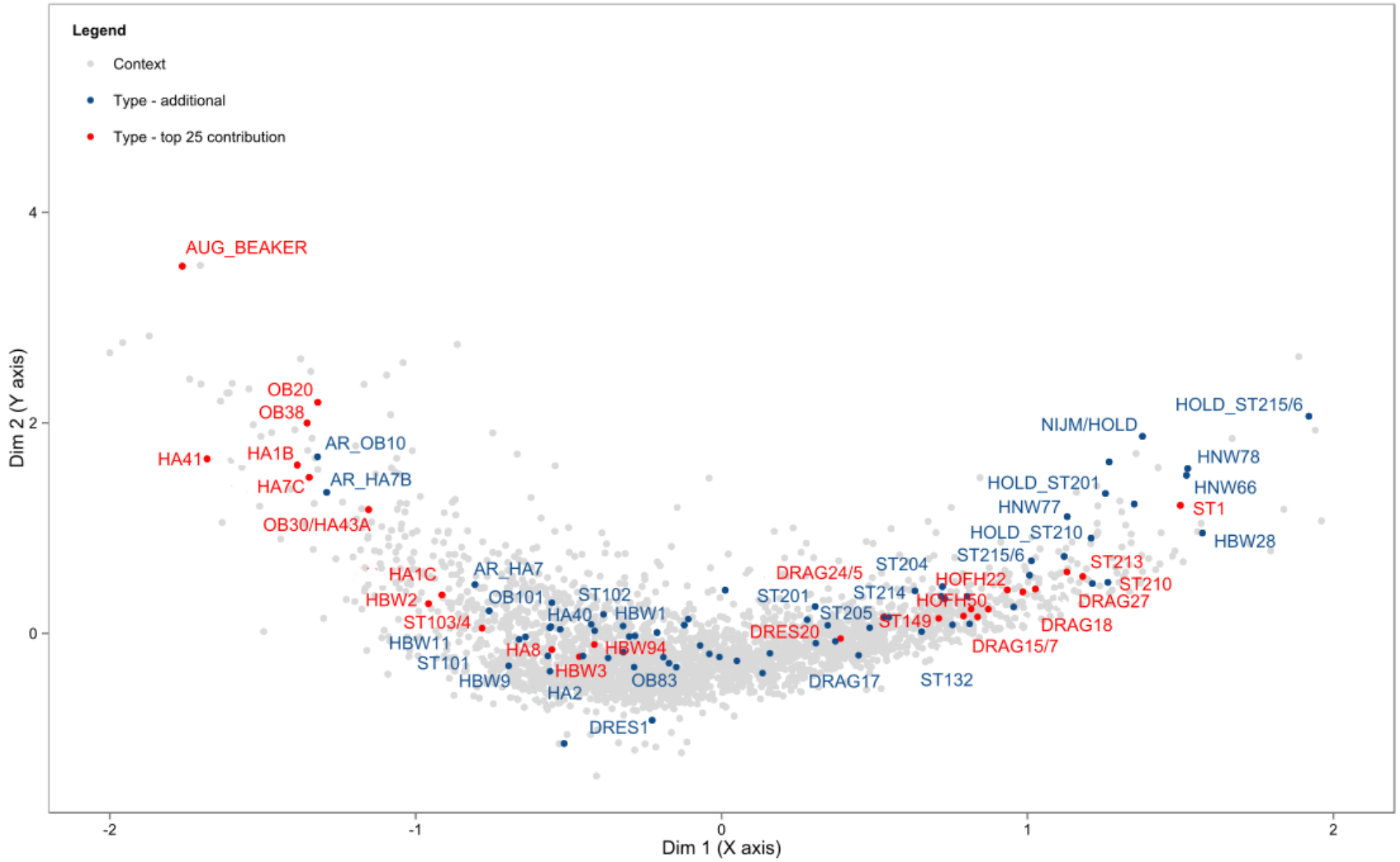


Fig. 2.1. Scatterplot of CA results. The 25 types that have the highest contribution to the ordering on the X axis are labelled in addition to several other types. The variance of dimension 1 and 2 are 3.372% and 2.050% respectively.

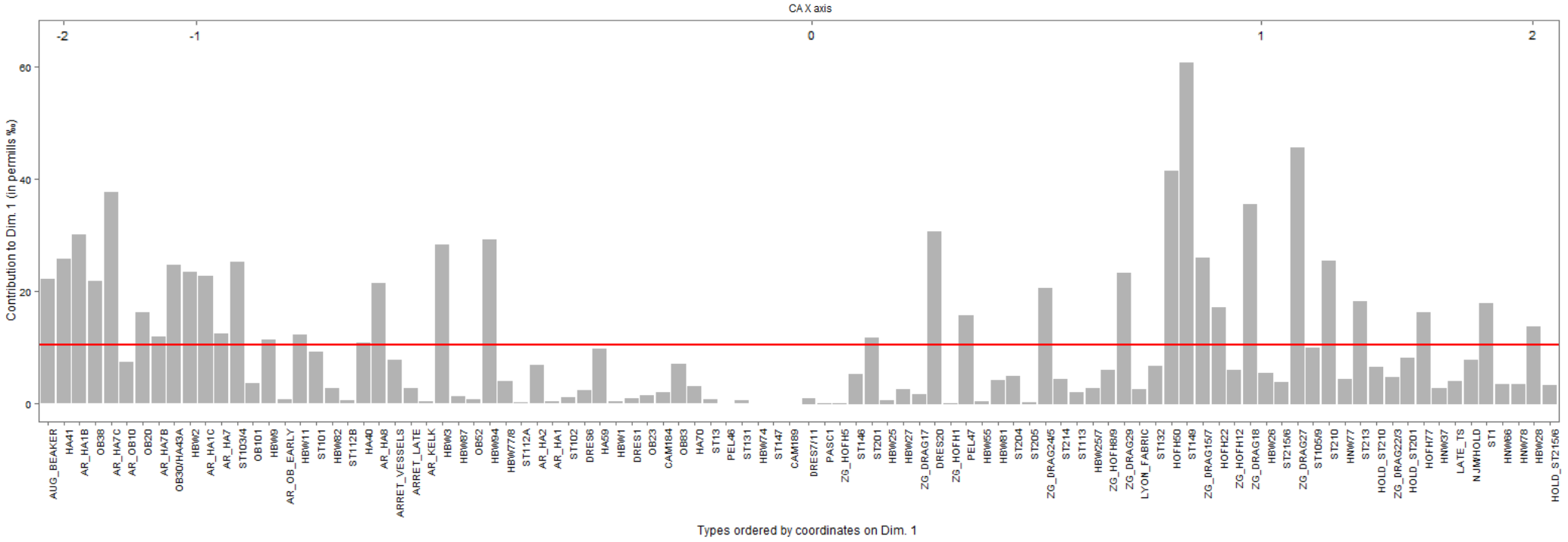


Fig. 2.2. Bar plot of the contribution (in permills ‰) of vessel types to the X axis (first dimension) and ordered on the X axis. The reference line indicates the threshold and is based on the average contribution of all types

2.5. Chronological distribution of diagnostic types

Besides the ordering of the individual types, we can analyse their distribution across the contexts to further examine the chronological significance of the X axis. Based on our current knowledge of ceramics it is possible to reconstruct whether specific vessel types increased or decreased in numbers during the occupation period on the Kops Plateau. A thorough analysis of these "diagnostic" vessel types will be discussed below. Two additional ceramic groups, coarse wares and potters' stamps, will be discussed. Although coarse wares are not really considered to be a diagnostic group and potters' stamps were not included in the CA, it will be shown that both can still contribute to the examination of the chronological ordering of the contexts.

2.5.1. Arretine & South Gaulish terra sigillata

During the initial interpretation of the CA results we already briefly explored the ordering of several Arretine and South Gaulish sigillata vessel types. Before mapping and analysing the chronological development of the individual types, let us first focus on the two main groups of sigillata; the Arretine[62] wares from Italy and Lyon, and the South Gaulish wares from La Graufesenque. It is important to explore the transition from Arretine to South Gaulish sigillata because it will further our understanding of the relative chronological ordering of the contexts produced by the CA.

In the Lower Rhineland, Arretine sigillata was primarily introduced during the military expeditions of Drusus between 12-9 BC. The production itself started earlier in Arezzo (Arretium) by ca. 30 BC[63] and Arretine styled sigillata quickly became a popular export product to military camps in the northern parts of the Empire. By the end of the century other production centres had been established in Pisa and Lyon (Lugdunum) in Gaul and from there the export of Arretine sigillata continued. By the first decade of the first century AD, again, new production centres emerged in South Gaul. At first, potters from this area copied the existing Arretine wares but soon they started producing new forms and thus creating a "South Gaulish" style of sigillata.[64] The majority of South Gaulish sigillata came from La Graufesenque, the largest and most successful production site in the region. Large-scale production here continued up until the early second century until it was finally surpassed by other sites in Gaul.[65]

Because the transition from Arretine to South Gaulish sigillata occurred during the occupation period of the Kops Plateau, chronological developments within this material group should become visible when mapping their distribution across the chronological ordered contexts. As a first example, a comparison is made between the contexts containing only Arretine forms, only South Gaulish forms or both groups of terra sigillata.

Based on the above mentioned development, the hypothesis is that contexts containing Arretine types should be concentrated on the left side of the axis centre, while terra sigillata types from South Gaul should be most prominent in contexts that are distributed on the "younger" right side. The contexts that contain both forms represent the transition period when the time South Gaulish ware was first

Type	Contexts	Sherds
Arretine	1177	5018
South Gaul	713	2183
Both forms	616	9996
Total	**2506**	**17197**

Table 2.1. Frequencies of contexts containing terra sigillata sherds.

[62] Terra sigillata from Italy and Lyon is usually called "Arretine" because of an erroneous assumption that it was only produced in Arezzo (Arretium).
[63] Ettlinger et al. 1990, 6.
[64] For a detailed survey of the South Gaulish production centres, see Polak 2000, 15-38.
[65] Ibid, 48-51.

introduced on Kops Plateau. Logically these contexts are predicted to be placed between the other two context groups.

A first look at the distribution of the contexts on the CA scatterplot seems to confirm the hypothesis (see figure 2.3). When we take the three groups separately and solely display their position in relation to the X axis, the chronological development from Arretine to South Gaulish forms becomes even clearer (see figure 2.4). Another way of looking at the distribution of the sigillata forms on the X axis is by visualising the data as a box plot (see figure 2.5). Also known as a "box-and-whisker plot", the box plot is an exploratory graphic used to visualise the distribution and skewness of a dataset at a glance. In short, the boxed area contains 50 percent of all row points (i.e. contexts), which in the context of this study can be interpret as representing the "peak" of a specific form.[66] In our example, the box plots clearly show that contexts containing only Arretine forms peak earlier on the timeline than the contexts containing only forms from South Gaul. Looking at their distribution range, we see that Arretine sigillata are well represented in contexts past -0.5 on the X axis, opposed to sigillata from South Gaul. The opposite occurs on the right side of the axis centre were we continue to find South Gaulish forms in contexts past the +1.0 but less Arretine forms. Those contexts that do contain Arretine forms are marked as outliers (symbolised by the "+" sign).[67] In turn, contexts with South Gaulish sigillata quickly decrease near +2.0 and the last contexts are also identified as outliers. This might indicate that the end of the Roman occupation of the Kops Plateau is situated somewhere between +1.0 and +2.0. The distribution peak of contexts containing both sigillata forms is evenly positioned between the other groups and placed on the axis centre, emphasising an even distribution across time. The distribution range between -1.0 and +1.0 nicely fits with the range of contexts containing only one of the two forms.

[66] See Appendix 3 for a detailed description on how to read boxplots.

[67] Interpreting outliers in the box plot is in the context of our study rather subjective and is largely based on the knowledge we have of the chronology of the vessel type. In the Arretine example discussed above, contexts on the edges of both sides are marked as outliers. However, the contexts on the left side should not by definition be seen as chronological outliers as it is expected that the oldest contexts contain Arretine ware. Only the contexts on the far right can be seen as chronological outliers.

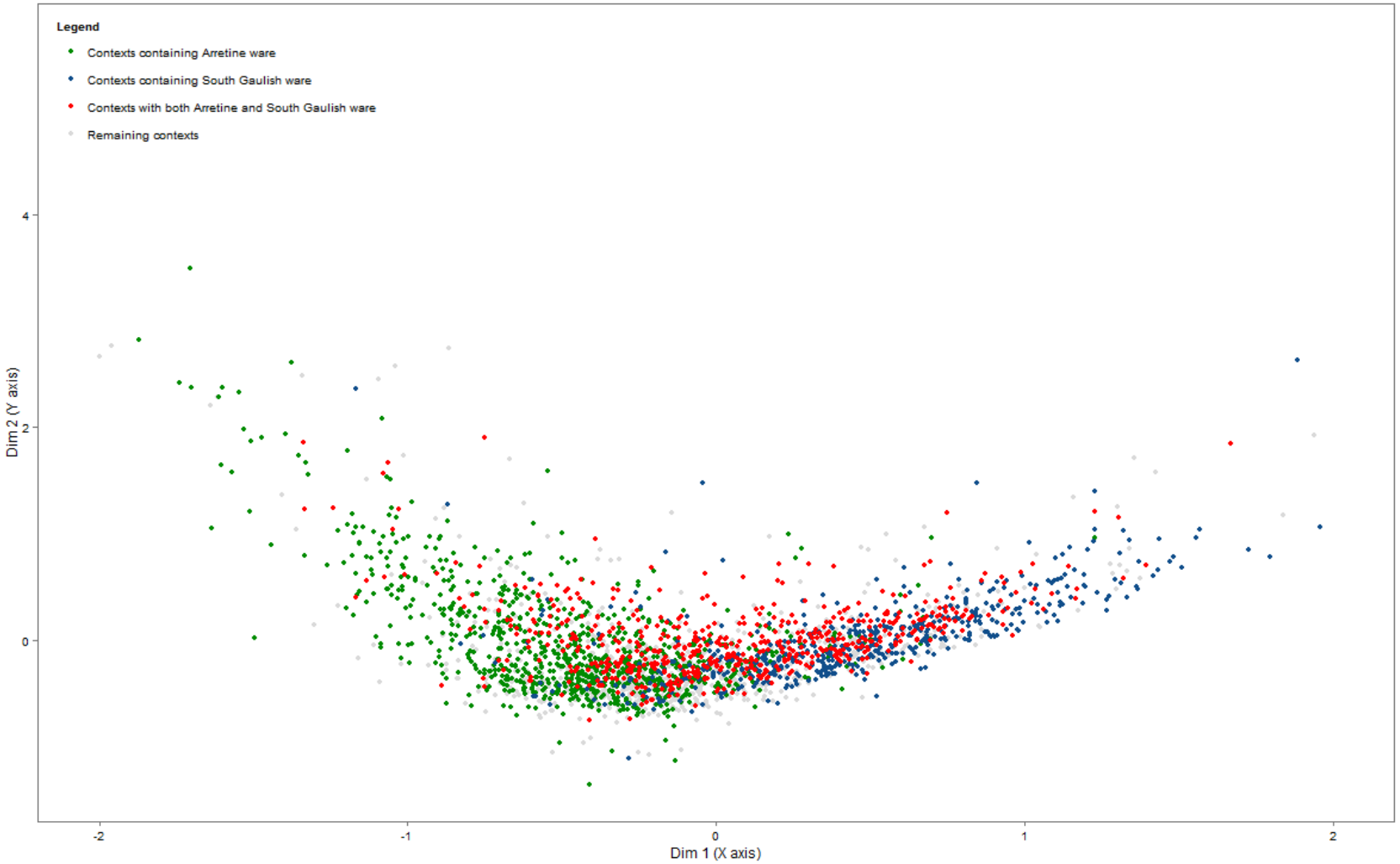


Fig. 2.3. CA scatterplot with highlighted contexts that contain terra sigillata forms.

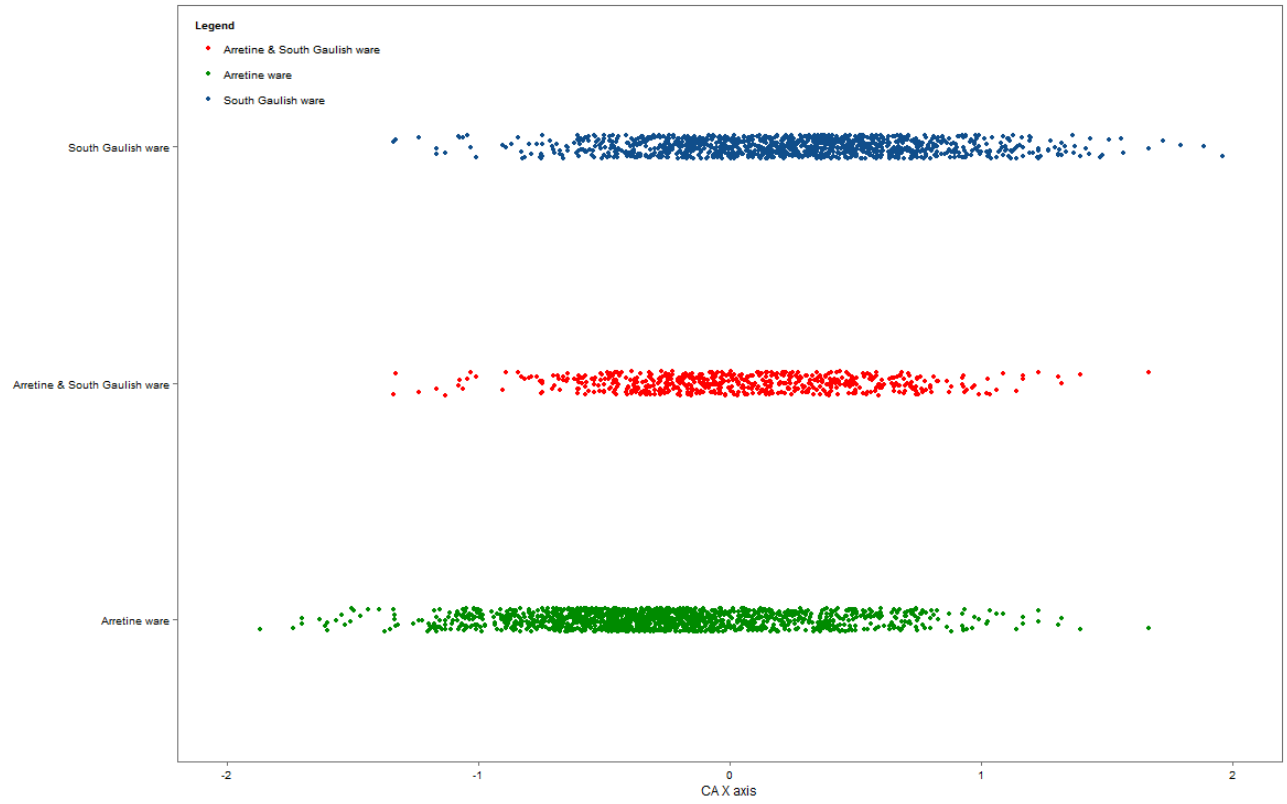


Fig. 2.4. Strip chart of context containing terra sigillata forms ordered on the CA axis.

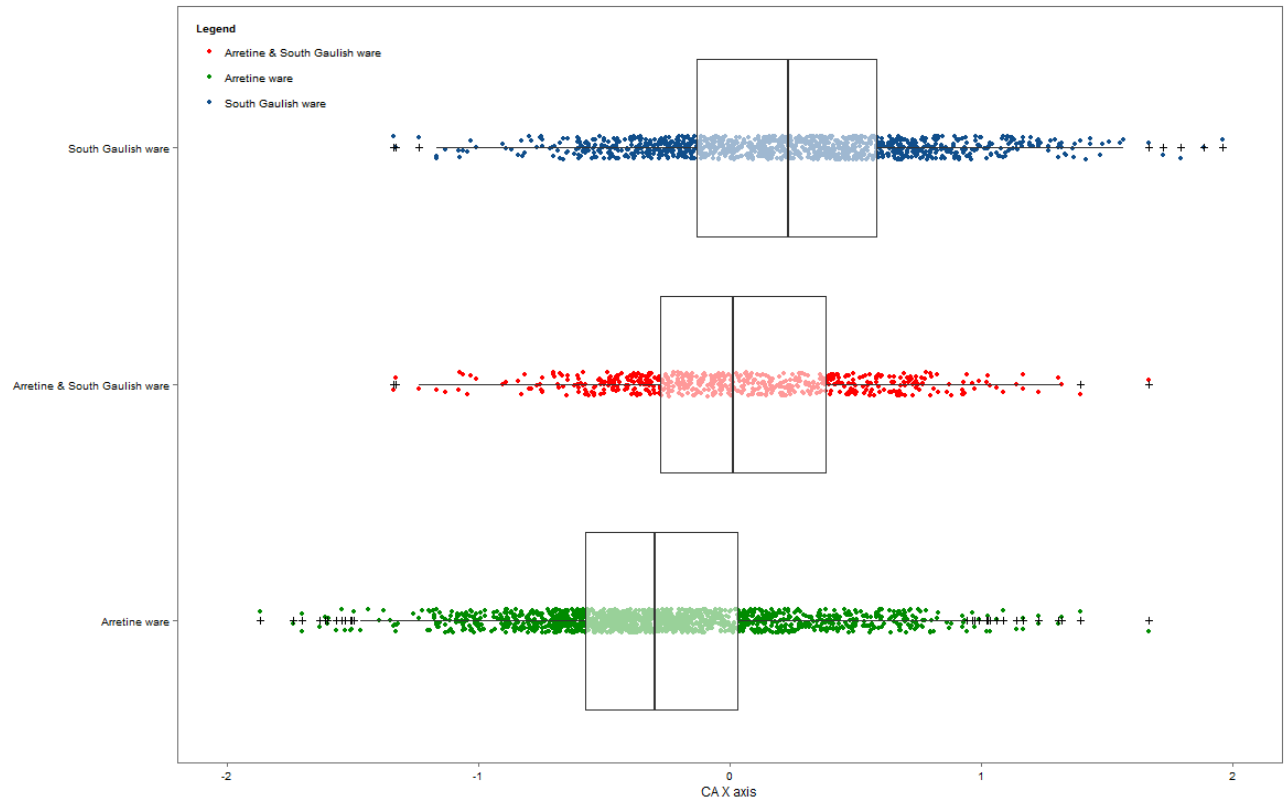


Fig. 2.5. Box plot of contexts containing terra sigillata forms ordered on the CA axis.

2.5.2. Terra sigillata wares

The Roman occupation period on the Kops Plateau was a time in which a number of terra sigillata forms rapidly succeeded each other. This is particularly true in the case of pre-Flavian sigillata dishes and cups. One of the earliest examples is probably the Dragendorff 17 dish which is considered to be the South Gaulish equivalent and successor of the Arretine form Haltern 2.[68] Together with the Dragendorff 15/17 dish it is one of the earliest forms that was exported from La Graufesenque and dishes of this type have been found in contexts dating back to the late Augustan period. Both forms went into production at La Graufesenque by AD 10 and quickly became the most important dishes for export.[69] By the time of Claudius however, their position was quickly taken over by the Dragendorff 18 dish. The production of Dragendorff 17 was ceased but Dragendorff 15/17 dishes continued to be made well after AD 60.[70] Dragendorff 18 is one of the few export products that remained in use during the whole production period of La Graufesenque from AD 10 – 120. The dish is rare in Tiberian contexts but by the time of Claudius it was the most popular form on the market.[71]

The succession from the Arretine Haltern 2 to Dragendorff 17 and 15/17 to eventually the Claudian Dragendorff 18 is clearly traceable on the relative timeline of the Kops Plateau seen in figure 2.6. The Arretine Haltern 2 peaks well before the axis centre as opposed to the South Gaulish forms. Dragendorff 17 is the first of the South Gaulish types to peak and it is clear that its popularity already waned with the arrival of the Dragendorff 15/17. The transition from Dragendorff 15/17 to 18 is less explicit but this is expected as both forms stayed in production during the Claudio-Neronian phase of the Roman occupation on the plateau. Similar to the previous example the contexts containing South Gaulish types do not extent much further than +1.5. This limit can again be seen as the end of the Roman occupation period.

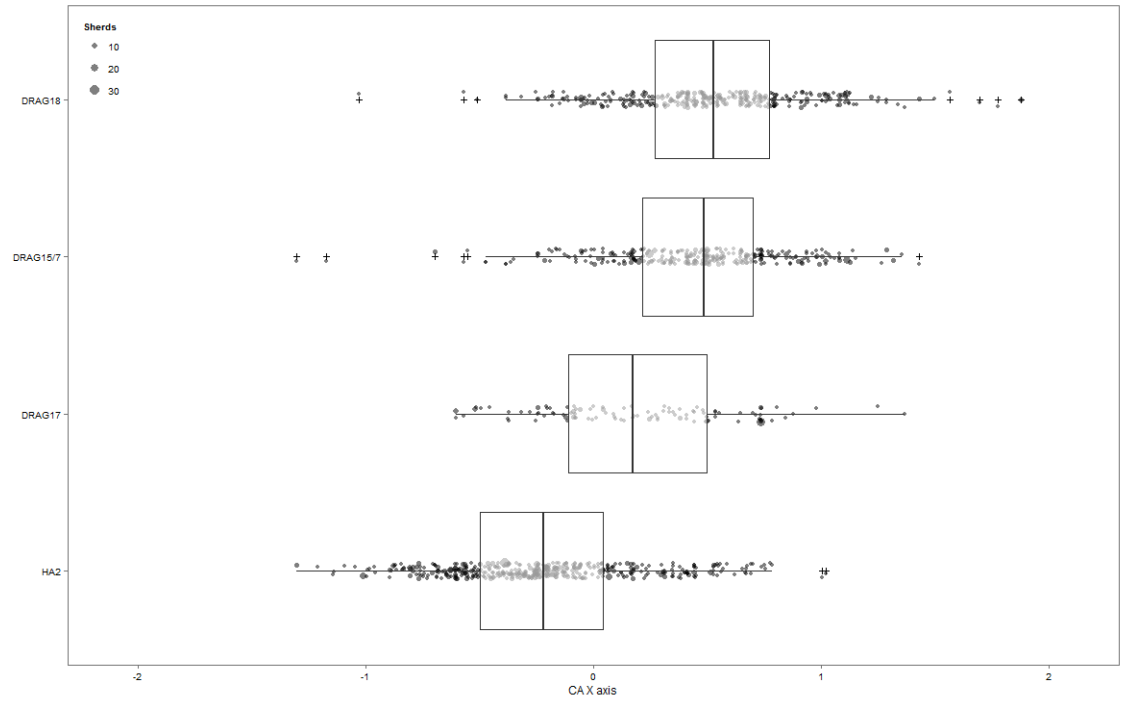


Fig. 2.6. Box plot of contexts containing terra sigillata dish forms

[68] Polak 2000, 87-91.
[69] Ibidem, 85
[70] Ibidem, 71.
[71] Ibidem.

A similar pattern of succession can be noted for pre-Flavian sigillata cups (see figure 2.7). The Arretine cups Haltern 8 and 12, both Augustan forms, were at the beginning of the Tiberian period replaced by the Hofheim 5[72] and Dragendorff 24/25[73] respectively. The form Dragendorff 27 was also introduced at the end of the Augustan period and eventually replaced the Arretine form Haltern 11.[74] By the time of Claudius it became the most popular and widespread cup form to be exported from La Graufesenque. Like with the sigillata dishes, the start of Claudius' reign signalled a second transition. While Dragendorff 27 was rising in popularity, the production of Hofheim 5 form stopped while the Dragendorff 24/25 continued until after AD 70.

Type	Sherds	Records
Halt. 8	1830	735
Halt. 2	1193	525
Drag. 27	922	494
Drag. 18	892	429
Drag. 24/25	886	465
Drag. 15/17	835	392
Hofh. 5	286	143
Drag. 17	254	254
Halt. 11	98	60
Halt. 12	48	31
Total	**7244**	**3528**

Table 2.2. Number of sigillata vessel types.

Again, the successions of the various described Arretine and South Gaulish forms can be traced on the relative timeline. All three Arretine forms peak on the left side of the axis centre while the South Gaulish Hofheim 5 peaks on the axis centre. Like with the Dragendorff 17 dish, the early peak and short distribution range of Hofheim 5 is probably caused by its production stop around AD 40 which resulted in a quick disappearance from the market. Because the Dragendorff 24/25 cup remained in production its peak is placed more towards the right as it could still be imported by the occupants of the Kops Plateau. Dragendorff 27 is clearly the last South Gaulish cup to peak and extents clearly past +1.0 on the axis.

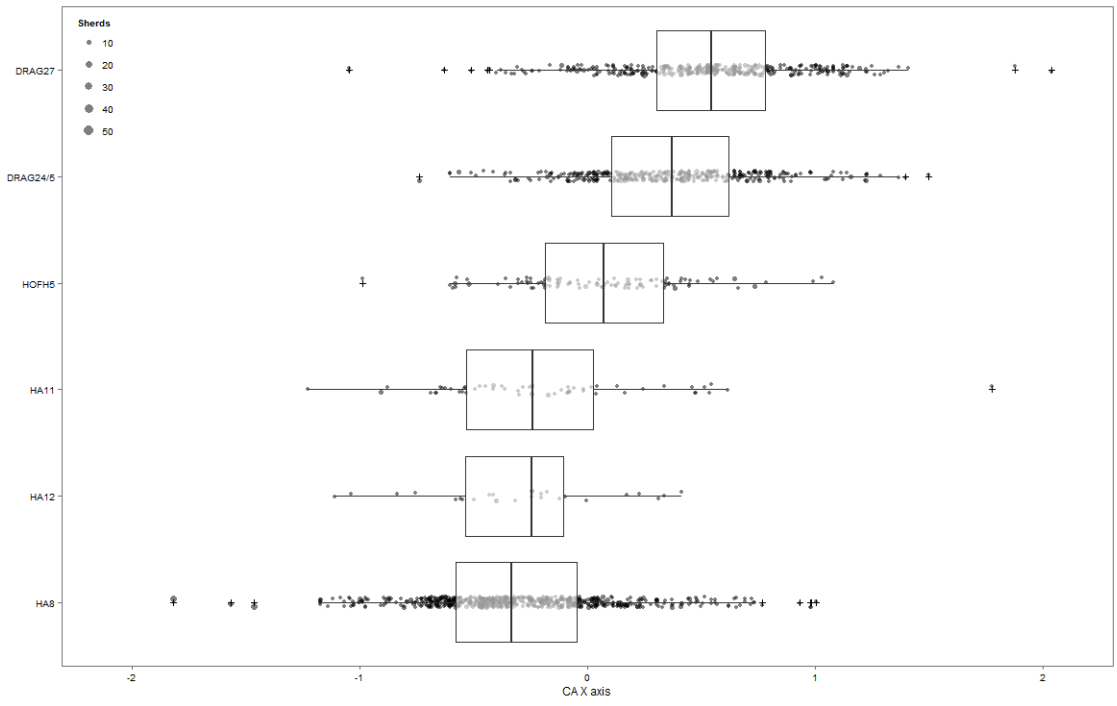


Fig. 2.7. Box plot of contexts containing terra sigillata cup forms.

[72] Polak 2000, 114.
[73] Ibidem, 117-118.
[74] Ibidem, 118-120.

The similarity of the chronological development of dishes and cups has led to the assumption that some of these types actually formed service sets.[75] The earliest service is the combination of the Haltern 2 dish and Haltern 8 cup, followed by the Dragendorff 17 dish and Hofheim 5 cup, the Dragendorff 15/7 dish and Dragendorff 24/5 cup and lastly the Dragendorff 18 dish and Dragendorff 27 cup. As shown in figure 2.8 the assumption that the mentioned pairs of forms constituted services appears to be confirmed by their similar behaviour on the timeline of the Kops Plateau.

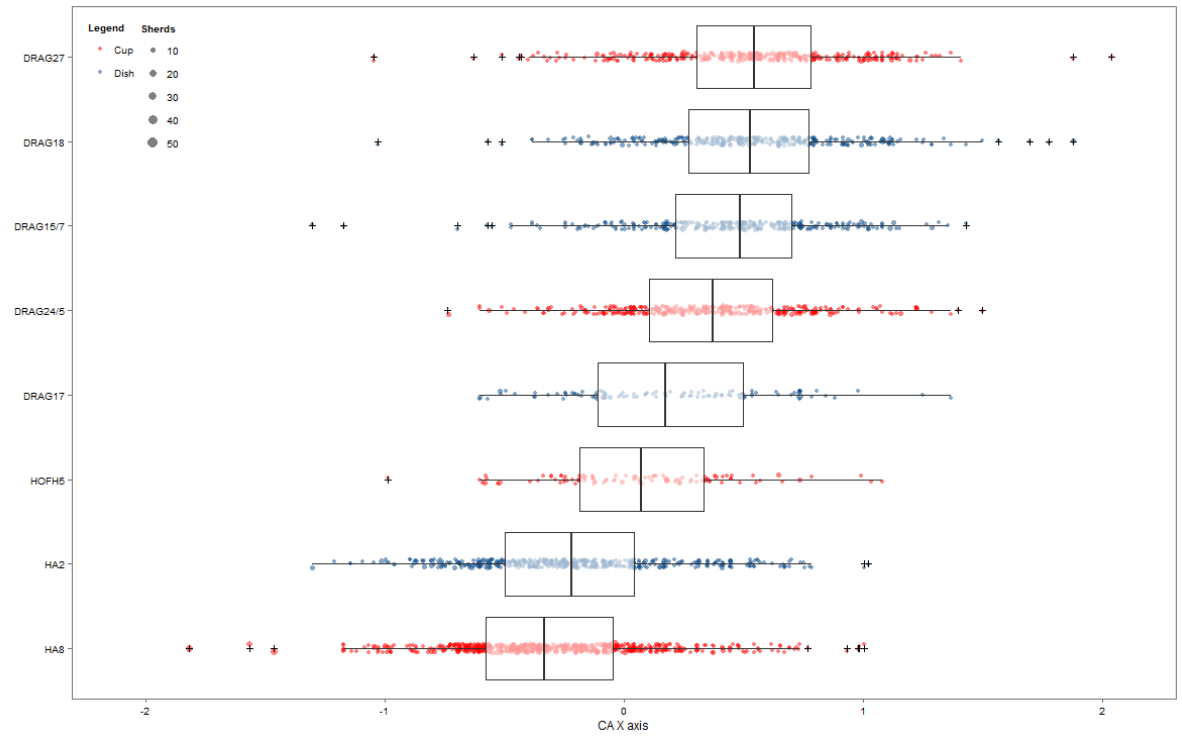


Fig. 2.8. Box plot of contexts containing terra sigillata services.

2.5.3. Colour-coated & painted ware fabrics

In the Lower-Rhine region, the majority of pre-Flavian colour-coated and painted wares can be found military contexts. Colour-coated wares can easily be dated based on technique or fabric and are therefore good diagnostic types to study. Vessels found during the excavation on Kops Plateau were divided into four fabrics.[76]

- Lyon ware: yellow greenish fabric with a brownish coating.
- Technique a: white fabric with an orange coating.
- Technique b: white fabric with an olive brown to near black coating.
- Technique c: red fabric with a dark to near black coating.

Lyonnaise wares originated from South Gaul and was introduced on the northern markets in the late-Tiberian period though it is usually found in Claudio-Neronian contexts. Techniques a and b are characteristic for products in the Lower-Rhine region from the Claudian period onwards. Both techniques coexisted during the first century AD. Technique c was introduced by the second half of

[75] Polak 2000, 73.

[76] The fabric division that was used during the excavation is based on Brunsting 1937, 70-71. Van den Brink gives a detailed overview of colour-coated and painted ware found on Kops Plateau (Enckevort 2014b, 151-182). Cf. Kloosterman's analysis of colour-coated ware found in the Augustan and Flavian contexts on the Hunnerberg (Polak *et al*. 2014, 65-135).

the second century AD. Two other techniques that have been found on the Kops Plateau, d and e/f are too rare to be analysed and will not be discussed here.

Painted wares form a separate group and consist of vessels that are not completely coated. A special group of painted wares are the so-called Pompeian red wares, dishes with a thick red coating on the interior which is named after the red painted walls typical for the Roman city Pompeii. The technique originated from the Italian peninsula and is commonly found in pre-Flavian military contexts.

Based on the above described dating of the fabrics, we can see in figure 2.9 that technique a, b and Lyon fabrics have a clear peak on the right side of the axis centre, which coincides with the predominately Claudio-Neronian dating of these fabrics. On the other hand, technique c is slightly more concentrated on the left side of the axis centre and shows a near even distribution across the timeline. This is strange considering that the technique was only introduced by the second half of the second century AD, well beyond the timeframe that the CA axis is supposed to represent. Based on entry descriptions found in the excavation database it becomes clear that "technique c" has mainly been used in reference to several pre-Flavian vessel types, in particular oil lamps and balsamaria (see table 2.3). The red/orange fabric of this type has probably been mistaken for the "real" second century technique c.[77] The distribution of "technique c" under discussion here therefore probably represents the distribution of oil lamps and balsamaria across the relative timeline of the Kops Plateau.

Type	Sherds	Records
Oil lamp	372	176
Halt. 35	156	40
Unknown	115	45
Hofh. 22	78	25
Halt. 30	49	24
Stuart 2	14	2
Halt. 34	12	6
Beaker	9	9
Halt. 33	9	5
Halt. 31	8	6
Plate	4	3
Fried. 24	2	2
Stuart 1	2	2
Hofh. 33	1	1
Hofh. 39	1	1
Total	**832**	**347**

Table 2.3. Number of vessel types done in technique c.

Lastly, the distribution of Pompeian red wares shows an even distribution across the timeline and coincides with the pre-Flavian dating of the group's most frequent form, the Stuart 13 dish.[78]

[77] This has been suggested by R. Kloosterman during a personal discussion. This is further strengthened by Van den Brink's decision to remove the Haltern/Loeschcke 35 from her analysis of colour-coated ware.
[78] Stuart 1977a, 27-28.

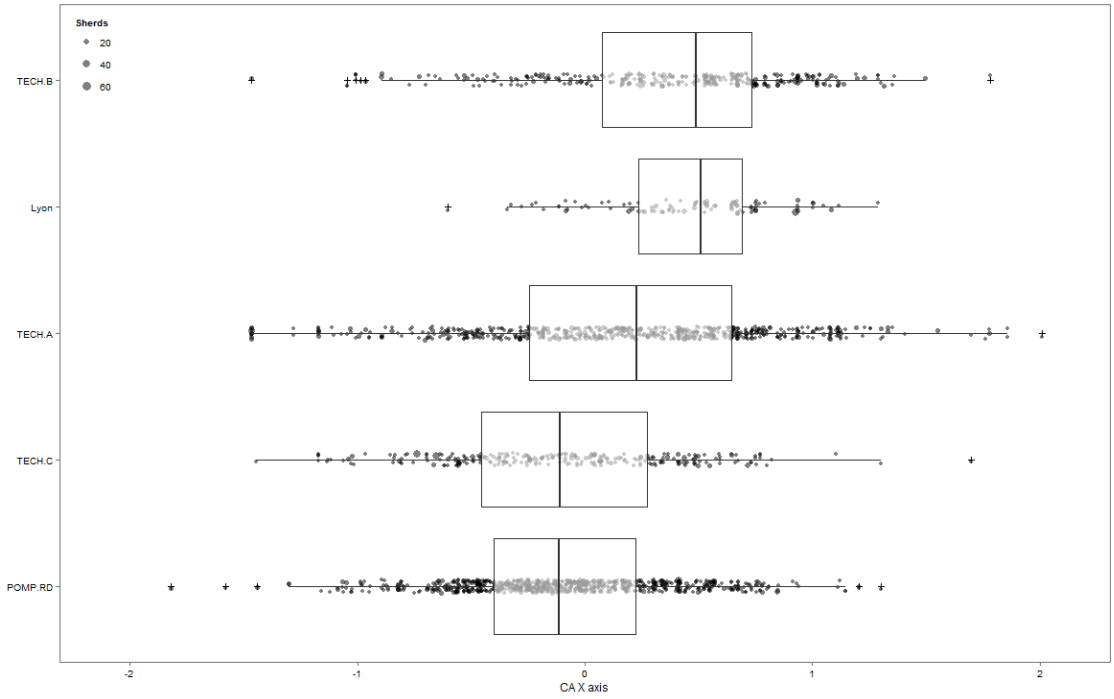


Fig. 2.9. Box plot of contexts containing colour-coated and painted wares.

2.5.4. Beakers and cups

Beakers and cups can be found in all Roman military contexts in the Lower Rhineland. The earliest vessels came in the form of "thin-walled" cups and beakers and were brought to the north by Roman soldiers from the Italian peninsula. During the Claudio-Neronian period new vessel forms became popular and eventually succeeded the older Italian forms.[79]

A well-studied transition that took place during the timeframe of the Roman occupation on the Kops Plateau is the development from the Italian cup Oberaden 38/Haltern 40 to the colour-coated cup Hofheim 22.[80] Although the earliest cups of the form Hofheim 22 can be dated to the time of Tiberius, they became only popular by the Claudian period. A second possible transition might have taken place between the same Hofheim 22 and the relative late-Claudian colour-coated beaker Stuart 1. A recent examination of the material on Kops Plateau has revealed several transitional forms that suggest a relationship between the two colour-coated vessel forms.[81]

The chronological developments of the above mentioned drinking vessels is reflected in their distribution across the chronologically ordered contexts (see figure 2.10). The Italian form Oberaden 38/Haltern 40 is clearly concentrated to the left of the axis centre, while the Hofheim 22 cup and the Stuart 1 beaker are more distributed towards the right of the axis. It is interesting to note the seemingly chronological development of the Italian cup on the timeline. The Oberaden 38 and Haltern 40A/B are usually grouped together because they are not thought to represent different chronological phases of the same form. In our case it is clear though that Haltern 40B peaks later than the other two types. This suggests that the distinction between Oberaden 38/Haltern 40A and Haltern 40B does represent some sort of chronological development.

[79] Kloosterman in Zandstra & Polak 2012, 128.
[80] Ritterling 1913, 250. Cf. Van den Brink in Van Enckevort 2014b, 161-165.
[81] Van den Brink in Van Enckevort 2014b, 175-177.

The suggested transition from Hofheim 22 to Stuart 1 is less clear. Although Stuart 1 was introduced later on Kops Plateau than Hofheim 22 and also peaks later, both forms continue to coexist alongside each other. It is possible that a transition from the cup to beaker eventually happened, but no definite succession was accomplished during the timeframe under discussion here.

Type	Sherds	Records
Halt. 40B	1.050	303
Hofh. 22	713	220
Ob. 38	584	123
Stuart 1	399	88
Halt. 40A	248	51
Halt. 40	45	13
Total	**1.927**	**490**

Table 2.4. Numbers of cup and beaker types.

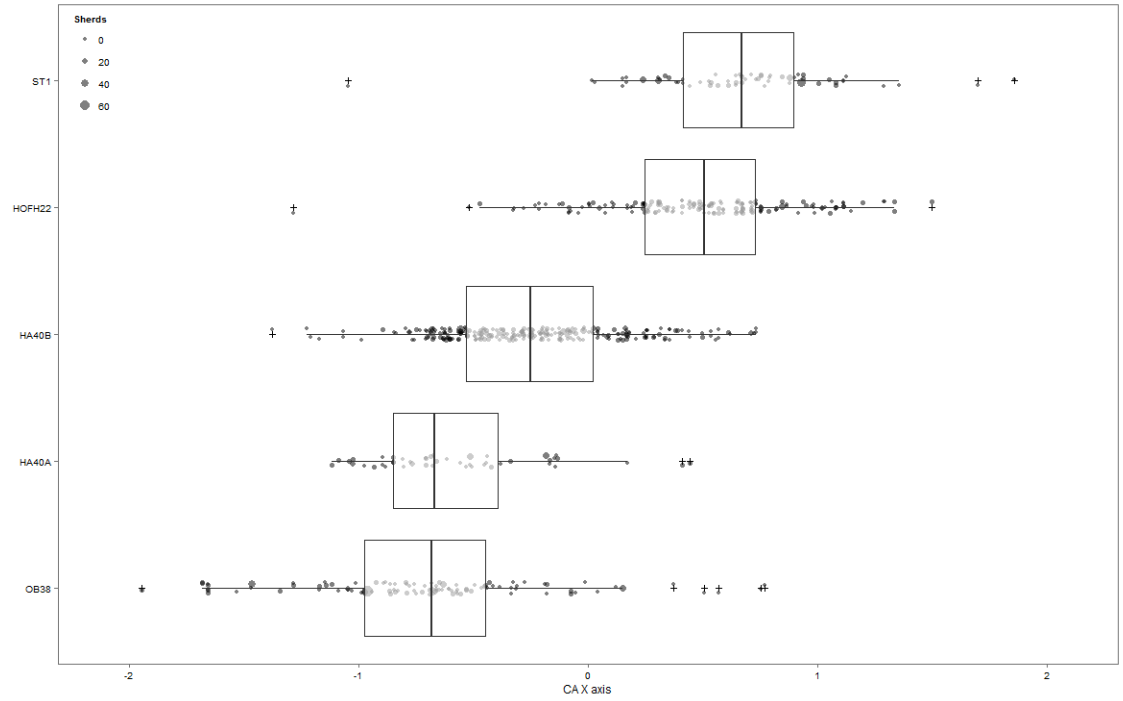


Fig. 2.10. Box plot of contexts containing cup and beaker vessels.

2.5.5. Jug vessels

Establishing a chronological typology for jug vessels has proven to be no easy task. The often used typologies based on vessels found at Haltern and Hofheim or described by Stuart are not always very clear and can be rather frustrating at times. Especially the now notorious classification of Stuart 105/109 as variations to the jug Hofheim 50/51 is known to be incorrect and based on a different form description by Ritterling of Hofheim 50/51.[82] However, two jug types, Stuart 101 and Hofheim 50, do show a clear chronological development and are therefore interesting for us to explore.

It has been noted in both Vechten and Velsen I that the two jug types are closely related to each other in form which has led to the idea that the Claudian period Hofheim 50 is a direct successor to the Augusto-Tiberian jug Stuart 101.[83] Looking at their distribution on the CA X axis it is clear that both forms peak opposite to each other on the axis centre (see figure 2.11). Contexts containing Stuart 101 jugs are more concentrated on the left side of the axis and do not extend much further to

[82] Stuart 1977a, 39-44. Cf. Zandstra & Polak 2012, 150 note 331.
[83] Vechten/Fectio: Zandstra & Polak 2012, 155, fig. 95 d-e. Velsen I: Bosman 1997, fig. 6.47.

the right than +0.5, while Hofheim 50 has a distribution ranging from -1.0 to +1.5. There is a clear overlap from -1.0 to 1.0 between the two types which can be interpreted as the transition period. This overlapping area would roughly be the time from Tiberius to Claudius. Based on their distribution across the contexts it is obvious that Stuart 101 and Hofheim 50 vessels behave like opposites, which strongly suggests a development similar to that attested at Vechten and Velsen I.

Type	Sherds	Records
Hofh. 50	4.404	773
Stuart 101	1.914	322
Stuart 105/9	377	97
Total	**6.695**	**1.192**

Table 2.5. Numbers of jug vessel types.

A comparison between Hofheim 50 and the grouped types of Stuart 105/109 shows that both types have similar distribution pattern. Strictly speaking, Stuart 105/109 refers to the same vessel form as Hofheim 50, but because the excavators found it important enough to clearly separate these two groups, it is interesting to note that both types show no fundamentally different chronology. It can therefore be suggested that any distinction made between Hofheim 50 and Stuart 105/9 does not seem to have any chronological relevance – at least not on Kops Plateau.

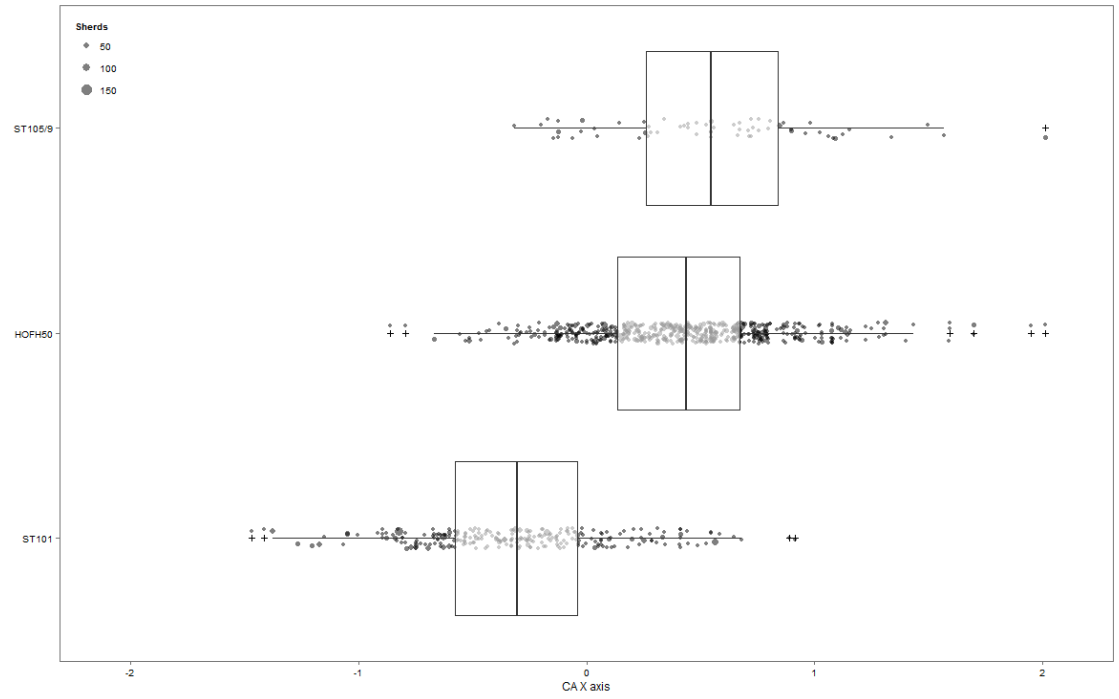


Fig. 2.11. Box plot of contexts containing jug vessels.

2.5.6. Mortaria

Mortaria vessels are heavy duty kitchen bowls used for crushing and grinding ingredients and are a typical tool in the Roman kitchen.[84] Although the term “mortarium” can actually refer to a wide variety of vessels used to process materials besides food, it is not certain whether our vessels also had this multipurpose function.[85] It is probable though that they were “simply” used for preparing foodstuffs.

[84] Kloosterman in Kloosterman, Zandstra & Polak 2014, 197.
[85] Symonds 2012, 170-172.

The majority of mortaria found on the Kops Plateau can be ranged under two main forms based on the shape of their rim.[86] The first form is Haltern 59 (=Oberaden 72) and has a typical vertically shaped rim. It is found in all Augustan military camps in north-western Europe and remained in use until the middle of the first century AD. The second form is Stuart 149 (=Hofheim 80B), a mortarium with horizontal rim. Although this type has been found in early Augustan contexts, it became popular only by the Tiberian-Claudian period.

A small number of sherds can be attributed to two other mortaria forms. Firstly, the Haltern 60 (=Oberaden 73, Hofheim 80A), characterised by a long projecting spout and dated in the Augustan period. Second is the so-called "Nijmeegse Holdeurn ware" (HNW) type 77, a local product originating from the pottery complex on the Holdeurn, just south-east of the Kops Plateau. Products from the Holdeurn are usually dated from the Flavian period onwards but this *terminus a quo* is not completely certain. The shape of the rim resembles that of the Stuart 149 mortarium.[87]

The distribution of the above mentioned forms over the relative timeline in figure 2.12 show no surprises. Both the Haltern 59 and 60 are concentrated to the left side of the axis centre and do not extent beyond +1.0. The younger Stuart 149 can be found on either side of the axis centre, indicating that its introduction was probably in the Augusto-Tiberian period. The peak of Stuart 149, however, shows that the type was more common in the later part of the occupation phase. The locally produced mortarium is heavily skewed towards the right with most of its contexts located near +1.0 on the axis which corresponds well to the Flavian character of type HNW 77. In conclusion, the relative chronological ordering of the contexts confirms the supposed development of mortaria with a vertical rim to those with a horizontal rim.

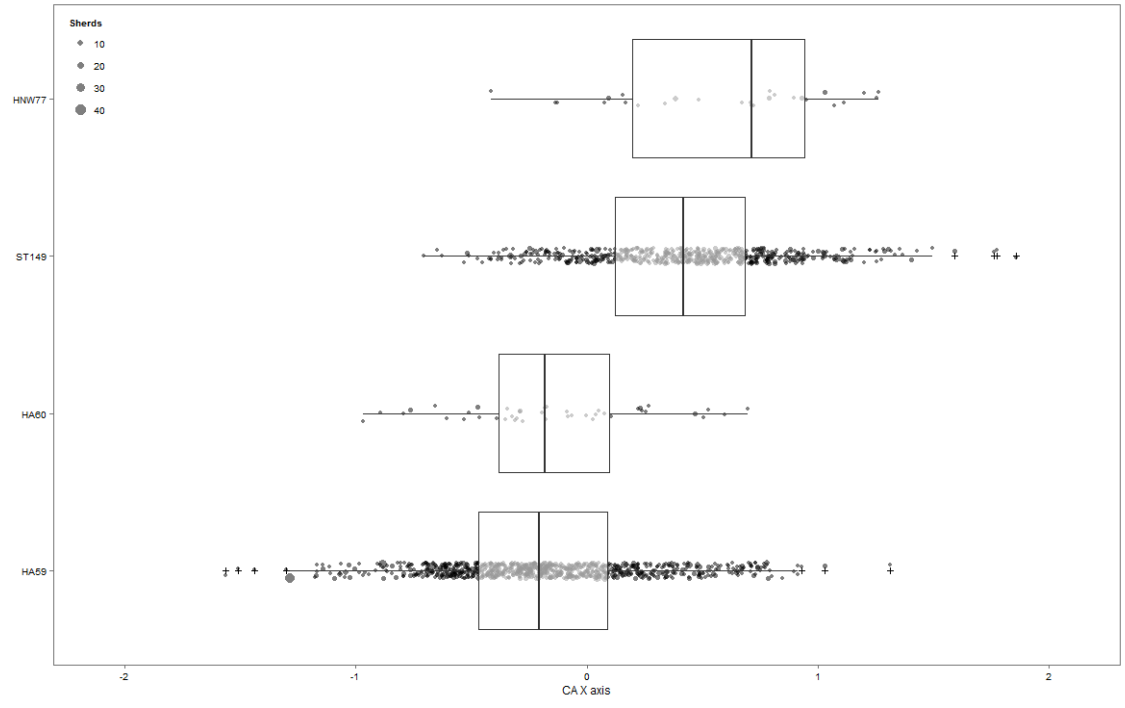


Fig. 2.12. Box plot of contexts containing mortaria.

[86] Cf. Kloosterman, Zandstra & Polak 2014, 198-201.
[87] Holwerda 1944, Plaat VII, no. 448-449.

2.5.7. Coarse wares

Coarse wares are characterised by their hard and heavily tempered fabric which give them a rough feel. Coarse ware vessels come in many shapes and forms including storage and cooking pots, jugs, dishes and beakers. Because many coarse ware vessels are found blackened by fire and have traces of cooked food on the inside, they are commonly seen as kitchen wares.

Few coarse wares can be dated exclusively to the pre-Flavian period based on their form and because most of these kitchen vessels changed very little over time they are not really considered diagnostic types. However, when we look at the average dating of coarse ware types it becomes apparent that they seem to be more common during the later years of the pre-Flavian period. It is interesting for us to see if the vessels from the Kops Plateau do indeed concentrate more on the right of the axis centre.

A quick look at the distribution of some of the more frequent vessel types indeed shows us that no coarse ware extends beyond -1.0 on the axis and all have their peak clearly placed on the right side of the axis centre (see figure 2.13). The most common coarse ware form is the Stuart 201 cooking pot which was used during the whole Roman period. The wide distribution range of Stuart 201, from -1.0 to +1.5 on the axis, shows that this form of cooking pot was also common on Kops Plateau. It is interesting to note though that its peak is slightly more concentrated on the right side of the axis centre. This suggests that the Stuart 201 cooking pot may not have been as widely used on Kops Plateau in the beginning of the Roman occupation period. A similar increase in frequency of Stuart 201 was also documented by Bogaers and Haalebos during their excavation of the Roman rubbish deposits near Kops Plateau.[88]

The distribution of the Stuart 204 cup, 210 bowl and the 213 handled-pot all extend to the left of the axis centre but have their peak on the right side. In both Velsen I and Vechten/Fectio these forms have rarely been found in Augustan-Tiberian contexts and are most common only in Claudian-Neronian contexts.[89] The Stuart 214 jug and the Stuart 215/6 dish, are hardly found in contexts on the left side of the axis centre. Both forms are considered to be Claudian period creations.[90]

Type	Sherds	Records
Stuart 201	9.708	1.589
Stuart 210	831	372
Stuart 214	649	113
Stuart 204	618	143
Stuart 213	604	155
Stuart 215/6	145	66
Total	**12.555**	**2.438**

Table 2.6. Numbers of coarse ware types.

[88] Bogaers, Haalebos 1975, 153.
[89] Bosman 1997, 233-234 (Velsen I). Zandstra & Polak 2012, 171-178 (Vechten). Cf. Bogaers & Haalebos 1975, 153.
[90] Stuart 1977a, 81-84.

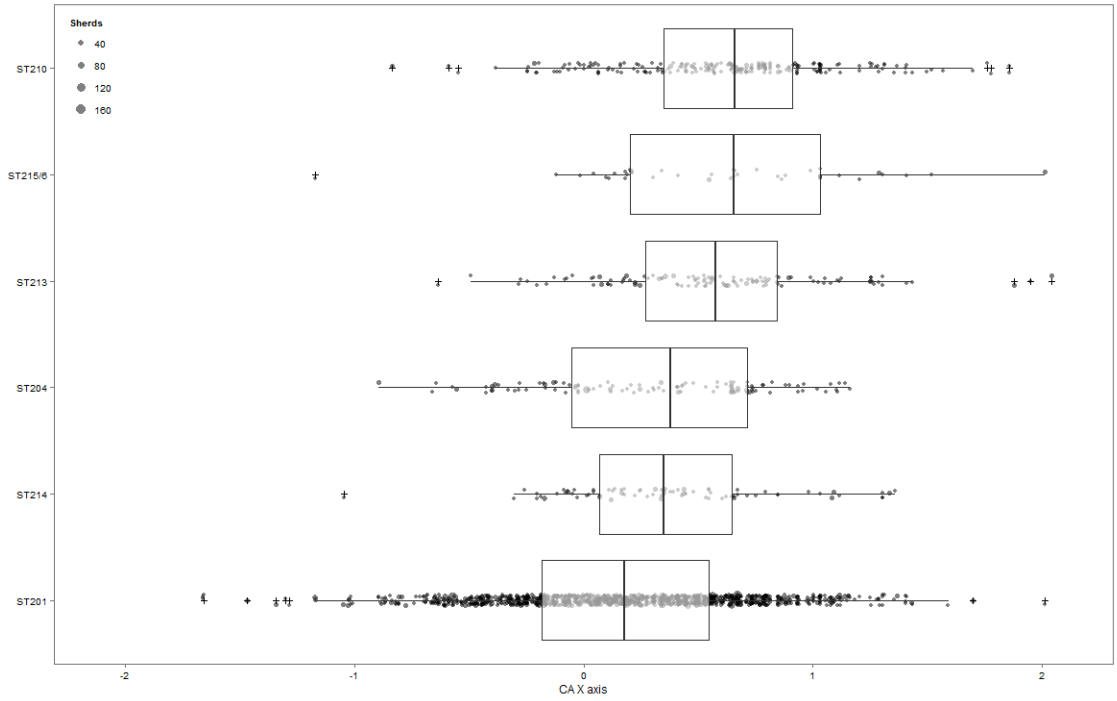


Fig. 2.13. Box plot of contexts containing coarse ware.

2.5.8. Potters' stamps

Although potters' stamps on terra sigillata vessels did not play any role in the actual analysis, it is nevertheless possible to see how the stamps are distributed across the contexts. Because name stamps can provide an accurate dating, it is possible to test if they are conform to the chronological ordering of their contexts.

The contexts that were used in the analysis have a total of 883 name stamps present in their assemblage. The dates of a selection of 228 stamps were adapted from a new analysis done by D. Visser.[91] Using the chronology of these stamps an average dating was calculated for their contexts. When we plot the contexts based on their average date and distribution across the CA X axis a linear development becomes visible (see figure 2.14).

Taking a closer look at the earliest and latest dated potters' stamps, we see on the left side stamps from Arezzo based potters L. Titius Thyrsus on a Haltern 1C dish and a rarely found stamp of Sex. Annius on a Haltern 7C. Both have an average dating of 8 BC but may well be earlier. The name stamps on vessels produced in Pisa belong for the majority to Cn. Ateius and are mostly dated between AD 1 and 15. In the outermost right context on the axis we can find Patricius i's name stamped on a Dragendorff 27g cup which has an average date of AD 75.

[91] D. Visser in Van Enckevort 2014b, 121-150.

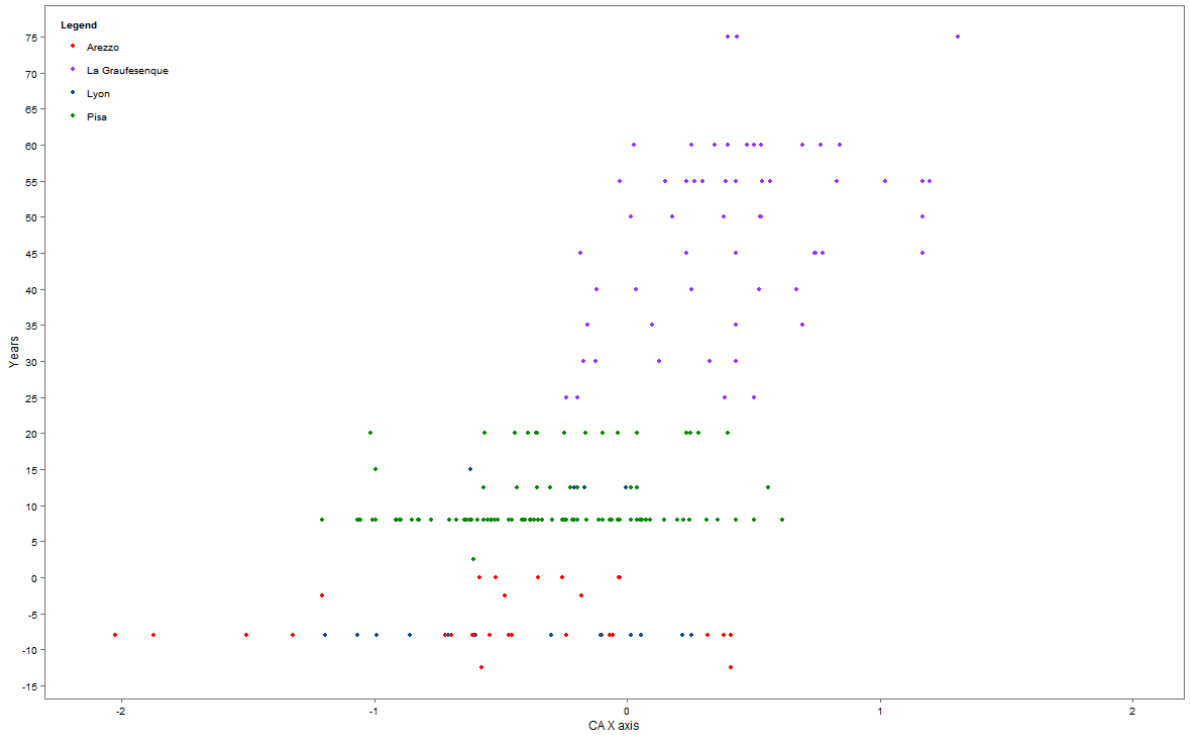


Fig. 2.14. Strip chart of average dating of terra sigillata stamps ordered on the CA axis.

2.6. Conclusion

The distribution of diagnostic vessel types across the contexts has confirmed that the ordering of contexts on the X axis of the CA is basically chronological in nature. Again, it is possible to divide the X axis into three phases. Starting from the left, the first phase is composed of contexts that are placed left of -1.0 and contain only "early" Augustan vessel types. Post-Augustan vessel types do not seem to reach further left than -1.0 on the axis. The second phase is between -1.0 and the axis centre. Contexts placed on this part of the axis seem to contain both Augustan and Tiberian types but no Claudian-Neronian material. The beginning of the third phase is harder to pinpoint but vessel types that became popular in the Claudian period all peak on the right side of the axis centre. On an interesting side note, the previous described Dragendorff 17 has its peak much later than we originally thought and begs to reconsider its "early" status on the Kops Plateau.

This three-part division of the axis is supported by the distribution of pottery stamps across the contexts. Based on their distribution we can try to give some "average" dates to the otherwise relative timeline of Kops Plateau. Left of -1.0 on the axis we see only one stamp that has an average date later than 10 AD. This single stamp is from the potter Cn. Ateius Crestus and has a date of AD 10-30. With the exception of Crestus' stamp the ordering coincides nicely with the "Augustan" character of the assembly of contexts on that part of the axis. Between -1.0 and the axis centre, apart from two individuals, no stamps can be found that are dated later than an average of 40 AD. The two exceptions are Silvanus i (AD 30-50) and Aquitanus (45-65) with only the latter posing as a real problem. However, the majority of stamps that are dated in the Claudio-Neronian period are found in contexts that are placed to the right of the axis centre.

Although the dates given by the potters' stamps only provide us with an average, their distribution still complements the ordering of the ceramic types. The identification of three phases within our contexts fit nicely in the existing narrative of the site and strengthens the hypothesis of the three distinct building phases.

3. Chronology of amphoras

During the excavation of 1986-1995 on Kops Plateau an extraordinary large amount of amphora sherds was uncovered. The rich diversity in vessel types and the rare and expensive content that some of these transport vessels carried has led to a lot of international attention. In 2011 an international team of specialists led by C. Carreras re-examined the amphora sherds. Not only did they redefined the typology of the amphora vessels, they also studied the content and origin of the material in greater detail. Compatibility problems made a direct comparison with the other ceramic material groups impossible.[92] Therefore it was decided not include the newly defined amphora types in the CA. However, as with the pottery stamps, it is instructive to analyse and compare the distribution of these new amphora types. Instead of focusing on the individual amphora types, the emphasis is placed on the production region of the amphora's and the content that they carried, for this might provide us with insights in the socio-economic developments on Kops Plateau.

3.1. Olive oil

Amphoras used for the transportation of olive oil are the most common of all transport vessels found on the Kops Plateau. The re-examination of the amphoras by Carreras has shown that olive-oil was imported from two regions, the Guadalquivir valley in the Iberian province of Baetica and the Adriatic coastal region. Based on the number of sherds of all olive-oil amphoras found on the Kops plateau, the majority originated from Baetica.

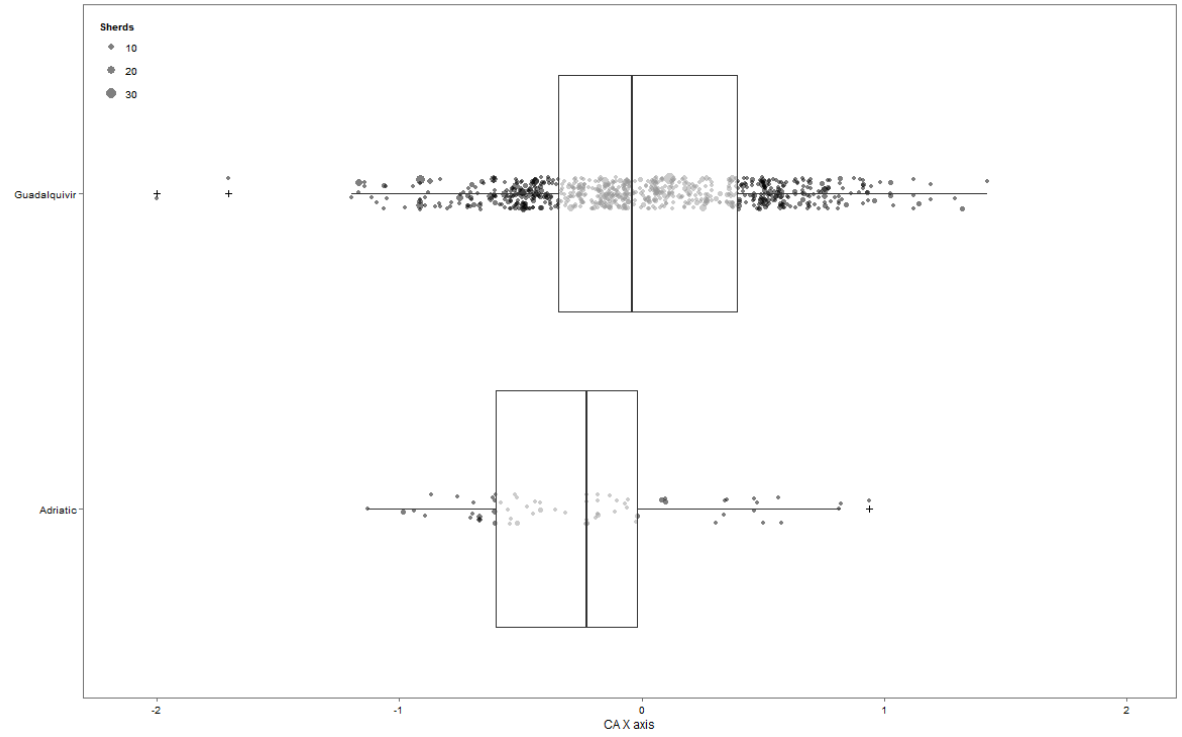


Fig. 3.1. Box plot of contexts containing olive oil amphoras grouped by production region.

[92] The main problem is that amphora sherds were counted and grouped differently from the original data which causes problems when merging the new data with the original database. It proved to be too time consuming to correct this problem within the timeframe of this study.

Figure 3.1 provide us with a clear image of the chronological distribution of olive oil containers. It is evident that amphoras from the Guadalquivir valley dominated the olive oil market on the Kops Plateau throughout the occupation period. This is emphasised in the box plot; the placement of the median near the centre of the axis, which points to an even distribution across time.

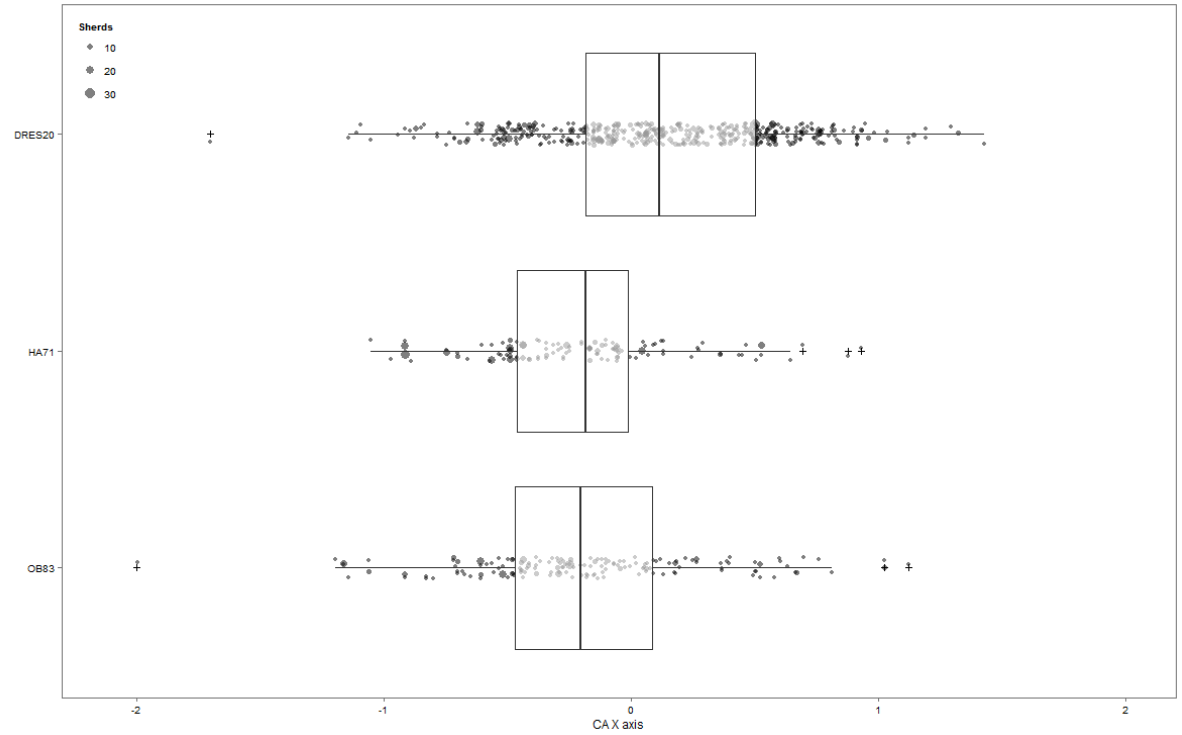


Fig. 3.2. Box plot of contexts containing Baetican olive oil amphoras.

Although Adriatic vessels seem to have coexisted with the Baetican amphoras, their contexts are slightly skewed to the left of the axis centre and peak earlier. This is not remarkable when we consider that the Dressel 6A is the sole vessel type that constitute the Adriatic olive oil group.[93] The presence of this vessel type is in the Lower-Rhine region usually connected with the military activities of Drusus in Germania between 12 – 9 BC.[94] It is possible that after the campaigns of Drusus the import of Adriatic olive oil slowly declined together with an increase of olive-oil from the Guadalquivir valley.

When we take a closer look at the individual vessel types that are labelled as olive oil amphoras from Guadalquivir, we can distinguish two groups (see figure 3.2).[95] Both the Oberaden 83 and Haltern 71 are present in contexts that are placed more on the left side of the axis centre. This is no surprise since both types represent two slight variations of the same Augustan vessel form.[96] In contrast, the Dressel 20 is the successor form of the Oberaden 83 and was introduced during the reign of Tiberius. Its peak is in comparison with the two Augustan types well established around the axis centre. This

[93] Discussion exists whether Dressel 6A amphoras were used for wine, olive oil or both. Based on the data provided by Carreras this type will be analysed as an olive oil container.
[94] Van den Berg 2010, 21: also found in Rödgen (10-8 BC). Cf. Van den Berg 2012, 224 and 226.
[95] This is not possible for the Adriatic olive-oil amphoras as the Dressel 6A is the sole vessel type that constitutes this production area.
[96] See De Almeide *et al*. 2014 for an overview of the chronological development of the Oberaden 83 and Haltern 71 on Kops Plateau.

corresponds with the general chronological development of the Dressel 20 as it became well established only by the Claudian period.[97]

Based on this analysis of the olive oil amphoras it can be argued that the Adriatic Dressel 6A has a strong association with the Augusto-Tiberian contexts on Kops Plateau. In comparison, the olive oil amphoras from the Guadalquivir valley can be found in both older and younger contexts and clearly peaks in the centre of the timeline, indicating an even distribution over time. The individual vessel types from Guadalquivir show a slight chronological development with the transition of Oberaden 83/Haltern 71 to the Dressel 20.

3.2. Olives

Several amphora types have been identified for transporting olives to the Kops Plateau. The majority of these amphoras came in the form of Haltern 70 and were produced in the Guadalquivir valley. [98] A small amount of fragments from the same vessel type originated from the adjacent regions of Las Marismas (the Lower Guadalquivir valley) and the Baetican coastal area. Imitations of Haltern 70 were produced outside Baetica in Lyon and other Gaulish centres.

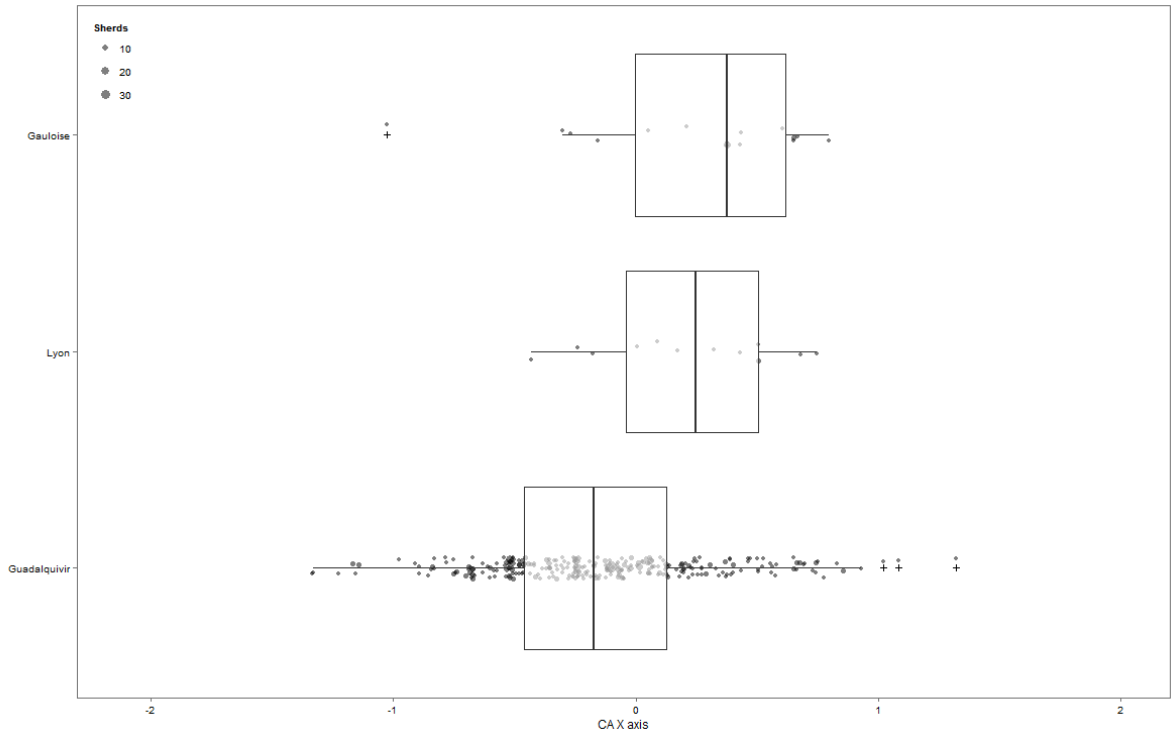


Fig. 3.3. Box plot of contexts containing olive amphoras grouped by production region.

Figure 3.3 shows a clear chronological development of the three production regions. Both Lyon and other amphoras produced in Gaul are clearly skewed towards the right side of the axis. In comparison, the Baetican produced Haltern 70 seems to peak earlier. Based on these findings it is likely that the occupants of the Kops Plateau started importing Gaulish imitations of Baetican

[97] Cf. Colls et al. 1977.

[98] It must be noted that the Baetican Haltern 70 amphora could contain a variety of different contents, including olives and wine. For this analysis the vessel type is counted as an olive container. Two arguments can be given for this decision. First, no other amphora type of substantial number has been found on the Kops Plateau. Two, because the younger Haltern 70 copies from Gaul do contain olives, the Baetican version can be seen as the predecessor of these later olive containers.

products by the Claudian period onwards. A possible explanation of this change could be transportation costs: Gaul lies in closer proximity to the Kops Plateau than the Baetica province.

3.3. Fish sauce

The Baetican coastal region and Lyon are by far the largest production centres from which fish-sauce amphoras were exported to Kops Plateau. Both production centres were complemented by small quantities of amphoras from adjacent regions. Because of their small numbers these amphoras have been omitted from the analysis. In figure 3.4 a comparison between the distributions of Baetican and Lyonnaise amphoras over the timeline shows that the Baetican products peak slightly earlier than those from Lyon.

The presence of Baetican fish-sauce vessels in early contexts is largely due to the high number of Dressel 7/11 sherds. This group of type is commonly associated with Augustan-Tiberian contexts.[99] Figure 3.5 shows the distribution of the types that constitute the Baetican amphoras. It is clear that Dressel 7 is the earliest of the vessel types to peak. The last of the Baetican amphoras that peak seems to be the Dressel 8 type. Again, this is no surprise as Dressel 8 is often assumed to have made its appearance at the end of the Augustan period, last of all the Dressel 7/11 types.[100]

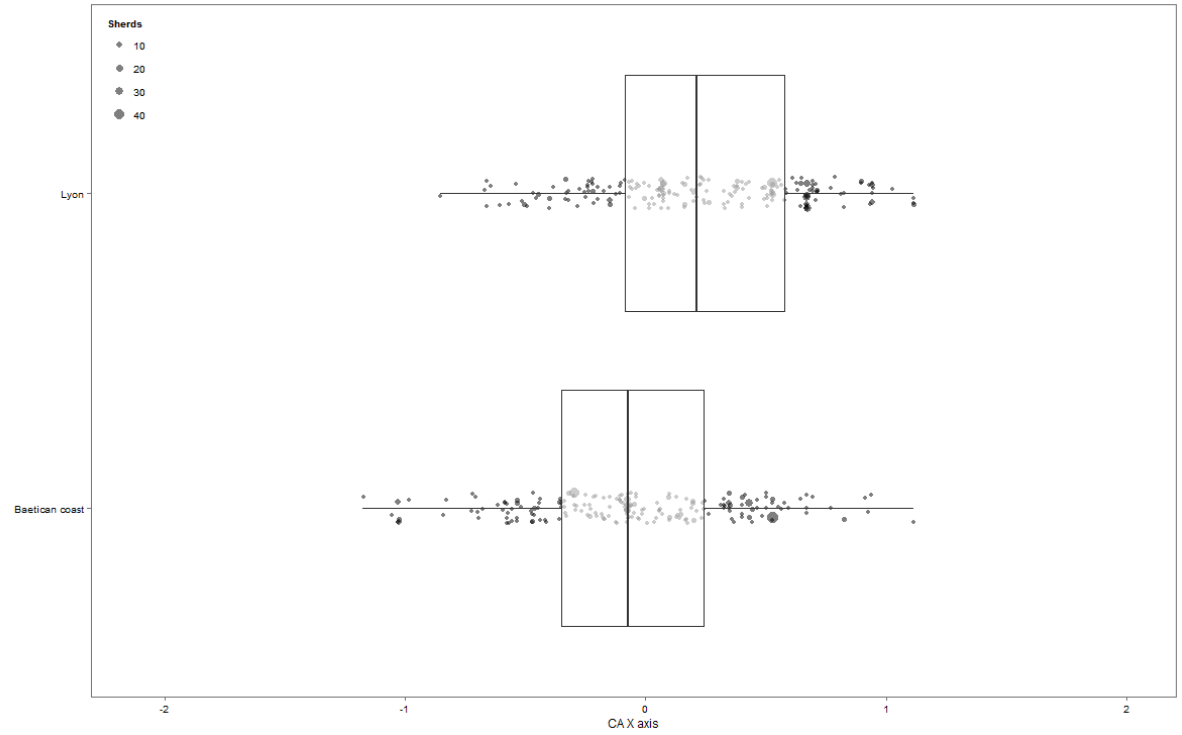


Fig. 3.4. Box plot of contexts containing fish-sauce amphoras grouped by production region.

In figure 3.6 we see that the individual vessel types from the region of Lyon do not show much chronological variation. Both the Lyon 3 amphoras and production imitations of Dressel 9 (similis) show a slight skewness towards the right side of the timeline. In short, fish-sauce amphoras found on Kops Plateau were initially imported from the Baetican coastal region in the form of Dressel 7/11. Later, copies of the Dressel 7 type from Lyon, together with other local variations from that region, began to show up in the camp. It seems that the import of Lyon products eventually surpassed that

[99] Carreras 2006, especially 30-37. See also Almeide *et al*. 2014, 385 for more information on the Dressel 7/11 group found on Kops Plateau.
[100] Almeide *et al*. 2014, 35.

of Baetica. Again, an explanation of this chronological change in import region could be transportation costs.

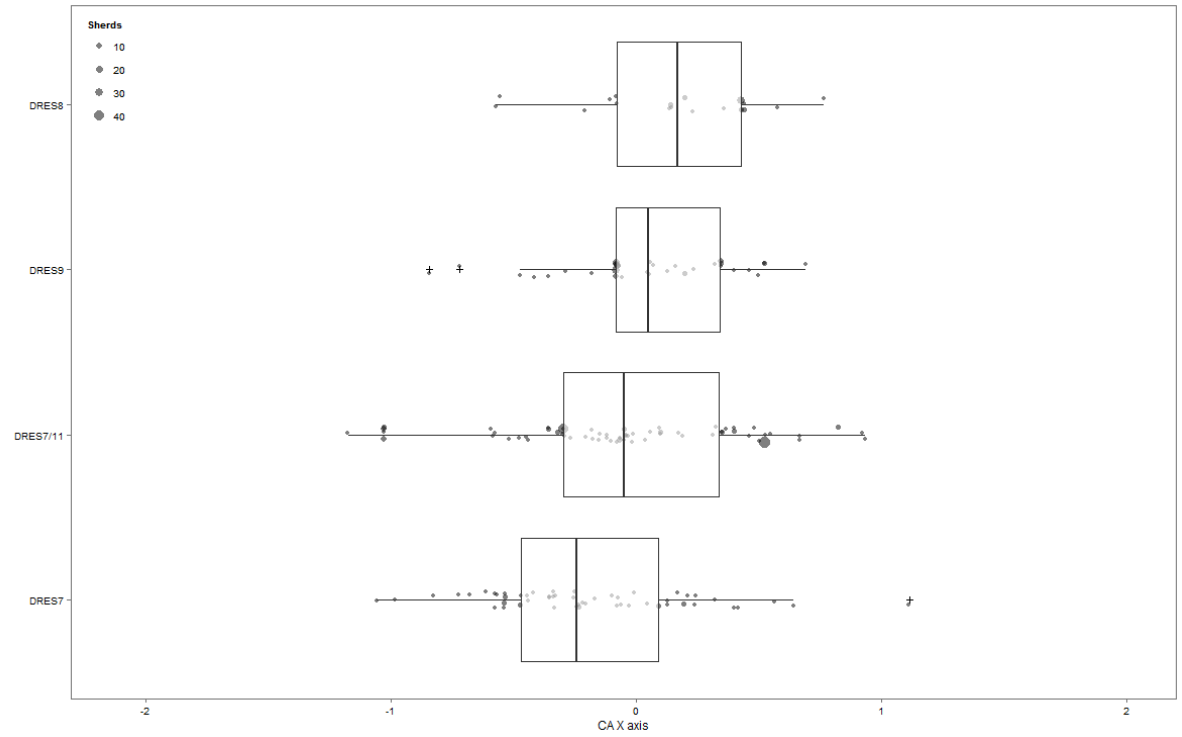


Fig. 3.5. Box plot of contexts containing Baetican fish-sauce amphoras.[101]

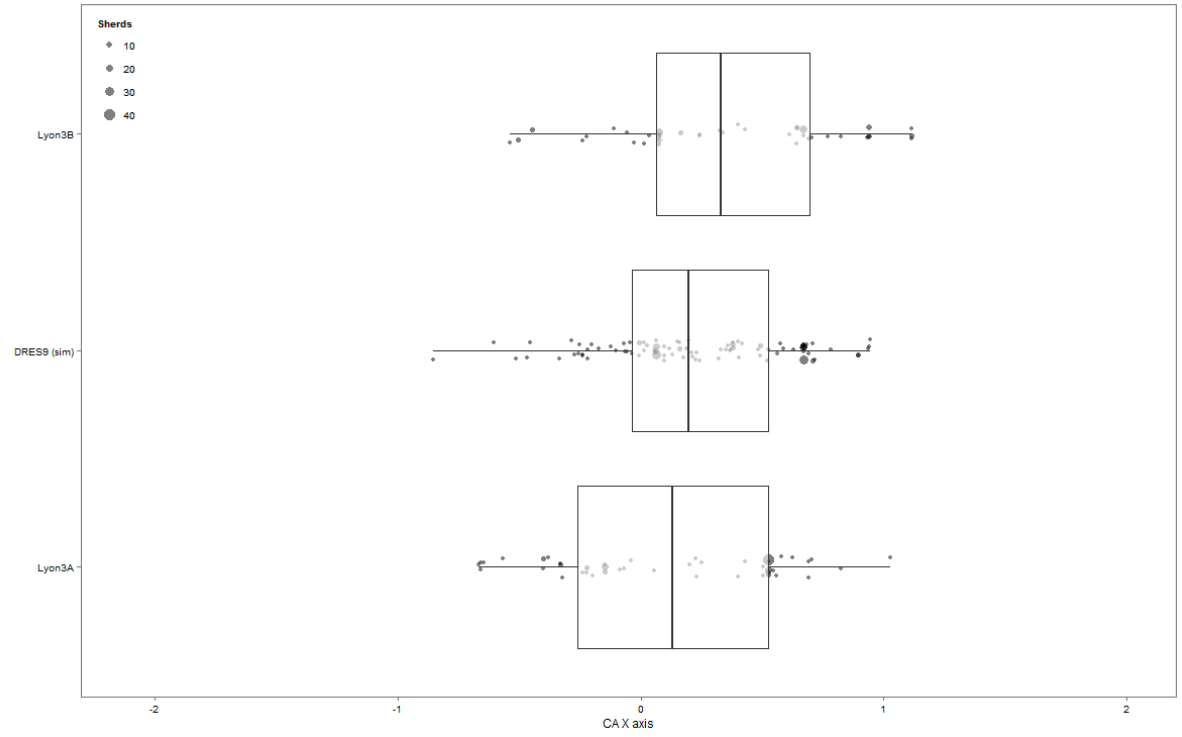


Fig. 3.6. Box plot of contexts containing Lyon fish sauce amphoras.

[101] Dressel 7/11 is a collection of the types 7, 8, 9, 10 and 11. The "Dressel 7/11" group in figure 3.5 are vessels that could not be identified as one of these individual types and are therefore collected under this general term.

3.4. Wine

Wine amphoras are the second most common transport vessels found on Kops Plateau, just behind olive-oil amphoras. They were imported from a wide variety of regions within the Roman Empire, ranging from the Iberian Peninsula to the eastern parts of the Mediterranean.

At a first glance, figure 3.7 suggests that most wine regions are well represented on Kops Plateau throughout the occupation period. This is certainly true for the Aegean wine and Rhodian *passum* which constitute the majority of the wine amphoras. The boxplots do reveal a slight development in time though, with Italian wines being skewed towards the left side of the axis while the Gaulish wines are more concentrated towards the right. The boxplots of both Aegean and Rhodian amphoras show that the contexts are evenly distributed across the X axis, emphasising a steady presence over time. It has been stated that compared with other military contexts in north-Europe, Kops Plateau has yielded an unusual high amount of east-Mediterranean wine amphoras. This has led to speculation about the spending power of the occupants of the site.[102] The even distribution of large quantities of Aegean and Rhodian wine vessels over the relative timeline seems to suggest that these financial capacities did not dwindle over time. Or, the occupants did not cut their budget on buying good quality wines.

Iberian wines do not seem to have been common on Kops Plateau. Apart from the Tarraconensis province only a small amount of fragments can be contributed to areas in Baetica (see figure 3.8). Comprised mostly of the early vessel type Pascal 1 and imitations of Dressel 2-4, the Iberian wine amphoras were probably imported during the initial occupation phase of Kops Plateau. When comparing the different Iberian production regions amphoras from the Guadalquivir valley seem to be more concentrated in the earliest contexts of Kops Plateau than the other regions. But because we are dealing with such small numbers it is not wise to put too much authority on their distribution.

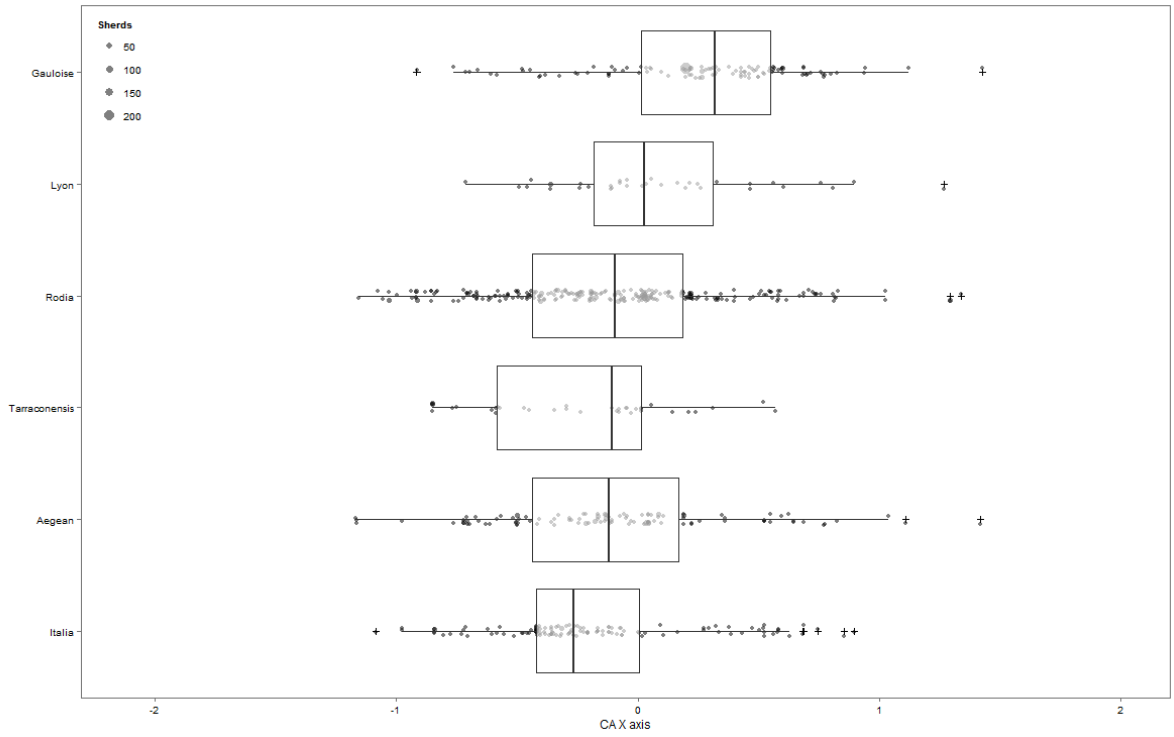


Fig. 3.7. Box plot of contexts containing wine amphoras grouped by production region.

[102] Van den Berg 2010, 21-22. Cf. Carreras 2006.

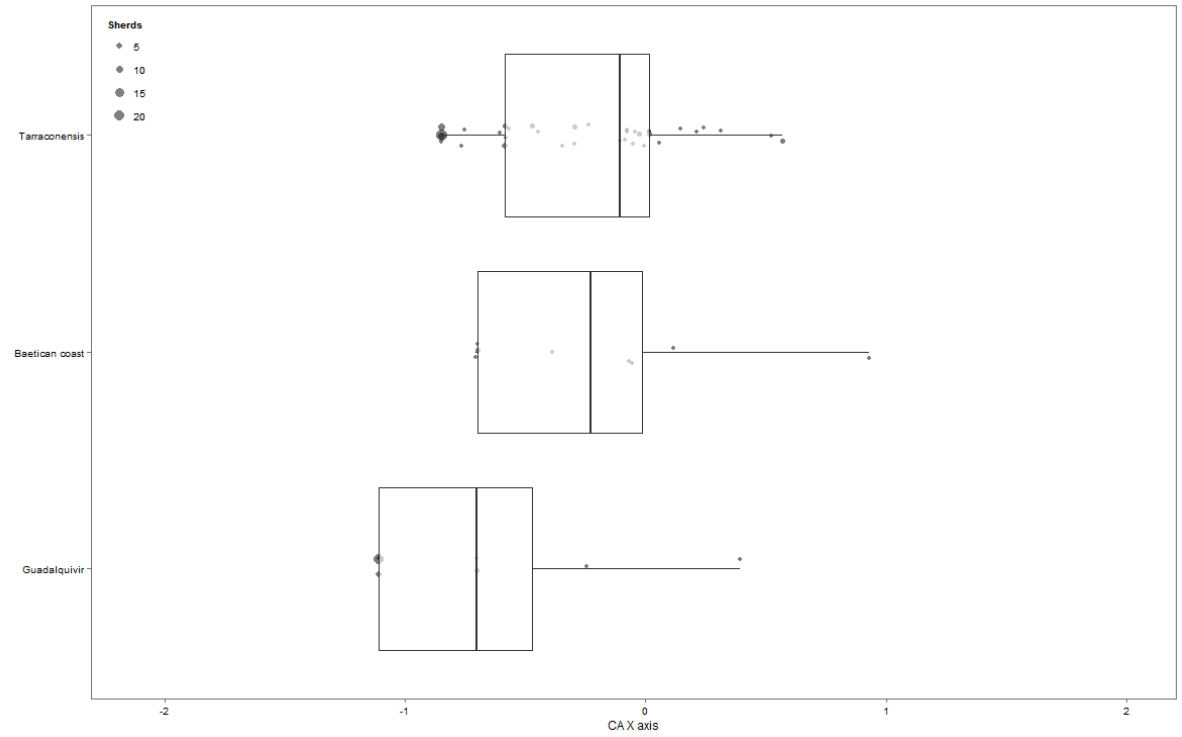


Fig. 3.8. Box plot of contexts containing Iberian wine amphoras grouped per region.

When taking a closer look at the Italian wine producing regions, their distribution does not show much development over time (see figure 3.9). Both amphoras from Campania and Etruria as well as those labelled “Italia” are clearly skewed towards the left side of the axis indicating a connection with the older contexts of Kops Plateau.

When we look at the individual vessel types we see the same chronological developments (see figure 3.10). The Republican and early Augustan vessel Dressel 1B is highly skewed towards the left side of the axis especially compared to the vessel types from Gaul. The later Lyon imitations of the Dressel 1B are contrasting the Italian version on the timeline even though we are again dealing with small numbers. The Iberian Pascual 1, another Augustan vessel type, seems to be more widely spread across the timeline. The Aegean Dressel 2/5 and Rhodian vessels again show the same wide distribution that seems to characterise the lasting popularity of east-Mediterranean wines on Kops Plateau. Lastly, the Italian Dressel 2/4 vessel is more concentrated on the left side of the axis centre while later imitations from Iberia and Gaul show a more even distribution throughout the occupation period of the camp.

We can conclude that Italian wine amphoras were mainly imported during the initial occupation of Kops Plateau. On the other hand, vessels from Lyon and other production regions in Gaul were introduced later on. Amphoras from the east-Mediterranean show a different pattern as they never seem to have lost popularity among the inhabitants of the Roman camp.

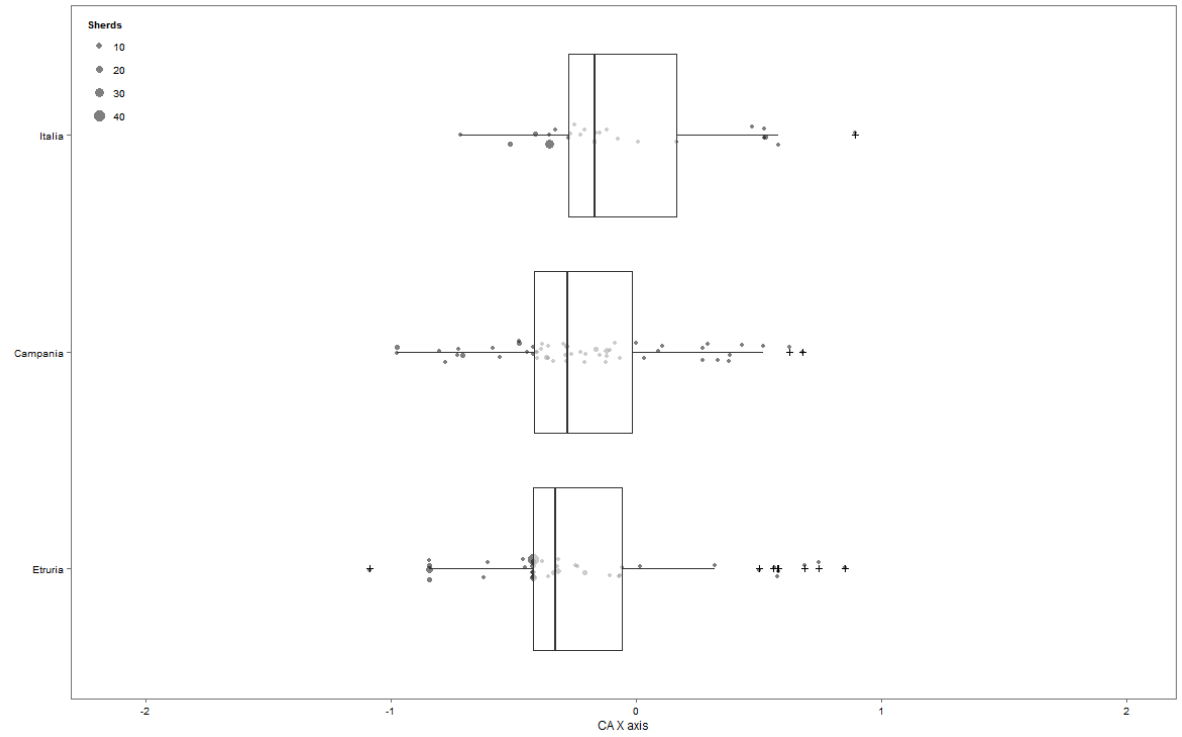


Fig. 3.9. Box plot of contexts containing Italian wine amphoras grouped per region.

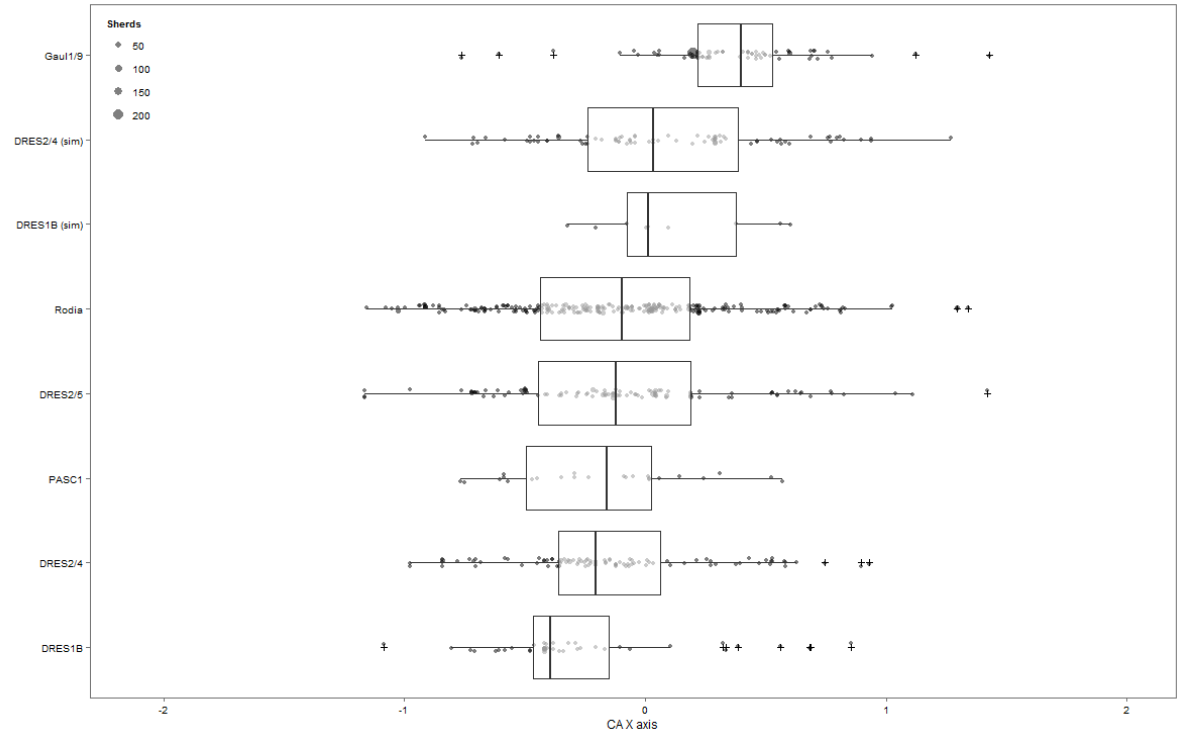


Fig. 3.10. Box plot of contexts containing wine amphoras grouped by vessel types.

3.5. Dates

Two types of amphoras that have been found on Kops Plateau were used for transporting dates from the Levant (present Israel, the Palestine areas and Lebanon). Described as “extremely luxurious”, these vessels have only been found in small quantities in the western part of the Empire.[103] First, the Kingsholm 117[104] is a small amphora shaped in the Phoenician-Palestinian tradition of “hole-mouthed jars”. Although amphoras of this type were rarely exported outside the Levant, a few have been recognised at sites in the West Europe. These exported vessels were probably first introduced in the beginning of the first century AD. Recorded Kingsholm 117 amphoras in the Lower Rhineland are very rare and so far this type has only been found at Kops Plateau and Neuss.[105]

The so-called “carrot” amphora, named after its carrot-shaped body, is the second vessel type that was probably used for transporting dates from the east.[106] This amphora type has been found numerous times at sites in West Europe and is far more common than Kingsholm 117.[107] Carrot amphoras are commonly associated with military contexts in the Lower Rhineland but they have also been found at several rural sites.[108] Although the earliest examples of this type date back to the early Augustan period they are most common from the Claudian period onwards.[109] On Kops Plateau, one recognisable example has been found in a context dated to the Claudian-Neronian period.[110]

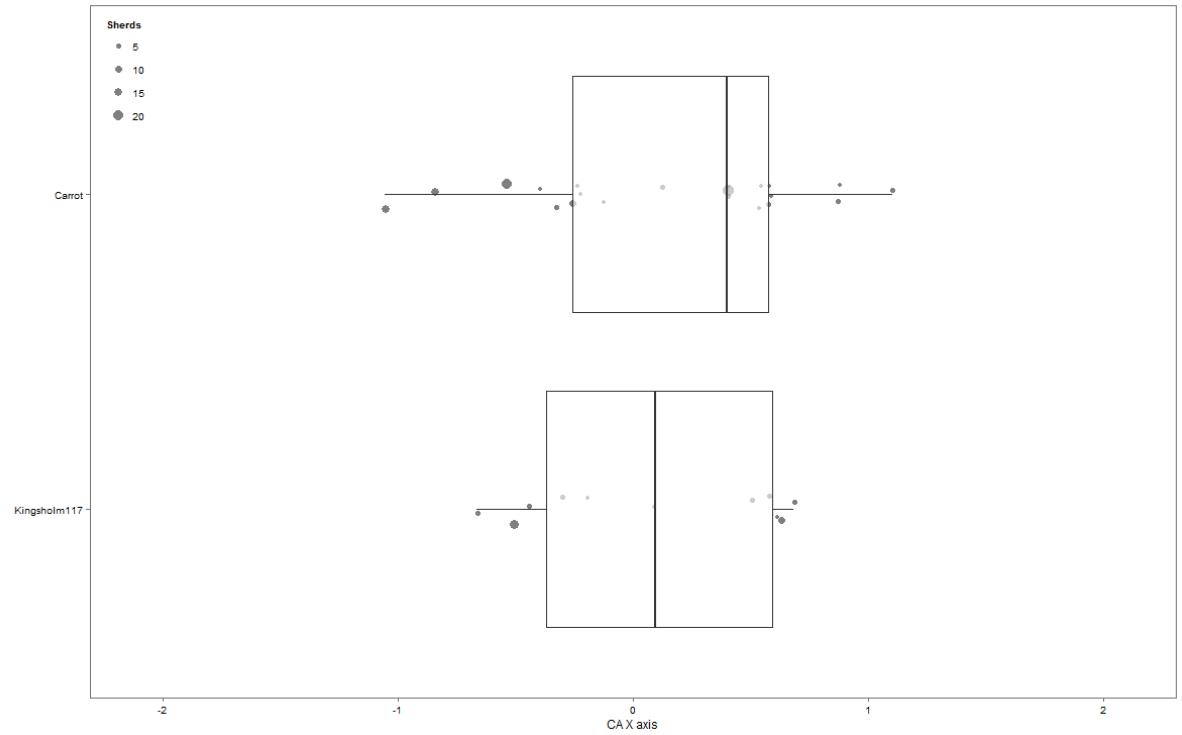


Fig. 3.11. Box plot of contexts containing date amphoras grouped by vessel type.

[103] Van den Berg 2010, 23.
[104] Also known as the Peacock & Williams class 66 type b.
[105] Van den Berg 2012, 222.
[106] Also known as the Peacock & Williams class 12 or Camulodunum 189.
[107] Van den Berg 2012, 220.
[108] Ibidem.
[109] Reusch 1970 (Claudian Hofheim). Hawkes, Hull 1947 (Claudian-Neronian Colchester).
[110] Van den Berg 2012, 220.

Figure 3.11 displays the distribution of contexts containing the two amphora types across the timeline of Kops Plateau. The Kingsholm 117 has a short distribution range compared to the carrot amphoras and its peak is near the axis centre, indicating an even distribution. The carrot amphora is widely distributed and is extremely skewed towards the right side of the axis. This strong association with the younger half of the timeline corresponds well with the Claudian starting date of the vessel.

Although we are dealing with a small number of contexts, the distribution of both amphora types shows that dates were imported probably during the whole occupation period of Kops Plateau. It can be suggested that over time the carrot amphora became the more common container for transporting dates to the camp.

3.6. Conclusions

In this chapter we have explored the chronological development of the amphoras by using the time-related ordering of contexts produced by the CA. Analysing the distribution of Adriatic oil and Italian wine amphoras has shown that these production sites tend to be more associated with contexts placed on the earlier left side of the axis. The early dating of Italian wines and Adriatic olive-oil makes it tempting to connect those vessels to the first phase of the fort. As stated before it was during this phase that the fort might have functioned as a headquarters for high ranking military officials, especially during the Germanic expeditions of Drusus. It is clear that whomever was present at the fort at that time, they possessed enough money to import products from the Italian peninsula. Even though the fort on the Kops Plateau supposedly lost its position as military headquarters after Drusus' campaigns, the wide distribution of Rhodian and Aegean wine amphoras suggests that this spending power remained throughout the occupation period. Also the continued import of dates seems to indicate that the occupants of Kops Plateau had enough financial power to import a wide variety of products from all over the Empire.

Another noticeable pattern that emerged with most content groups is that amphoras from Gaul and Lyon tend to increase in the younger part of the timeline. This "shift" from the Mediterranean production centres to the more northern sites in Gaul could be a matter of reducing transportation costs. But the apparent spending power of the occupants of the fort might suggests other reasons for the introduction of Gaulish and Lyon products. When we compare the distribution of Gaulish amphoras with South Gaulish sigillata we see a similar pattern as both ceramic groups are highly concentrated on the right of the axis centre. This might suggest that ceramic production centres in Gaul became more popular in general. Another interesting suggestion is that the increase of Gaulish products might reflect the possible arrival of new occupants on the Kops Plateau. Could it be that cavalrymen from a Batavian *ala* had a taste for Gaulish wine?

4. Spatial development of the contexts

In the previous two chapters we have demonstrated that there is a basic chronological order in the archaeological data of the excavations 1986-1995 on the Kops Plateau. In this fourth chapter we will explore the spatial distribution of the contexts by using a statistical spatial analysis. We will examine if the chronological ordering of the contexts might also reveal spatial patterns. This will be done with the help of a cluster analysis to explore potential spatial clustering of contexts which have a similar relative dating according to the CA. Following W. Tobler's First Law of Geography of "everything is related to everything else, but near things are more related than distant things"[111], the existence of clusters might provide us with new insights in the spatial development of the Roman fort over time. Moreover, clusters can reveal areas on the plateau that are significantly connected to a certain phase.

4.1. Cluster analysis

In order to identify the possible existence of time-related clusters we first tried to visualise the contexts used in the CA by scaling their colour to their positioning on the X axis. In figure 4.1 we can see the spatial distribution of the contexts across the excavation area. The contexts are visualised with a colour ramp running from blue to red, with the coordinates of the CA X axis used as a scale.

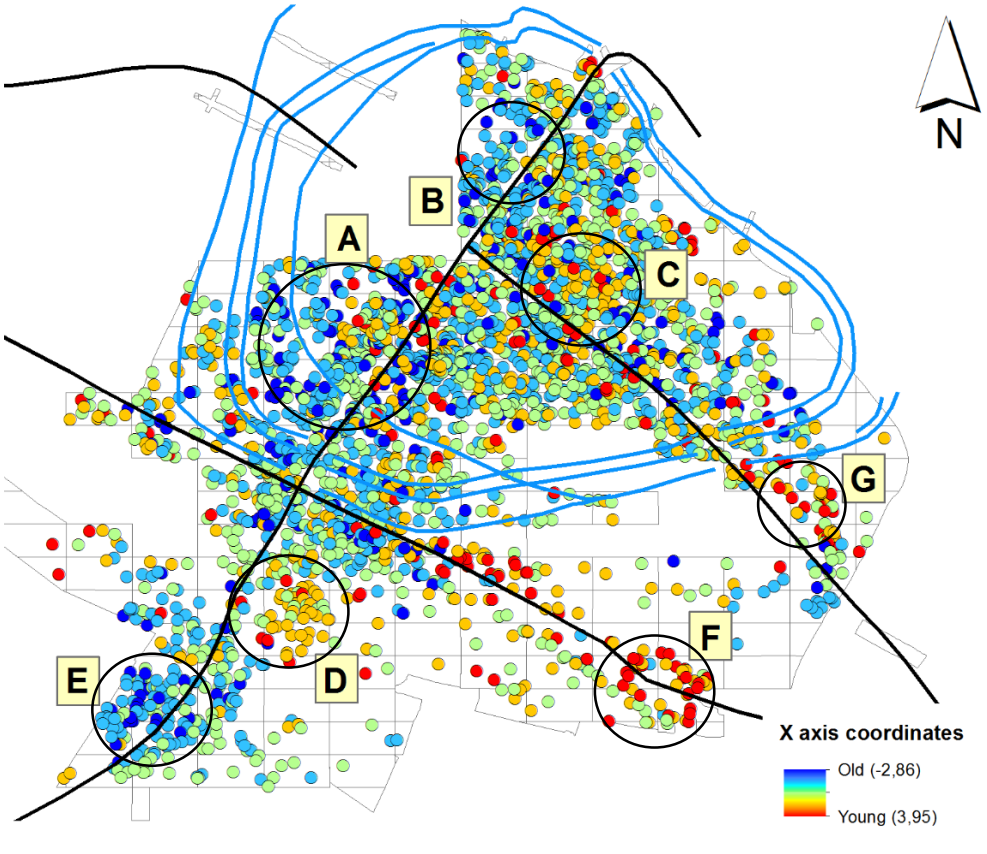


Fig. 4.1. Distribution map of contexts used in the CA on Kops Plateau.

[111] Tobler 1970, 236.

The resulting map demonstrates that certain areas seem to show some form of clustering of contexts that have similar axis coordinates. Starting inside the fort, to the south and north of the *principia* (locations A and B respectively) are large concentrations of relative early contexts. On the other hand, the situation around the *praetorium* and adjacent *insulae* suggests the opposite with a high density of younger contexts (location C). Outside the fortifications four more locations show signs of clustering of homogeneously dated contexts. Just south of the camp we see again a possible west-to-east shift of old to younger contexts (locations E and D respectively). Alongside the roads running from the east two more clusters of younger dated contexts might be identified (locations F and G).

These clusters, however, are based solely on subjective visual interpretation. To see if these possible clusters are statistically valid, we applied two spatial statistics embedded in the ArcGIS software[112]; Global Moran's I and Anselin Local Moran's I.[113] Spatial statistics are simply tools in a GIS that use statistics to "cut through the map display and get right at the patterns and relationships in the data".[114] Global Moran's I is a global statistic used to identify whether clustering of features (i.e. contexts) occurs within a dataset. Clustering of features means a geographic distribution in which groups of similar features are in close proximity to one another. This implies two things:

- A critical distance in which contexts are considered part of a cluster.
- A critical number of contexts that share a similar attribute value, in our case their coordinate on the X axis.

Because clustering can occur at different distance scales, we have to identify the distance at which the clustering of contexts is most significant.[115] Essentially this means that that Global Moran's I is determined numerous times at various distance intervals. At each interval, the Moran's I index value of the context distribution is calculated. The Moran's I index measures whether a dataset is clustering, dispersed, or randomly distributed.[116] Global Moran's I is not only computed from the distance between contexts, but also takes into account an attribute (i.e. CA X axis coordinate) that is associated with these contexts. When the Moran's I index value is near +1.0, it usually indicates that the contexts are clustered. On the other hand, when the value is around -1.0, then the contexts tend to be dispersed. Moreover, the global statistic compares the distribution of contexts to a hypothetical random distribution, or null hypothesis.[117] To find out if the distribution of contexts is not simply a random occurrence, the z-score and p-value of the distribution are calculated. The z-score is the number of standard deviations above or below the mean of its distribution and can assist us in deciding whether we should reject the null hypothesis. The p-value is the probability measure that indicates the change of falsely rejecting the null hypothesis.[118] Both the z-score and p-value are associated with the standard normal distribution. Very high or low z-scores that are associated with a very small p-value are found in the tails of s normal distribution. Therefore, when the analysis yields small p-values and either a very high or low z-score, it indicates that the observed spatial pattern is

[112] For this study the 10.2 version of ESRI's ArcGIS is used.
[113] For a detailed mathematical overview of the two spatial statistics tools, see Anselin 2003 and ESRI.com 2011a.
[114] Mitchell 2005, 2.
[115] The distance scale is the range at which the statistics will compare features with neighbouring features. It can best be seen as a buffer that is placed around an individual feature which is then compared with all neighbouring features that fall within this buffer.
[116] Anselin 2003. ESRI.com 2011a.
[117] The null hypothesis is essentially a theoretical random scattering of the same amount of features over the geographic field of analysis.
[118] If the spatial distribution of features has a p-value of 0.01 that indicates there is a 1 percent change that these features are randomly distributed.

unlikely to be some version of the theoretical spatial random distribution suggested by the null hypothesis.[119]

While the Global Moran's I index is used to examine at what distance contexts with similar X axis coordinates form clusters, the calculation of Anselin Local Moran's I can further identify where these clusters are located. Unlike the Global Moran's I index, which only calculates an index value for the whole dataset (hence the name "global"), Anselin Local Moran's I calculates the index value together with the z-score and p-value for every individual context (i.e. "local"). As a result each feature can be examined to see if it is statistically significant. In ArcGIS the results of the analysis classify features in five different groups:

- Not statistically significant features.
- Low-low clusters of features with similar low attribute values.
- High-high clusters of features with similar high attribute values.
- Low-high clusters of features with similar low attribute values surrounded by clustering features with a high attribute value (outlier).
- High-low clusters of features with similar high attribute values surrounded by clustering features with a low attribute value (outlier).

In the context of this study, applying the X axis coordinate of each context as the attribute to Anselin Local Moran's I calculation allows us to identify clusters of contexts that are either relatively old (i.e. low X axis coordinates) or relatively young (i.e. high X axis coordinates). Locations that show significant clustering of outliers can be interpreted as places where human activity remained constant throughout the occupation period.

In sum, the Global Moran's I index can inform us whether contexts are clustering and Anselin Local Moran's I can further assist us in recognising where clusters are located. These results can then be compared with the visually recognised patterns.

4.2. Results

To identify the critical distance at which the clustering of contexts with similar X axis coordinates is most significant, the analysis ran 15 times starting from a distance of 1 meter with intervals of 5 meter.[120] The analysis results indicate that clustering is most prominent at a distance of 45 meter. Although this distance scale does not hold any relevance from an archaeological point of view, from a mathematical standpoint it is the distance at which clustering is most statistically significant. Running Global Moran's I at the distance scale of 45 meter, the global statistics calculated an I index of 0.17 while the z-score is 22.88 and the p-value is lower than 0.01. This indicates that the contexts with similar X axis coordinates tend to form statistically significant clusters.

Figure 4.2 shows the results calculated by Anselin Local Moran's I. As explained earlier, the calculation of the local statistics in ArcGIS not only identifies where clusters with similar X axis coordinates are located but it also determines whether these clusters are high, low or outlying valued clusters. Basically this gives us a contrast between relative old and young contexts. The result

[119] Anselin 2003.

[120] The distance of 1 meter was chosen based on the results from the ArcGIS tool "Calculate Distance Band from Neighbor Count". This spatial tool helps to identify the distance at which spatial features have at least one neighbour. The results from this tool show that the minimum distance for some contexts to have a neighbouring context is 0.00 meter, indicating that these contexts lie directly on top of each other. The maximum distance at which every context has at least one neighbour is 121.39 meter. Lastly, the average distance at which most contexts have neighbours is 0.70 meter. The average distance band was rounded up to 1 meter.

shows us that the previous identified clusters are statistically significant. In addition, the west-to-east spatial development over time is also present in the analysis results, with low-valued (early) clusters in the west and high-valued (late) clusters in the east.

When we look at the distribution of the contexts classified as high and low clusters on the X axis, it becomes clear that the local statistics draws the line between old and young clusters on the axis centre (see figure 4.3). Therefore, based on the results of the previous chapter, old clusters can be identified as belonging to the Augustan-Tiberian phase, while the younger clusters are more towards the Claudio-Neronian phase.

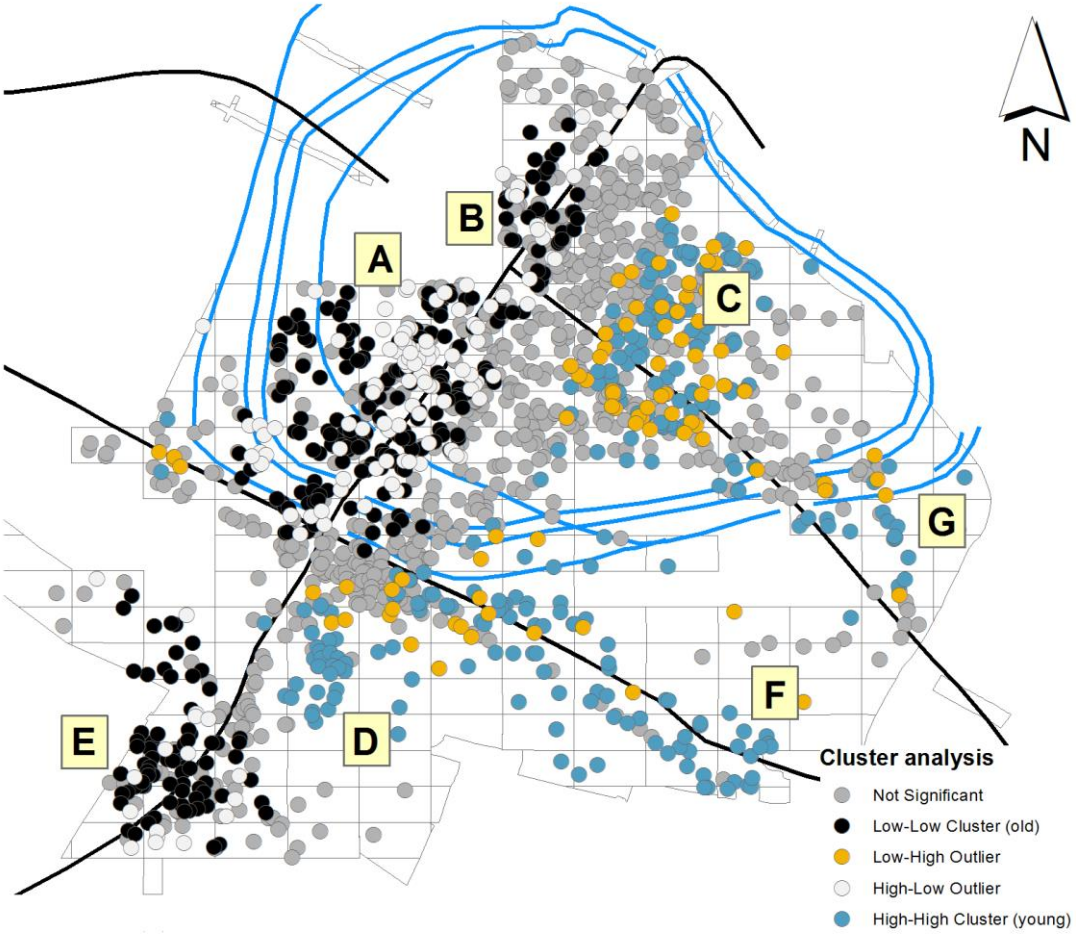


Fig. 4.2. Distribution map of clustering contexts used in the CA on Kops Plateau.

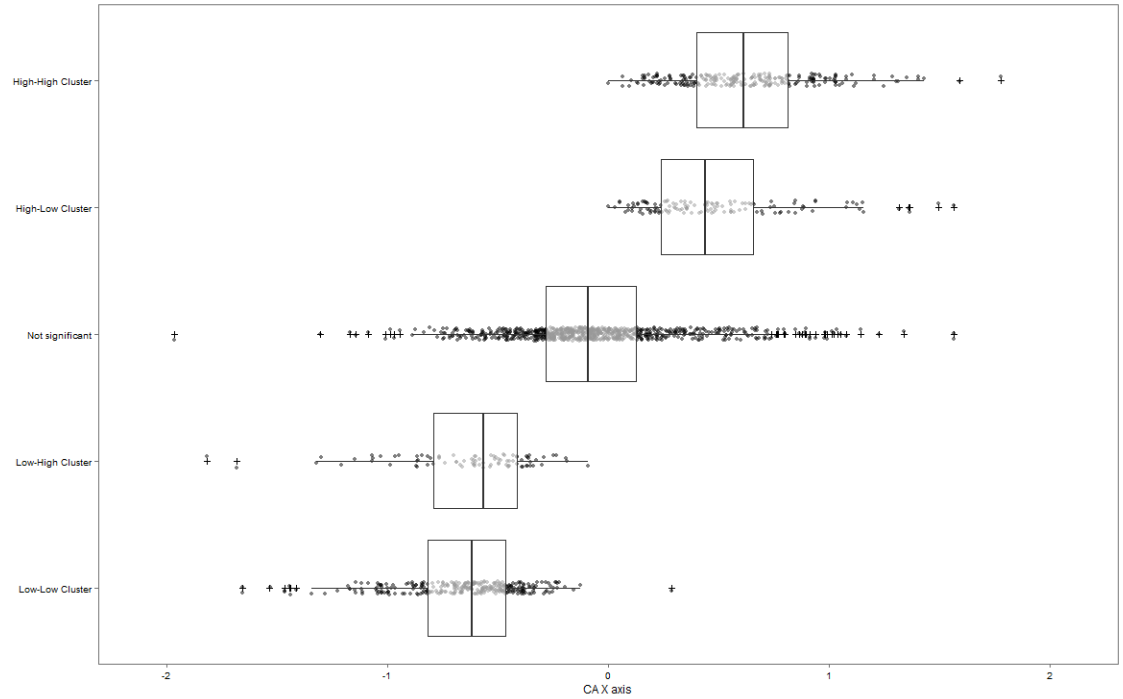


Fig. 4.3. Box plot of contexts by their classification of Anselin Local Moran's I cluster analysis.

4.3. Discussion

The main purpose of this analysis was to identify spatial patterns in the excavated area and to further interpret how the occupants of the fort on the Kops Plateau organised their space. Each cluster of contexts may represent an area where human activity was heavily concentrated. It is tempting to interpret the west-to-east development of old to younger clusters as the result from a shift in human activity over time. However, we must consider the possibility that this pattern is actually the result of post-depositional processes on the plateau. As a result, archaeologists might have had difficulty detecting the younger Roman contexts on the west side of the site compared to the east side. One explanation could be that the west side of the plateau lies higher and is therefore more susceptible to natural erosion which in turn could have affected the upper stratigraphic layers. However, when we look at the elevation model of the site we can see that both the west and east part of the fortification are similar in height (see figure 4.4). This suggests that natural erosion did not have a substantial impact on the upper stratigraphic layers since the eastern part of the fort does contain significant clustering of younger contexts.

If natural processes probably did not have a big effect the preservation of young and old contexts, maybe the west-to-east pattern can be explained by human activities. It might be possible that post-Roman building activities had a destructive effect on the stratigraphy of the Kops Plateau.

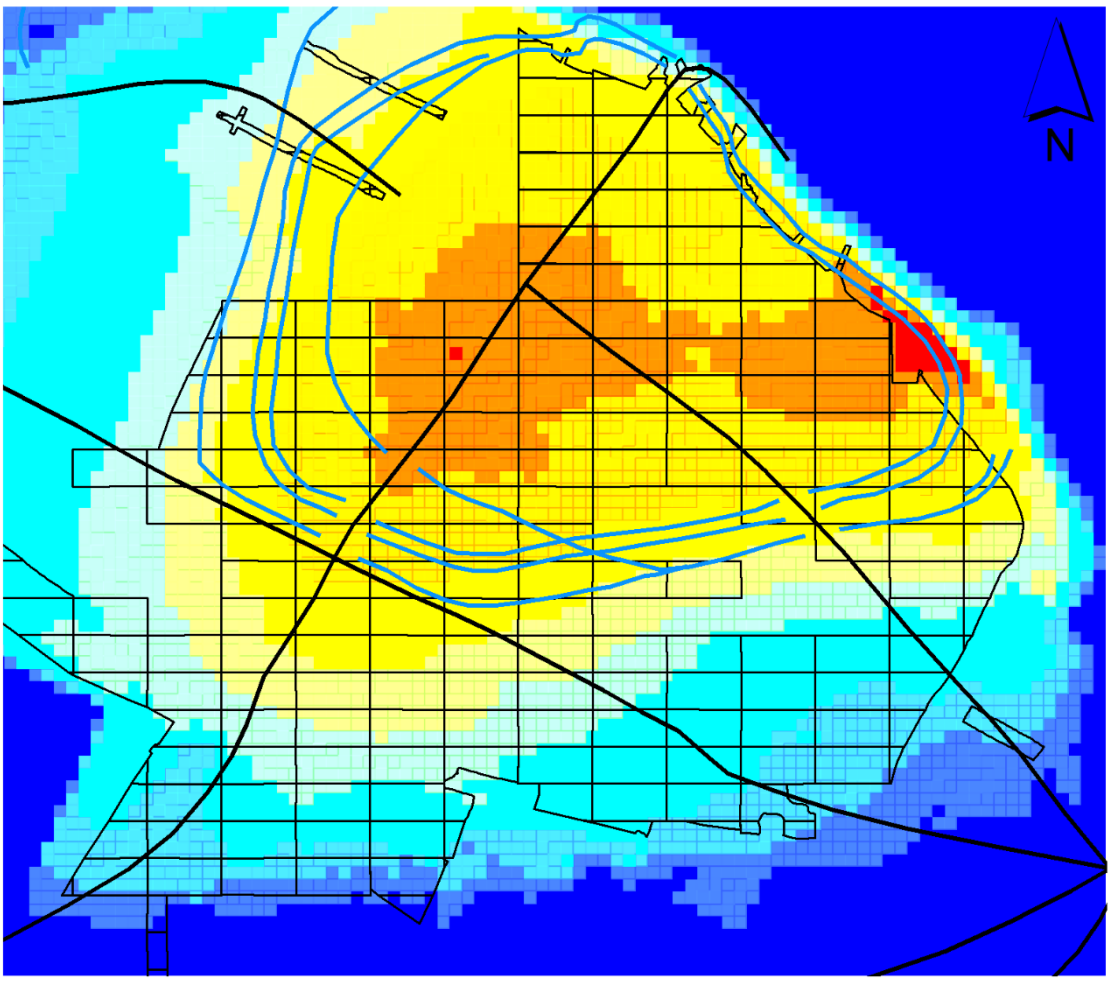


Fig. 4.4 Elevation model of the Kops Plateau. The colour scale goes blue (low elevation) to red (high elevation). Base map: Lidar-based digital elevation model (AHN – Actueel Hoogtebestand Nederland, www.ahn.nl).

4.3.1. Post-deposit disturbances

There are two instances in the post-Roman history of the Kops Plateau where human activity might have disrupted the upper stratigraphic layers on the west side of the site. First, in October 1591, the city of Nijmegen was besieged by the Dutch regent Maurits of Nassau. During the siege, the Dutch forces were stationed on both the Hunnerberg and the Kops Plateau. Several fortifications of that historical event were uncovered on the west side of the plateau during the excavation 1986-1995 (see figure 4.4).[121] Besides remnants of the military defences, several large latrines from the same period were also found directly south of the *principia*. The second possible disturbing activity took place during the Second World War when the German occupation forces constructed an anti-aircraft guns on the west slope of Kops Plateau (figure 4.5).[122] Foundations of the gun instalments were found during the excavation.

[121] Van Enckevort 2014a, 31, fig. 4.4.
[122] Ibidem, 39, fig. 4.11.2.

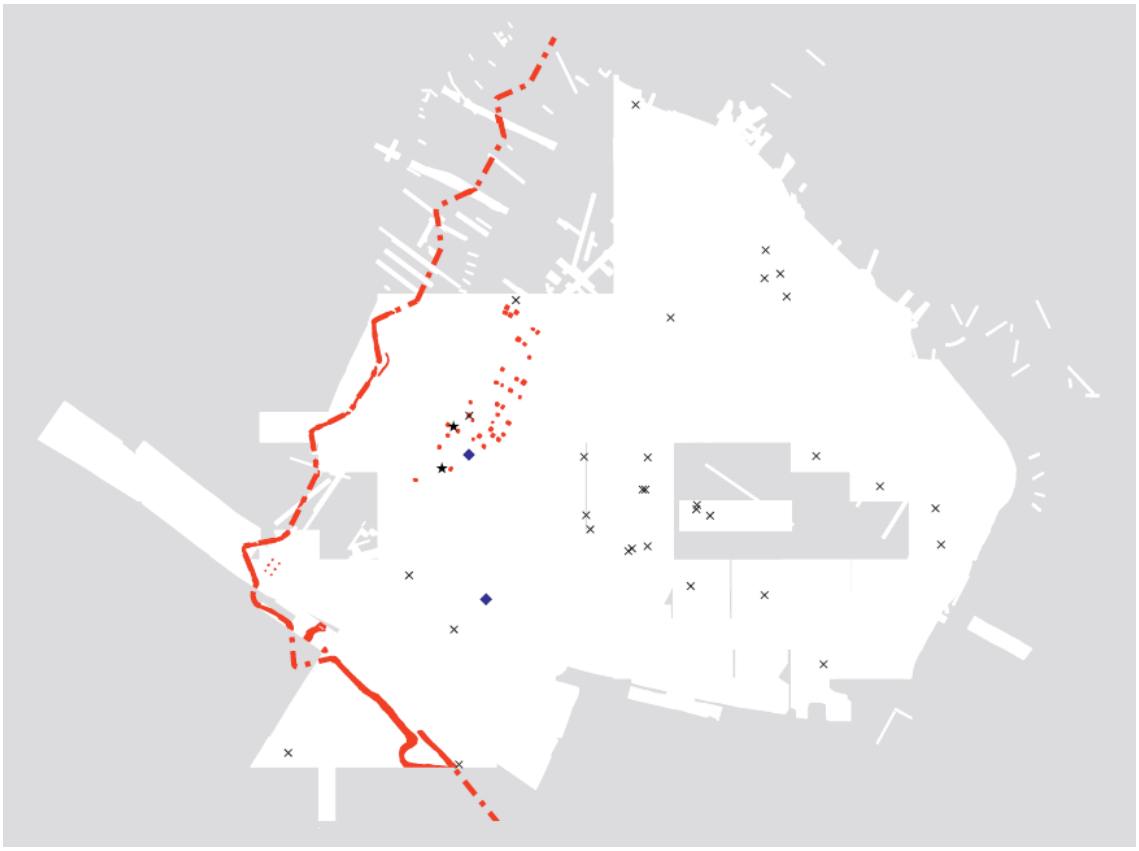


Figure 4.4. The military defensives (in red) built by the Dutch regent army in 1591. Black stars: army shovels. Black crosses: musket balls. Blue diamonds: cast irons of musket balls (copy from Van Enckevort 2014a, 31 fig. 4.4).

Figure 4.5. German anti-aircraft gun instalments on September 17 1944. 1: destroyed structures. 2: concrete walls. 3: roads. 4: structures (copy from Van Enckevort 2014a, 39 fig. 4.11.2).

Could these post-Roman building activities have disrupted the upper stratigraphic layers in such a way that the younger Roman contexts could no longer be identified? It seems unlikely as the above mentioned building activities do not show any large-scale impact on the archaeological make-up of the area west on the Kops Plateau and traces of these activities were only sporadically found. Also, the analysis did identify several clusters of high-valued outliers in the area, indicating that younger stratigraphic contexts were not completely absent.

Another possible explanation is that the pattern is not the result of any historical development but actually the result of field technicians using different excavation techniques.[123] However, this does not seem to be a very convincing when we look at the division of the excavation site by the two main field technicians (see figure 4.6). We can clearly see that most of the trenches inside the fort were supervised by Greving while the areas outside the fortifications were done by Tak. This division could hardly have resulted in the clear cut west-to-east opposition in old and young contexts.

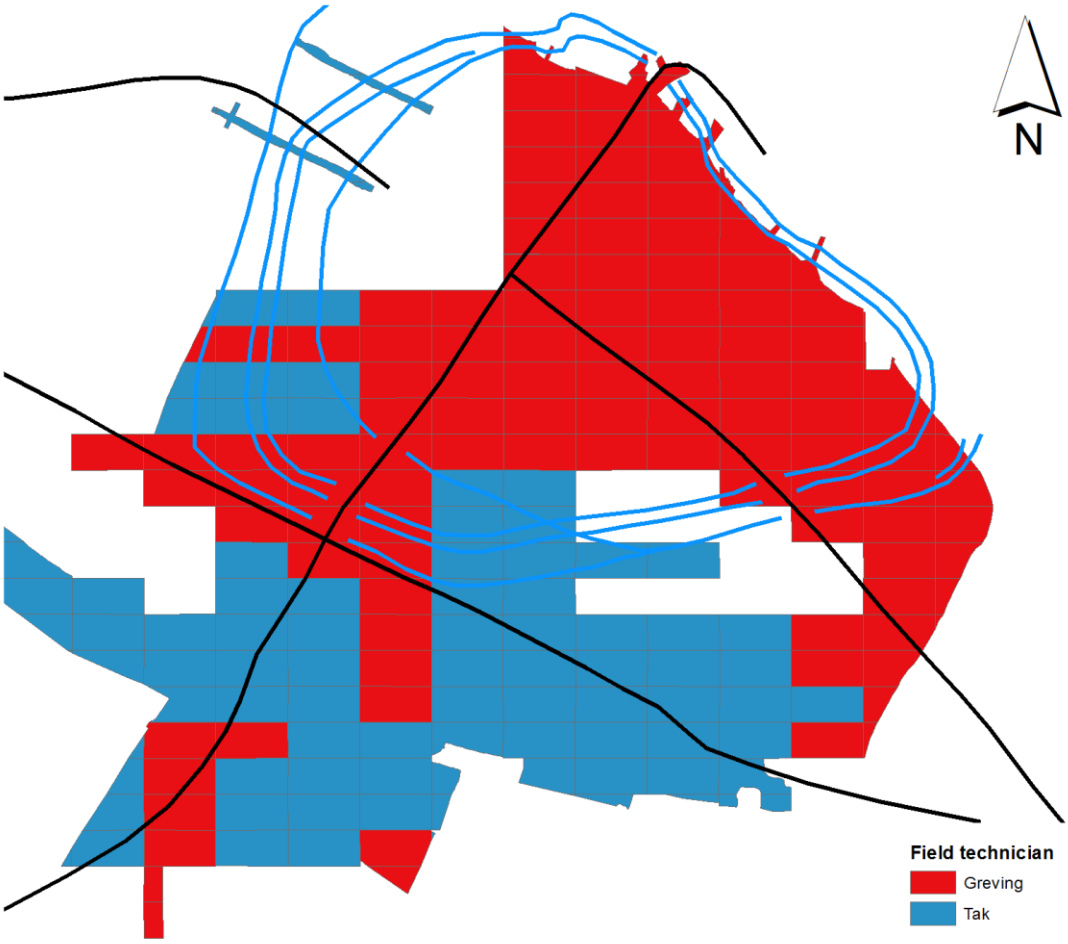


Fig. 4.6. Division of excavation trenches by field technicians.

[123] This was suggested by the audience of the Aardewerkdag 2015 conference in Nijmegen after presenting some preliminary results of this study.

4.3.2. Activities within the fort

If no post-Roman activities have convincingly created or influenced the west-to-east development of old to younger contexts, the pattern might well reveal a shift in human activity during the Roman occupation on the Kops Plateau. It is interesting to note that inside the fort the older contexts either cluster around the main *via principalis* (location A and B) or just to the west of it. As for the younger contexts, they concentrate between the *praetorium* and the *via praetoria* (location C). On the contrary, the area between the *principia* and *praetorium* has no significant clustering of contexts with similar coordinates. Contexts in this area have such diverse CA coordinates – ranging from very old to young – that statistically they do not form clusters. However, the absence of clustering in this area actually complements the idea of a shift in human activity from west to east. Visually the grey band of not-significant contexts forms a perfect transition between the old and younger clusters.

Figure 4.7 gives us an overview of the context types of each cluster classification. Figure 4.7.1 shows that the clustering of old context found at location A and B are for the most part (rubbish) pits and postholes. The same goes for the younger contexts that are classified as outliers (figure 4.7.3). Together with two old contexts that have been identified as latrines, it may be suggested that location A and B might have been partially used as an area for disposing of rubbish and house sanitation facilities. Because of the large amount of younger contexts that are present in the area, it is probable that the deposition of waste continued during the whole Roman occupation period. The clustering of the (rubbish) pits so close to the fort's headquarters is remarkable to say the least. It should be noted that when we look at the distribution of structures inside the fort, as identified in this study, we can see that the area south of the *principia* is rather empty – exactly where the old pits and postholes are clustering. Another interesting observation is that part of the clustering at B is concentrated around a previous unidentified building. Both the basement and latrine that are supposed to be part of this building are clearly identified as older contexts. It remains unclear as to why locations A and B show such a strong clustering of old postholes and pits while no buildings could be identified. It is clear that additional research in this area is needed.

The clustering around location C can for a large part be connected to activities in and around the *praetorium* and the possible adjacent *insulae*. As discussed in the introduction chapter, the luxurious residence complex was supposed to be most actively used during the first phase of the fort, although it probably remained in use during the whole Roman occupation period. The large concentration of older contexts, identified by the cluster analysis as outliers, can be associated with this early phase of the residence (figure 4.7.2). These contexts include two basements situated inside the structure and three latrines located just outside. Five basements that are part of the younger cluster suggest that the *praetorium* was indeed still in use during the later phases of the camp. The contexts near the adjacent *insulae* are for the most part pits. The basement and nearby latrine of a possible building just south of the *via praetoria* can also be seen clustering. Because of the basement and latrine contexts it seems clear that this residence area was still in use during the later phases of the fort. However, the large concentration of young pit contexts with several postholes on top of the lower east *insula* does seems to be a little odd and raises the question of that building's function (or existence) in the later phase of the fort.

Explaining the shift in concentrated clusters is a difficult task. Suggested here is that the *principia* building lost its function over time which may have resulted in a shift in activity towards the other monumental structure in the fort: the *praetorium*. As the residence became more the central point of the camp it is only natural that this led to an increase in activities around the structure.

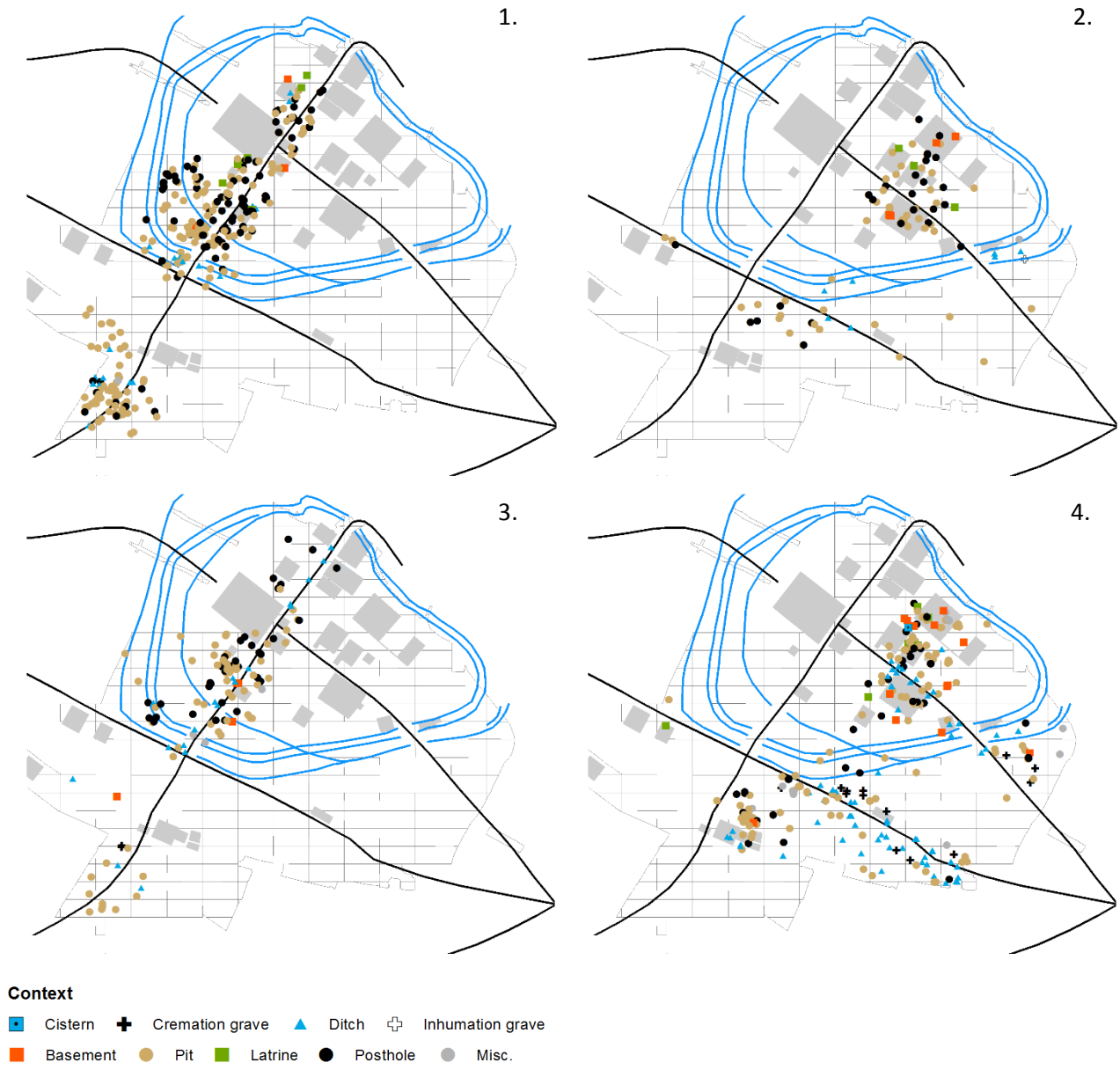


Fig. 4.7. Distribution map of clustering contexts used in the CA on Kops Plateau. 1: Old contexts. 2: Old contexts surrounded by younger contexts. 3: Younger contexts surrounded by older contexts. 4: Young contexts.

4.3.3. Activities *extra muros*

Outside the fort we can see that clustering is most apparent around the major roads. Again, the older contexts cluster around the south-north road (location E), while a younger cluster is found just opposite of the road (location D). This cluster of young contexts is actually part of a much larger concentration of contexts that is connected to an auxiliary camp that was concentrated around the stable complex discussed in the introduction chapter. The hypothesis that this annex dates to the Claudio-Neronian phase is strengthened by the statistically significant clustering of younger contexts. It is unclear how the cluster at location E is to be interpreted. Figure 4.7.1 shows that the majority of the contexts are pits – similar to the high number of pits located at the Claudio-Neronian campsite. It is tempting to suggest that the older cluster we observe here represents another campsite, maybe even a predecessor of the nearby Claudio-Neronian site. A more detailed study of the contexts and stratigraphy of that area is certainly advisable.

Moving towards the east side of the excavation area, two groups of younger contexts cluster around major roads (locations F and G). In particular location F, where the ancient road runs parallel to the modern-day Ubbergseveldweg, shows a large clustering of young contexts consisting for a large part of ditches and cremation graves. That a majority of the road ditches are part of young clusters coincides with the existing interpretation of this road as a Flavian construction.[124] Near the eastern gateway (location G) of the fort are cremation graves located as well. In that same area a single inhumation grave is classified as an old context outlier. But based on the stratigraphy it is more likely that this grave is a younger context.[125]

4.4. Conclusions

In this chapter we have discussed the spatial distribution of relatively dated contexts on the Kops Plateau. The goal was to map the spatial developments of contexts that might reflect some form of human activity. For this, we employed two main steps in the spatial analysis: first, visualising the spatial distribution of contexts used in the CA by colour-coding them according to their position on the X axis; second, applying spatial statistics to confirm the results of the visualisation and to explore how the occupants of the fort might have organised their activities over time. Although the initial visualisation of the distribution of contexts already offers multiple clues of where contexts might have been most concentrated, the application of the global and local Moran's I spatial statistics provided other ways to re-examine the nature of these patterns. Although it remains unclear how we should interpret the apparent shift in concentrated contexts, it can be suggested that the spatial organisation inside the fort changed over time.

[124] Cf. Willems et al. 2008, 93-94 with afb. 36.

[125] The inhumation grave was found in the filling of the outermost defensive ditch. Because this ditch lost its function most probably after AD 40, it can be suggested that the grave could only be created somewhere after this date when the ditch was refilled with earth. The assemblage of this grave, however, is more similar to that of older contexts as it contains a single HBW 94 cork ware sherd, one sherd of a Haltern 59 mortarium and another sherd of a Haltern 70 amphora.

5. Spatial distribution of amphoras

The combined results of the CA and the spatial statistics of the Global and Local Moran's I indicate that the intensity of context depositions shifted over time on Kops Plateau. However, the results only show a chronological development but do not provide any insight into the socio-economic developments. Trying to reconstruct any form of socio-economic organisation at an intra-site level hinges on the possibility to pinpoint places where different kinds of activities were performed in the past. Taking the distribution of amphoras as a case study, it will be shown how a distribution analysis of these transport vessels can be used to explore the relation between space and certain products used by the inhabitants. In this chapter we will expand our spatial analysis by including all contexts that have amphora sherds in their assembly and not only those that were used in the CA. For this purpose, we will again be using the data that was provided by C. Carreras' re-examination of the amphora vessels found at Kops Plateau.

Two steps of analysis were conducted in order to determine the distribution of amphoras on the Kops Plateau. To begin with, we first tried to locate the contexts that contain the highest numbers of amphora sherds. Similar to the statistics used in the previous part of this chapter, a hot-spot analysis tool is used from the ArcGIS software to locate statistically significant clusters, or hot-spots, of contexts with large numbers of amphora sherds. It is suggested here that clustering contexts with large numbers of amphoras can be interpreted as dumps. The use of hot-spot analysis can therefore provide us with a first visualisation of where amphoras were purposefully disposed.

Secondly, the hot-spot analysis only provides us with information about individual amphora groups. For a comparison to be made between distribution patterns of amphora groups – where are relatively large or small quantities of a specific group location compared to the rest? – it is necessary to compare the sherd frequency of individual groups with the total amount of amphora sherds. This second step will enable us to determine where relative "high" and "low" sherd numbers of a specific amphora group are located.

5.1. Hot-spot analysis

We will first look at the numbers of sherds across the excavation area. Figure 5.1 shows contexts scaled to the amount of amphora sherds found in their assembly. This is a great means of visualising the dataset in a relative simple manner and helps us with the initial identification of areas containing large numbers of amphora sherds. It becomes immediately clear that large numbers of sherds cluster at several places both within the camp as well and alongside the main roads.

Similar to the analysis discussed in the previous chapter, the visualisation does not provide a clear indication of whether the areas we see as clusters of large numbers of amphora sherds meet the test of statistical significance. To find out if and where statistical significant clustering of contexts containing amphoras occur, we once again need to use the Global statistics of the Moran's I. The statistics tool ran 15 times starting from a distance of 1 meter with intervals of 5 meter. This time, the results indicate that clustering is maximised at two distance scales; 10 and 60 meters with the latter providing the highest z-score. Although clustering is most prominent at 60 meter, we have to ask ourselves if this distance scale is still useful for our study. Running the Global Moran's I analysis at 60 meter results in massive bloated clusters that lose any form of detail. In this case, the 10 meter distance is the better option as it provides us with more subtle clustering which gives us a more detailed overview of the spatial patterning of amphora sherds. At this distance the Global Moran's I calculates an index value of 0.04 together with a z-score of 7.15 and a p-value of less than 0.01. The

clustering of contexts containing amphora sherds can therefore be interpreted as statistical significant.

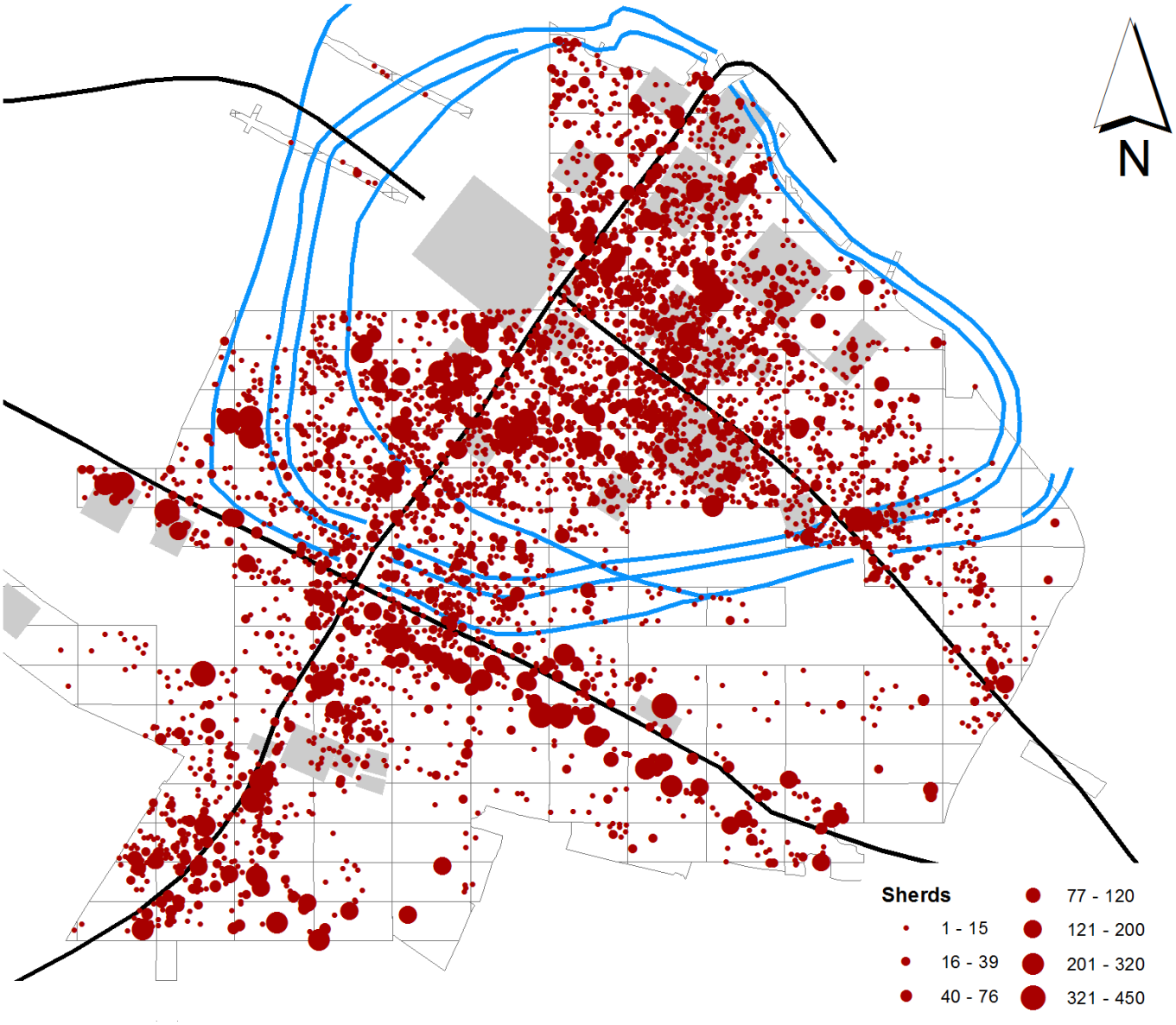


Fig. 5.1. Distribution of contexts containing amphoras. Contexts are scaled based on the frequency of amphora sherds in their assembly.

Next, we could use the local Moran's I again, though in this case we are only interested in the clustering of contexts with large numbers of amphora sherds. The Getis-Ord Gi* (pronounced as "Gi-star") is a statistic is found in the toolset of the ArcGIS software and is specifically designed for identifying statistically significant clusters of contexts which have a high value attribute frequency (i.e. number of sherds).[126] To use the terminology of the Getis-Ord Gi* statistic, these clusters are called "hot-spots". Similar to the local Moran's I analysis, Getis-Ord Gi* calculates the z-score and p-value of every individual context that contains amphora sherds. The resulting output of the hot-spot analysis is a classification of the contexts in seven groups based on the confidence level of the clustering:

[126] For a mathematical description of the Getis-Ord Gi* statistics, see ESRI.com 2012c.

- 99 percent statistically significant cold-spot.
- 95 percent statistically significant cold-spot.
- 90 percent statistically significant cold-spot.
- Not significant feature.
- 90 percent statistically significant hot-spot.
- 95 percent statistically significant hot-spot.
- 99 percent statistically significant hot-spot.

In the context of this study, the focus will be on the contexts that are classified as hot-spots. Although cold-spots also identify statistically significant clusters of contexts, their similarity is based on their collective low number of amphora sherds.

5.2. Relative distribution of amphoras

In order for us to compare the distribution of different groups of amphoras, we have to compare the numbers of an individual group to the whole dataset of amphoras.[127] By calculating the percentage of sherds from a specific amphora group relative to the complete assembly of amphora sherds allows us to assess where relative high or small numbers of that group are present. To make a comparison possible, the individual contexts need to be aggregated into larger units. Luckily the excavation dataset already provides us with an aggregated feature: the excavation trench. A total number of 245 trenches were excavated and all individual contexts that were identified during the excavation are connected to one of these overarching excavation units.

To compare the sherd numbers of amphoras per trench, all trenches need to be equal in size. Some trenches are, however, not completely excavated. To compensate for the incomplete trenches, the sherd numbers of these excavation units are multiplied by the quotient of the surface area of a complete trench (450 m2). Trenches that were excavated less than half of a complete surface area are removed from the analysis because the corrected frequencies would be too unreliable.

To find out if a trench contains relative “high” or “low” numbers of a specific amphora group, a scale is calculated based on the mean and the standard deviation of the group’s sherds found in all trenches. The standard deviation expresses the average deviation from the average amounts of sherds that is found in the trenches. Those trenches that have a sherd number of more than one standard deviation above average therefore contain a relative high amount of amphora sherds. As a result, a colour scale of three classes can be used: below average (green); up to one standard deviation above average (orange); more than one standard deviation above average (red).

5.3. Results

The graphical result of the Getis-Ord Gi* statistic in figure 5.2 demonstrates that several hot-spots of contexts containing large numbers of amphora sherds are present on the Kops Plateau. Four of these hot-spots can be found inside the fort at the locations of A, B, C and H (also note the cold-spot below H). Outside the fort, high numbers of amphora sherds are found alongside the main roads, particularly the previous discussed Flavian road (locations D, G, I, and L).[128] Two more hot-spots are located near the auxiliary camp and the stable complex (locations E and K). Lastly, two minor hot-

[127] This analysis method is based on a method discussed in Van den Berg, Polak & Alders 2012. Cf. Polak 2014.
[128] Note that hot-spots G and L were separated because of the distinct clustering of contexts near G. Further discussion below will make the distinction more apparent.

spots that seem to be less dense are located somewhat farther from the north-south road (location F and J).

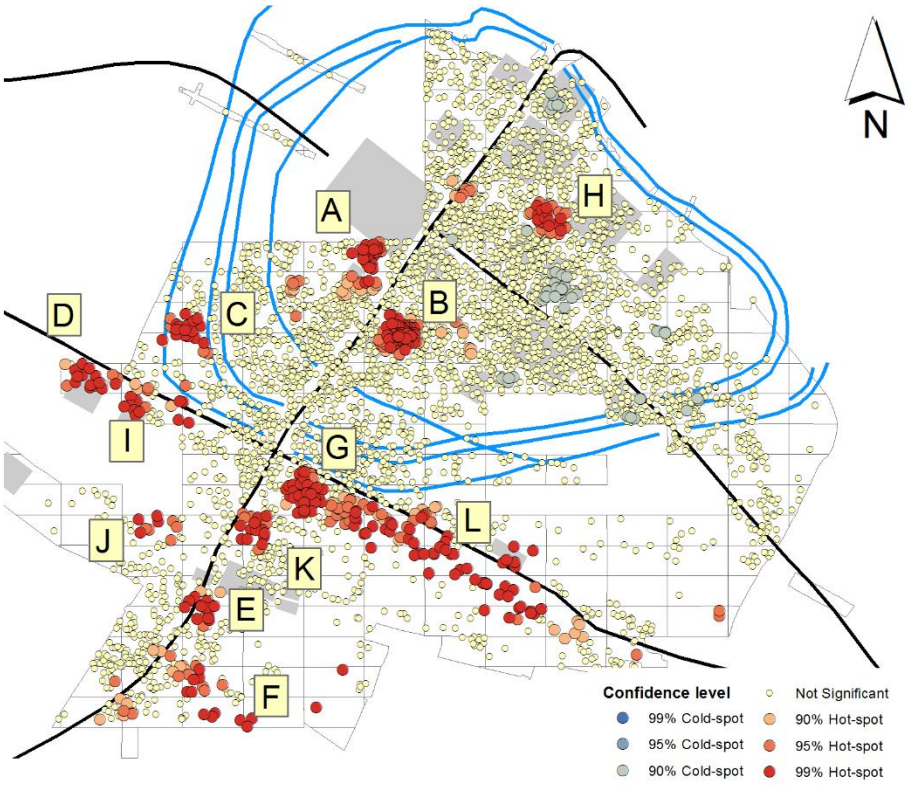


Fig. 5.2. Hot-spot analysis of contexts containing amphora sherds.

Now that we have established a rough idea of where amphora hot-spots are located, the next step is to find out where specific groups of amphoras are concentrated. To start with, the transport vessels were divided into four groups based on their content: fish-sauce, olives, olive-oil and wine.[129] Figure 5.3 shows the distribution of the four content groups across the plateau. In the left column we see the hot-spots that have been identified by the Getis-Ord Gi* statistic and in right column we see the relative distribution of the content groups across the trenches. The values in every trench box is the absolute amount of amphora sherds. In table 5.1 additional information about the hot-spot analysis can be found.

Content	Distance	Moran's I index	Z-score	P-value
Fish-sauce	10	0.087	2.546	0.011
Olives	30	0.032	2.409	0.012
Olive-oil	25	0.029	3.719	< 0.001
Wine	5	0.115	3.296	< 0.001

Table 5.1. Diagnostics of the hot-spot analysis.

[129] Dates from the Levant were excluded from the analysis because of their extreme small frequency.

Figure 5.3.1 displays the distribution of fish-sauce amphoras. In the left panel we see that contexts containing high frequencies of fish-sauce amphoras are for the most part located inside the fort, especially at location H near the *praetorium*. Also contexts at location E, the stable complex, form a hot-spot for fish-sauce amphoras. The right panel shows the relative distribution of fish-sauce vessels compared to all amphora sherds. It is clear that the hot-spots inside the camp correspond with an above average percentage of fish-sauce amphora sherds compared to the overall distribution of that content group. However, no spatial significant hot-spot was identified near the south-east entrance of the camp, even though the trenches in that area do show an above average percentage of fish-sauce amphoras.

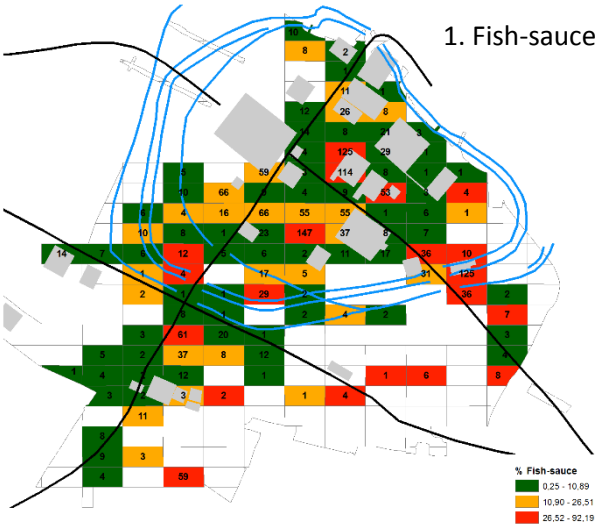
Figure 5.3.2 shows the distribution of amphoras that contained olives. In the left panel we see that the two areas that contain hot-spots of olive amphoras are concentrated in the west part of the excavation site. Location D in particular has a large hot-spot of contexts containing olive amphoras. Although this area has a statistically significant hot-spot, the relative distribution, seen in the right panel, makes clear that the contexts in that trench only have an average percentage of sherds compared to the overall distribution of amphoras containing olives.

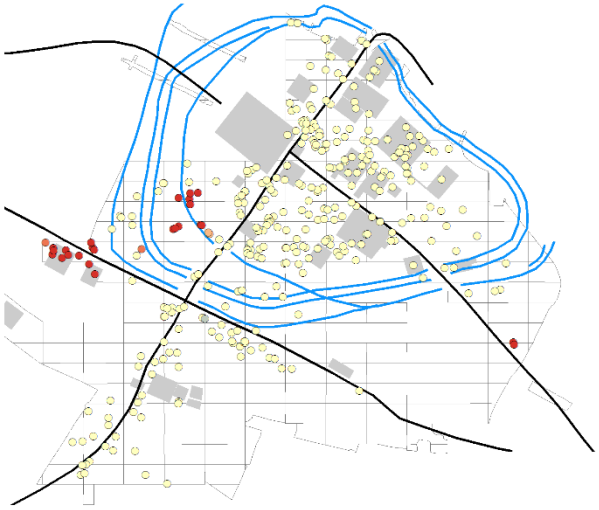
Figure 5.3.3 shows the distribution of olive-oil amphoras. Similar to the amphoras containing olives, contexts at location D form a hot-spot for olive-oil amphoras. Also a clear hot-spot in the centre of the camp has been identified, near the p*rincipia*. In the right panel we see that this hot-spot also has an above average relative amount of sherds compared to the overall distribution of the content group. On the contrary, the hot-spot at location D clearly has a below average frequency of olive-oil amphoras.

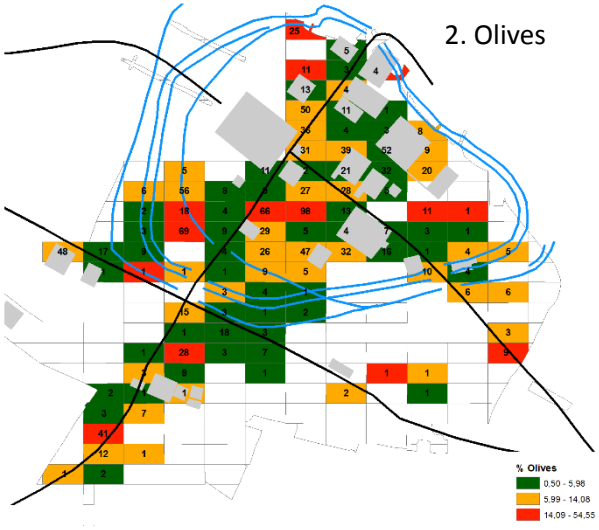
Figure 5.3.4 displays the distribution of wine amphoras across Kops Plateau. The wine amphora is the most dispersed content group with small hot-spots located both within and outside the camp. Similar to olive and olive-oil amphoras, the Getis-Ord Gi* statistic has identified a hot-spot of wine amphoras at location D (though it is only a single context). Based on the relative distribution, this hot-spot has a relative average amount of wine amphora sherds compared to the rest. Contrary to what the hot-spot analysis shows, the trenches near the southern entrance of the fort do have an above average amount of wine amphoras.

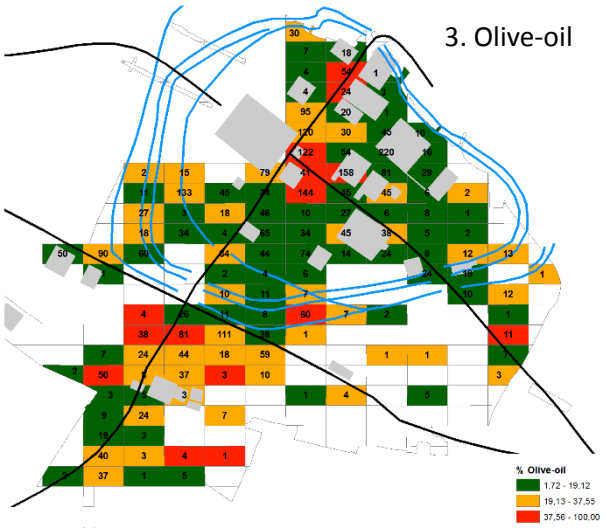
Lastly, figures 5.4 and 5.5 show us additional information about the distribution of olive-oil and wine amphoras. In the previous chapter we have seem that the production regions of these content groups show a clear chronological development and therefore they are analysed in more detail. In figure 5.4 the hot-spots of Adriatic olive-oil amphoras are displayed together with their relative distribution across the trenches.[130] Both the hot-spots and the trenches with a relative high numbers of Adriatic amphora sherds are located within the fort. Figure 5.5 only displays the relative distributions of Italian and Gaulish wine amphoras as no hot-spots were identified by the Getis-Ord Gi* statistic. The relative distribution, however, does show some differences between the two production regions, in especially outside the fort. Whereas relative high numbers of Italian wine amphoras are found at location F in the south part of the excavation site, Gaulish amphoras are more concentrated at location D. Amphoras from both production centres are found in relative high numbers at location K, the stable complex.

[130] The distribution of amphoras produced in the Baetican coastal area are not shown as they have an above average distribution in all other trenches of the excavation site.


1. Fish-sauce
% Fish-sauce
0,25 - 10,89
10,90 - 26,51
26,52 - 92,19




2. Olives
% Olives
0,50 - 5,98
5,99 - 14,08
14,09 - 54,55


3. Olive-oil
% Olive-oil
1,72 - 19,12
19,13 - 37,55
37,56 - 100,00

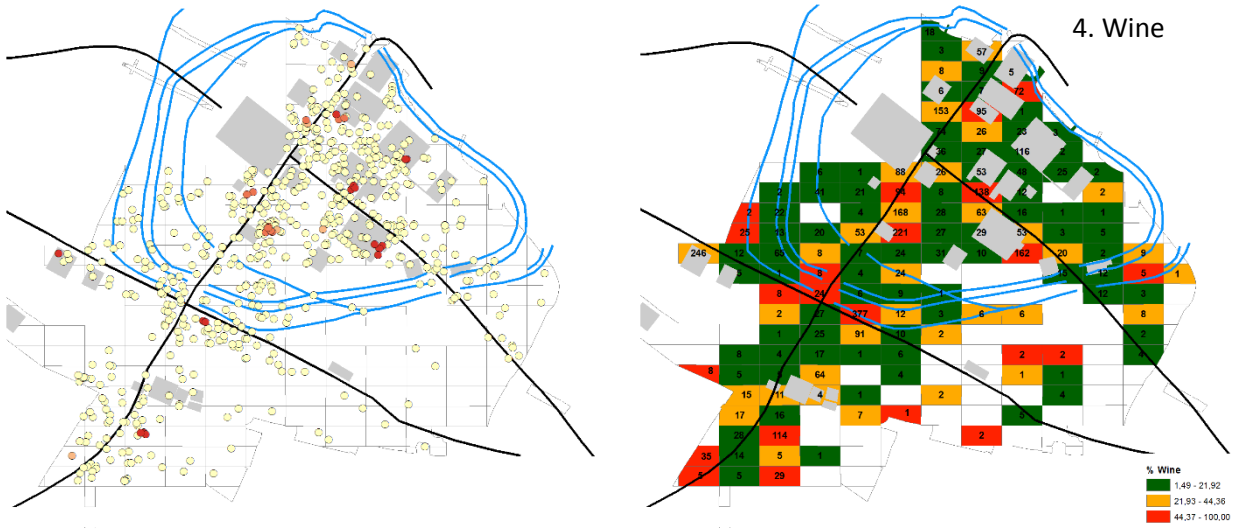


Fig. 5.3. Distribution of the amphora content groups.

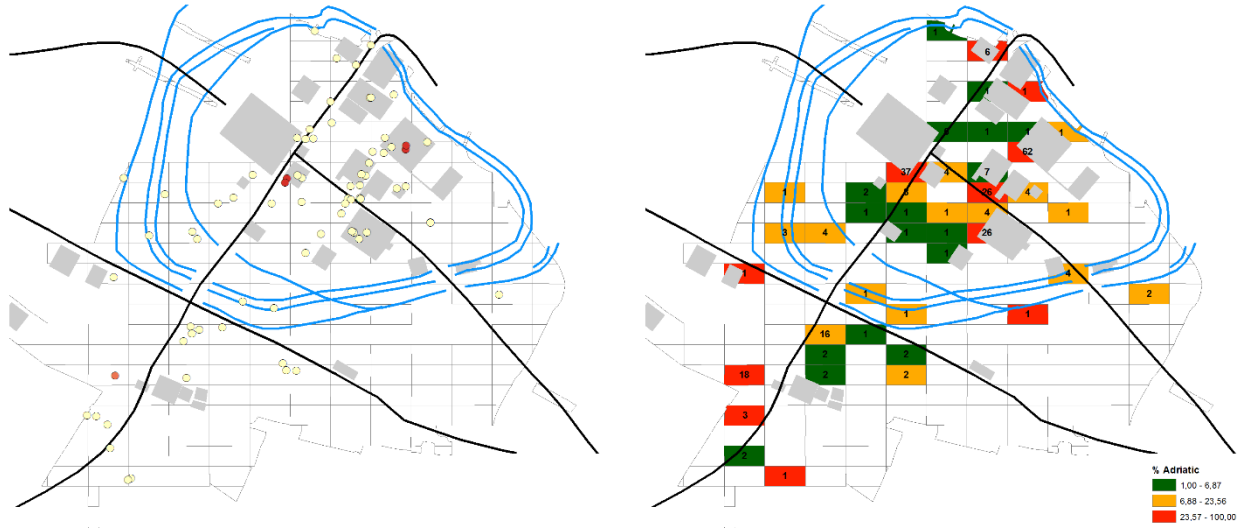


Fig. 5.4. Distribution of Adriatic olive-oil amphoras.

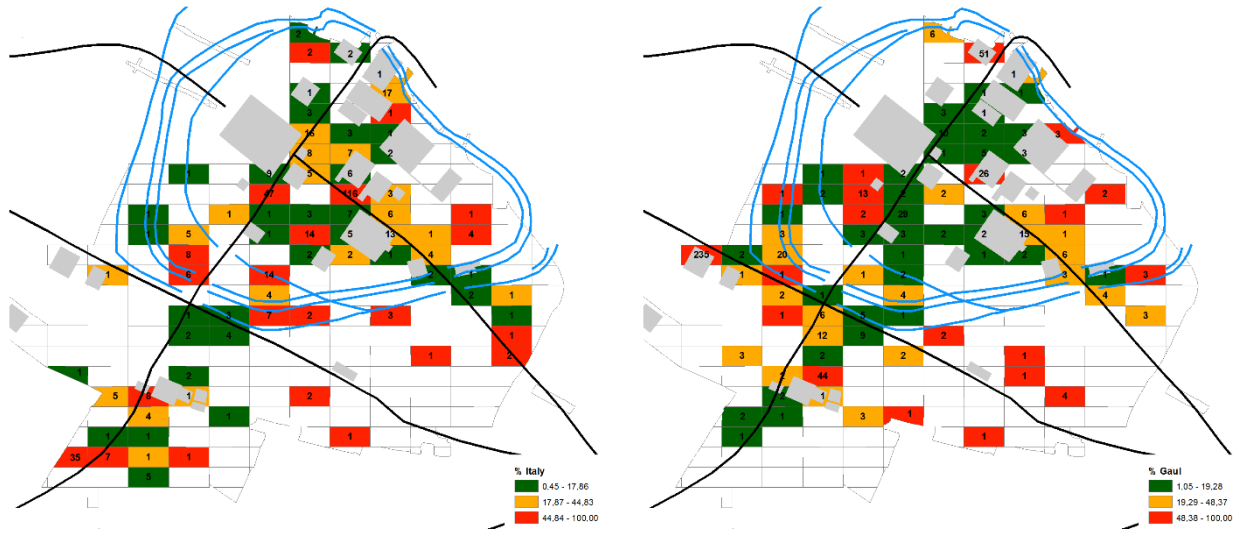


Fig. 5.5. Distribution of Italian (left) and Gaulish (right) wine amphoras.

5.4. Discussion

The goal of this case study is to reconstruct any spatial form of social-economic organisation by the ancient occupants of the Kops Plateau. Based on the results of the hot-spot analyses and relative distribution comparisons several remarks have to be made on the spatial distribution of amphoras. First of all, the hot-spot analysis on the complete set of contexts containing amphoras has identified multiple areas were amphora vessels were discarded in large quantities. Moreover, the hot-spot analyses on the four content groups also indicate that on the level of content different dumps can be distinguished, both inside and outside the camp. There is no single dumpsite that is a statistically significant hot-spot where all amphoras were discarded. This leads to the assumption that the various contents of amphora vessels were primarily used at different locations which would have resulted in the unique spatial distribution patterns that the content groups show.

A second thing to notice is that almost none of the separate content groups have hot-spots at locations G and L with the exception of amphoras containing olive-oil and a single context containing wine amphoras. This is surprising because the area does contain statistically significant hot-spots of amphoras in general. An explanation for this is that the contexts at these locations have such a diverse assemblage of amphora vessels that no contexts spatially form hot-spots for a specific content group. In fact, most of the contexts that have been identified as hot-spots of amphoras in general are road ditches and not (garbage) pits. This suggests that the area around the road was not a specific dumps but more of a general waste site where occupants of the fort discarded their rubbish.

Thirdly, the distribution pattern of amphoras based on their production centre provide us with some additional insight in the spatial development over time. For instance, in first part of this thesis we have seen that both Adriatic olive-oil and Italian wine are content groups that have a strong connection with older contexts. These two groups both have their highest amount of sherds located in trenches within the camp, while the Gaulish wine content group has a massive hot-spot outside the camp at location D. Wine from this production centre has been identified as primarily a late product on Kops Plateau. This might imply that the contexts at this location are associated with activities of the younger phase of the fort.

5.5. Conclusions

In this chapter we have discussed the rubbish depositions on the Kops Plateau by using the spatial distribution of amphoras as a case study. The spatial analysis was done in two steps: first, by applying the spatial statistic of the hot-spot analysis tool available in the ArcGIS software, we were able to identify several hot-spots of amphora sherds on Kops Plateau. Second, by calculating the relative distribution of the different groups of amphoras allowed us to assess where relative high or small amounts of those groups are present. The results show us that hot-spots do not always mean that an area produced a relative large numbers of sherds when compared to the overall distribution of amphoras.

Let it be clear that there was no intention of providing a clear-cut answer to the question on how the occupants of Kops Plateau organised their space from a socio-economic perspective. The case study discussed here merely provided us with a first step in that direction.

6. Conclusions

The main question of this study is:

"How did the Roman camp on Kops Plateau developed during the pre-Flavian period, and in what ways was space utilised by its occupants?"

To answer this question, we have used a variety of exploratory statistics to gain insight in the chronological and spatial developments on the Kops Plateau during the Roman occupation. Further, a first exploration of the socio-economic organisation of the fort was made by means of two case studies on amphoras. For our study we employed two steps. First, we established a chronological seriation of the contexts based on their ceramics assemblage. By using the graphical output of the CA we were able to distinguish three different phases in the chronological ordering of the contexts: an Augustan phase, a second phase that incorporated both the reigns of Augustus and Tiberius, and a final phase that starts with the reign of Claudius. The results from the chronological ordering corroborates the existing hypothesis that the fort had three building phases. Up to now this theory was only based on the presence of the three different defensive ditches of varying sizes that surround the camp. The relative chronological ordering of contexts also allowed us to study the distribution of amphoras over time. By focusing on the provenance and contents of amphoras we were able to map the changing popularity of products from various production areas across the Roman Empire.

The second step is dedicated to the spatial development of the fort. We combined the results from the chronological ordering of the contexts together with the analysing and visualising capabilities of spatial statistics available in the ArcGIS software. By exploring the spatial distribution of "old" and "young" contexts we were able to reconstruct a possible west-to-east swift in concentrated rubbish depositions. Inside the fort the dumps may have shifted from the *principia* to the *praetorium*. This raises the question why the occupants of the fort decided to dump their rubbish somewhere else. A possible cause might be a change in the spatial organisation. Outside the fort the analysis has resulted in the possible clustering of older pits that is in close proximity to the Claudian annex of the fort. It has been suggested here that the older pits might belong to a camp that preceded this Claudian annex. In addition, by exploring the distribution of amphoras has identified several possible rubbish dumps in and around the fort. Some of these dumps show a strong connection to specific content groups of amphoras, suggesting that not all contents were consumed or processed on the same location.

Taking advantage of the processing power that modern-day computers provide together with the spatial statistical capabilities of GIS, we explored the spatial development of the contexts on Kops Plateau from various angles. However, no illusions should be held that with these results we have fully answered the main question. We have to remember that even with our quantitative approach we did not exploit all the available data from the excavation. So far, we have only examined ceramic materials while there are several other artefact groups that can complement the analyses. Also, no comparison has been made with other sites. Comparing the spatial characteristics of the fort on the Kops Plateau with similar sites might answer some of our remaining questions. And lastly, no synthesis can be accomplished solely by using a quantitative approach. Although we have been able to examine broad developments both in time and space by incorporating as much data possible, explaining specific patterns still needs a qualitative approach for providing a more detailed explanation.

On a final note, a suggestion of a possible approach for future research will be made. So far we have utilised the exploratory capabilities of the CA for establishing a chronological seriation of the contexts. However, by changing the way we organise the data we can also use the CA to extent our study on the socio-economic organisation on the Kops Plateau. In the current analysis we have grouped ceramic artefacts based on the typology that is rooted in chronology. But, if we were to order the material into groups based on their function (i.e. cooking, pouring, eating, drinking etc.) we might reveal patterns between contexts based on these possible socio-economic variables. One may imagine the visualisation of the CA with clusters of context that primarily contain cooking wares, or luxurious drinking wares. Performing such an analysis might compliment the results that have been discussed here.

In conclusion, it goes without saying that more study needs to be done in order to truly understand the chronological and spatial developments of that small and curious fort on Kops Plateau. This study is merely a first exploration of the site and its massive amount of archaeological data.

Appendix 1: CA data preparations

Preparing the data for the CA was done in three steps. First, context records were selected based on three criteria:

- Contained ceramic material
- Contained a minimum of three unique types
- Not identified as "recent"
- Context type is known (i.e. "posthole, ditch, etc.)

Secondly, find records were selected based on three criteria:

- Find is part of a ceramic material group
- Part of a context (no stray finds)
- Type is spread across a minimum of three unique contexts

Thirdly, several types were merged into groups. In most cases these combined types were created because of the small number of sherds each individual type possesses. The groups, however, have much larger sherd numbers and prevent the individual types from acting as outliers in the CA. Types were merged together when they share a similar dating. In the case of Oberaden 30 and Haltern 43(A) they were merged because both types correspond to the same vessel form.[131]

CA label	Combined types	Sherds	Records
AR_OB_EARLY	Oberaden 13/15	65	11
ARRET_LATE	Haltern 4/5 and 11	192	91
ARRET_VESSELS	Haltern 10/13, 15/16 and 18/19	674	227
AUG_BEAKER	Oberaden 31, 34 (ACO beaker), 37, 39 and 42	267	70
LATE_TS	Dragendorff 18/31 (Middle and East Gaulish sigillata), 35/36 and 37	51	28
NIJM/HOLD	HNW 29, 32, 35/36, 61/64	77	40
OB30/HA43A	Oberaden 30 and Haltern 43(A)	839	185

The end results of the CA were based on 15881 records which contain 2799 unique contexts and 96 unique ceramic vessel types (see table below).

[131] Kloosterman in Zandstra & Polak 2012, 127.

CA label	Type	CA contribution	Sherds	Records
AR_HA1	Haltern 1	0.039	85	34
AR_HA1B	Haltern 1B	3.012	588	156
AR_HA1C	Haltern 1C	2.272	643	271
AR_HA2	Haltern 2	0.684	1048	534
AR_HA7	Haltern 7	1.238	304	186
AR_HA7B	Haltern 7B	1.188	240	75
AR_HA7C	Haltern 7C	3.759	510	203
AR_HA8	Haltern 8	2.142	1700	735
AR_KELK	Arretine chalice	0.034	17	8
AR_OB_EARLY	Oberaden 13, 14 and 15	0.072	65	11
AR_OB10	Oberaden 10	0.734	121	31
ARRET_LATE	Haltern 4/5 and 11	0.277	192	91
ARRET_VESSELS	Haltern 10/13, 15/16 and 18/19	0.775	674	227
AUG_BEAKER	Oberaden 31, 34 (ACO beaker), 37, 39 and 42	2.215	267	70
CAM184	Camulodunum 184	0.203	1672	621
CAM189	Camulodunum 189 (carrot amphoras)	0	301	67
DRES1	Dressel 1(B)	0.089	315	170
DRES20	Dressel 20	3.008	11095	3355
DRES6	Dressel 6	0.235	617	245
DRES7/11	Dressel 7/11	0.111	13833	6729
HA40	Haltern 40	1.088	1261	351
HA41	Haltern 41	2.579	294	85
HA59	Haltern 59	0.975	2255	1426
HA70	Haltern 70	0.311	3672	1646
HBW1	HBW1	0.045	85	54
HBW2	HBW2	2.336	890	252
HBW3	HBW3	2.834	7158	1853
HBW9	HBW9	1.133	694	223
HBW11	HBW11	1.217	986	294
HBW25	HBW25	0.076	315	77
HBW25/7	HBW25/7	0.286	171	62
HBW26	HBW26	0.545	287	46
HBW27	HBW27	0.265	1057	229
HBW28	HBW28	1.357	222	55
HBW55	HBW55	0.053	35	18
HBW74	HBW74	0.002	392	114
HBW77/8	HBW77/8	0.404	587	213
HBW81	HBW81	0.423	328	137
HBW82	HBW82	0.277	203	80
HBW87	HBW87	0.13	194	60
HBW94	HBW94	2.908	6634	2149
HNW37	HNW37	0.281	70	23
HNW66	HNW66	0.351	19	18
HNW77	HNW77	0.447	51	43
HNW78	HNW78	0.353	45	14

CA label	Type	CA contribution	Sherds	Records
HOFH22	Hofheim 22	1.692	567	176
HOFH50	Hofheim 50	4.076	3623	717
HOFH77	Hofheim 77	1.602	705	98
HOLD_ST201	Stuart 201 (Holdeurn fabric)	0.81	220	57
HOLD_ST210	Stuart 210 (Holdeurn fabric)	0.648	62	51
HOLD_ST215/6	Stuart 215/216 (Holdeurn fabric)	0.345	33	9
LATE_TS	Dragendorff 18/31, 35/36 and 37	0.404	51	28
LYON_FABRIC	Hofheim 22 (Lyon fabric)	0.271	78	38
NIJM/HOLD	HNW 29, 32, 35/36, 61/64	0.774	77	40
OB101	Oberaden 101	0.364	207	54
OB20	Oberaden 20	1.629	603	104
OB23	Oberaden 23	0.155	791	358
OB30/HA43A	Oberaden 30 and Haltern 43(A)	2.474	839	185
OB38	Oberaden 38	2.187	575	135
OB52	Oberaden 52	0.07	231	30
OB83	Oberaden 83	0.704	9985	3886
PASC1	Pascual 1	0.029	301	145
PEL46	Pelichet 46	0.001	62	9
PEL47	Pelichet 47	1.552	2737	723
ST1	Stuart 1	1.761	404	71
ST13	Stuart 13	0.073	1083	491
ST101	Stuart 101	0.913	1809	292
ST102	Stuart 102	0.113	351	105
ST103/4	Stuart 103/104	2.526	2395	408
ST105/9	Stuart 105/109	0.983	414	76
ST112A	Stuart 112A	0.023	135	12
ST112B	Stuart 112B	0.059	53	17
ST113	Stuart 113	0.219	78	38
ST131	Stuart 131	0.065	9048	1502
ST132	Stuart 132	0.669	403	103
ST146	Stuart 146	0.526	2121	715
ST147	Stuart 147	0.001	8420	4069
ST149	Stuart 149	5.953	1712	1111
ST201	Stuart 201	1.147	7765	1569
ST204	Stuart 204	0.499	527	124
ST205	Stuart 205	0.04	10	8
ST210	Stuart 210	2.489	487	186
ST213	Stuart 213	1.807	485	117
ST214	Stuart 214	0.446	520	83
ST215/6	Stuart 215/216	0.396	82	38
ZG_DRAG15/7	Dragendorff 15/17	2.566	630	362
ZG_DRAG17	Dragendorff 17	0.179	227	128
ZG_DRAG18	Dragendorff 18	3.477	725	435
ZG_DRAG22/3	Dragendorff 22/23	0.48	60	30
ZG_DRAG24/5	Dragendorff 24/25	2.021	691	411

CA label	Type	CA contribution	Sherds	Records
ZG_DRAG27	Dragendorff 27	4.468	743	459
ZG_DRAG29	Dragendorff 29	2.283	745	373
ZG_HOFH1	Hofheim 1	0.033	23	13
ZG_HOFH12	Hofheim 12	0.607	119	69
ZG_HOFH5	Hofheim 5	0.029	224	119
ZG_HOFH8/9	Hofheim 8/9	0.599	153	98

Appendix 2: Amphora combined with CA results

Content	Provenance	Type	Sherds	Records
Dates	Levantine	Carrot	111	26
		Kingsholm117	48	13
Total			**159**	**39**

Content	Provenance	Type	Sherds	Records
Fish-sauce	Baetican coast	Beltran2A	2	2
		DRES10	15	12
		DRES11	4	4
		DRES12	5	5
		DRES7	93	65
		DRES7/11	236	72
		DRES8	66	23
		DRES9	149	45
		DRES9/10	1	1
		Saumure	1	1
	Gauloise	Augst33/4	1	1
		DRES7/11	4	2
		DRES9	23	9
	Guadalquivir	DRES7/11	1	1
	Lusitana	DRES14	2	1
	Lyon	Augst17	1	1
		DRES16	3	3
		DRES7	8	4
		DRES9	309	99
		DRES9A	165	63
		DRES9B	161	59
		Saumure	1	1
	Marismas	DRES12	1	1
		DRES7/11	12	8
		DRES8	1	1
		DRES9	1	1
Total			**1266**	**485**

Content	Provenance	Type	Sherds	Records
Olive-oil	Adriatic	DRES6A	164	76
	Guadalquivir	DRES20	1460	572
		HA71	534	148
		OB83	401	190
		OVOID4	2	2
Total			**2561**	**988**

Content	Provenance	Type	Sherds	Records
Olives	Baetican coast	HA70	1	1
	Gauloise	HA70 simils	36	18
	Lyon	HA70 simils	16	13
	Marismas	HA70 simils	2	1
Wine/Olives/Muria	Guadalquivir	HA70	868	350
Total			**55**	**33**

Content	Provenance	Type	Sherds	Records
Wine	Adriatic	Lamboglia2	4	2
	Aegean	Crete	3	3
		DRES2/4	4	4
		DRES2/5	492	113
	Africa	DRES2/4	1	1
	Baetican coast	DRES2/4	5	5
		Urceus	5	4
	Gauloise	DRES1B	7	7
		DRES2/4	52	44
		Gaul1	2	2
		Gaul2/3	8	8
		Gaul3	2	2
		Gaul4	373	53
		Gaul5	5	5
		Gaul6	1	1
		Gaul8	6	2
		Gaul9	1	1
		PASC1	2	1
	Germania	Gaul1	240	49
	Guadalquivir	DRES2/4	9	6
	Italia	CAM167	1	1
		DRES1B	165	48
		DRES2/4	219	111
	Lyon	DRES1B	3	3
		DRES2/4	57	35
		Gaul2/3	1	1
		PASC1	2	2
	Marseille	DRES2/4	58	13
		Gaul2/3	9	8
	Rodia	Rodia	965	294
	Tarraconensis	DRES2/4	6	4
		OB74	54	8
		PASC1	41	27
	Unknown	DRES2/4	2	2
Wine/honey	Guadalquivir	Urceus	48	4
Total			**2853**	**874**

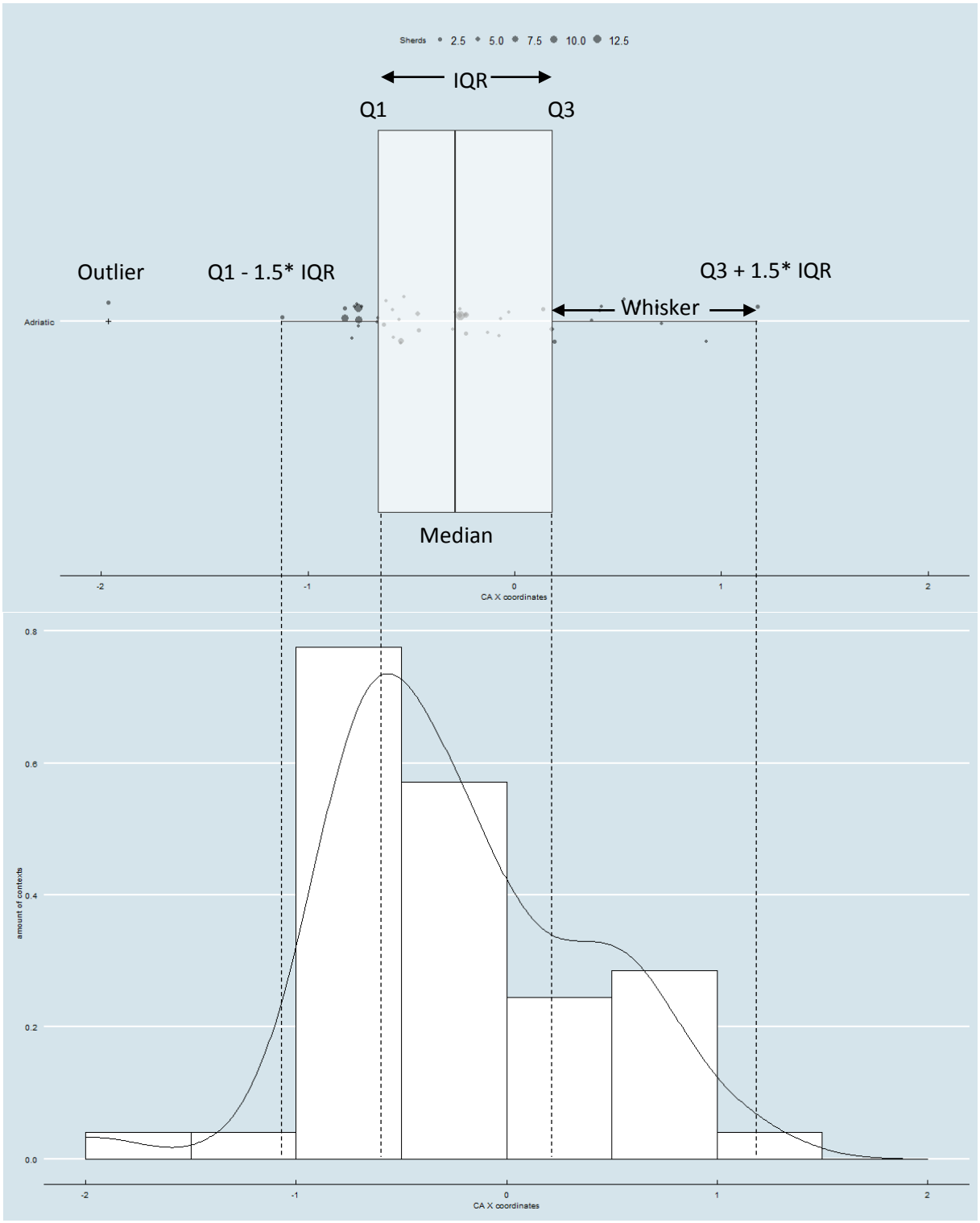
Appendix 3: How to Read a Boxplot

The boxplot, or "box-and-whisker plot" is an exploratory graphic used to visualise the distribution of a dataset (at a glance). Boxplots provide a useful way to quickly study the range and skewness of a dataset. The boxplot is based on **robust statistics** because it is more resistant (robust) to the presence of outliers than classical statistics based on normal distribution. This is achieved by using the **median** as the measure of central tendency as it is less affected by extreme values than the mean. In the example below the distribution of olive-oil amphoras from the Adriatic region is visualised both as a boxplot and as a standard histogram. Although both boxplots and histograms are used to graphically represent data, it is clear that the latter provides a more subtle picture of the distribution.[132]

The median marks the mid-point of the dataset and evenly divides it in two equal parts of 50%. The first and third **Quartile** (Q1 and Q3) encapsulate the total of observations (i.e. contexts) between 25% and 75% respectively. The **Interquartile Range** (IQR) is the difference between the first and third Quartile and therefore represents the middle 50% of all observations. The IQR is an important measurement because it also helps to identify possible outliers within the dataset. If an observation deviates more than 1.5*IQR from either the first or third Quartile it can be considered an outlier as it statistically deviates too far from the majority of the observations. The observations that fall outside the middle 50% but within the 1.5*IQR range are represented by the horizontal line or **Whisker**.

In short, the boxplot is a useful tool to quickly analyse where on the CA X-axis (i.e. relative timeline) a specific find category has the highest clustering. The box of the boxplot can be interpret as the time frame in which the type was most common on the Kops Plateau.

[132] Cf. Massart *et al.* 2005 for more information about the use of boxplots for analysing data.



These two plots show the distribution of contexts on the CA X-axis in which Adriatic olive-oil amphoras were found. The upper plot visualises the individual contexts scaled by the amount of sherds, combined with a boxplot. The lower plot is histogram with a kernel density curve of the same dataset.

Summary

This thesis is about the Roman fortification on Kops Plateau that was occupied from ca. 12 BC to AD 69/70. The site is situated on one of the highest plateaus of a lateral moraine that runs from Nijmegen to Xanten. With its good view over the river Waal and the surrounding lowlands, Kops Plateau proved to be of great strategic value for the Romans during the pre-Flavian period.

Described as the "Nachtwacht van de Nederlandse Archeologie" (The Night Watch of the Dutch Archaeology), the Roman fort is today considered to be one of the richest and most extensive documented archaeological sites of the Lower Rhineland. The goal of this thesis is to visualise and analyse the spatial organisation of the Roman fort on Kops Plateau. To analyse the fast amount of archaeological data a new quantitative approach was developed which employs the processing power of today's computers in combination with a series of exploratory statistics. By focussing on the well-studied pottery assembly it was possible to analyse a large portion of the archaeological contexts both chronologically and spatially.

The analysis is done in two steps. First, a chronological ordering is made of the contexts based on their ceramics assemblage. Utilising the versatile statistics of the correspondence analysis it is possible to organise the contexts into three chronological phases. In addition, the results also allow for a detailed comparison to be made between the chronological developments of different types of ceramics.

Second, using the chronological ordering of contexts and analysing their spatial position in GIS reveal changing patterns in context concentrations. The spatial analysis also pinpoints the locations where these activities were most concentrated during various stages of the occupation.

Parallel to the general study on the pottery assemblage of contexts are two case studies on a specific pottery group: amphoras. These case-studies incorporate the results from a new research done by Caesar Carreras on the amphoras of the Kops Plateau. Studying the chronological and spatial developments of the transport vessels' contents and origins tell a revealing story of the changing popularity of products consumed by the inhabitants of the fort. Results from the chronological analysis of amphoras show a changing popularity of products from various regions within the Roman Empire over time. In addition, by studying possible rubbish dumps of amphoras a number of areas can be identified which show a strong association with specific products. These results reveal both chronological and spatial developments of products imported and used by the inhabitants of the Kops Plateau.

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