Cultural Heritage Agency
*Ministry of Education, Culture and Science*

Nederlandse Archeologische Rapporten 043

# A Kaleidoscope of Gathering at Keinsmerbrug (the Netherlands)

*Late Neolithic Behavioural Variability in a Dynamic Landscape*

# A Kaleidoscope of Gathering at Keinsmerbrug (the Netherlands)

*Late Neolithic Behavioural Variability in a Dynamic Landscape*

B.I. Smit, O. Brinkkemper, J.P. Kleijne,
R.C.G.M. Lauwerier & E.M. Theunissen (eds)

Colofon
Late Neolithic Behavioural Variability in a Dynamic Landscape:
a Kaleidoscope of Gathering at Keinsmerbrug (the Netherlands)

Authors: S.M. Beckerman, D.C. Brinkhuizen, V. Garcia Diaz, L. Kubiak-Martens, G.R. Nobles, T. F.M. Oudemans, J.H.M. Peeters, B.I. Smit, H. Van Haaster J.T. Zeiler, O. Brinkkemper, J.P. Kleijne, R.C.G.M. Lauwerier, E.M. Theunissen, D.C.M. Raemaekers & A.L. Van Gijn
Editors: B.I. Smit, O. Brinkkemper, J.P. Kleijne, R.C.G.M. Lauwerier, E.M. Theunissen
Illustrations: Gary Nobles, Marjolein Haars (BCL- Archaeological Support), S. Boersma (Groningen Institute of Archaeology, ceramics chapter 4), J. Porck (faculty of Archaeology, Leiden University, flint/stone tool drawings chapter 5), the authors, Cultural Heritage Agency of the Netherlands, unless otherwise stated
Editor of illustrations: Marjolein Haars (BCL- Archaeological Support), O. Brinkkemper.
English correction and translation: Sue Mc Donnell
Design and lay-out: uNiek-Design, Almere

ISBN/EAN: 9789057992032



Cultural Heritage Agency of the Netherlands
P.O. Box 1600
3800 BP Amersfoort
The Netherlands
www.cultureelerfgoed.nl

This research was supported by the Netherlands Organisation for Scientific Research (NWO, Den Haag), Cultural Heritage Agency (RCE, Amersfoort), BIAX Consult, ArchaeoBone, Kenaz Consult, Groninger Instituut voor Archeologie Faculty of Archaeology, University of Leiden, Provincie Noord-Holland, and Stichting Nederlands Museum voor Anthropologie en Praehistorie (Amsterdam).

Kenaz Consult

# Preface



Archaeologists performed a huge number of excavations in the twentieth century. They were necessary to prevent the loss of the Netherlands' buried history as industrial sites, residential areas, roads, ports and railway lines were built. The archaeological challenge was so great that researchers often did not manage to analyse and publish all excavations. Fortunately, several years ago, under the Odyssey programme funded by the Netherlands Organisation for Scientific Research (NWO) and the Ministry of Education, Culture and Science, money was made available to analyse a small proportion of the information, which lay gathering dust in archives, and to make that information accessible to academics and the public.

The Late Neolithic site at Keinsmerbrug in Noord-Holland was one of the sites selected. Only a small proportion of this interesting excavation had been analysed, and only a few very general pieces had appeared in rather inaccessible Dutch reports and papers, while just one review paper was available in English. The present publication makes the basic data available for the first time, and provides a comprehensive interpretation of the site for an international readership. The monograph before you is the first in a three-part publication that will be entitled: 'Unlocking Noord-Holland's Late Neolithic Treasure Chest: Single Grave Culture behavioural variability in a tidal environment'.

The analysis of the Keinsmerbrug site took the form of a multidisciplinary project involving a number of partners: the Cultural Heritage Agency, the universities of Groningen and Leiden, Noord-Holland provincial authority and various commercial parties – BIAX Consult, ArchaeoBone and Kenaz Consult. The research group, had 16 members, including both established and new researchers. To ensure consistency, a number of inspiring presentation and discussion meetings were held, where the results of every study and every researcher could be presented in context with the others.

At the outset, the analysis of this Late Neolithic site was expected to produce some special results, but in the end it exceeded all expectations. The analyses provided new insights into the food economy, occupation and society in the coastal area of Noord-Holland province in the Late Neolithic. As such, the Keinsmerbrug site is a fine example of this internationally unique type of agricultural society.

I should like to thank all who took part in this project for their efforts, and to compliment them on the magnificent result. Finally, I should like to thank NWO for its guidance and financial support, and to wish the reader a great deal of pleasure in perusing the report.

**Jos Bazelmans**
*Head, Immovable Heritage Knowledge Research and Knowledge Sector, Cultural Heritage Agency*

# Summary


**Keinsmerbrug: a kaleidoscope of gathering**
The analysis of the Keinsmerbrug site, excavated in 1986, was the first step in our research as part of the Odyssey project entitled 'Unlocking Noord-Holland's Late Neolithic Treasure Chest: Single Grave Culture behavioural variability in a tidal environment'. The unpublished data available suggested Keinsmerbrug was a small site lacking clear structures. The limited scale of the excavation (area approx. 300 $m^2$, excavated in a single campaign) made this site the obvious choice as a test case for the approach to be adopted in the Single Grave Culture project. A group of specialists worked together to unlock and integrate cultural/ecological information and research data. The project team consists of 16 people tackling different subjects and working in various institutional settings (commercial agencies, universities and the Cultural Heritage Agency).

The good preservation of the archaeological remains at Keinsmerbrug allowed us to gain an insight into the exploitation of animal and plant resources there. Based on the archaeozoological evidence it is clear that subsistence was based on a combination of cattle breeding, fishing and fowling. Besides cattle, some sheep or goats and young pigs were consumed. The few wild mammals present like wolf, polecat and marten were probably hunted for their furs. Fish from both saline and brackish waters was an important part of the diet. Flatfish – particularly flounder – and sturgeon were caught. By far the most astonishing aspect is the huge quantity of bird bones discovered. Different kinds of birds, especially ducks (mallard, teal/garganey and wigeon), were caught in huge numbers.

Estimates of the total number of birds caught range from 5000 to 10,000. Naked barley and emmer wheat were brought to the site as cleaned or semi-cleaned grains. Besides cereals, seeds of various orache species were gathered for food. It is remarkable that no other wild plant foods such as crab apple, berries, hazelnuts and acorns were consumed. Evidence for the gathering of roots and tubers for food is also lacking. Chemical evidence has shown that grain was cooked in liquid and that starch-rich foods were mixed with a small amount of animal fat or fish oil. Meat and fish were probably prepared for consumption using fire (open or otherwise), in the form of smoking, grilling or preparation in ashpits. Similar cooking strategies and drying on racks were used to conserve the large number of ducks and fish which must have been prepared for storage and transport to other settlements.

Although the number of finds is not very high the study of the material culture revealed some important results. One intriguing aspect of the ceramics is their variation. Although the ceramics are low in number the variation in thickness, tempering and decoration is high. It is likely that this variation is caused by differences in the origins of the vessels or the origins or preferences of the individual potters. People from different local SGC traditions probably visited this specific location at different times,

each bringing their own vessels which they used for the preparation of one specific type of food. The absence of imported material suggests that the flint, hard stone and amber were probably collected in nearby areas, at the coastal beach barrier or on the glacial till deposits at Wieringen. The flint was carried to the site in small nodules and the knapping process was performed at the site to obtain the tools needed. During the excavation of the site in 1986 no patterns or configurations were observed in the stake- and postholes. Using a set of fresh eyes and applying currently available spatial analysis programmes to a multitude of datasets, five structures or dwellings have been identified. The spatial analysis of all the data shows the presence of at least seven identifiable activity areas. Three of the five structures have been identified as dwellings (house plans) based on their more or less regular outline. The dwellings are all two-aisled, similar to known dwellings at other Neolithic settlements. The structures are likely to have been relatively light constructions. The presence of burnt reed fragments in the cultural layer could be indicative of the deliberate burning of reed shoots when the settlement was revisited, to create an open surface.

The analyses have shown that Keinsmerbrug was a temporarily occupied settlement, used occasionally or perhaps even only seasonally within the time span of 2580-2450 cal BC. The limited range of other activities combined with the characteristics of the material culture (low numbers of flints and ceramics, variation in the tempering of the ceramics, small range of different flint and stone tools) is indicative of such short-term use. The main period of use – probably consisting of several episodes of short-term use – occurred from spring to autumn.

In conclusion, the site at Keinsmerbrug has been interpreted as a non-residential settlement: a gathering settlement in the broadest sense of the word, for the gathering of people and resources (special activity site). It seems that mainly one type of food was cooked in the vessels at Keinsmerbrug: a starch-rich porridge of emmer grain, orache and water mixed with some fat from either animals or fish.

Keinsmerbrug was a settlement where people from different households or groups gathered for special reasons like feasting, besides the hunting of fowl, fishing and/or herding of cattle. These people gathered on occasion to hunt huge numbers of ducks and fish and simultaneously used this period to share information and eat specific foods. During their stay dwellings, pits/unlined wells and specific activity areas structured the settlement area. Since this was a non-residential settlement, the question of where the contemporaneous seasonal and residential settlements might be naturally arises. Future analysis of the sites at Mienakker and Zeewijk might show that these locations are the counterparts of the settlement at Keinsmerbrug.

# Samenvatting

**Keinsmerbrug, een verzamelplaats voor mens en voedsel**

Het Odyssee-project 'Het openen van de laat-neolithische schatkist van Noord-Holland' startte met de uitwerking van de site Keinsmerbrug, opgegraven in 1986. De opgravingsgegevens wezen destijds op een kleine vindplaats zonder duidelijke structuren. De beperkte omvang van het onderzoek – een oppervlak van 300 m², opgegraven tijdens één campagne – maakte Keinsmerbrug tot een ideale test case voor de aanpak binnen het EGK-project. Om alle culturele/ecologische detailinformatie en andere onderzoeksgegevens te ontsluiten en goed met elkaar te integreren, was een nauwe samenwerking van allerlei specialisten noodzakelijk. Het projectteam bestond uit 16 personen met elk hun eigen expertise, werkend vanuit verschillende instanties (bedrijven, universiteiten en de Rijksdienst voor het Cultureel Erfgoed).

De gunstige bewaaromstandigheden van de kwetsbare, organische resten bieden een buitengewoon inzicht in de exploitatie van de dierlijke en plantaardige bronnen. De archeozoölogie geeft aan dat het bestaan was gebaseerd op een samenspel van veehouderij en de jacht op vis en gevogelte. Behalve runderen zijn ook wat schapen en/of geiten en jonge varkens gegeten. Wilde zoogdieren zoals wolf, bunzing en marter zijn waarschijnlijk gejaagd vanwege hun pels/vacht. Vis afkomstig uit zowel zoute als brakke wateren vormde een belangrijk deel van het dagelijkse voedselpakket. Platvis, vooral bot, en steur zijn gevangen. Het meest verbazingwekkende is de enorme hoeveelheid vogelbotten. Verschillende vogelsoorten, vooral eenden (wilde eend, wintertaling en smient) zijn in grote aantallen gevangen. Schattingen van het totale aantal gevangen vogels variëren van 5000 tot 10 000 stuks. Naakte gerst en emmertarwe zijn naar de site gebracht als (half-) geschoonde oogst. Naast deze cultuurgewassen zijn verschillende strandmeldesoorten verzameld als voedsel. Het is opmerkelijk dat er geen andere wilde planten zijn aangetroffen, zoals wilde appel, bessen, hazelnoten of eikels. Aanwijzingen dat de bewoners wortels en knollen verzamelden, ontbreken eveneens. Chemische analyse toont aan dat het graan in een vloeistof is gekookt en dat de zetmeelrijke pap was vermengd met een kleine hoeveelheid dierlijk vet of visolie. Vlees en vis zijn waarschijnlijk bereid met vuur, door roken, grillen en bereiding in askuilen. Dergelijke kooktechnieken en het drogen op rekken (droogrekken) zijn gebruikt om de grote hoeveelheden eenden en vis te bereiden voor opslag en transport naar andere nederzettingen.

Hoewel het aantal vondsten gering is, leverde de studie naar de materiële cultuur interessante resultaten op. Een intrigerend aspect van het aardewerk is de grote variatie. Het aantal aardewerkscherven is laag, maar de variatie in dikte, de gebruikte magering en versiering is hoog. Het is aannemelijk dat deze variatie is ontstaan door verschillen in herkomst van de potten of, beter nog, de herkomst van de

pottenbakkers die het aardewerk maakten. Personen van verschillende lokale Enkelgrafcultuurtradities bezochten Keinsmerbrug op verschillende momenten. Daarbij bracht een ieder hun eigen potten mee en gebruikten ze voor de bereiding van één type voedsel. De afwezigheid van geïmporteerd materiaal geeft aan dat het (vuur-)steen en barnsteen werd verzameld in nabijgelegen gebieden, aan het strand en op plekken waar het keileem opduikt, zoals op Wieringen. Vuursteen is naar de site gebracht in kleine knollen en het bewerkingsproces vond daar plaats op het moment dat een werktuig nodig was.
Tijdens de opgraving van Keinsmerbrug in 1986 zijn geen patronen of structuren herkend in de vele paalsporen die zijn opgetekend. Gewapend met een frisse blik en de toepassing van ruimtelijke analysemethodieken – nu 25 jaar later – zijn vijf gebouwstructuren herkend. De ruimtelijke analyse van verschillende dataesets wijst op ten minste zeven activiteitszones. Drie van de vijf structuren zijn geïnterpreteerd als huisplattegronden op basis van een regelmaat in de layout. De gebouwstructuren hebben allen een tweebeukige plattegrond, vergelijkbaar met de reeds bekende exemplaren in andere neolithische nederzettingen. Het gaat om vrij lichte, vermoedelijk tijdelijke constructies. De aanwezigheid van verbrand riet in de cultuurlaag kan wijzen op het doelbewust verbranden van rietbossen op het moment dat de site werd herbezocht, om een open areaal te creëren.
De analyses geven aan dat Keinsmerbrug een tijdelijk bewoonde nederzetting was, af en toe gebruikt – vermoedelijk tijdens één bepaald seizoen – binnen een tijdspanne van 2580 tot 2450 v.Chr. Enerzijds zien we een specifieke range aan activiteiten en anderzijds wijzen ook de kenmerken van de materiële cultuur op een kortetermijngebruik. Ze bezochten de site regelmatig, in de periode van lente tot aan de herfst. De eendenvangst vond waarschijnlijk in de ruiperiode plaats, in juli en augustus.
Samenvattend kunnen we concluderen dat Keinsmerbrug geïnterpreteerd kan worden als een niet-permanente nederzetting: een verzamelsite in de breedste zin van het woord, voor het bijeenkomen van mensen en de door hen vergaarde voedselbronnen. Het is een special activity site, in die zin dat door herhaald gebruik een 'stapeling' van specifieke activiteiten ontstond, zowel de bereiding en consumptie van één type voedsel, als de jacht op eenden en platvis en het verzamelen van strandmelde. Mensen van verschillende huishoudens of (verwantschaps-) groepen kwamen daarvoor bijeen en gebruikten deze momenten om informatie, wellicht op feestelijke wijze, te delen/uit te wisselen. Tijdens hun verblijf was de bewoonde plek ingedeeld met tijdelijke gebouwen, (water-)kuilen en zones waar specifieke activiteiten werden uitgevoerd. Als we uitgaan van een niet-permanente site dringt de vraag aan ons op waar de gelijktijdig seizoenale en meer permanent gebruikte nederzettingen liggen. Uitwerking van de sites van Mienakker en Zeewijk zal hopelijk in de nabije toekomst uitwijzen of zij de tegenhangers zijn van de Keinsmerbrug, of niet.

# Content

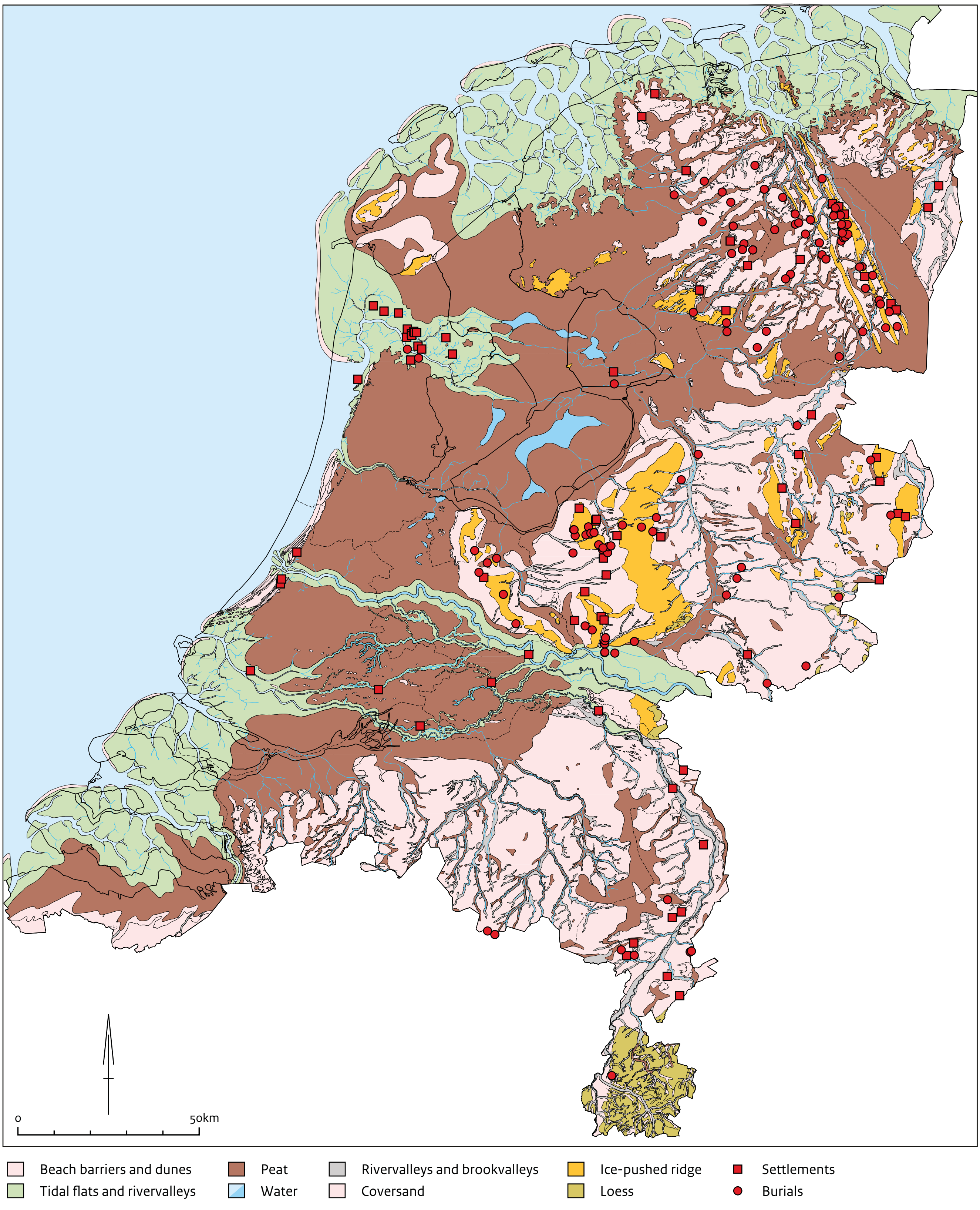



Fig. 1.2: General overview of SGC settlements and burials in the Netherlands (adapted from Drenth, Brinkkemper & Lauwerier 2008) plotted on palaeogeographic reconstruction of the Netherlands around 2750 BC adapted from Vos & Kiden 2005.

# 1 Introduction

*E.M. Theunissen, J.H.M. Peeters & B.I. Smit*

## 1.1 Odyssey framework

This monograph is the first publication from the Odyssey project 'Unlocking Noord-Holland's Late Neolithic Treasure Chest: Single Grave Culture behavioural variability in a tidal environment', known for short as the 'Single Grave Project'.[1]

The project was initiated by the Cultural Heritage Agency and received a € 500,000 grant from the Netherlands Organisation for Scientific Research (Nederlandse Organisatie voor Wetenschappelijk Onderzoek, NWO), representing four years of funding under the Odyssey programme. The Odyssey programme was launched in 2009 as a one-off incentive from the Ministry of Education, Culture and Science and the Netherlands Organisation for Scientific Research.

The aim of the Odyssey programme is the scientific disclosure of internationally important archaeological field research carried out between 1900 and 2000 that was not further investigated or published at the time. 32 projects will be carried out from 2009 to 2013: four long-term investigations (lasting four years) and 28 short-term studies (lasting one year).[2] The outcome of these projects will help provide new narratives about the past for local residents and help define research questions for new research.

Thanks to this grant and subsidiary grants from the universities of Leiden and Groningen, combined with the involvement of various specialists from commercial companies and the Cultural Heritage Agency (RCE), a multidisciplinary project on the Late Neolithic Single Grave Culture (SGC) of Noord-Holland saw its official launch in September 2009.

## 1.2 Research approach

West-Friesland, and the 'De Gouw' district in the province of Noord-Holland in particular, are home to an impressive number of well-preserved sites that can be attributed to the Late Neolithic Single Grave Culture (Fig. 1.1).[3]

In the second half of the 20th century, coring campaigns were conducted and test trenches


Fig. 1.1: Location of the research area (red square).

dug at most of these sites. Some of the sites underwent large-scale excavation. This research demonstrated the excellent preservation of organic remains (including human burials), inorganic materials and settlement features. This quality, combined with the fact that the sites are located in similar palaeoenvironmental settings (a tidal zone), makes this set of sites one of the most important Late Neolithic cultural landscapes in Northwestern Europe.[4] Within the Netherlands, its quality far exceeds that of the SGC sites in the surrounding sandy Pleistocene areas, where the SGC is mainly known from burials (settlement sites are barely recognisable) or from sites where long-term reuse of locales has resulted in loss of chronological and spatial resolution (Fig. 1.2) .[5] Noord-Holland's site complexes therefore offer vast opportunities to increase our understanding of SGC subsistence, settlement variability, cultural differentiation, material culture and human-landscape interaction.

However, the analysis of excavation data and find categories lags far behind the efforts put into the fieldwork carried out by various institutions. Some analyses have been performed in the past, but were recorded only as internal reports or in handwritten notes, or have been digitally stored in computer files or on disks which are now difficult to access due to

1 www.singlegrave.nl.
2 Van Ginkel 2010; www.erfgoednederland.nl/odyssee dossiernr: 315-60-003.
3 Van Heeringen & Theunissen 2001; Drenth, Brinkkemper & Lauwerier 2008.
4 Dörfler & Müller 2008.
5 Fokkens 2005; Hogestijn 2005; Drenth, Brinkkemper & Lauwerier 2008.

technological developments. In conclusion, few results have been published, and most of them have been in Dutch. Due to the absence of internationally accessible publications, the sites feature only sporadically in the international literature on the SGC and the Northwestern European Late Neolithic in general.[6] Hence, current interpretations of SGC subsistence and settlement variability are based on incomplete analyses and are thus by definition not well-founded. Dissemination of old and new research results will therefore contribute significantly to the international debate on cultural dynamics in the third millennium BC.

In view of the above, the aim of the research project is threefold: (1) to unlock and integrate cultural/ecological data in order to expand our knowledge of the SGC, (2) to test and develop models of SGC subsistence and settlement variability, and (3) to provide a sound basis for the development of management approaches to and public appreciation of the SGC heritage.

Three research themes have been defined for the Single Grave Project. (A) The study of settlement variability, which focuses on the identification of functional differences between sites. (B) The study of the use and role of material culture, which will first of all contribute input on several of the above-mentioned aspects of site variability and group composition, as well as focusing on the identification of the cultural biographies of objects.[7] (C) The study of landscape usage, which explores how SGC communities exploited resources and structured the landscape in broader terms.

To explore these themes, specific research questions have been formulated:

1. What is the spatial extent of settlement areas and how can any intra-site spatial differentiation be characterised?
2. What activities are represented in the artefact assemblages (ceramics, lithics, bone/antler tools, ornaments)?
3. What activities are represented in the characteristics of the archaeozoological and archaeobotanical remains?
4. What is the functional nature of structures and features?
5. What indicators exist for occupation length and seasonality?
6. What evidence exists for group composition?
7. What variability exists in the 'cultural biography' of objects?
8. What ecozones are represented in the archaeozoological and archaeobotanical assemblages?
9. What is the possible origin of inorganic resources?
10. How do the characteristics of the SGC settlements in Noord-Holland compare to SGC/Corded Ware phenomena in the wider geographical setting?

## 1.3 Choice of key sites; selection of Keinsmerbrug

The degree to which insight into the above aspects can be obtained depends chiefly on the possibility of linking finds to context information (e.g. features, layers). An inventory of Neolithic sites in the 'Kop van Noord-Holland' and 'De Gouw' areas published in 2001 lists 37 sites the majority of which date to the SGC.[8] Of these, 17 sites are considered particularly valuable, and eight sites have a uniquely high potential information value. These are the sites at Zeewijk, Aartswoud, Kolhorn, Mienakker and Keinsmerbrug, which have been subjected to 'complete' excavation or large-scale test trenches. The data are very diverse, in terms of both quantity and quality. However, the lack of coherence in the data presents the greatest problems. Different find categories have been studied at several sites, which makes inter-site comparison impossible (e.g. at Kolhorn). In other cases, analyses have been performed but no final report has been published (e.g. Keinsmerbrug).

Since the total body of excavation data and finds is too large to be covered in its entirety in the context of the Odyssey project, a selection of sites has had to be made. This was done according to specific criteria: (A) accessibility of excavation documentation, (B) availability and quality of find materials, (C) representativeness of the excavated area and (D) settlement size/type variability. The sites at Kolhorn, Zeewijk, Mienakker and Keinsmerbrug fit these criteria

[6] Drenth & Hogestijn 2001; Van der Beek & Fokkens 2001; Bakels & Zeiler 2005; Hogestijn 2005.
[7] Kopytoff 1986; Fontijn 2002.
[8] Van Heeringen & Theunissen 2001.

best. All other sites listed in the 2001 inventory have only been subjected to small-scale test trenches and coring campaigns and are less suitable for further analysis in relation to the research themes given the limited amount of archaeological data available from these sites. The general information from these other sites might however be used as global reference material.

Our research therefore commenced in September 2009 with the analysis of the Keinsmerbrug site. The available unpublished data suggested this site represented a small site lacking clear structures. The limited scale of the excavation (area approx. 300 m², excavated in a single campaign) made this site the logical first step in our project, serving as a test case. After Keinsmerbrug we will turn our attention to a large site, Zeewijk, and to Mienakker, as representative of a small site with dwelling structures. At first, Kolhorn was chosen to represent a large site, but initial attempts to assess Kolhorn proved very troublesome, as crucial context data are missing. It was therefore decided to replace Kolhorn by the very similar double-star site at Zeewijk. After analysis of Zeewijk we will consider a different way of approaching Kolhorn.

Some of the research questions mentioned above can now be answered with reference to Keinsmerbrug. Given the fact that this is the first monograph to be published, the more general questions will be addressed after the other sites (Mienakker, Zeewijk, Kolhorn) have been analysed.

## 1.4 Project team and organisational structure

Since the project aims to unlock and integrate cultural/ecological information and research data, a group of specialists are working together (Fig. 1.3). The project team consists of 16 people tackling different subjects and working in various institutional settings (commercial agencies and universities), with organisational and scientific backup from senior researchers at the RCE.

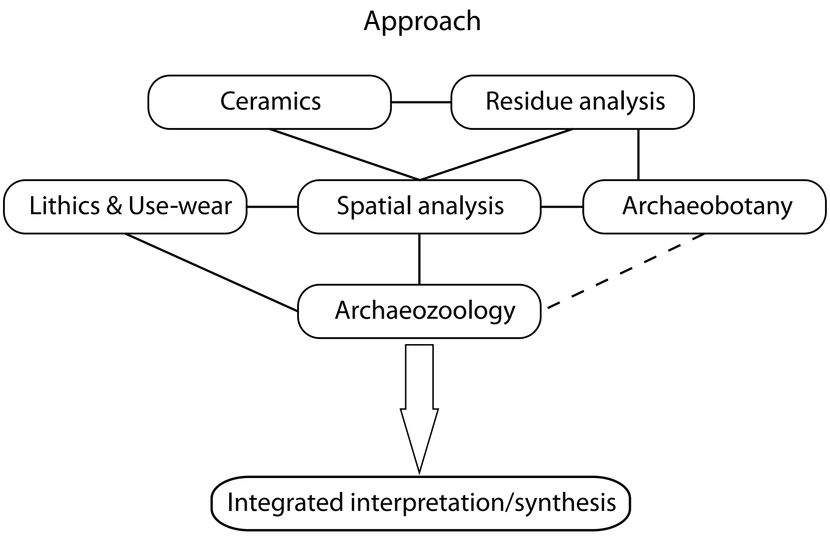



Fig. 1.3 – Scheme of relations between the main research topics.

Archaeobotany is being studied by L. Kubiak-Martens (BIAX Consult), supported by O. Brinkkemper (RCE). The chemical analysis of organic residues present on the ceramic vessels has been carried out by T.F.M. Oudemans (Kenaz-consult).

Archaeozoology is being studied by J.T. Zeiler (ArchaeoBone), in the case of mammals and birds, and D.C. Brinkhuizen is analysing the fish remains. Both are being supported by R.C.G.M. Lauwerier (RCE).

The spatial analysis is being performed by G.R. Nobles and ceramics are being studied by S.M. Beckerman, both of whom are PhD students at the University of Groningen, supervised by D.C.M. Raemaekers and J.H.M. Peeters.

Analysis of lithics, bone and antler tools and ornaments is being carried out by V. Garcia Diaz. She is a PhD student at Leiden University supervised by A.L. van Gijn. Van Gijn will also study the amber objects from the selected key sites.

The Single Grave Project as a whole is being led and managed by B.I. Smit (RCE). E.M. Theunissen (RCE) is acting as liaison and focusing on disseminating new knowledge to the general public, together with R. van Eerden (Noord-Holland provincial authority). J.P. Kleijne (RCE) is on the editing committee, along with his four RCE colleagues mentioned above.

## 1.5 Structure of the monograph

It was decided to divide the monograph into eleven chapters. The first two chapters introduce the Single Grave Project and the site at Keinsmerbrug. The features are presented in chapter 3. In chapters 4 and 5 two material categories are dealt with: the ceramics and flint, amber and stone artefacts. The results of the botanical analysis are presented in chapters 6 and 7, and the organic residues are discussed in chapter 8. The faunal remains, of mammals, birds and fish, are discussed in chapter 9. The spatial information will be presented and evaluated in chapter 10. Chapters 3-10 thus present the reports of the specialist analyses, each based on its own research questions. Chapter 11, the final chapter, brings together the conclusions from the different studies, to discuss and synthesise the archaeological data from the site at Keinsmerbrug. This chapter is based on the input from the specialists and must be seen as a joint interpretation of the site by the project team.

## 1.6 Administrative information

| | |
|---|---|
| Province | Noord-Holland |
| Municipality | Zijpe |
| Location | Keinsmerbrug |
| Toponym | Keinsmerbrug (Keinse or Zijpe) |
| Centre Coordinate (Dutch coordinate system) | 115.320/536.210 |
| Land use | farmland |
| Year of discovery | 1985 |
| Excavation | 1986 |


## 1.7 Acknowledgements

During the process of the research and production of this monograph numerous people have contributed in several ways. Their advice, help and critique is greatly valued by the authors. Thanks goes out to:
Stijn Arnoldussen, Everhard Bulten, Wim Bosman, Jos Deeben, Erik Drenth, Rob van Eerden, Theo Geurtsen, Willem Jan Hogestijn, Jan Lanting, Martin Konert, Eric Mulder, Jean Roefstra, Carla Soonius, Martin Veen, Annemieke Verbaas, Diederik van der Waals, Mark van Waijjen, Wilko van Zijverden.

We also would like to thank all those unnamed people who were involved excavation of Keinsmerbrug.

# 2 Landscape, geology and absolute dates

*B.I. Smit*

## 2.1 Landscape

For an effective understanding of prehistoric behaviour a clear picture of the environment surrounding prehistoric settlements and sites is needed. Palaeogeographical reconstructions of the former landscape have proven very useful in studies of prehistoric communities.[9]

To provide a picture of how the landscape might have looked, the location of Keinsmerbrug has been depicted on a 'cut out' of the nationwide palaeographical reconstruction of the Netherlands, with the map depicting the landscape around 2750 BC as the moment of reference (Fig. 2.1).[10]

It is important to bear in mind that this map is not a 'real' depiction of the landscape in and around Keinsmerbrug at the time of late Neolithic activities. However, the landscape features (a beach barrier, gullies and streams, salt marshes, peat swamps and Pleistocene outcrops) shown were present at and around Keinsmerbrug in the Late Neolithic.

Geological and physical-geographical studies conducted in the last century are relevant to our study area. Unfortunately, few more recent large-scale studies and no geological maps are available. We have therefore been forced to use the available data, which may be outdated in some respects.

Van Zijverden states that the palaeogeographical studies based on $^{14}C$ dates from the 1970s and 80s are especially problematic due to the fact that bulk samples from peat were generally used.[11] Nowadays, when dating peat, seeds or other small organic fragments which have a short lifespan themselves are selected. This critical selection process allows more accurate dates to be obtained. Although Van Zijverden is correct in his criticism, this does not mean that these older dates and the interpretations based on them are useless. These dates and the descriptions of the development of the landscape based on them still provide a basis – albeit somewhat rough – which can and will be used here. Besides that these rough descriptions of the landscape are now and then corroborated by archaeological finds. Furthermore, in the absence of enough high resolution dates, there are only two options. One is not to use the old data and accept that we cannot use the older palaeogeographical reconstructions. This option has severe implications for our ability to understand Late Neolithic occupation in this area. The other option is to use these older data and dates and accept the fact that our understanding of landscape dynamics is based on a rough outline. We have decided on this latter option, and hope that in the future this rough outline will be fleshed out as new and more precise data and dates are obtained.[12]

The existing geological data obtained many years ago do provide a valuable insight into past landscapes. Their resolution may be lower then we would prefer, but the picture these studies provide point to a very dynamic landscape in terms of topography, vegetation and different habitats for a wide range of animals. This gradient-rich and dynamic landscape was dominated not so much by high relief differences, as by the presence of saline, brackish and fresh water.[13]

The Late Neolithic SGC occupation in Noord-Holland was concentrated in a completely different landscape/environment from the dry Pleistocene sandy soils of the eastern parts of the Netherlands. Numerous Late Neolithic graves, tumuli and pottery/flint surface scatters are known in these parts. Due to the absence of organic material, information on subsistence and internal settlement structure is generally lacking. One advantage of the Late Neolithic occupation in Noord-Holland is that a totally different environment was used by Late Neolithic communities in this region. Here, they inhabited a clear wetland environment which was submerged after the Neolithic. This had a positive effect on the preservation of the archaeological remains.

To provide an overview of the developments in the landscape during the period under study it is necessary to zoom out from the site level to a more regional level. In our Odyssey project we are focusing on Late Neolithic habitation in West-Friesland and the Kop van Noord-Holland. These areas comprise the northern part of Noord-Holland province (excluding the island of Texel). The sites are situated in the northeastern part of these areas.

The underlying Pleistocene topography had an impact on the geological development of West-Friesland. This part of the province of

9 For example Arnoldussen 2008; Louwe Kooijmans 1974; Fokkens 1998, see also Nationale Onderzoeksagenda Archeologie (NOaA), National Archaeology Research Agenda: www.noaa.nl Deeben, Hallewas, Vos & Van Zijverden 2005.

10 A series of nationwide palaeo-geographical recontructions was produced by P. Vos (Deltares) for the NOaA. A new version of the series of reconstructions was published in Bazelmans, Weerts & Van der Meulen 2011.

11 Van Zijverden 2011.

12 In a recently launched NWO project at Leiden University entitled Farmers of the Coast, coastal farming communities on the southern North Sea coast, 2000-800 BC W. van Zijverden will study the physical landscape and its habitation potential. Although his research will focus on the landscape of the eastern part of West-Friesland during the Bronze Age, we hope that some new insights into past landscapes in West-Friesland and the Kop van Noord-Holland will also be revealed.

13 Hogestijn 2001, 145

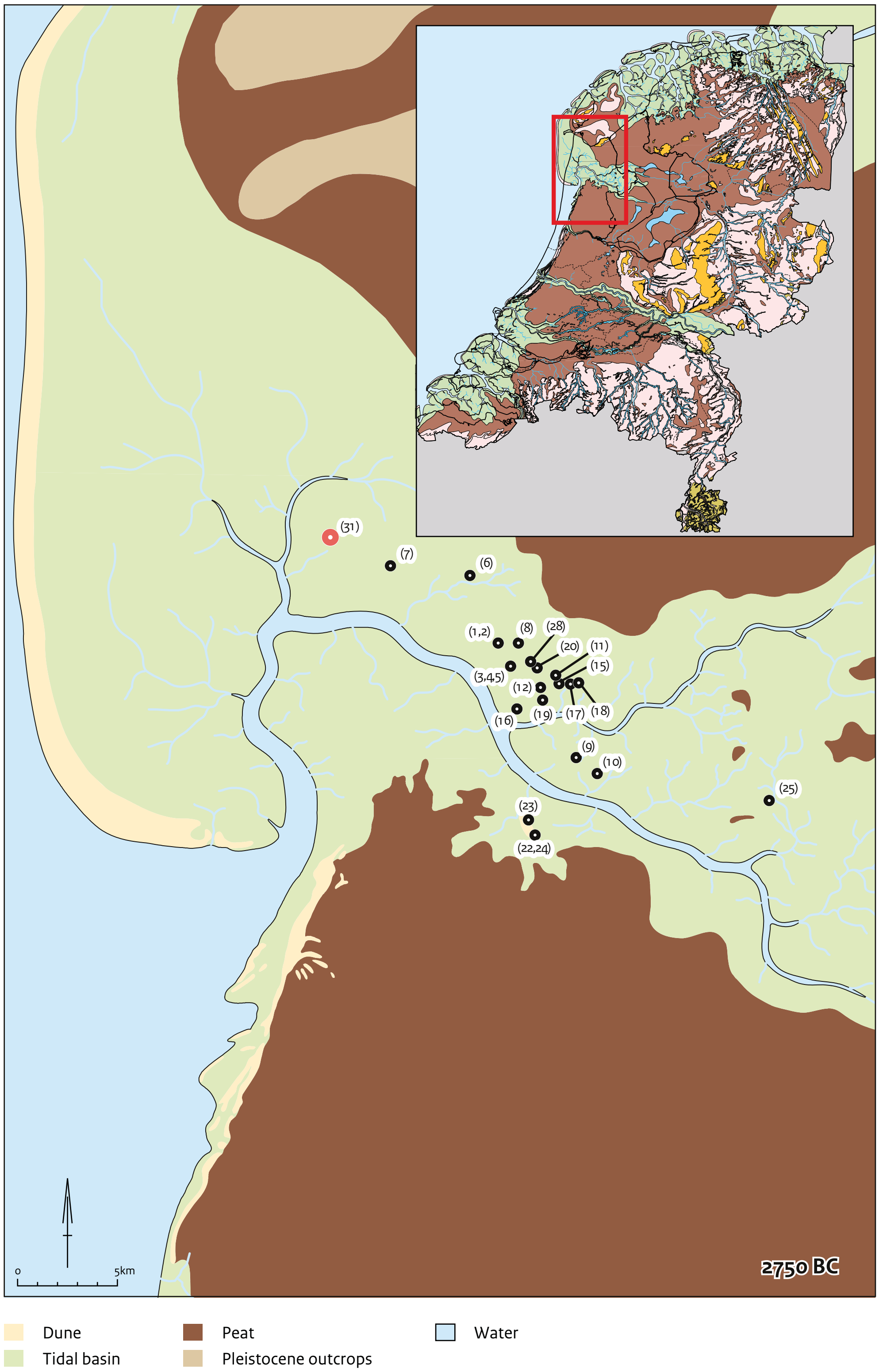



Fig 2.1: Location of Keinsmerbrug depicted on palaeogeographical map of around 2750 BC (adapted from Vos & Kiden 2005), with known Late Neolithic sites.
1, 2: De Vrijheid
1 and 2; 3, 4, 5: Flevo
1,2a and 2b; 6: Kolhorn;
7: Poollland;
8: Zeewijk;
9: De Veken;
10:Meester Juffer;
11: Aartswoud;
12: Gouwe;
15: Maantjesland;
16: Mienakker;
17: Molenkolk 1;
18: Molenkolk 2;
19: Portelwoid;
20: Rhomneyhut;
22: Zandwerven 1;
23: Zandwerven 2;
24: Zandwerven 3;
25: Westfrisiaweg;
31: Keinsmerbrug (red dot)
(numbers after Van Heeringen & Theunissen (2001)).

Noord-Holland is situated on top of the Pleistocene river valley of the rivers Vecht and IJssel (Fig. 2.2). [14]

The large tidal basins of West-Friesland started to silt up between 4500 and 4000 BC as a result of sea level rise. The existing inlets become smaller and the existing beach barriers extended laterally and seawards.[15] Based on geological and archaeological studies we know that the higher parts of this landscape in the tidal basins become habitable around 2900-2800 BC.[16] Research has shown that the earliest occupation in this area can be dated to the Funnel Beaker period (TRB). At the Bouwlust Slootdorp site a small settlement has been excavated where, besides finds of numerous pottery sherds and flint artefacts, a house plan has also been recognised.[17] At the Kreukelhof site an occupation layer containing artefacts, botanical and zoological material was found during evaluative research (manual coring and two small test pits).[18] Recently a dug-out canoe also dating to the TRB period was discovered in the Wieringermeer.[19] It was found in a gully which borders a Pleistocene coversand ridge, which shows that in this area, as well as in other parts of the Netherlands, these geomorphic units (coversand ridges and perhaps also hillocks) were potential settlement areas for prehistoric communities. Furthermore, this latter find also provides a glimpse into the modes of transport used by the earliest settlers of this area. These finds prove that some parts of the region were already habitable in earlier periods.

Before we zoom in on the site and the immediate surroundings of Keinsmerbrug we must draw a general outline of coastal development in West-Friesland.[20] The focus will be on the period 5000-3000 BP (approx. 3200-1250 BC). Until 5000 BP the coastal area was characterised by numerous tidal flats intersected by a number of west-east oriented channels. Lagoons developed to the east of this area. At the start of the third millennium the first beach barriers developed, resulting in a more closed shoreline. As a result, behind these barriers the influx of clastic sediments decreased and peat started to grow.

From the inlet at Bergen, several large tidal channels originated which penetrated the hinterland in northeasterly direction. With the narrowing of the inlet at Bergen between 4500 and 4300 BP (approx. 3200-2900 BC) the shoreline was almost completely closed, though some marine influence remained. Behind the shoreline, consisting of beach barriers with low dunes, a lagoon formed, which is likely to have been present for several centuries. At the end of this period the surface had a distinctive microrelief characterised by different gradient zones. During this period the first indications of occupation are found on marine sediment alongside a large channel which lies north of present-day Kolhorn and south of Middenmeer.[21]

In the period 4300-3800 BP (approx. 2900-2250 BC) the large tidal channel developed two new branches. The southern branch originated at Bergen and had northeast orientation towards Medemblik. The northern branch was oriented towards Kolhorn, where it turned to the south. As a result, the northern tidal channel north of Schagen became inactive around 2800 BC.[22] The southern branch ended its active phase a little later than the northern branch, in around 3900-3800 BP (approx. 2400-2200 BC). During this period a varied environment with extensive microrelief developed. It was in this gradient zone-rich landscape that numerous late Neolithic settlements flourished until rising groundwater levels caused the peat to start growing again. In this period the landscape was relatively stable; in the triangle between Schagen-Hoorn-Enkhuizen there was a largely brackish marsh environment in which a former channel was present. At the western border this marsh was protected by a complex of beach barriers several kilometres wide. To the south of the marsh there was a large open water system of the Vecht and IJssel connected to the sea. The eastern border was formed by extensive peat bogs, whereas the northern border was marked by the Pleistocene outcrops (glacial till and coversand deposits) of Wieringen and Texel.[23]

The forming of large peat bogs resulted in a smaller habitable land area. Furthermore, the existing tidal channel migrated southwards and its northern branch gradually silted up around 2100 BC. The influence of this tidal channel diminished, and the relief flattened. Only a few archaeological sites dating to this period have been discovered and it seems that the focus of habitation moved to the east. By around 1400

14 In fact this Pleistocene river valley was carved out by a predecessor of the river Rhine which originally had a branch situated north of its current branch in the central Netherlands.
15 Vos & Kiden 2005.
16 De Mulder & Bosch 1982; Van Ginkel & Hogestijn 1997.
17 Hogestijn & Drenth 2001.
18 Van Heeringen & Theunissen 2001 part II.
19 Kruidhof *et al.* 2011.
20 This information is based largely on Mulder & Bosch 1982; Van Heeringen & Theunissen 2001; and the work done by Lenselink 2001a; 2001b; 2001c.
21 Van Heeringen & Theunissen 2001 part I, 55.
22 Van Zijverden 2011.
23 Van Ginkel & Hogestijn 1997,19-24.

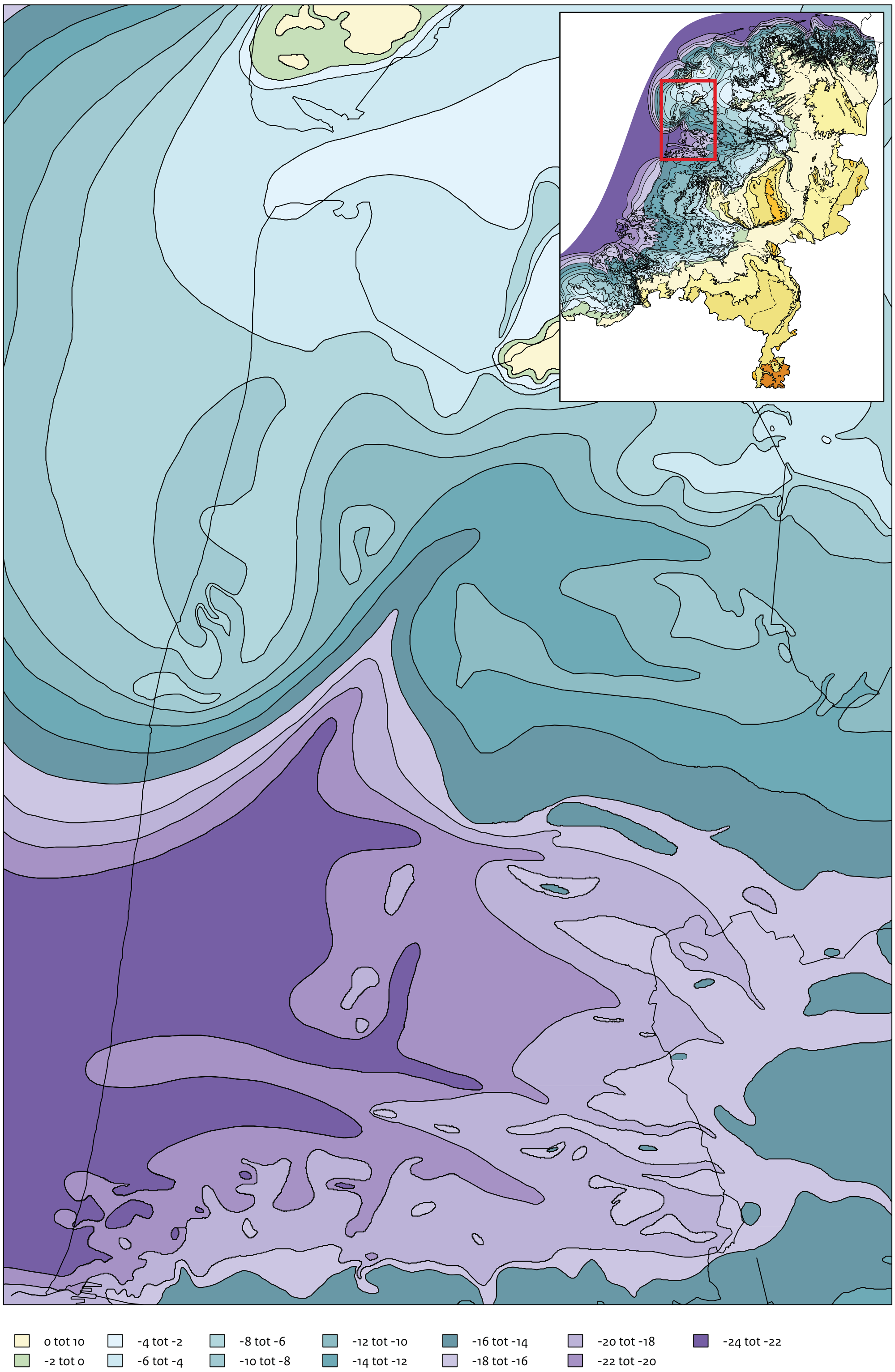



Fig 2.2: Reconstruction of the Pleistocene relief in metres above or below Amsterdam ordnance datum at the start of the Holocene (adapted from Vos & Kiden 2005).

BC the inlet at Bergen was completely closed and as a result the channel system in Oost Friesland silted up and became inactive.

Occupation is found on the higher parts of the former tidal landscape, high-lying silted up creek and levee systems in the tidal area. The tidal flats in this area were periodically submerged during high tides, spring tides and storms.[24] When these flats silted up high enough vegetation started to develop and a transformation to salt marshes occurred.[25] These salt marshes provided potential grazing areas for cattle and other domesticates. The higher parts of this landscape, the Pleistocene outcrops to the North (Wieringen, Texel), the levees and silted up creeks and some high salt marshes were favourable settlement locations. The other (lower) parts of the landscape provided a varied environment where various plant and animal species were present.

Freshwater was brought into this tidal landscape by rain and the former courses of the IJssel and Overijsselsche Vecht rivers. Marine influences entered through large gullies and the estuary, especially through the Bergen inlet.[26] All the sites found in the former coastal area were once characterised by numerous tidal flats, channels and gullies of different sizes, marsh creeks, salt marshes and levees. Furthermore, the presence of low dunes on nearby beach barriers is relevant. A varied spectrum of animals and plants were able to flourish in this aquatic environment, with salt, brackish and fresh water. Sandy clays were deposited near gullies, forming levees, and heavy clay sediments were deposited in the hinterland.[27] As a result of these successive floods and a high water table, archaeological remains (both organic and inorganic) have been preserved, providing opportunities for research on a wide spectrum of archaeological data. Due to the silting up of creeks and channels, the closing of the coastline and the continuous rising of the groundwater level, the formerly dry tidal area was gradually submerged and peat started to develop. As a result, occupation potential in this area shifted to the more eastern parts, where Bronze Age occupation has for example been found near Bovenkarspel, Andijk, Hoogkarspel, Enkhuizen and recently near a large gully in Hoogwoud.[28]

The Noord-Holland tidal area is part of the estuarine environment of the western Netherlands. The communities of the Late Neolithic occupied a dynamic varied landscape consisting of numerous different gradient zones and therefore ecological niches. Activities of daily life occurred on the borders between wet and dry and between fresh and salt water.[29] It was this varied landscape which set the boundaries within which prehistoric men made their own choices regarding subsistence and other aspects of daily life. This dynamic landscape is regarded to having been an integral part of the life of Late Neolithic communities, as both an economic and a social and ideological setting.[30]

## 2.2 Geology

The information on the geological substrate of Keinsmerbrug is derived largely from observations made by Bosman during the excavation at Keinsmerbrug.[31] Keinsmerbrug is the most northwestern settlement within the known distribution of SGC sites in this region. The archaeological remains were embedded in the lowest levels of peat covering tidal flats. Pits and posts were dug into the tidal flats.

The site at Keinsmerbrug is situated on the highest parts of the tidal flats in the subsurface. It seems that a natural shell bank seen in the southern parts of the excavation is partly responsible for the minor relief in the former landscape. The landscape around the settlement of Keinsmerbrug is formed by a transition zone of tidal flats and swamps. The site is covered with peat and, finally, with clay sediments which date to the Middle Ages. During the excavation and geological research a gully was discovered. However, additional research has shown that this gully is a feature dating to the Middle Ages which has no relation to the Late Neolithic occupation.[32] The presence of peat and clay is the reason why the archaeological remains were preserved approx. 75 cm below the present surface, and only came to light again during the excavation in 1986.

24 Vos & Kiden 2005, 31.
25 Van Ginkel & Hogestijn 1997,16.
26 Drenth, Brinkkemper & Lauwerier 2008, 155; Hogestijn 1992, 199.
27 Drenth, Brinkkemper & Lauwerier 2008, 156
28 Roesingh & Lohof 2011; Fokkens 2005b; IJzerreef & Van Regteren-Altena 1991; Brandt 1988; C. Soonius pers. comm.
29 Van Ginkel & Hogestijn 1997,13.
30 Ingold 2000.
31 Bosman 1986.
32 Bosman 1986.

## 2.3 Absolute chronology

Before the start of this Odyssey project the archaeological remains at Keinsmerbrug were dated on the basis of the typological characteristics of the ceramics and of stratigraphical observations made during the excavation. Fortunately it proved possible to obtain several $^{14}C$ dates during this project.[33] A total of six samples were dated at the laboratory at Groningen University using the $^{14}C$ AMS dating method (Tab.1). The material used for dating was selected from the samples of botanical macroremains. Due to the fact that the excavation took place almost 25 years ago it was not possible to select samples from stratigraphical sequences. The samples selected were therefore chosen from contexts which, based on the preliminary botanical analyses, might possibly indicate different activity areas spread over the settlement area (Fig 2.3)

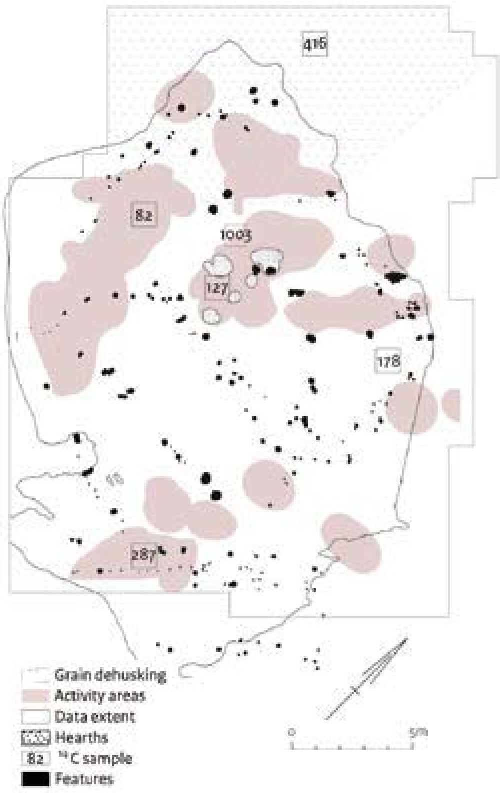



Fig 2.3 : Location of $^{14}C$ samples (in dark grey) Samples were taken from the squares: 82, 127, 178, 287, 416 and from feature 1003.

The BP dates all fall within a limited range and the calibrated time range is also fairly limited. Oxcal 4.1 was used for the calibration (Fig. 2.4).[34]

As can be seen from figure 4 the calibrated dates fall in the broadest sense in the period between 2900 and 2300 cal BC. However, the figure suggests a tighter period between 2580 and 2430. For now this visual comparison provides us with no more indication that one or more activities took place at the site under consideration in this period. It might have been one activity, or more, but given the small range of BP dates we are at the limits of the $^{14}C$ dating period.

Visual comparison of calibrated $^{14}C$ dates has been criticised on numerous occasions. Bayliss and others, in particular, argue that the use of Bayesian statistics and the dating of well-chosen stratigraphical sequences is a better alternative to visual comparison of calibrated $^{14}C$ dates.[35] However, in their studies of Neolithic long barrows they really seem to want to pinpoint specific activities relating to those barrows, like the first building phase, different periods of use and the end phase of this type of monument. One might wonder whether $^{14}C$ dating combined with Bayesian statistics can provide such insight, though they do in fact construct scientific models or hypotheses to be used in the understanding of prehistoric activity. Unfortunately this is not an option in this study, as we do not have the detailed stratigraphical information combined with $^{14}C$ samples that Bayliss and others used in their studies. Furthermore, in the period under consideration – the Late Neolithic in the Netherlands, currently dated between 2800 and 2400 BC – the calibration curve shows a clear plateau which prohibits a final delimitation of calibrated dates. In conclusion, we would argue that the dates provide arguments in support of placing the activities which took place at Keinsmerbrug firmly in the Late Neolithic.

33 Stichting Nederlands Museum voor Anthropologie en Praehistorie, BIAX Consult and the RCE provided funding for this dating research.
34 Bronk Ramsey 2009; Reimer *et al.* 2009.
35 Bayliss *et al.* 2007.

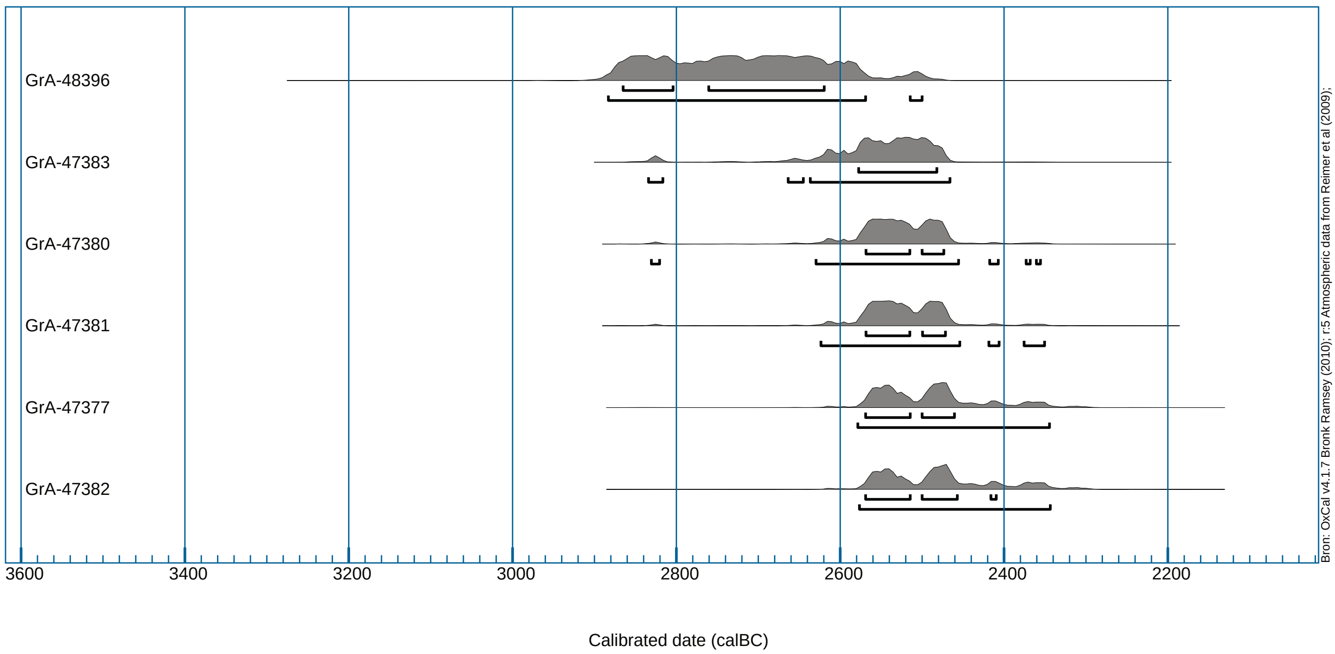



Fig. 2.4 Multiplot of calibrated ¹⁴C outcomes.

## Table 2.1 Results of ¹⁴C-dated samples.

| laboratory number | date (BP) | location of the sample | plant material sent for AMS |
|---|---|---|---|
| GrA-47377 | 3970 ± 40 | square 82 | Triticum dicoccon (emmer) – grain 1x, Atriplex patula/prostrate 5x (all charred) |
| GrA-47380 | 4000 ± 40 | square 127 | Hordeum vulgare var. nudum (naked barley) – grains 3x (all charred) |
| GrA-47381 | 3995 ± 40 | square 178 | Hordeum vulgare var. nudum – grain 1x (charred) |
| GrA-47382 | 3965 ± 40 | square 287 | Hordeum vulgare var. nudum - grain 2x+ 1frg (all charred) |
| GrA-47383 | 4025 ± 40 | square 416 | Hordeum vulgare var. nudum – grain 3x (all charred) |
| GrA-48396 | 4130 ± 60 | feature 1003 | Stellaria media 10x, Polygonum aviculare 1x, Urtica dioica 16x, Chenopodium ficifolium 10x, Apium graveolens 14x, Carex otrubae 2x, Carex riparia 1x, Chenopodium glaucum/rubrum 1x (all waterlogged) |

# 3 Features

*G.R. Nobles*

## 3.1 Introduction

The site was first investigated by Frans Diederik in 1985 using a single test pit in which a quantity of bird remains was discovered.[36] The following year a team led by G. Van Haaff conducted a full excavation prior to the site's destruction for bulb production. The team also included P.J. Woltering as scientific advisor and W.J. Hogestijn. They were all consulted during the course of this project.

In 1986 the site was divided into four quadrants separated by a one metre wide baulk. Each quadrant was stripped of topsoil down to a depth of 60 to 70cm. The following sections are based on the original unpublished report and field notes from the archive.

### 3.1.1 Trench 1

The north-western quadrant, trench 1, was excavated to the peat layer. At this point pits were seen to cut into the peat. Initially it was thought that these pits were for the extraction of the clay that lies below the peat, although further investigation revealed that the pits did not reach beyond the limits of the peat layer. The unpublished report suggests these pits were dug to extract peat for compost material, although peat can also be used as a source of fuel or roofing material. It was observed that the peat was cut in 'brick-like' sods which left a clear turf wall. The base of one of the pits appeared to have been pre-cut ready for the extraction of the peat, which for some reason was never removed.

These pits contained very few archaeological finds, although they did yield two sherds described as local Roman ware. The report states that the southwest corner of trench 1 was akin to firm humus clay putty and was towelled with great difficulty. Trowelling nevertheless continued as a previous trial trench had revealed bird bones.

The previous statement is inaccurate as the trial trench was in trench 3 as opposed to trench 1. There is very little information about finds other than what has previously been mentioned. Only one plan exists for trench 1. All the features are assumed to be Medieval, although it is possible that some contemporary Roman features existed.

### 3.1.2 Trench 2

Trench 2 was located to the south, adjoining to trench 3 to the east. As with trench 1, it was excavated down to the peat layer. The first excavated level revealed Late Neolithic remains. The northeast area of trench 2 was composed of peat which lay higher than its surroundings. The peat in this area was described as being peatier than that on the clay edges. The initial finds were gathered under a single number and included a scraper, quite a few bird bones and some sherds of a Protruding Foot Beaker from the Single Grave Culture.

This area was excavated in metre squares at depth intervals of 5cms. Where possible the positions of the finds were plotted. Each metre square was excavated by trowel and the finds were marked on the trench plan at a scale of 1:20. Finds under 1cm were not marked, though they were still collected. The finds were not attributed to a height measurement, but a height point was said to have been taken at the centre of every metre square. No information regarding these elevations was found in the archive. The soil from each square was sieved. Since little material was retrieved it was decided only to sieve the peaty material.

It became apparent that the area requiring excavation was much larger than previously thought. The excavators therefore stopped plotting the finds and collected them by metre square and catalogued them under the square number. After trowelling the square was cleaned and the features were drawn and sectioned. The feature was then excavated in its entirety. Finds were numbered from 2-1-1 to 2-1-69.

### 3.1.3 Trench 3

The methodology changes again in trench 3. Squares of four metres were introduced, sub-divided into four metre squares. At least one of these squares was excavated by spade and the soil sieved directly; the remaining three squares were trowelled. Zoological samples were not taken, as sieving was performed using a 2mm mesh, although botanical samples were taken in a checkerboard pattern over the entire trench.

[36] Diederik 1986; Van Heeringen and Theunissen 2001 part I & II.

## Table 3.1: Methodological summary

| | trench 1 | trench 2 | trench 3 | trench 4 |
|---|---|---|---|---|
| **finds** | unknown | plotted in x,y * | collected by m² | unknown |
| **zoological samples** | unknown | unknown | yes via sieve | unknown |
| **botanical Samples** | unknown | yes | yes per m² | unknown |
| **numbering** | unknown | 2-1-1 to 2-1-69 | 3-1-70 to 3-1-325 | unknown |
| **elevation (planes)** | unknown | yes ** | yes ** | unknown |
| **elevation (peat)** | unknown | yes | yes | yes*** |
| **excavation method** | unknown | trowel | three squares trowelled to one square by spade | unknown |
| **photographs** | unknown | unknown | yes** | unknown |

* Although this changed to m² in the southern area
** Although data unavailable
*** Only partially

Continuing from trench 2, finds were numbered from 3-1-70 to 3-1-325. The southeast corner of the trench is said to have been fairly empty of finds. As in trench 2, sieving was abandoned in areas of high clay content.

### 3.1.4 Trench 4

No information regarding the fourth trench is presented in the original site report. It is thought that this is because the report is a summary of the initial results. It is therefore also assumed that a similar methodology was used to that employed in trench 3. Finds would therefore be numbered in a similar manner, as 4-1-380 etc. This is reflected in the archive (Table 3.1).

### 3.1.5 Original conclusions

The conclusions in the original report are limited. The latest phase of activity dates to the Medieval period. Some contemporary Roman material is noted, but no features are identified as Roman. The earliest phase of activity is the Neolithic, with hearths, pits and postholes. Nothing is said about the plough marks. The cow hoof marks (n=80) are in one sentence said to be later than the settlement, this is then contradicted later when it is said they are earlier than the hearths.

Many of the Neolithic features were initially thought to be Medieval, as the tops of the features had Medieval layers compacted into them. The posts were hit into the ground rather than a hole being dug and then backfilled. There is an area of the habitation layer which is noticeably thicker than its surroundings, possibly caused by build-up due to habitation or by erosion of the layer surrounding it caused by compaction due to occupation. Several peaty layers are said to signify returning habitation. The phasing can be illustrated by a very simple Harris Matrix (Fig 3.1).

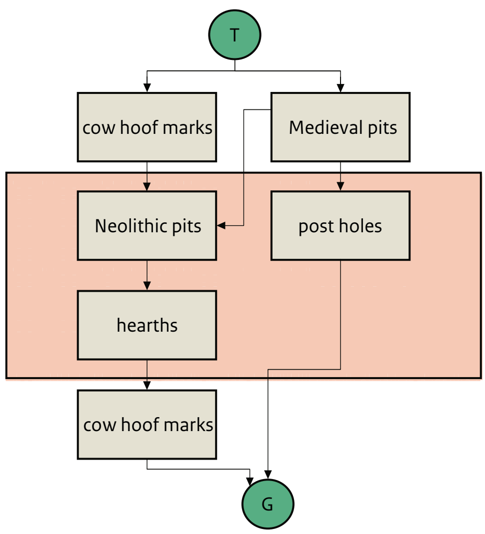



Figure 3.1 A simplified schematic of the original report matrix derived from the text. (G represents the Natural and T the Topsoil).

Dating of the site is extremely difficult as the report says the pottery is from the Bronze Age, SGC and possibly the Vlaardingen Culture. The striking quantities of bird remains, as well as remains of fish, pig and dog, are noted.

### 3.1.6 Assumptions and sources of error

In the interests of transparency, every inference, assumption and guess has been noted. In some cases an educated guess has had to be made.

Most of the square numbers could be located from the site drawings. However, some had duplicate or double numbering. All references in regard to direction in this section relate to grid north (which points northeast). In trench 2 numbering starts at 3 and goes to 62, running in four columns north to south. Squares 16 and 17 are also numbered 255 and 270 respectively; this is a result of the baulk removal and derives from the numbering system in trench 3. All finds were changed to squares 16 and 17. Six additional squares (63-68) were added as the excavation was extended further south.

Square 69 does not exist. The numbering in trench 3 began at 70 and continued to 323, running east to west starting in the northwest. Squares 81 to 83 are duplicated, although one set are also numbered 334 to 336. Those with multiple numbers are therefore assumed to be 334 to 336.

Trench 4 starts at 324 in the southwest corner and continues to 437 in the northeast corner, the numbers increase consecutively except in the southwest corner. Square 338 occurs twice, so the square in the far southeast has been omitted. On the basis of the fish remains (later backed up by the other animal remains) one square is numbered 4-1-1, and occurs on more than one occasion. There is a single square missing in trench 4 which is diagonally opposite square 3. This square is also the centre point marked on the excavation plans and it is thought to be the location of a borehole. Having taken all this into account it is assumed that this is the location of square 1. Square 2 has therefore been logically placed to the west of square 1 and to the north of square 3.

Some interpretation was required for the location of some of the metre squares. Figure 3.2 shows a plot of the squares.

## 3.2 Methodology

Digital data for this site had to be acquired from the original site plans and sections by scanning. The site drawings were in digital form in jpg format. No Exif metadata was available from the images, so it is not known how they were digitally captured, what processing they have undergone and what equipment and software were used.

As they were all drawn on permatrace with an underlying 1cm grid the software VPmap pro from Softelec could be used to adjust the distortion to the grid and rapidly digitise the drawings using its semi-automated functions. Digitising was originally conducted over the course of a month using ArcGIS. However, VPmap pro proved to be much more efficient and accurate, taking only three days to re-digitise the same plans.

## 3.3 Levels

As previously stated, levels were said to have been taken at the top and base of every 5cm excavated square. This data is absent from the archive, though height measurements do exist for the top and base of the habitation layer, also referred to as the cultural layer. In addition there is a contour plot of a shell bank upon which the site is located. The contour lines are marked in such a way that a digital reproduction could be made.

Figures 3.3 and 3.4 show the height of the base and thickness of the cultural layer respectively. No height data exists for much of the south-eastern extent of the cultural layer and for the extremities to the northwest and southeast. The resulting digital elevation model was interpolated from regular points which were taken every metre. Some height points were absent, so these areas of the elevation model were estimated during the interpolation. All interpolation was conducted using the kriging method. The inverse distance weighted method (IDW12) was initially used, but inspection of the derived slope values suggested the kriging method would give a more accurate result.

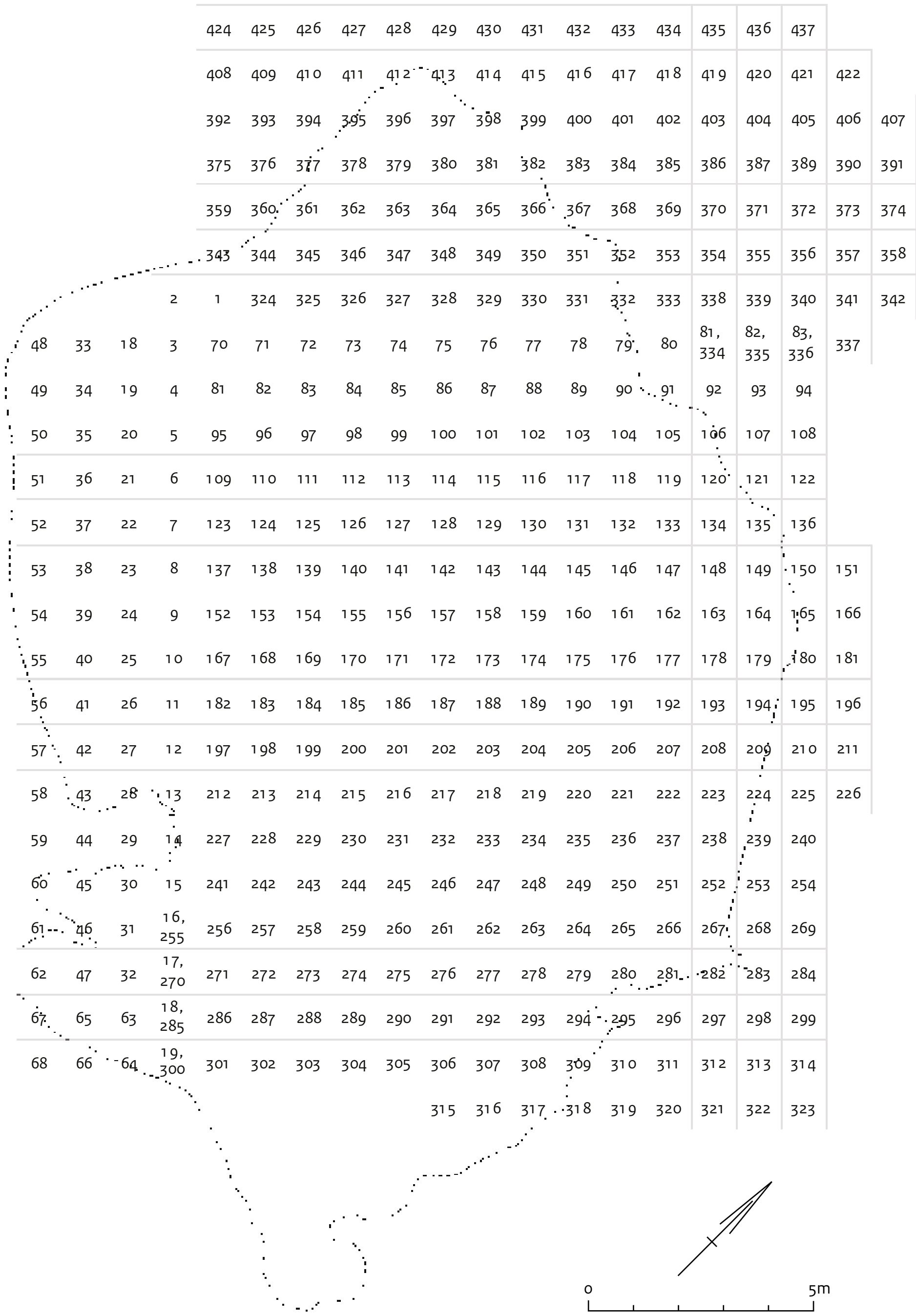


Figure 3.2 The reconstructed site grid with duplicate numbering included.

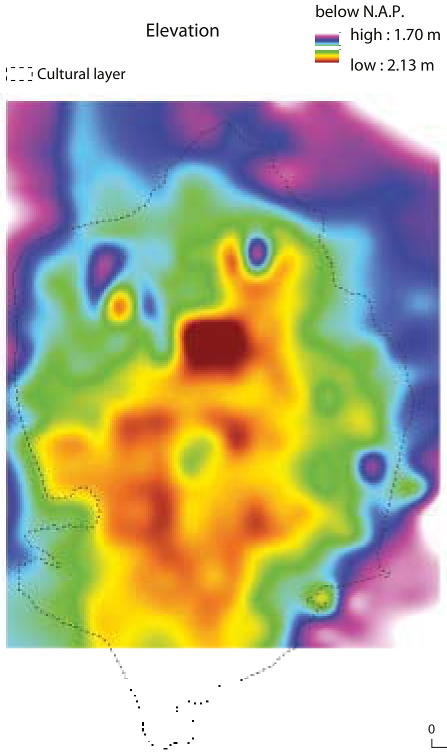



Figure 3.3 The base of the cultural layer.

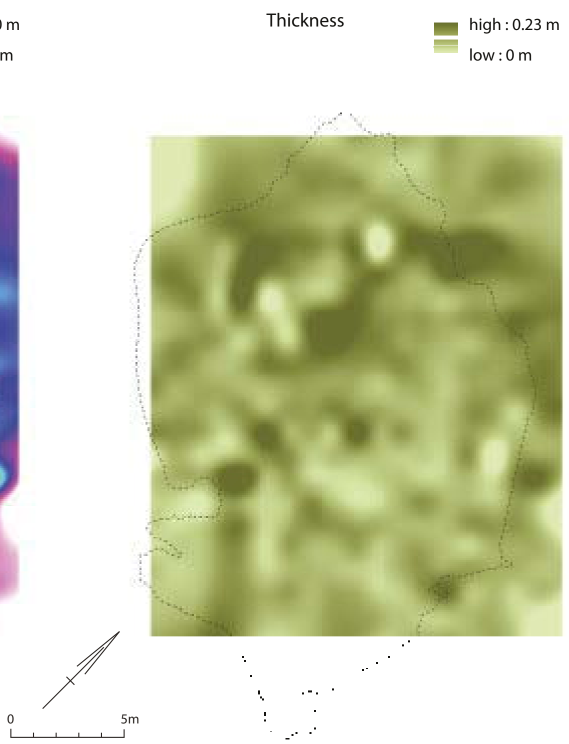



Figure 3.4 The thickness of the cultural layer (max. 23 cm).

The shell bank was digitised from annotated contour lines. Points were sampled at one metre intervals and interpolated. The contour lines were spaced at intervals of 5m ranging from 190m in the centre to 255m at the furthest recorded extent, giving a concave feature. Examination of the north to south section showed that it should be convex. Documentation also describes it as a bank. It was therefore inferred that these heights were indeed negative numbers below NAP, and thus in need of inversion.

## 3.4 Classification and phasing

The site contained Medieval, Local Roman and Neolithic remains. The topsoil was 60 to 70cm above a Medieval subsoil. This Medieval layer filled the tops of many of the underlying features. Trench 1 appears to contain all of the Medieval archaeology and there is little impact on the Neolithic remains (Fig 3.5).


Figure 3.5 The trenches and neolithic features.

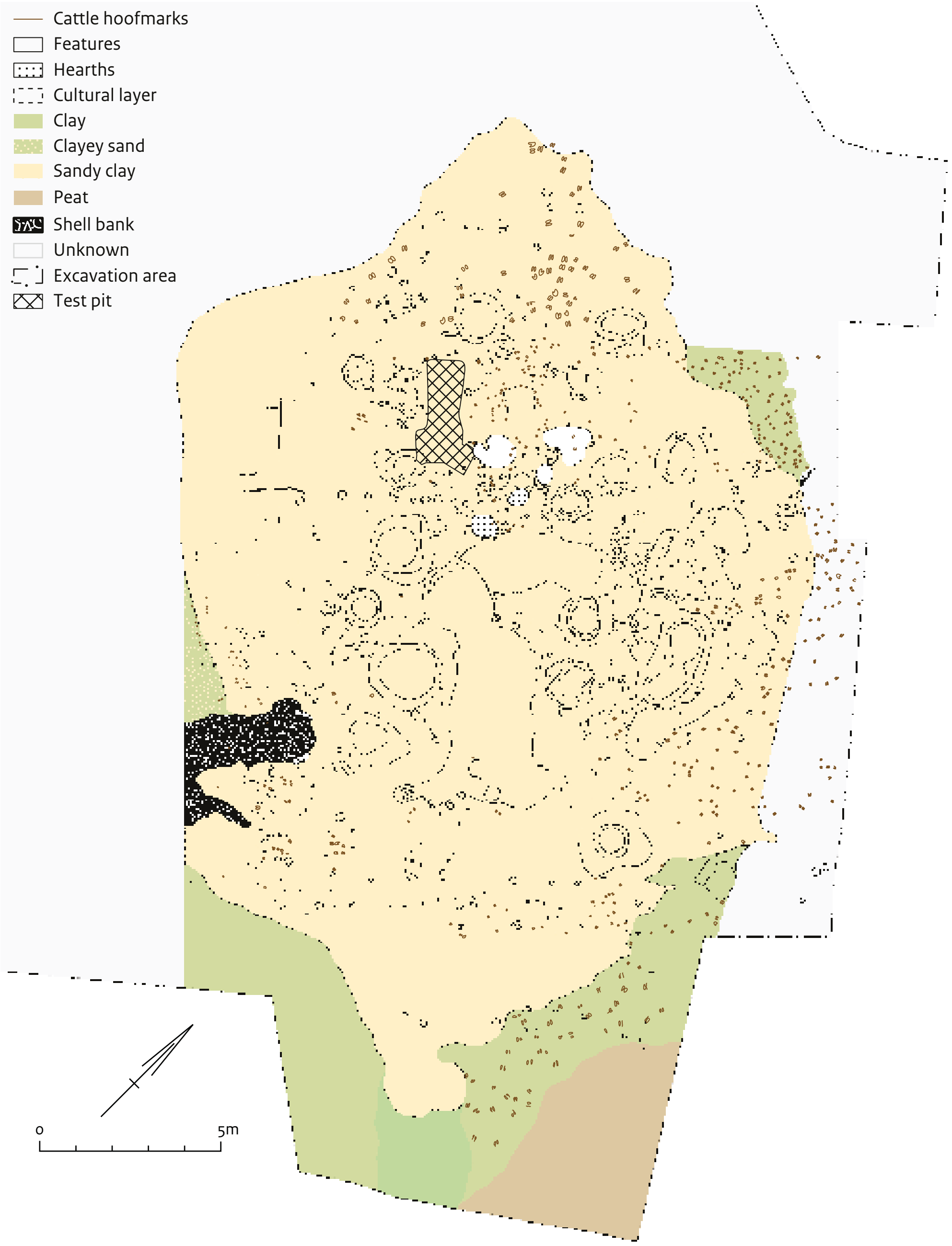



Figure 3.6 The Neolithic site.

### 3.4.1 Neolithic remains

To aid in the phasing of the site a Harris Matrix was attempted.[37] However, due to the lack of stratigraphical information, the attempt was abandoned. Only a small fraction of features had their profiles drawn, even though many were sectioned, making the stratigraphy difficult to interpret. No context records exist for the site, and any contextual information was taken directly from the site drawings (Fig 3.6).

**The pits**

The pits (n=25) are the earliest anthropogenic feature at the site (Fig 3.7-3.10). They show signs of rapid natural backfilling and relatively few finds were recovered from them. Many of the pits were waterlogged during excavation and

[37] cf. Harris 1997

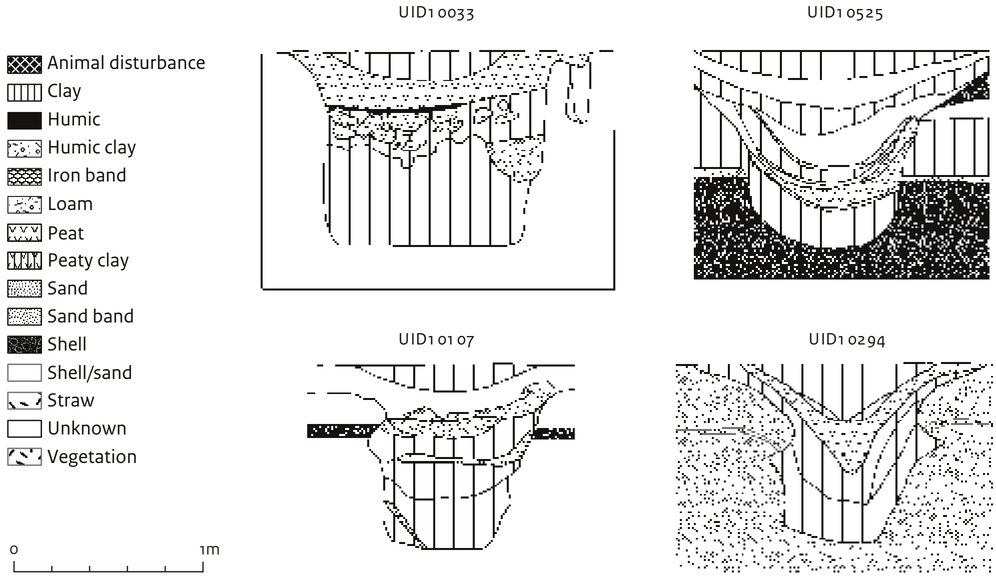



Figure 3.7 Sections of pits (unknown direction).

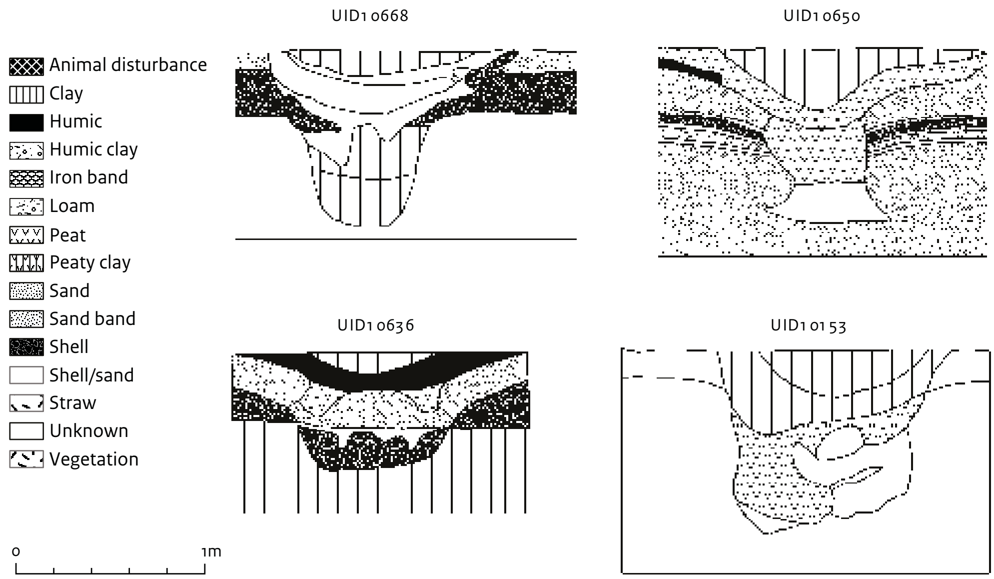



Figure 3.8 Sections of pits (unknown direction).

went down to depths of one metre. All of the pits cut the underlying shell bank, and some also cut thinner shell bands. Many postholes cut the pits but it is not possible to assign any of them to an individual phase.

**The cultural layer**

The cultural layer fills the tops of many of the pits above the natural backfill. This layer is up to 20cm thick, and could be represented in the baulk profiles as multiple layers, indicating at least a few habitation phases. Within this layer, five charcoal areas have been interpreted as hearths. The hearths cover one of the pits, supporting the theory of an earlier phase.

Cattle hoof marks cut into a few of these hearths and are present below others. It is conceivable that these prints are contemporaneous with at least the later phase of the site. The location of the hoof marks suggests that the cows or the herder had some knowledge of the settlement, either through

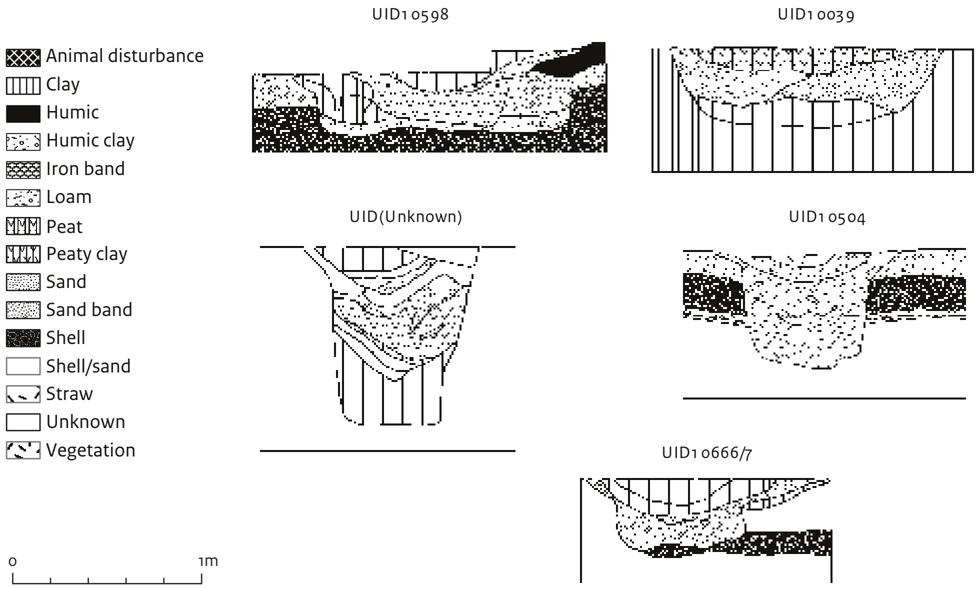



Figure 3.9 Sections of pits (unknown direction).

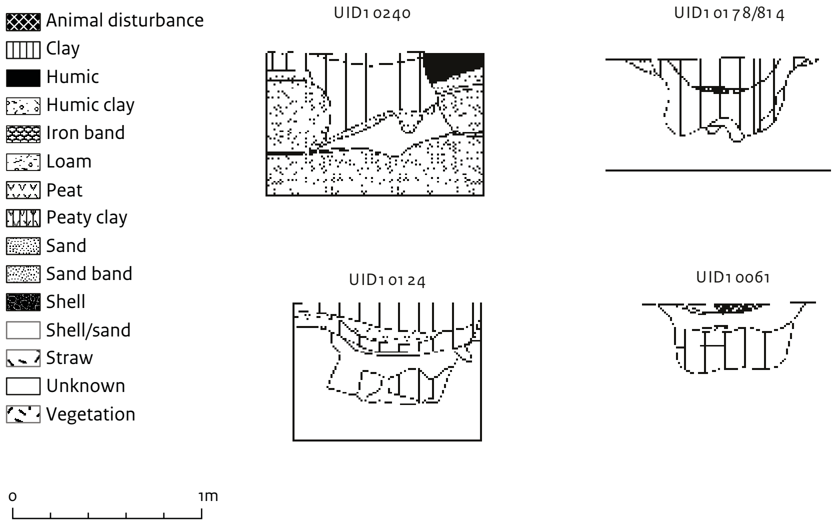



Figure 3.10 Sections of pits (unknown direction).

memory or from structural remains.

Finding hoof marks within a Neolithic context is not unique. Similar hoof marks were found at the settlement site at Ypenburg near The Hague.[38]

**Postholes and stakeholes**

Postholes and stakeholes (n=666) form the majority of features at the site (Fig 3.11, 3.12). Many features could not be accurately classified, so if the interpretation of a feature was missing it was classed as a post- or stakehole. An attempt was made to distinguish between the stake- and postholes by looking for a break between the perimeter values, but there was no identifiable split in the dataset. Postholes and stakeholes have therefore been kept in the same class and are referred to hereafter only as postholes.

There are some differences in the character of the postholes (Table 3.2). Most are single

[38] Koot, Bruning & Houkes 2008, 365


Figure 3.11 Posthole depths.

postholes but three sets are double postholes within a pre-dug post pit. These are the only features that contradict the original interpretation that the posts were hit into the ground.

Some sections show evidence of post replacement, through extraction and replacement, or just replacement.

### Other features

In the west of the site there are four possible plough marks, two of which cross at right angles. Without knowing the stratigraphical

**Table 3.2: Shape and quantities of postholes.**

| shape | number |
|---|---|
| circle | 649 |
| triangle | 21 |
| rectangle | 95 |
| irregular | 42 |
| unknown | 3 |
| total | 840 |

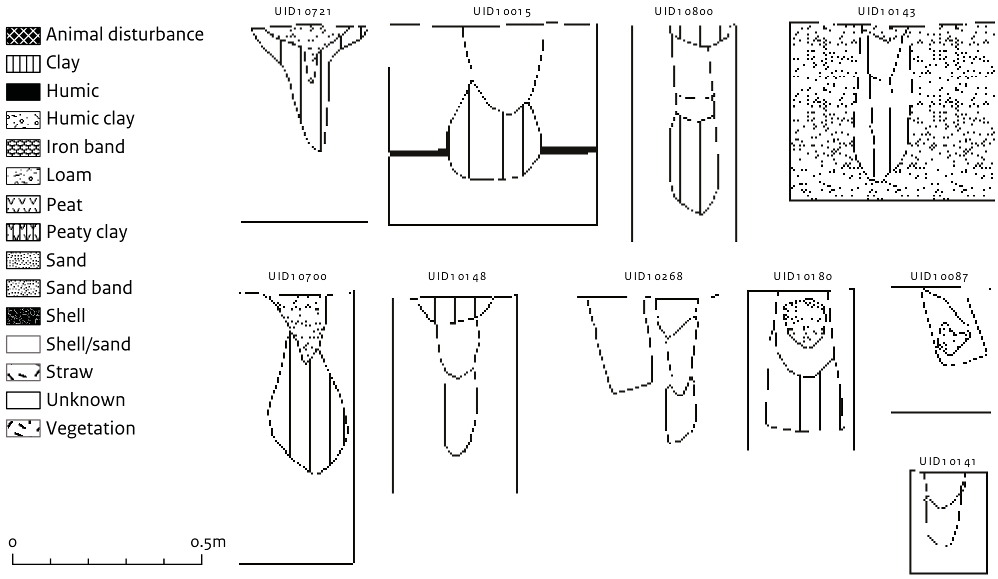



Figure 3.12 Sections of postholes.

relationships, or at least the layer which covered them, it is impossible to attribute them to a certain period. They could be Neolithic, Medieval or Modern. However, they could be from a level broadly contemporary with the settlement as they were originally recorded on the same plans as the Neolithic features. Their interpretation remains unclear.

**Structures**

No house structures are apparent from the posthole arrangements. Looking at the series of lines of posts and possible groups of postholes in isolation, it is impossible to interpret any convincing structures. The spatial analysis in chapter 10 helps to shed light on the activities that took place at the site.

### 3.4.2 Underlying stratigraphy

The underlying stratigraphy of the site is formed mostly of sand with areas of shell with clay and sandy clay around the edges of the site. Below this is a series of thin shell bands and a shell bank. The shell bank would have been visible on the ground surface as it protruded through the top of the cultural layer. It is possible that this bank might have formed a geographical feature in the local landscape, discrete but still visible. It may have been covered by vegetation, but this would have led either to greater or to stunted growth of the plant life. The original excavators believed this bank to have natural origins. In the absence of further evidence to oppose this view, the original interpretation remains.

Below the shell bank is a thick clay layer. Only a few features reach this layer and none extends beyond it. The full extent of this clay is not known.

# 4 The ceramics

*S.M. Beckerman*

## 4.1 Introduction

In this chapter the ceramics found at Keinsmerbrug will be presented and discussed. The context of the study of SGC ceramics is first presented in section 4.2. In the past a great deal of attention has been focused on ceramics from funerary contexts, but much remains unknown about SGC settlement ceramics.

This new analysis of settlement ceramics yields information on the use, role, function and chronological differentiation of the ceramics and of this site as a whole. In order to gain this information, a macroscopic study of the Keinsmerbrug ceramics was performed to analyse the technological and morphological characteristics and decoration. The methodology will be described in section 4.3. In section 4.4 the results of the analysis are presented. These results are compared with the results of the spatial analysis and the functional analysis in section 4.5. Conclusions will be drawn in section 4.6.

## 4.2 SGC ceramics

The ceramics from SGC funerary contexts have been extensively studied. A first typological and chronological division of the beaker wares was presented in 1955 by Van der Waals and Glasbergen. Based on pot morphology and decoration the beakers were divided into five Protruding Foot types (1a-1f), three All Over Ornamented types (2IIa-c) and six Bell Beaker types (2Ia-f).[39] Lanting, Lanting and Van der Waals, and Drenth and Lanting made some adjustments to this typochronological division.[40] The key proposition of this unilinear model is that the development of the ceramics from the beaker cultures was continuous. In 1999 Drenth and Hogestijn proposed a different cultural development.[41] Their model starts at the end of the SGC culture and proposes a two-track development rather than a unilinear one. A new type division is not presented.

Ceramics from SGC settlement contexts have not received as much attention. The typochronologies are therefore largely based on ceramics from graves and are not suitable for the analysis of settlement ceramics.[42] Although no comprehensive study of the ceramics from any SGC settlement in our research area has ever been performed, various studies of samples of these assemblages have been conducted. These include the study of short-wave moulded pots (*Golfbandpotten*) by Floore, the comparison of the types and sizes of ceramics between different types of sites by Hogestijn, the study of pot fabrication by Roorda and the study of the technological characteristics of the ceramics from Zeewijk by Sier.[43]

Both the type division based on the funerary ceramics and the above-mentioned studies of samples of settlement ceramics provide very useful background information for this new study. The present research can start to fill the gaps in our knowledge of SGC settlement ceramics. However, the absence of a standardised methodology for describing these ceramics must be tackled with a new method of analysis based on all the characteristics of the different pot types.

## 4.3 Methodology

The Keinsmerbrug site yielded 512 sherds.[44] All 291 SGC sherds with a weight of 3 g or more were analysed. 204 sherds weighed less than 3 grams. One sherd was so strongly weathered that too many of its characteristics had disappeared for it to be studied. Sixteen sherds were more recent, and they were also excluded from the analysis (Table 4.1). Some of the 291 SGC sherds suitable for study also showed signs of weathering; 50 sherds were flaked off, five were flaked off and rounded, and two were rounded. This weathering could have happened during use, deposition or after deposition. The weathering has caused many characteristics to disappear.

In order to obtain information on the use, role, function and chronological differentiation of the ceramics, both the technological and morphological characteristics and the decoration were examined. These variables are in part a reflection of the available resources and techniques, but are also a product of choices made or rules applied by the potter and, as such, yield more information on the potter and his or her society. Technological analysis plays a key role since many morphological characteristics

39 Van der Waals & Glasbergen 1955
40 Lanting 1973; Lanting & Van der Waals 1976; Drenth & Lanting 1991.
41 Drenth & Hogestijn 1999.
42 Van Heeringen & Theunissen 2001 part I, 146.
43 Floore 1991; Hogestijn 2001; Roorda 2001; Sier 2001.
44 The Keinsmerbrug ceramics were previously analysed by Hogestijn, but the results were not published. Since the original sub-division into vessels was not satisfactory, it has been replaced by a new one. The original numbers are listed in appendix II.

have disappeared due to fragmentation and weathering processes. Attention is paid to the tempering materials used, their quantity and size, the firing method resulting in the colour of the cross-sections, the thickness of the sherds, the construction, and the internal and external surface treatment of pots (Appendix I).

The morphological characteristics are initially studied at sherd level, focusing on the partition of the pot and the shape of the rim and base. After completion of the analysis, all the rim and base sherds and the neck, shoulder and wall sherds that either fit to them or have characteristics that suggest they are likely to belong to the same vessel were studied again as an assemblage. The pots were drawn and the diameter of the rim, widest belly circumference and the base were measured and a description of the shape was given (Appendix I).

The techniques and motifs of the decorated sherds were analysed. The decoration, in combination with the shape of the vessel, was also compared to the Van der Waals and Glasbergen types (Appendix I).[45]

## 4.4 Results

### Tempering

Study of the tempering materials shows great diversity in the types of materials that where added. Seven different materials were visible; grog, sand, quartz, red granite, granite, shell and plant material. Sand is found in the majority of the sherds. It was probably not added by the potter but already present in the clay. The presence of small sand particles in the clay may have been a positive criterion in the selection of clay for the production of vessels. Since the presence or absence of sand thus reflects a technological choice, this characteristic is included in the study. The other materials were most likely deliberately added by the potter, grog being the most commonly used. The other materials – red granite, quartz, granite, plant material and shell – were far less frequently present. Combinations of tempering materials occur and 14 different methods of tempering were used (Table 4.1). If sand is considered a tempering agent 76% of the sherds are tempered with two materials, and 4% with a combination of three materials. The other 20% only show one material. If sand is excluded, 20% are tempered with two materials and 80% with just one material.

Not only was the presence of the different tempering materials studied, but also their size and quantities. Contingency tables have been produced for the different tempering materials (except shell) to study the relation between the amount and size of the material and the number of times the different combinations of amount and tempering were used (Tables 4.2-4.7). All tempering materials, except for sand and shell, are present in different sizes. The amount of material added also varies, but most of the time there is a relation with the size of the particles. There are notable differences between the materials; the plant particles are almost always very small (<1 mm) and added in small quantities; granite, granite red and quartz particles on the other hand are never very small. Grog is used in many different sizes and amounts. Sand is by nature always smaller than 1 mm and is always present in small or modest quantities. The observed differences show that the amount and size of the tempering materials added was also a deliberate choice made by the potter. Different workshops where pots were produced might have made different choices of tempering material, or it may be that different tempering materials were available in the vicinity of these workshops. The different workshops can be seen as or led to different 'technological micro-traditions'.

Four more contingency tables have been produced for sherds tempered with a combination of two materials to study the relation between the size and amount of the different particles added (Tables 4.8-4.11). These tables show that, generally speaking, there is a strong correlation between the size and amounts of particles.

[1] Van Der Waals & Glasbergen 1955.

## Table 4.1: Technological characteristics.

| | n | % |
|---|---|---|
| number of sherds | 512 | 100% |
| analysed | 291 | 57% |
| grit | 204 | 40% |
| indet/younger | 17 | 3% |
| | | |
| **tempering** | | |
| quartz | 1 | 1% |
| quartz and grog | 11 | 7% |
| granite | 4 | 2% |
| granite and grog | 3 | 2% |
| granite and sand | 1 | 1% |
| granite, grog and sand | 1 | 1% |
| red granite | 2 | 1% |
| red granite and grog | 10 | 6% |
| red granite, grog and sand | 1 | 1% |
| grog | 23 | 14% |
| grog and sand | 96 | 58% |
| grog and plant | 2 | 1% |
| grog, sand and plant | 3 | 2% |
| sand | 4 | 2% |
| plant and shell | 1 | 1% |
| | | |
| **thickness (mm)** | | |
| 5-5.5 | 22 | 9% |
| 6-6.5 | 59 | 25% |
| 7-7.5 | 56 | 23% |
| 8-8.5 | 41 | 17% |
| 9-9.5 | 43 | 18% |
| 10-10.5 | 20 | 8% |
| 11-11.5 | 1 | 0% |

| | n | % |
|---|---|---|
| **colour (1)** | | |
| da-da-da | 103 | 56% |
| da-da-li | 12 | 7% |
| da-li-da | 15 | 8% |
| da-li-li | 1 | 1% |
| li-da-da | 17 | 9% |
| li-da-li | 22 | 12% |
| li-li-da | 4 | 2% |
| li-li-li | 10 | 5% |
| | | |
| **surface treatment outside** | | |
| rough | 209 | 86% |
| smooth | 33 | 14% |
| | | |
| **surface treatment inside** | | |
| rough | 228 | 91% |
| smooth | 22 | 9% |
| | | |
| **decoration** | | |
| undecorated rims | 30 | 63% |
| decorated rims | 18 | 38% |
| | | |
| undecorated walls | 210 | 74% |
| decorated walls | 72 | 26% |

(1): from left to right: outside, core, inside; da=dark; li=light.

## Table 4.2: Size and amount of grog particles.

| **grog** | | | | |
|---|---|---|---|---|
| **size ↓ amount →** | **very little** | **little** | **average** | **many** |
| **<1** | 1 | 38 | | |
| **1-2** | 30 | 54 | 26 | 44 |
| **2-3** | 17 | 1 | 59 | 7 |

## Table 4.3: Size and amount of sand particles

| **sand** | | | | |
|---|---|---|---|---|
| **size ↓ amount →** | **very little** | **little** | **average** | **many** |
| **<1** | 7 | 108 | 53 | 2 |
| **1-2** | | | | |
| **2-3** | | | | |

### Table 4.4: Size and amount of plant particles.

| plant | | | | |
|---|---|---|---|---|
| size ↓ amount → | very little | little | average | many |
| <1 | | 26 | | |
| 1-2 | | 4 | 1 | |
| 2-3 | | | 1 | |

### Table 4.5: Size and amount of granite particles.

| granite | | | | |
|---|---|---|---|---|
| size ↓ amount → | very little | little | average | many |
| <1 | | | | |
| 1-2 | | 3 | 1 | 3 |
| 2-3 | | | 2 | |

### Table 4.6: Size and amount of granite, red particles.

| granite, red | | | | |
|---|---|---|---|---|
| size ↓ amount → | very little | little | average | many |
| <1 | | | | |
| 1-2 | | | 12 | |
| 2-3 | | | 2 | |

### Table 4.7: Size and amount of quartz particles.

| quartz | | | | |
|---|---|---|---|---|
| size ↓ amount → | very little | little | average | many |
| <1 | | | | |
| 1-2 | | 3 | 2 | |
| 2-3 | 7 | | | |

### Table 4.8: Relation between the size and amount of grog and sand tempered sherds

| sand → | size | <1 | | | | 1-2 | | | | 2-3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| grog ↓ | amount | very little | little | average | many | very little | little | average | many | very little | little | average | many |
| size | amount | | | | | | | | | | | | |
| <1 | very little | | | 1 | | | | | | | | | |
| | little | | 11 | 1 | | | | | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |
| 1-2 | very little | 1 | | 24 | | | | | | | | | |
| | little | | 25 | 20 | 2 | | | | | | | | |
| | average | 2 | 12 | 4 | | | | | | | | | |
| | many | 2 | 21 | | | | | | | | | | |
| 2-3 | very little | | | | | | | | | | | | |
| | little | | 1 | | | | | | | | | | |
| | average | 4 | 2 | | | | | | | | | | |
| | many | 1 | 4 | | | | | | | | | | |

## Table 4.9: Relation between the size and amount of grog and plant tempered sherds

| **plant →** | size | <1 | | | | 1-2 | | | | 2-3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **grog ↓** | amount | very little | little | average | many | very little | little | average | many | very little | little | average | many |
| size | amount | | | | | | | | | | | | |
| <1 | very little | | | | | | | | | | | | |
| | little | | 26 | | | | | | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |
| 1-2 | very little | | | | | | | | | | | | |
| | little | | | | | | 1 | | | | | 1 | |
| | average | | | | | | 3 | | | | | | |
| | many | | | | | | | | | | | | |
| 2-3 | very little | | | | | | | | | | | | |
| | little | | | | | | | | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |

## Table 4.10: Relation between the size and amount of grog and granite, red tempered sherds

| **sand →** | size | <1 | | | | 1-2 | | | | 2-3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **grog ↓** | amount | very little | little | average | many | very little | little | average | many | very little | little | average | many |
| size | amount | | | | | | | | | | | | |
| <1 | very little | | | | | | | | | | | | |
| | little | | | | | | | | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |
| 1-2 | very little | | | | | | | 2 | | | | | |
| | little | | | | | | | | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |
| 2-3 | very little | | | | | | | 10 | | | | | |
| | little | | | | | | | | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |

**Table 4.11: Relation between the size and amount of grog and quartz tempered sherds**

| **sand →** | size | <1 | | | | 1-2 | | | | 2-3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **grog ↓** | amount | very little | little | average | many | very little | little | average | many | very little | little | average | many |
| size | amount | | | | | | | | | | | | |
| <1 | very little | | | | | | | | | | | | |
| | little | | | | | | | | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |
| 1-2 | very little | | | | | | | | | | | | |
| | little | | | | | | 3 | 1 | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |
| 2-3 | very little | | | | | | | | | 7 | | | |
| | little | | | | | | | | | | | | |
| | average | | | | | | | | | | | | |
| | many | | | | | | | | | | | | |

## Thickness

The thickness of the sherds is bimodal (Fig. 4.1). The first peak of the graph is at 6 to 6.5 mm, and the value 7 to 7.5 mm also occurs frequently. After a dip at 8 to 8.5 mm a second, but smaller, peak is found at 9 to 9.5 mm. The graph presented was compiled for measurements of single sherds. Vessels show variation in their thickness however; for example, the neck may be thinner than the wall. To further study the thickness, another graph was produced for the wall sherds only. The graph based on the wall thicknesses also shows a bimodal division (Fig. 4.2).The different vessels do show variation in their thicknesses; the wall may be thinner than the rim, or vice versa. We can however conclude on the basis of the study of thicknesses that there are two classes of ware.

## Tempering and thickness

The next step in the analysis was to determine whether there is a relation between the thickness of the sherds and the tempering materials used. This would indicate that the intended thickness of the vessel was already envisaged during preparation of the clay. Figure 4.3 shows the tempering materials in relation to the thickness of the sherds. Figures 4.4-4.8 show this relation for the different combinations of tempering materials. The graph highlights some interesting differences between the thickness of the sherds and the tempering materials used. Quartz and plant material are used almost exclusively to produce thin-walled vessels. Granite and red granite, on the other hand, are visible in coarser sherds. Grog and sand occur in both classes of ware.

There is a relation between the thickness of the sherds and the size and amount of the tempering materials added. For grog (the most frequently used tempering material), a graph has been produced showing the relation between the size of the particles and the thickness of the sherds. Figure 4.9 shows that fine particles with a width of less than one mm are only added to

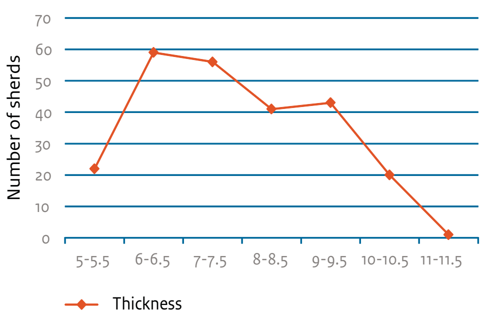



Fig. 4.1 Thickness of all sherds in mm.

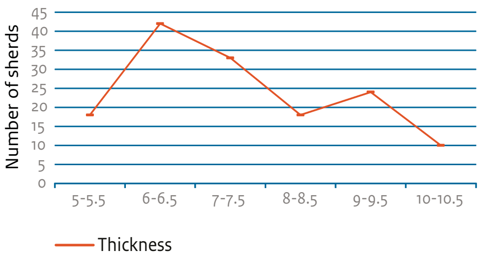



Fig. 4.2 Thickness of wall sherds in mm.

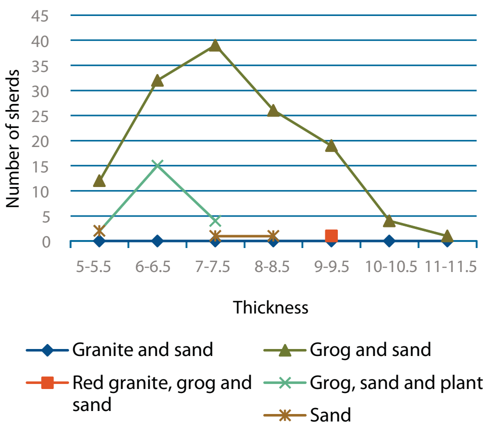



Fig. 4.5 Tempering and thickness of the sherds tempered with sand and combinations with sand.

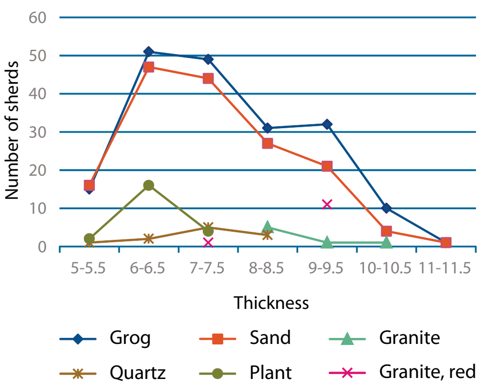



Fig. 4.3 Tempering and thickness of the sherds.

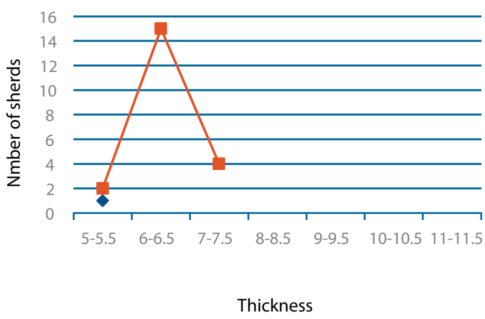



Fig. 4.6 Tempering and thickness of the sherds tempered with plant material and combinations with plant material.

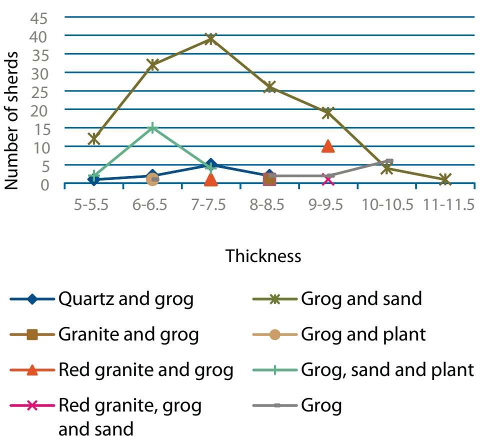



Fig. 4.4 Tempering and thickness of the sherds tempered with grog and combinations with grog.

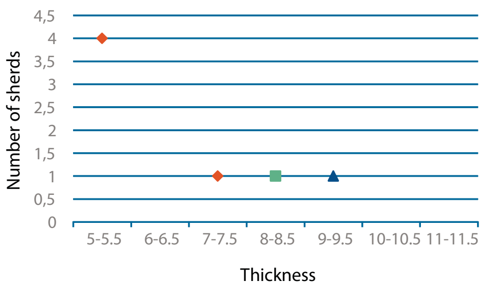



Fig. 4.7 Tempering and thickness of the sherds tempered with granite and combinations with granite.

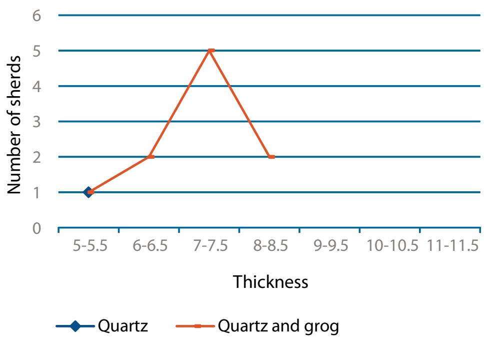



Fig. 4.8 Tempering and thickness of the sherds tempered with quartz and combinations with quartz.

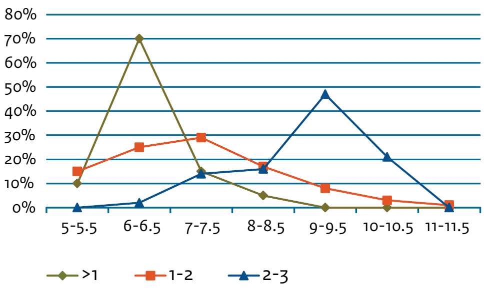



Fig. 4.9 Size of grog particles (mm) in percentages, in relation to the thickness of the sherd (mm).

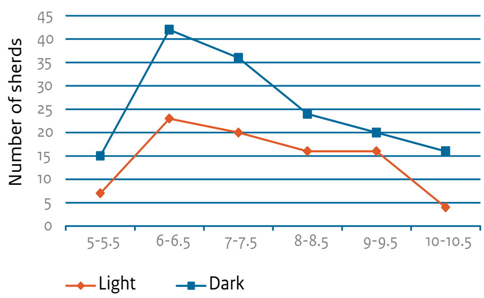



Fig. 4.10 Colour and thickness compared.

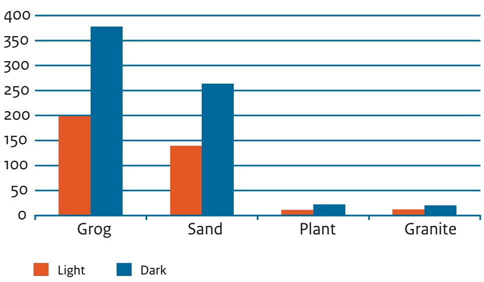



Fig. 4.11 Tempering and colour compared.

thin-walled sherds, whereas larger particles of between 2 and 3 mm are more frequently added to thick-walled sherds. One to two mm particles are most frequently added to sherds with a wall thickness between 6 and 7.5 mm. The grog-tempered sherds can thus be divided into two groups; the grog- and plant- or quartz-tempered ones are thin and contain little tempering material, the grog- and red granite-tempered ones are thicker and contain more tempering material. We can thus conclude that the relation between the thickness, size and amount of tempering materials indicates that deliberate choices were made by the potter, and the pots were probably made in different workshops.

**Firing method**

The colour of sherds is related to the firing and cooking atmosphere. An oxygen-rich fire leads to light-coloured vessels, whereas an oxygen-poor fire leads to dark-coloured vessels. Changing the oxygen levels during firing leads to differences in the colour of the core and the inside and outside of the vessel. The choice of firing method and thus the colour of the pot may be related to the function of the vessel, or this may be a cultural choice.

The firing method of 184 sherds was determined. The majority are completely dark. Both the inside, outside and core of these sherds have a (dark) grey or (dark) brown colour. The other 81 sherds show as many as seven other colour schemes (Table 4.1). In figure 4.10 the colour of the outside of the sherds and the thickness of the sherds is compared. This shows that both the thin-walled and the thick-walled ware include dark and light vessels. The thick-walled sherds are proportionally more likely to be light-coloured. The colour of the outside of the sherds has also been compared to the tempering added; there is no correlation between these characteristics (Fig. 4.11).

However, the level of oxygen in the fire is not the only influence on the colour of the vessels. The colour can also change during use, deposition and post-deposition. On many of the studied sherds dark stains are visible which are probably related to their function as cooking vessels. A selection of sherds with charred food remains has been studied by T. Oudemans and L. Kubiak-Martens.[46] Some sherds have been re-fired, which also leads to changes in coloration. These sherds are brittle and are black, blue or

[46] Oudemans & Kubiak-Martens this volume.

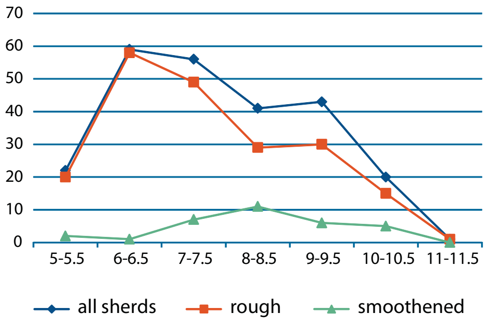



Fig. 4.12 Surface treatment outside and thickness compared.

white. The re-firing could also have happened, deliberately or otherwise, after their useful life had ended.

**Surface treatment**

Most sherds have a rough outer (209 sherds) and inner (228 sherds) surface. Only 33 sherds have been smoothed on the outside, 14 of them lightly. Twenty-two sherds have been smoothed on the inside, of which six just lightly. Of the sherds with a smooth or lightly smoothed inside finish, 16 are also smoothed on the outside; six are rough on the outside, and four of these sherds show decoration on the outside.

There is a relation between the thickness and the tempering method the smoothed sherds (Fig. 4.12). Thicknesses of 8-8.5 mm are fairly uncommon on this site, but over a third of the sherds with a smoothed outside wall are this thick. These sherds are also frequently tempered with stone grit; 15 are stone-tempered, mostly in combination with grog; 18 are grog- and/or sand-tempered. Both quartz (most frequently used to temper thin-walled vessels), and granite and red granite (most frequently used in coarse vessels) occur in combination with a smoothed outside wall. Fourteen of the sherds with a smooth outside wall are tempered with stone grit; just eight of the sherds with a rough outside wall are tempered with stone grit. Twenty-five of the smooth sherds have a dark external colour; eight have a light external colour. Just one of the sherds smoothed on the outside is decorated (vessel 8).

**Decorated vessels**

Three vessels are decorated with oblique spatula impressions placed in hatched rows with alternating direction.[47]

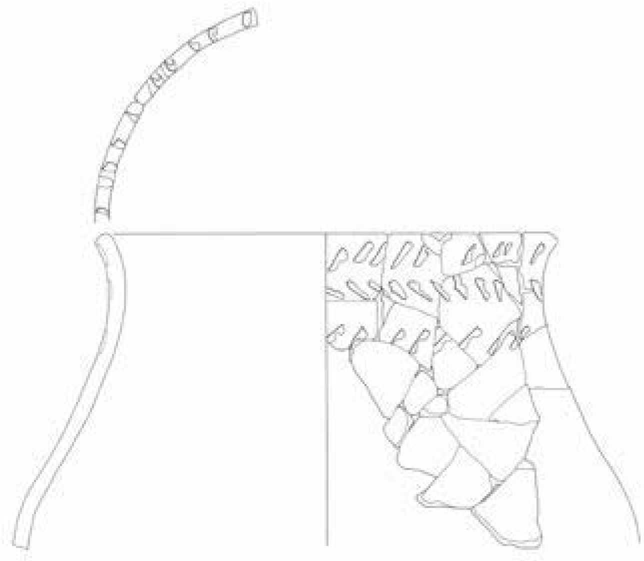


Fig. 4.13 Vessel with hatched rows in alternating directions (1:4) (vessel 1).

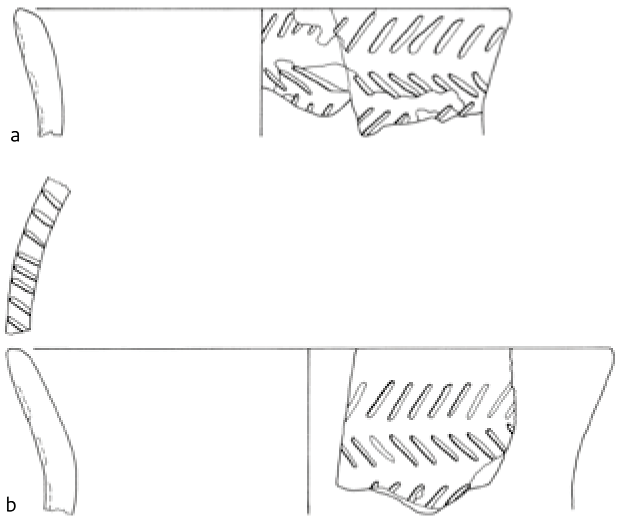



Fig. 4.14 Vessels with hatched rows in alternating directions (1:2) (vessel 2 (14.4b) and 3 (14.4a)).

*Vessel 1* is grog- and sand-tempered, has a wall thickness between 7.5-9 mm, a three-partite profile with a thick belly, a maximum wall diameter of 33 cm and a rim diameter of 24 cm (Fig. 4.13).

*Vessel 2* is also tempered with grog and sand, thinner-walled (6.5-8.5 mm), and is three-partite with a very gentle S-shaped curve (Fig. 4.14).

*Vessel 3* is grog-tempered, thin-walled (6.5-8.5 mm) and three-partite, with a very gentle S-shaped curve (Fig. 4.14).

[47] Van der Waals & Glasbergen 1955, 11: type 1d.

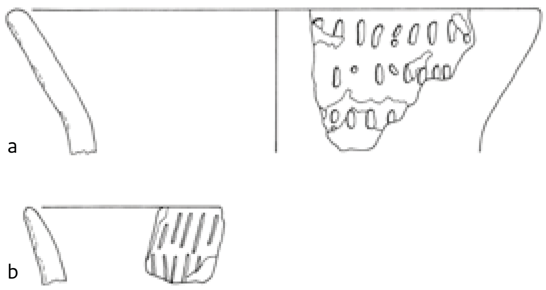



Fig. 4.15 Vessels with spatula impressions in horizontal rows (scale 1:2) (vessel 4 and sherd 2-1-5/6).

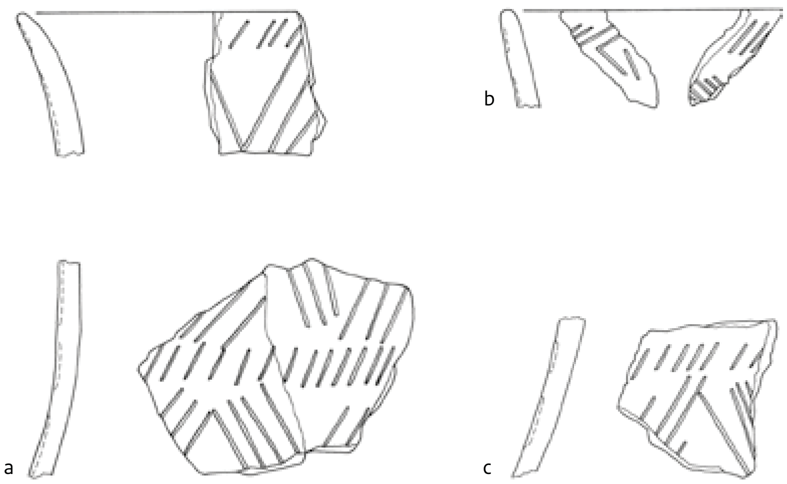



Fig. 4.16 Vessels with zigzag decoration (scale 1:2) (vessel 5 and sherds 3-1-126 and 4-1-429).

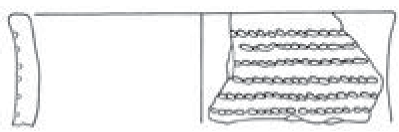


Fig. 4.17 Vessel with rope decoration (scale 1:2) (vessel 6).

*Vessel 4* is decorated with spatula impressions in horizontal rows consisting of oval impressions (Fig. 4.15). The vessel is tempered with small particles of grog, plant material and sand and has a thin wall (5-7 mm). The rim is rounded and the base is flat.

In squares 5/6, 19, 20 (5) and 21 (2) five rim and four wall sherds were found that were decorated in the same way (Fig. 4.15). All these decorated sherds had a weight of less than 3 g. Four small wall sherds, from squares 5/6, 20, 28 and 42, probably belong to the same vessel and had a weight of over 3 g. These all have a wall thickness of just 5.5 mm and contain sand and grog particles. The decoration consists of thin slanting lines placed in horizontal rows. This vessel is comparable to Van der Waals and Glasbergen type 1e.

*Vessel 5* is decorated with horizontal lines containing oblique lines alternated with zones with longer oblique lines in zigzag patterns. This pot is tempered with grog and also contains sand, the wall is very thin (5.5-7 mm), and the profile is very slightly S-shaped (Fig. 4.16).

A very small rim sherd from square 126 and the wall sherd from square 126 are decorated in the way as the pot described above (Fig. 4.16). One notable feature of the rim sherd is that it also has decoration on the inside of the rim.

*Vessel 6* is decorated with rope impressions (Fig. 4.17). Van der Waals and Glasbergen classified halfway-down rope-decorated (PF) beakers as type 1a; all-over rope-ornamented beakers were classified as type 2IIb.[48] Since we have an incomplete vessel without parts of the underside we cannot with any certainty compare the beaker with one of these types. Vessel 6 is grog-, sand- and plant-tempered, the wall is 5.5 mm thick, and the pot has a gentle profile and a rim diameter of just 10 cm.

Two vessels decorated with fingertip impressions were found at the site (Fig. 4.18). These vessels are coarser than most of the vessels described above.

*Vessel 7* is decorated with loose nail and fingertip impressions on the wall. The pot is tempered with grog and sand, the wall is thick (8-10 mm), and the rim diameter measures 20 cm.

*Vessel 8* is decorated with fingertip impressions on the wall and on top of the rim. The clay of this vessel also contains sand and grog and the wall is also between 8-10 mm thick; the outside of the wall is smoothed.

Four other wall sherds found at Keinsmerbrug were also decorated (Fig. 4.19). Wall sherds from squares 56 and 59 are decorated with zigzag impressions (Fig. 4.19). In

48 Van der Waals & Glasbergen 1955.

contrast with the vessels described earlier, the decoration of these sherds consists only of zigzag impressions uninterrupted by horizontal rows of oblique impressions. The spatula impressions are also thicker. The sherd from square 56 is 6.5 mm thick and contains grog and sand. The technological characteristics of the sherd from square 59 have not been analysed; this sherd weighs less than 3 g.

In feature 1006 a wall sherd with fingertip impressions was found (Fig. 4.19). The sherd is broken just above an irregular horizontal row of impressions. It is unclear whether the vessel was originally decorated with just this one row, more rows or individual impressions. The 6.5 mm thick sherd contains grog and sand. The last decorated sherd from this site comes from squares 384/385/401/402 (Fig. 4.19). This 5.5 mm thick sherd contains only sand. The decoration consists of four sloppily made horizontal lines.

**Undecorated vessels**

On the basis of the count of unique rim fragments, eleven undecorated vessels were found. Three of the undecorated vessels can be seen as fine ware, given their wall thickness.

*Vessel 9* is tempered with sand and has a thin wall (5.5 mm). This vessel has a 17 cm rim diameter and a very faint three-partite profile with a high upstanding rim and neck (Fig. 4.20).

*Vessel 10* is tempered with sand and has a 7 mm thick wall. The rim and neck slope outwards.

*Vessel 11* is tempered with quartz and grog and is thin-walled (5 mm). The profile of this vessel is a little more S-shaped compared to the two pots described above (Fig. 4.20).

*Vessel 12* has a wall thickness ranging between 6.5 and 9.5 mm. The rim and neck part of this pot are very coarse; from the shoulder downwards the walls are much thinner. The rim and neck slope very slightly inwards; the rim has a diameter of 19 cm (Fig. 4.20). One of the wall sherds is broken on a joint. This means the vessel was coil-built, small strips of clay being pasted together to construct it. The vessel was made using the Hb-technique (Hb), which means the clay strips were connected in an oblique manner.[49]

Five undecorated vessels have a wall

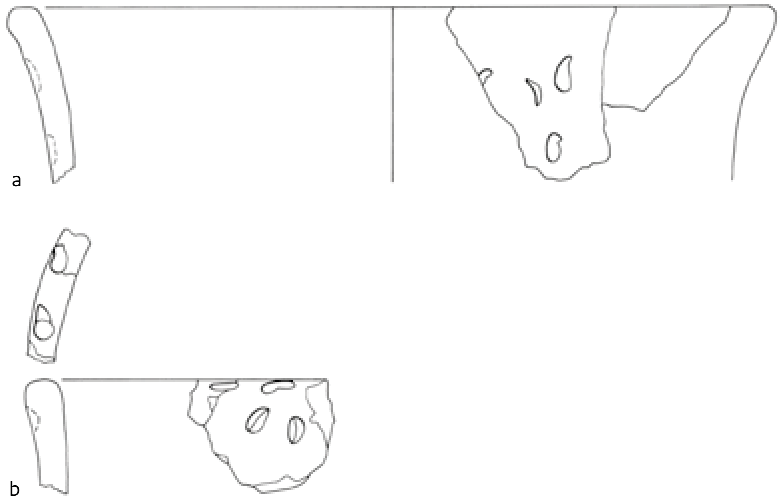



Fig. 4.18 Vessels with fingertip impressions (scale 1:2) (vessels 7 and 8).

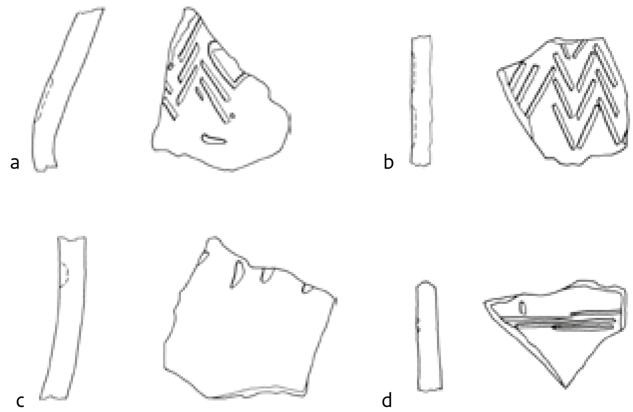



Fig. 4.19 Decorated wall sherds (scale 1:2) (sherds 2-1-56, 3-1-59, 3-2-1006 and 4-1-384/385/401/402).

thickness of 8 or 8.5 mm. This is remarkable since these thicknesses do not occur often. All these vessels have a rim and neck with an outward sloping shape.

*Vessel 13* is a grog- and sand-tempered vessel with an 8.5 mm thick wall. The pot has a very large rim diameter of 27 cm (Fig. 4.20).

*Vessel 14* is also tempered with grog and sand, has an 8.5 mm thick wall, but has a more modest rim diameter of 19 cm (Fig. 4.20).

The diameters of the rims of the other three pots with a wall thickness of 8 or 8.5 mm could not be measured.

[49] Stilborg & Bergenstråhle 2000, 31.

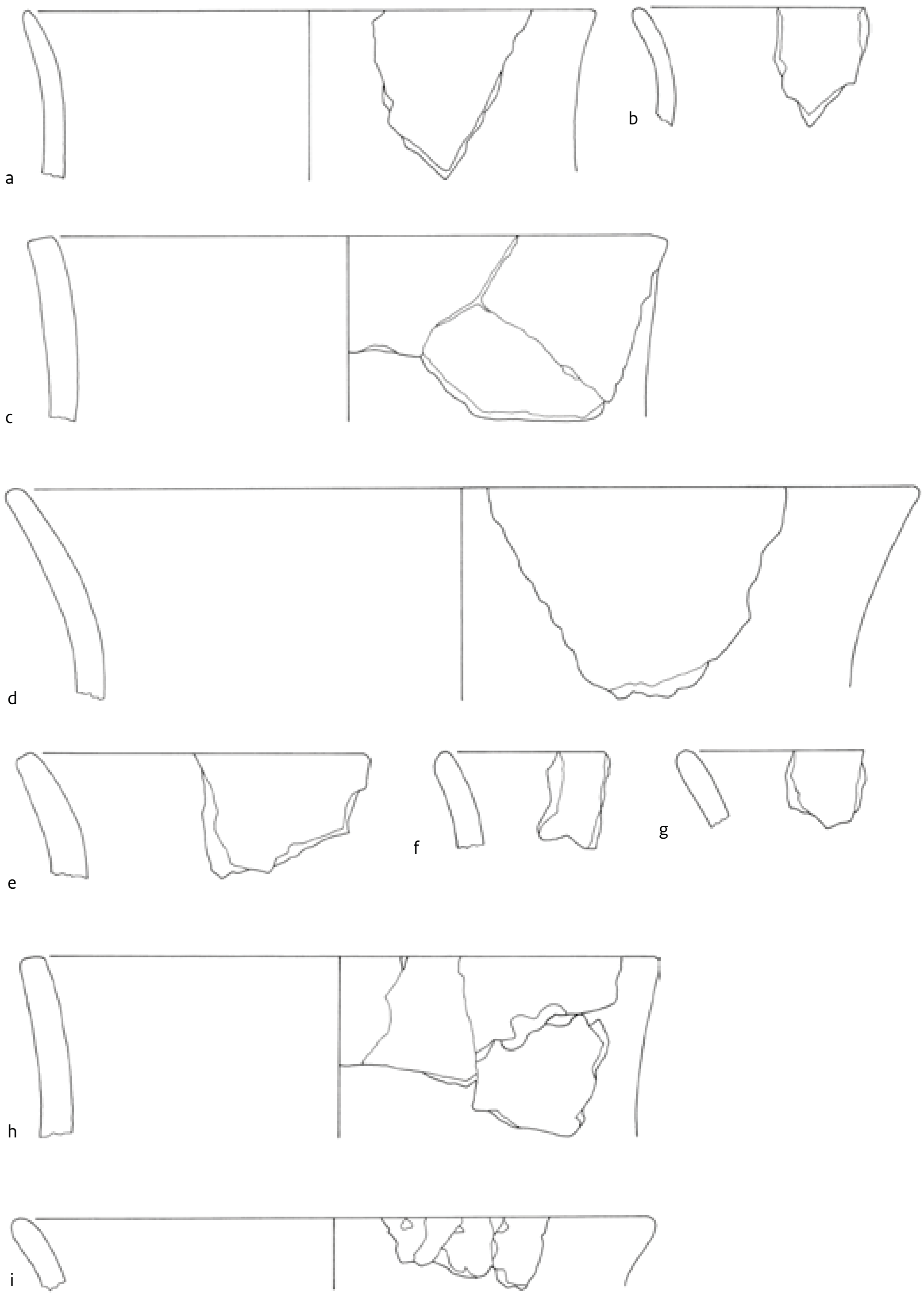



Fig. 4.20 Undecorated vessels (scale 1:2) (vessels 9, 11, 12, 13, 14, 15, 17, 18 and 19).

*Vessel 15* is grog- and sand-tempered and has an 8-10 mm thick wall which is smoothed on the outside (Fig. 4.20). This vessel has a flat base with a diameter of 10 cm (Fig. 4.20).

*Vessel 16* is also grog- and sand-tempered and has an 8.5 mm thick wall.

*Vessel 17* is sand-tempered and 8 mm thick (Fig. 4.20). The last two undecorated vessels have coarser wall thicknesses.

*Vessel 18* is grog-tempered and has a 9-10 mm thick wall. The rim and wall are long and slope only very slightly outwards. The diameter of the rim measures 19 cm (Fig. 4.20).

*Vessel 19* is granite-tempered and has a 8.5-10.5 mm thick wall; both the inside and outside of the wall is smoothed. The three-partite pot has a slightly outward sloping rim and neck (Fig. 4.20).

**One last pot**
In square 10, 39 wall sherds and 40 pieces of grit were found, probably all belonging to the same vessel, as their temper and firing methods are alike. No rim or base sherds were present, or are so severely damaged that they can no longer be recognised as such. All the wall sherds are severely weathered; the inside and outside have flaked off in almost all cases. The sherds are tempered with grog and are between 7 and 10.5 mm thick.

**Other base fragments**
Fragments of six different bases have been found, three of which have been related to rim fragments of a vessel (vessels 2, 4 and 15). Vessel numbers 20, 21, and 22 contained base fragments (Fig. 4.21). All the fragments show a flat base. The diameters range between 7 and 10 cm. No clearly squeezed out, protruding, base fragments were found. This feature of the PF-beakers (and the origin of their name) is thought to be highly typical of the start of the Single Grave Culture; beakers with a flat or hollow base are found only in late contexts.[50]

**Perforations**
One sherd found at this site has a perforation (Fig. 4.22). The tiny wall fragment has a cylindrical hole measuring 4.8 mm on the outside and 2.5 mm on the inside. This perforation is a repair hole; parts of an broken vessel could be reconnected by perforating them and threading a piece of string through the holes.

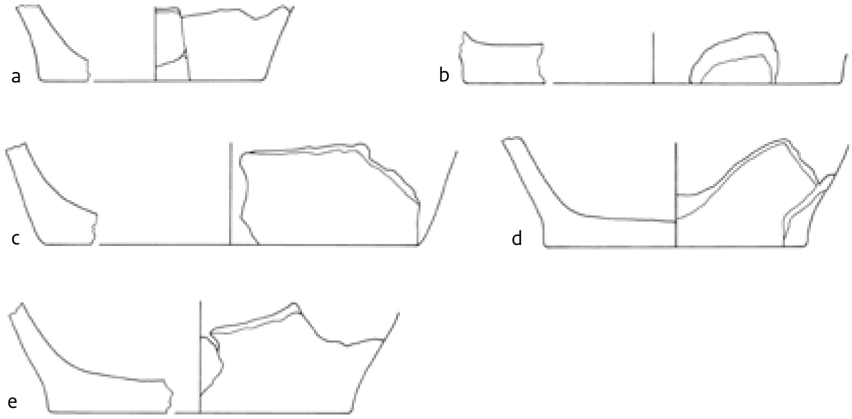



Fig. 4.21 Base sherds (scale 1:2) (vessels 4, 15, 20, 22 and 21).

Fig. 4.22 Perforated sherd (scale 1:1) (sherd 2-1-57).

## 4.5 Spatial distribution

The variation in the ceramics described above may be caused by chronological differences, functional differences, or the pots could have been produced in different workshops. To further study these differences the spatial distribution of the ceramics were examined. Patterns may point towards different phases of use or different activities executed on different parts of the site.

The weights and tempering of the sherds found in the different squares is plotted on the map in Fig. 4.23, produced by G. Nobles. This map does not show any clear patterns. The spatial distribution of the different types of ware is presented in figures 4.24-4.26. These maps also show that the different types of ware were found dispersed all over the site. The small concentrations visible are due to the fact that more than one sherd from one vessel was found

50 Lanting & Van Der Waals 1976, 5.

in that area. To see whether the sherds from all the different vessels were found close together Nobles produced a further series of maps showing the spread of different sherds belonging to one vessel. This was done for the five vessels of which three or more sherds were found. In combination with the map showing the spread of the weights the maps allow some conclusions to be drawn.

Most vessels were not deposited where they were used. The maps showing the distribution of vessels 3 and 5 show that the sherds belonging to these vessels were found in different parts of the excavated area (Figures 4.28 and 4.30). These vessels probably broke during the habitation of the site and were dispersed to the edges of the settlement. Since most other sherds, not belonging to these three vessels, were also found at the edges of the settlement, we can probably regard these as waste too.

The maps showing the distribution of vessels 1, 4 and, to a lesser extent, vessel 12 show a different pattern (Figures 4.27, 4.29 and 4.31). These vessels were found close together in activity area 3. They probably did not break during the habitation of the site but were left *in situ*. Vessels 4 and 12 have residues on them, indicating their use as cooking pots.[51] Vessel 1 does not have residues. This area may have been used for preparing, cooking and/or storing food; this might explain why these vessels ended up in this area inside the house, not far from the hearth pits.

The strongly weathered but (in comparison to others) fairly complete vessel from square number 10 was found in area 1.[52] Some more sherds were found in this zone. This area lies in the central house. Square 10 is situated near the wall, not far from the hearth. This is the same position in which vessels 1, 4 and 12 were found in the northern house. Presumably the vessel from square 10 was used in the household too and was left there *in situ*.

To further examine the spatial distribution a comparison was made of the weight and weathering of sherds found inside one of the five structures and outside the five structures defined by Nobles.[53] Although sherds that were found inside a structure do not necessarily relate to that structure (if the site has different phases of use they may be older or younger), this analysis might yield more information on the use of the site. Differences could be caused by a number of factors; trampling inside the structures could lead to smaller and more weathered sherds but the sherds could also have benefited from flooring inside the structures, and ended up less damaged and larger than sherds that were left in a trampling zone outside the structures. The results of the comparison show no significant differences in weight, however. The average weight of the sherds found inside the structures is 6.91 g and outside it is 6.79 g. More sherds from inside one of the structures are weathered, but this number is strongly influenced by the large number of strongly weathered sherds from square 10 described above. A comparison of the weight and weathering of the sherds found in the different structures does not show very clear patterns either. The sherds found in the southern structures are a little larger, at 8.47 g on average (n11), those from the central structure weigh 7.32 g (n107) and the sherds from the northern structure are a little smaller with an average weight of 6.56 g (n147). These differences are very slight but could indicate different phases of use of the different structures. If the northern structures are later the older sherds might be smaller due to longer trampling. This is the only observed difference. There are no differences in the tempering materials of the sherds from the different structures, for example.

Since there is no stratigraphy or remarkable spatial pattern, chronological differences are not a likely explanation for the variety in the ceramics. Functional differences, different activities performed with different vessels, or people from different SGC micro-traditions with pots produced in different workshops using the site seem the most likely explanations for the observed differences.

[51] Oudemans & Kubiak-Martens this volume.
[52] Nobles this volume (chapter 10).
[53] Nobles this volume (chapter 10).

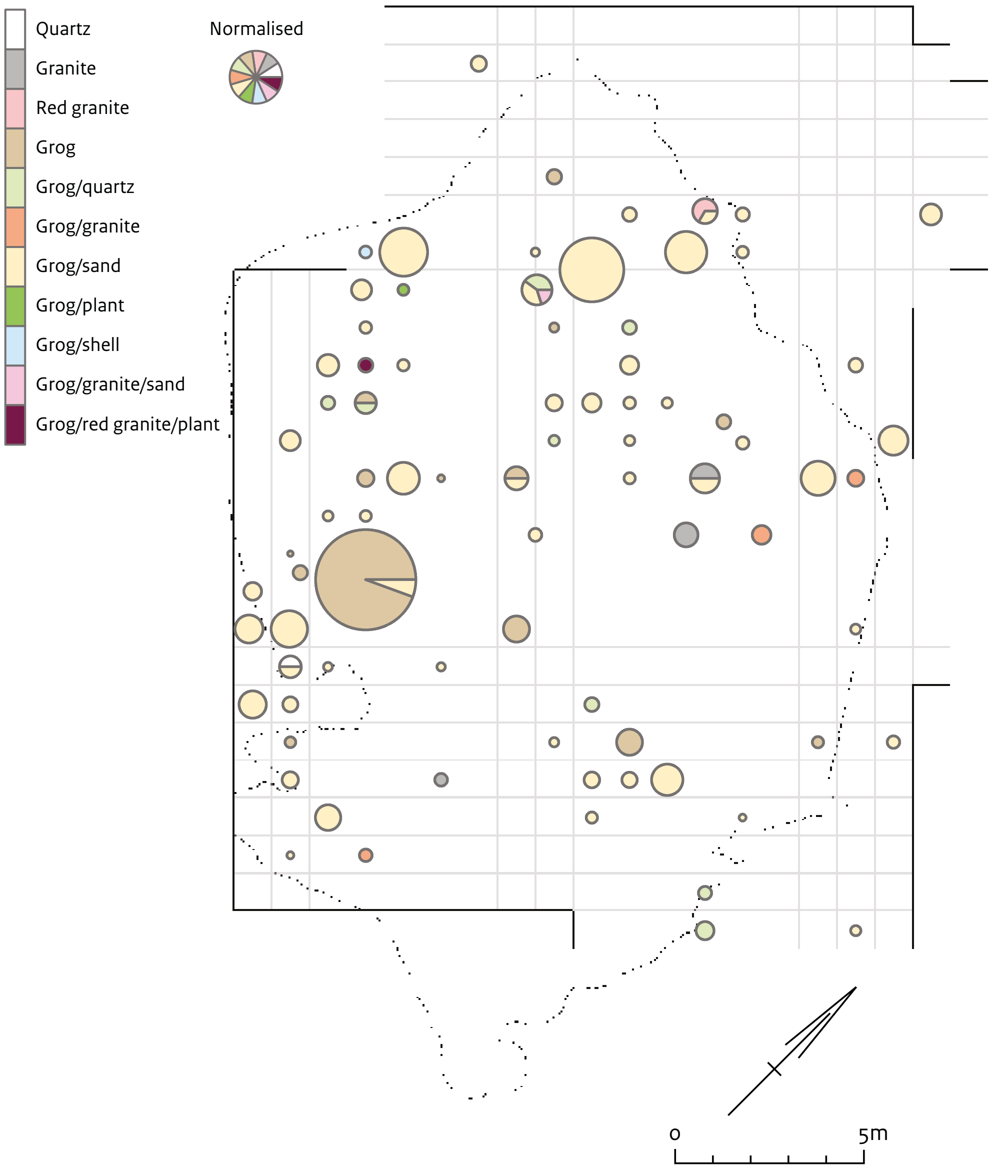



Fig. 4.23 Distribution of the sherds, their tempering and weight.

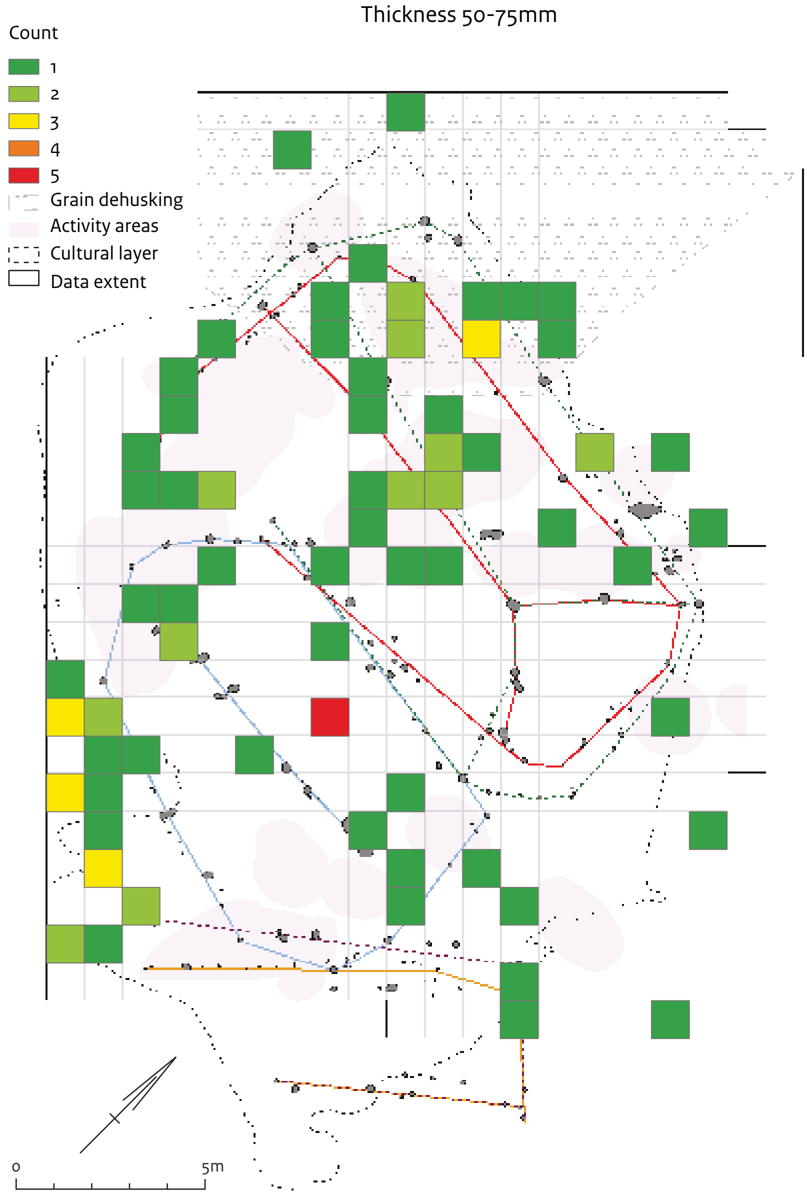



Fig. 4.24 Distribution of the thin-walled sherds.

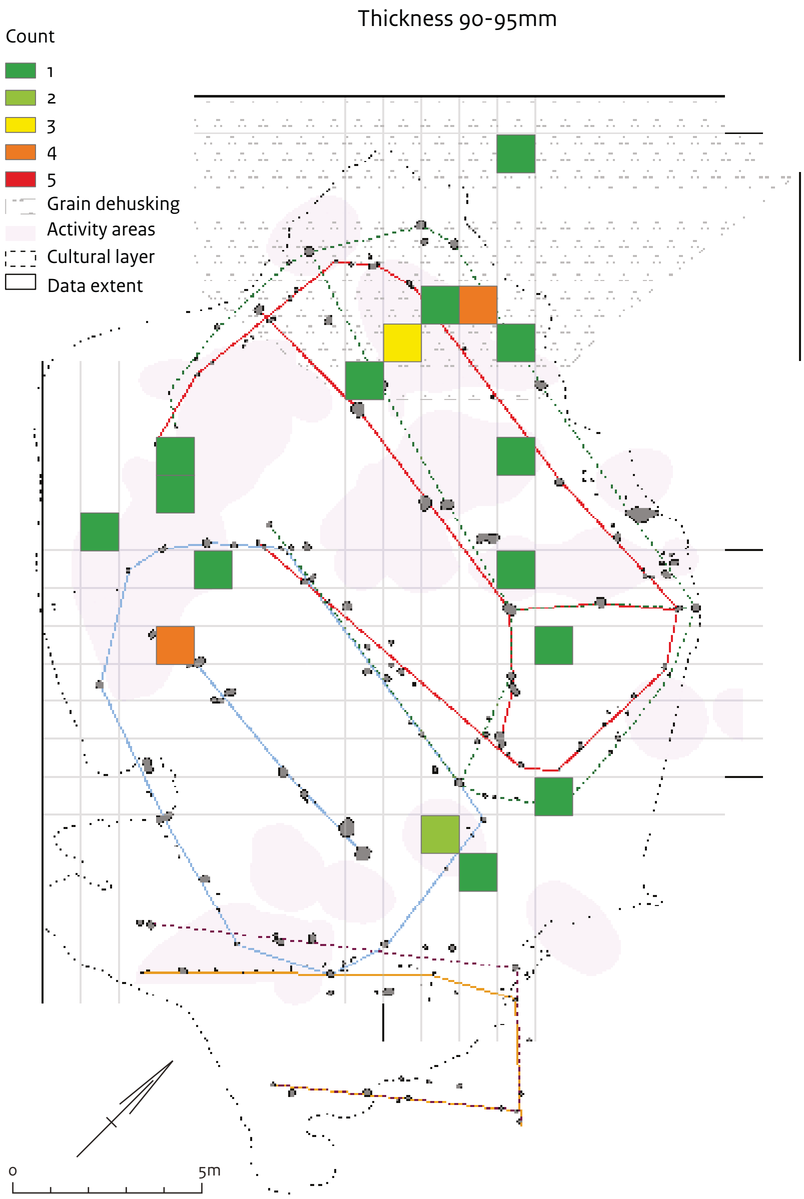



Fig. 4.25 Distribution of the thick-walled sherds.

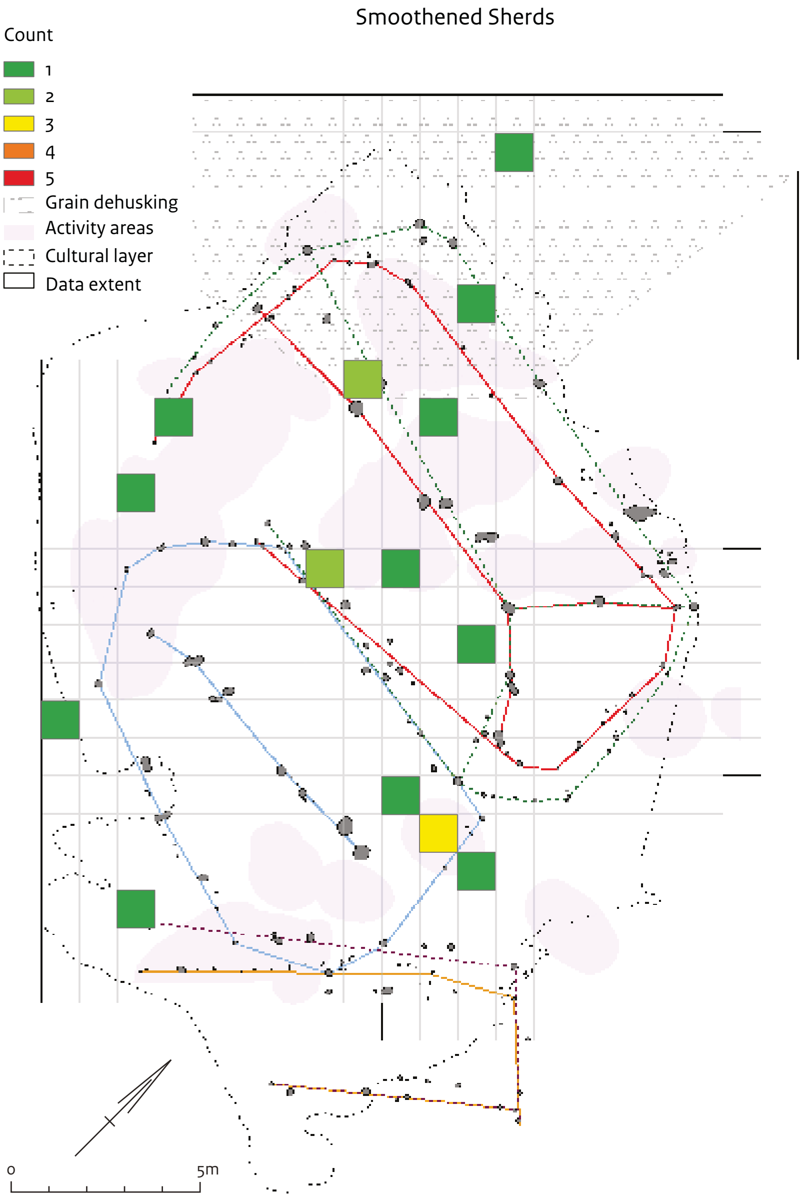



Fig. 4.26 Distribution of the smoothed sherds.

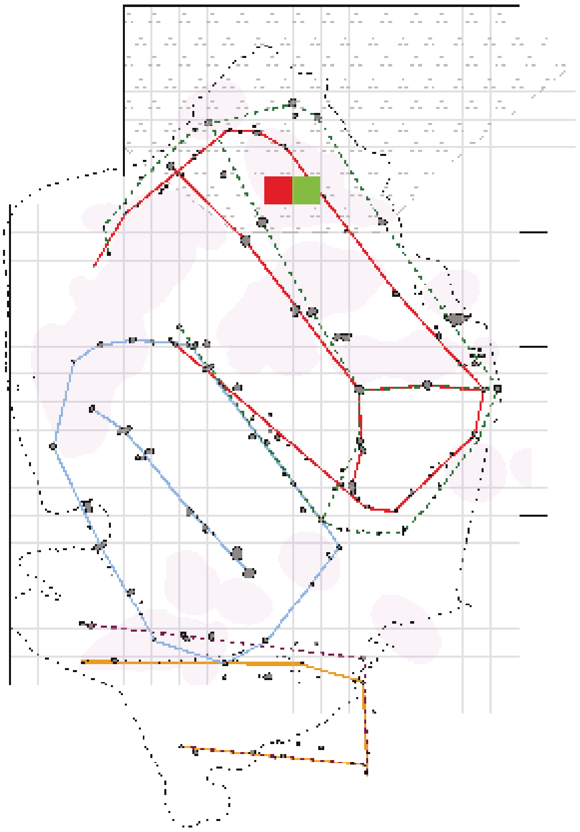


Fig. 4.27 Distribution of sherds from vessel 1.

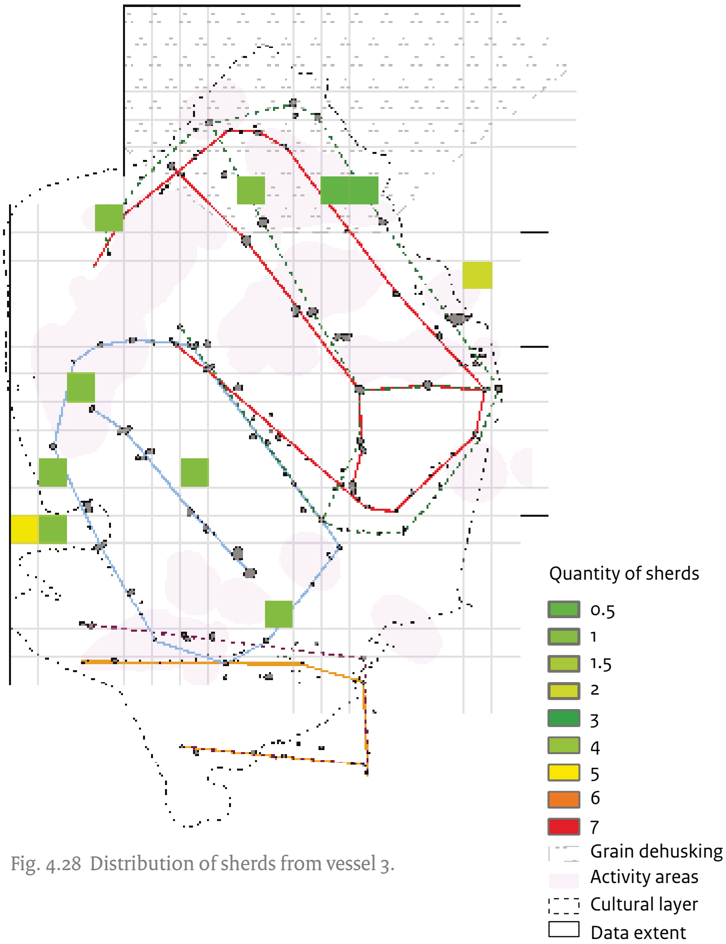



Fig. 4.28 Distribution of sherds from vessel 3.

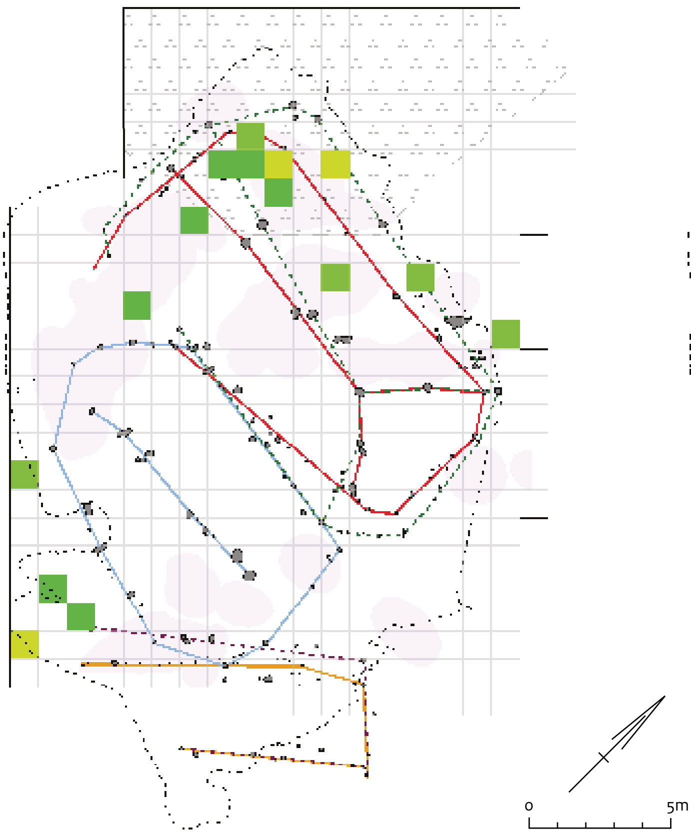



Fig. 4.29 Distribution of sherds from vessel 4.

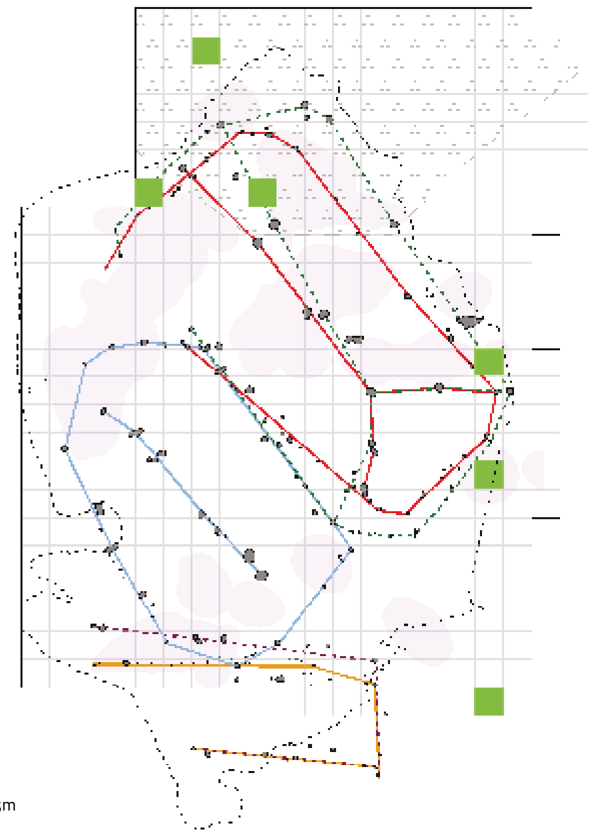


Fig. 4.30 Distribution of sherds from vessel 5.

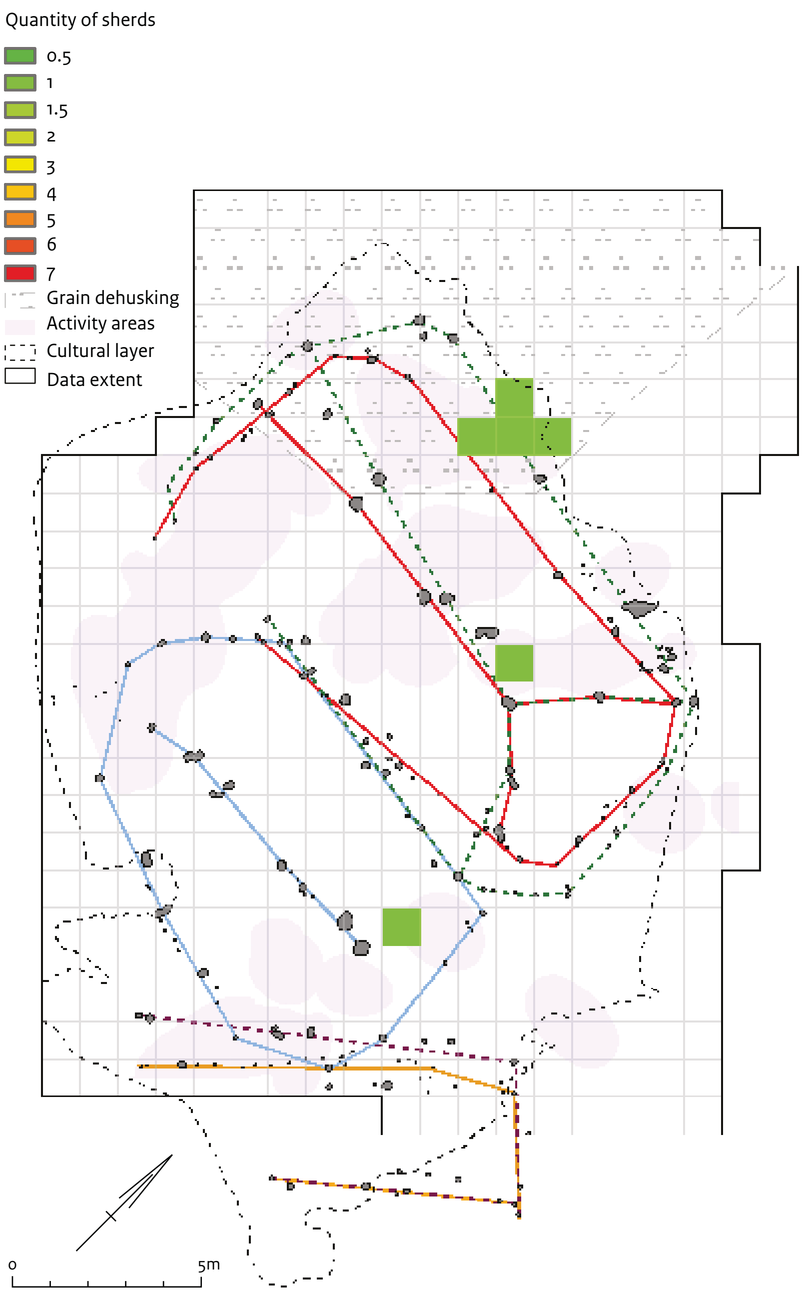



Fig. 4.31 Distribution of sherds from vessel 12.

## 4.6 Conclusions

Although only 291 sherds were studied and, on the basis of the count of unique rim fragments, the site yielded only 19 different vessels, there is great variety in the ceramics. There are three different types of ware. The largest class comprises fine ware with thicknesses ranging between 6 and 7.5 mm. The second type of ware is coarser, comprising sherds with thicknesses of 9-9.5 mm. The last and smallest class of ware is defined by its smoothed surface; this ware is medium thick-walled. Seven different tempering materials were present, used in 14 different ways. Most of the sherds contain grog and/or sand; these materials are visible in both fine and coarse ware. Quartz and plant material were used to make thin-walled vessels; red granite and granite were used for coarser wares. The smoothed vessels are frequently tempered with stone grit. The decoration also shows variability in the techniques used and motifs applied. Eight of the 19 vessels are decorated. Five fine, two coarser and one smoothed pot have decoration. The decoration on the fine ware is comparable to Van der Waals and Glasbergen types 1d, 1e 1a or 2IIb and the un-numbered zigzag decorated type.[54] One coarse pot has decoration similar to type 1d. One coarse vessel and a smoothed vessel have fingertip impressions.

Since there is only one pot profile present from the rim to the greatest belly circumference it is difficult to drawn conclusions concerning the differences in pot morphology. Almost all the vessels that do show some morphological characteristics have a high, almost straight or (slightly) outward sloping rim and neck zone. Some of the vessels from the thin-walled class have a gently bent rim and neck zone, a fluid S-shaped profile. The bases are all flat. The rims are rounded, flat or slope inwards.

**Dating on the basis of decorated vessels**
It is hard to give a relative date for the site on the basis of the ceramics, since there is no typochronology for SGC settlement ceramics. The occurring Van der Waals and Glasbergen types points to a date in the later phases of the SGC.[55] Arguments for a late dating are the occurrence of types 1d and 1f and the zigzag type strongly related to type 1d, which only occurs in funerary contexts of the third and fourth phase.[56] Flat-based vessels are also a late phenomenon in funerary contexts.[57]

**Differences in function or origin?**
Spatial analysis showed that it is unlikely that the differences in the ceramics are caused by chronological differences. The observed variety may therefore be caused by differences in the function or origin of the vessels and/or the potter's different SGC background, or a combination of these factors. The tempering materials quartz, plant material, granite and red granite seem to be specifically chosen to make either fine or coarse ware. But different potters, making both fine and coarse ware, might also have had personal preferences or worked in different workshops with different preferences and materials available, leading to different SGC micro-traditions.

Use-wear analysis of the vessels has been conducted on the basis of the residues encrusted on them. L. Kubiak-Martens studied the botanical remains and came to the conclusion that all the samples (from vessels 8, 21, 22 and sherds 2-1-58 and a sherd from an unknown location) showed signs of having been used to cook emmer grain food. Vessel 18 showed signs of cooking (vegetative) parenchymatous tissue. The chemical analysis of organic compounds performed by T. Oudemans showed animal fat/ oil and starch on vessels 8, 13, 21, and 22. Animal lipids and starch were detected on vessel 4, and traces of animal lipids and starch were found on vessel 10 and a sherd from square 10. The residues are thus very uniform. Although the vessels may have had other or multiple intended functions when they were made, at this site they were used only to prepare one type of meal. Both decorated (vessels 4 and 8) and undecorated (vessels 10, 13, 21 and 22), and both fine (vessels 4, 10, 13 and 22) and one coarser smoothed vessel (8) were used for cooking this type of meal.

The observed variety in the technological characteristics of the ceramics cannot be explained by differences in time and/or differences in the use of the vessels. This variety is most likely the result of many people from different SGC micro-traditions visiting and using the site, each of whom brought their own vessels. The different potters applied different methods of tempering and used clays from different sources.

54 Van der Waals & Glasbergen 1955.
55 Van der Waals & Glasbergen 1955; Drenth & Lanting 1991.
56 Drenth & Lanting 1991.
57 Lanting & Van der Waals 1976.

# 5 Flint, amber and stone artefacts: technology, typology and use-wear analysis

*V. García-Díaz*

## 5.1 Introduction

Flint, stone and amber implements constitute a major proportion of the materials recovered during the Keinsmerbrug excavations in 1986. Unfortunately, no analysis was carried out after the fieldwork. The only reference to this assemblage is a general description by Van Heeringen and Theunissen in 2001. A site report was produced and a limited description of flint implements was also published. The flint assemblage was described as consisting of between 200 and 400 implements. For the most part, small scrapers and flakes were recovered during the fieldwork. No information about the hard stone assemblage was included, except that the number of implements was unknown. Finally, no information about amber was published.[58] One of the aims of the 'Unlocking Noord-Holland's Late Neolithic Treasure Chest' project is to understand cultural material from Keinsmerbrug. The information extracted from these studies will not only elucidate the economic behaviour of Keinsmerbrug inhabitants, it will also shed light on the character of the Single Grave Culture of the Noord-Holland area. Of course, flint, amber and hard stone technology and use-wear have an important role to play.

The study of flint, amber and stone implements will have several objectives. The first is to try to determine the sources of raw material in order to understand the relationships and mobility patterns of the people from Keinsmerbrug. Secondly, a technological analysis of the implements will attempt to establish how they produced their tools. In addition to this, the use-wear analysis will give information about the subsistence and craft activities in which the people at Keinsmerbrug engaged. Furthermore, this information will be useful in interpreting the economic activities that occurred at the site, and thus the behaviour of the inhabitants. Finally, all this information will also help to understand what kind of site Keinsmerbrug was and how the surrounding landscape was used at the time of the Single Grave Culture.

## 5.2 The material

A total of 416 flint implements were recovered at Keinsmerbrug. Most of the flint was picked up by hand, but an undetermined number of implements came from the sieve. A unique identification number was given to each of the implements. Flakes are the most represented tool at the site. A few blades and some cores were also recovered during the fieldwork. Finally, two strike-a-lights were found. All of the material was subjected to typomorphological analysis. Because of the small number of objects it was possible to carry out a use-wear study on the entire assemblage. This had the additional advantage of illuminating the kind of edges people chose to perform the different tasks. This is important because so few artefacts were intentionally retouched and shaped into typologically classifiable tools.
A total of 94 pieces of stone were recovered. Most of the pieces are very small (between 10 and 50 millimetres), with no traces of manufacture or use. Even though all the stones were observed under a stereomicroscope, only one piece showed convincing traces of use. Finally, half a bead and two small fragments of amber were recovered.

## 5.3 Methodology

### 5.3.1 Morphological study

All the hard stone, amber and flint implements were described in terms of their morphological characteristics in accordance with the specifications of the Laboratory for Artefact Studies at Leiden University. Some of the attributes examined included the metrical attributes (in mm), the raw material, primary classification, the kind and extent of cortex, grain size and the degree of burning or patination.

[58] Van Heeringen & Theunissen 2001.

### 5.3.2 Technological study

The main objective of this analysis was to understand how the tools were produced and the strategies related to raw material. The flint artefacts that display technological features were studied to understand the characteristics of the production process. These artefacts were mainly cores (N=9), core fragments (N=6), pebbles (N=4), tested pebbles (N=2), primary flakes (N=5) and tools like flakes (N=159) and blades (N=23). These materials were characterised in terms of their technological features. The stones and the amber artefacts were also examined for production traces using a stereomicroscope.

### 5.3.3 Use-wear analysis

All the flint implements from Keinsmerbrug were analysed for use-wear. This decision was taken for two reasons. First, the flint assemblage from Keinsmerbrug is small enough to analyse all the implements at low magnifications. Secondly, the Keinsmerbrug use-wear analysis will form the basis for the subsequent analysis to be performed on Mienakker and Zeewijk implements. While the Mienakker and Keinsmerbrug assemblages are small enough to be analysed completely, Zeewijk consists of thousands of flint implements (a sample of around 7000 pieces was subjected to preliminary analysis in the past).[59] The results from Keinsmerbrug will thus help to define a better sampling strategy for Zeewijk. The use-wear analysis was performed using a stereoscopic microscope in the range of 10-160x and an incident light microscope in the range of 50-500x. Photographs were taken with a Nikon DXM 1200 camera. The majority of the tools were cleaned with water and soap to remove adhering dirt and alcohol was also used to remove any finger grease or superficial dirt.

The analysis of stone tools is still in its infancy, largely because of the state of preservation of the tools and the methodology employed. Traditionally, only typological analyses are performed, with no functional analysis. Analyses are generally performed using only a stereomicroscope.[60] In this case, following the work of other authors, the use-wear analysis also included use of an incident light microscope (50-300x).[61]

The use-wear analysis can also provide interesting information about the use of the amber beads. Sometimes, the friction of the cord on the surface of the amber provides important information to help us understand the use and shape of the ornaments. The amber bead was observed using the stereomicroscope (10-160x) and an incident light microscope (50-500x).

### 5.3.4 Phytolith analysis

Just one stone implement was selected for phytolith analysis. The distal side of the stone was immersed in distilled water for one night. No chemicals were used to extract the phytoliths.[62] The glass slides were examined under a transmitted light microscope (50-500x).

## 5.4 Taphonomy

The level of fragmentation in both hard stone and flint implements from Keinsmerbrug is very high. More than 80% of the flint implements display some kind of fracture and in some tools, like flakes, the percentage is even higher. Out of a total of 159 flakes only 45 are complete (28%). The same is true of blades and cores. This may be attributable to the large quantity of waste fragments collected at the site. It also suggests, as will be shown below, that knapping took place at the site. Another reason for the high level of fragmentation at Keinsmerbrug could be the extent of burning. More than 50% (N=218) of the flint implements show different signs of burning. In most cases (N=128) the surface of the implements is *craquelé*. This complicates not just the use-wear analysis but also attempts to determine the source of the flint, since a lot of information about the tools has been lost. Moreover, some of the flint implements had some post-depositional alterations like patinas and abrasion but, in most cases, the edges and use-wear could still be readily analysed using a microscope.

[59] Peeters 2001.
[60] Semenov 1981; Adams 1988; Risch 2002.
[61] Clemente 1997; Van Gijn 2006; Zurro *et al.* 2005.
[62] See protocol in Nieuwenhuis & Van Gijn 2006.

Most of the stone fragments also display a high level of degradation, especially granite, which is very degraded as a consequence of weathering. In some cases, this has resulted in some fragments of granite being almost entirely reduced to gravel. At the same time a high percentage of granite (42.3%) shows signs of burning which has caused clear physical modifications in the stones, including colour changes and decomposition of the stone. In all likelihood the extensive fragmentation and burning of the granite will be attributable to natural or accidental causes. In contrast, alteration of quartzite due to burning or fragmentation is not as extensive as in the granite. However, the surfaces of quartzite are not very well preserved either, due to the post-depositional alterations like patination and abrasion. As a result, the use-wear traces on the hard stone artefacts are not very well preserved and interpretation of the worked raw material was not possible. Finally, no residues were observed.

Even though the amber artefacts are well preserved, the level of fragmentation is very high. In the case of the bead, a recent fracture was observed and just half a bead was preserved.

## 5.5 Raw materials

### 5.5.1 Flint

At least six kinds of raw material were distinguished at Keinsmerbrug (Fig. 5.1, Table 5.1 and 5.2). The categorisation of these materials was based on the physical characteristics of the fragments. As mentioned above, the amount of material with alterations caused by contact with fire is very high. In fact, around 30% of the flint recovered from the site could not be characterised in terms of the raw material for this reason.

- Raw material 1: a grey, fine-grained flint containing fossils. This represents almost 35% of the flint recovered at the site. This group mainly consists of flakes (44%; N=64), but the relatively high frequency of blades or blade fragments (6.9%; N=10) and cores (2.7%; N=4) or core fragments (3. 4%; N= 5) is also notable.
- Raw material 2: a grey, fine-grained flint with no fossils or mineral inclusions. Around 13% of the implements recovered are made of this kind of flint. This flint was mainly used for flake production (40.7%; N=22). In addition, one core and one core fragment (3.6%) and three blades (5.5%) were recovered during fieldwork.
- Raw material 3: all the flint that displays old surface. It is mostly represented by flakes (39.7%; N=29), but the presence of four cores (5.4%) of this kind of flint is also noteworthy.
- Raw material 4: rolled pebbles with a rounded shape and a rough white surface. The flint itself is grey and fine-grained. Just two complete pebbles and two tested pebbles of this flint were recovered.
- Raw material 5: a grey flint with no fossils but with light inclusions. This is a fine-grained flint that is sometimes more translucent at the edges. This flint is not well represented (3%). Most of the implements produced from this flint are flakes (69.2%; N=9).
- Raw material 6: a fine-grained flint with a yellow and grey mottled colour. Just one flake of this kind of flint was distinguished.

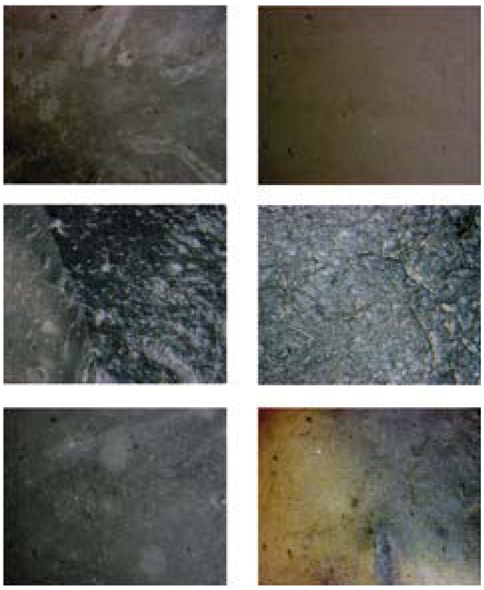


Figure 5.1 Flint raw material. From left top to right bottom. RM1: grey and fine-grained flint with fossils. RM2: grey and fine-grained flint without fossils or mineral inclusions. RM3: flint with old surface. RM4: rolled pebbles. RM5: grey flint without fossils but with light inclusions. RM6: fine-grained flint with a yellow and grey mottled colour.

**Table 5.1: Flint primary classification versus flint variety (%).**

| % | flake | waste | corefragment | core | cpdf | blade | splinter | pebble | tested pebble | unspecified | total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 40.3 | 30.5 | 83.3 | 44.4 | 40.0 | 43.5 | 25 | 0.0 | 0.0 | 0.0 | **34.9** |
| R2 | 13.8 | 12.1 | 16.7 | 11.2 | 20.0 | 13.0 | 37.5 | 0.0 | 0.0 | 0.0 | **13** |
| R3 | 18.2 | 16.8 | 0.0 | 44.4 | 20.0 | 13.0 | 12.5 | 0.0 | 0.0 | 25.0 | **17.5** |
| R4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100 | 100 | 16.7 | **1.4** |
| R5 | 5.7 | 1.1 | 0.0 | 0.0 | 20.0 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | **3.1** |
| R6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.2** |
| indet. | 21.4 | 39.5 | 0.0 | 0.0 | 0.0 | 26.1 | 25 | 0.0 | 0.0 | 58.3 | **29.8** |
| total | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |

**Table 5.2: Flint primary classification versus flint variety (N).**

| | flake | waste | corefragment | core | cpdf | blade | splinter | pebble | tested pebble | unspecified | total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 64 | 58 | 5 | 4 | 2 | 10 | 2 | 0 | 0 | 0 | **145** |
| R2 | 22 | 23 | 1 | 1 | 1 | 3 | 3 | 0 | 0 | 0 | **54** |
| R3 | 29 | 32 | 0 | 4 | 1 | 3 | 1 | 0 | 0 | 3 | **73** |
| R4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | **6** |
| R5 | 9 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | **13** |
| R6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| indet. | 34 | 75 | 0 | 0 | 0 | 6 | 2 | 0 | 0 | 7 | **124** |
| total | **159** | **190** | **6** | **9** | **5** | **23** | **8** | **2** | **2** | **12** | **416** |

### 5.5.2 Variety of stone and sources

The variety of stones found at Keinsmerbrug is very low (Table 5.3). The most frequently occurring type of hard stones are igneous rock (82.9%), mainly granite, with a total weight of 3 077 grams. As mentioned above, the granite is very fragmented, mainly because of natural alterations such as weathering.

Metamorphic rocks (12.76%) are also represented, mostly quartzite, with a total weight of 113 grams. The varieties of quartzite represented here are all fine-grained with a dark grey colour.

A small number of other varieties of stones have also been recorded. One fragment of an unspecified type of sedimentary rock and one fragment of jet conclude the inventory of raw materials.

### 5.5.3 Amber

Amber is a fossil resin. The amber found at Keinsmerbrug is a translucent orange. There are three possible provenances for amber. First, amber nodules may have been washed out from Saalian boulder clay deposits. Secondly, amber nodules may also have been washed out by

### Table 5.3: Raw material frequencies.

| | | N= | % |
|---|---|---|---|
| metamorphic | | | |
| | quartzite | 12 | 12.8 |
| igneous | | | |
| | granite | 78 | 82.9 |
| sedimentary | | | |
| | unspecified | 1 | 1.1 |
| others | | | |
| | jet | 1 | 1.1 |
| indet. | | | |
| | | 2 | 2.1 |
| **total** | | **94** | **100** |

### Table 5.4: Flint artefact type versus flint variety.

| | flake | retouched flake | blade | retouched blade | borer | scraper |
|---|---|---|---|---|---|---|
| R1 | 64 | - | 9 | 1 | - | 1 |
| R2 | 21 | 2 | 3 | - | - | - |
| R3 | 28 | 1 | 4 | - | - | - |
| R4 | - | - | - | - | - | - |
| R5 | 10 | - | 1 | - | - | - |
| R6 | 1 | - | - | - | - | - |
| indet. | 35 | - | 5 | - | 1 | - |
| **total** | **159** | **3** | **22** | **1** | **1** | **1** |

marine transgressions in the Baltic area. And finally, some of the amber may also derive from lignite deposits dating from the Pliocene in the northern Netherlands and Germany.[63] As in the case of flint and stone, amber could have been collected in nearby coastal areas of Noord-Holland province.

## 5.6 Technology and typology

### 5.6.1 Flint technology

The presence of cores and fragmented cores as well as core preparation flakes shows that the raw material from Keinsmerbrug was carried to the site and knapped locally. This process focused on flake production and most were produced by hard percussion (Table 5.4). In only two cases might the pointed platform indicate another kind of percussion (probably a soft percussion). The raw material of the cores and fragmented cores is diverse but the flint most frequently represented is R1 (four cores and five core fragments). The production sequence is present at the site in all the different flint categories, except R5 and R6. However, the size of the cores, between 12 and 53 mm, shows that these are exhausted cores. Five cores display evidence of a bipolar approach, but just one flake and two blades show evidence of bipolar flaking.

Rolled pebbles were also exploited at Keinsmerbrug. Two complete pebbles and two tested pebbles have been recovered at the site. However, only one of these small pebbles shows clear traces of flake production. The other tested pebble is so altered by a very hard patina that it was not possible to recognise any kind of production parameters. The complete pebbles also have small dimensions (between 50 and 55 mm). Pebbles were probably also carried to the site and worked locally.

Blades are not well represented at Keinsmerbrug and only 23 were collected. They were all produced by hard hammer percussion. The absence of blade cores suggests that blades were an accidental product of flake production. Just 13% of them (N=3) are complete, while 21% (N=5) are almost complete. Most of the fragments are medial-proximal fragments (43.47%; N=10), but medial and distal ends are also present. Most of the blades are small (between 7.5 and 32 mm) and made of R1 flint (43.4%; N=10). The platform or impact point is generally missing; where present, no preparation of the platform has been observed. The widths of the platforms vary between 1 and 30 mm and the angles of percussion range from 50 to 130 degrees. The impact point is mostly flat but sometimes displays a slight cone of percussion. This suggests that the implements were knapped using a hard percussion technique.

[63] Van Gijn 2006.

### 5.6.2 Flint tool typology

Flakes are the most common tool type represented at Keinsmerbrug. Almost 38% (N=159) of the assemblage are flakes. However, only 45 flakes are complete. The rest have distal or lateral fractures and their platform is absent. Around 50% of the flakes (N=81) show a cortical surface. None of the flakes is very large, at between 5 and 36 mm in length.

As mentioned above, blades are not very common and only 23 were recovered. They are mostly fragmented (N=20). Proximal fragments are the most common, but medial and distal fragments were also found. The complete blades are relatively small, with a length between 29 and 22 mm. Just one broken but almost complete blade measures more than 30 mm.

A small number of retouched tools were found at Keinsmerbrug. Only five implements show retouch. The retouched tools include one end scraper (1465), three retouched flakes (1485, 1471 and 1721) and one retouched blade (1856). Furthermore, one borer produced from a blade was recovered at Keinsmerbrug (1671). The borer is highly altered by contact with fire, so it is not possible to distinguish the retouch. However, the proximal side has been modified to obtain an elongated edge.

Two strike-a-lights were also recovered. One of them (1486) has a pointed shape and the other one (1783) has a prismatic shape, but both have a rounded point on one of the edges.

### 5.6.3 Stone tool technology and typology

Except for one hammer stone of granite and one flake, all the other stone implements recovered from the site show no modifications that could be related to manufacture or use (Table 5.5).

Only one quartzite flake was recovered. The flake (1901) is only 4 cm in length, 2.6 wide and 0.4 cm thick, and has a total weight of 4.12 grams. The flake has a very well developed bulb of percussion, suggesting the use of hard percussion. The surface is altered like the rest of the material, with two fractures on the proximal side and the dorsal face.

One hammer stone was recovered from Keinsmerbrug (Fig. 5.2). The tool is a fragment of granite 6.2 cm in length, 3.8 cm wide and 3.8 cm thick, and weighs a total of 90 grams. The tool does not have any fractures, so it is one of the few complete implements from the site. The

**Table 5.5: Raw material versus artefact type.**

| | | artefact type | | | | | |
|---|---|---|---|---|---|---|---|
| **raw material** | | **hammer stone** | **flake** | **modified** | **not modified** | **total** | **% modified** |
| **metamorphic** | | | | | | | |
| | quartzite | - | 1 | 1 | 11 | 12 | 8.3 |
| **igneous** | | | | | | | |
| | granite | 1 | - | 1 | 77 | 78 | 1.3 |
| **sedimentary** | | | | | | | |
| | unspecified | - | - | - | 1 | 1 | 0.0 |
| **others** | | | | | | | |
| | jet | - | - | - | 1 | 1 | 0.0 |
| **indeter** | | | | | | | |
| | unspecified | - | - | - | 2 | 2 | 0.0 |
| **total** | | **1** | **1** | **2** | **92** | **94** | **9.6** |

surface shows slight weathering but the tool does not show any traces of burning or any other kind of alterations.

### 5.6.4 Amber technology

The few implements found at the site provide little information about the amber ornaments. The analysis of the bead shows that the amber was modified to create a circular shape. Amber can be worked in two different ways: by cutting and by flaking.[64] Flaking marks were observed in the surface of the bead (Fig. 5.3). Also, a circular perforation was made in the middle of the bead. As the analysis suggests, the perforation was made from two directions. The perforation is also scratched. A flint borer was probably used to produce the perforation. Small archaeological borers have been found at other Neolithic sites such as Mienakker. The preliminary analysis of the borers suggests that they were used to produce beads and amber ornaments. Similar borers were found at Aartswoud.[65] Unfortunately, no borer with these characteristics was found in Keinsmerbrug, so we cannot determine whether this bead was made locally.

## 5.7 Use-wear analysis

### 5.7.1 The use of flint artefacts

Since the total number of flint implements from Keinsmerbrug is low, all of them were observed at low magnifications (between 5-160x) to determine if they displayed traces of use-wear. A small percentage of flint implements show clear use-wear traces. Just sixteen artefacts (3.8%) have been recovered, with 18 used zones (Fig. 5.4 and 5.5, Table 5.6). Seven implements have some non-interpretable use-wear traces. All of them are so deteriorated because of contact with fire that it is not possible to determine use-wear. Most of the artefacts that display use-wear are blades (N=5) and flakes (N=7), but there are also four waste fragments that have traces of wear.

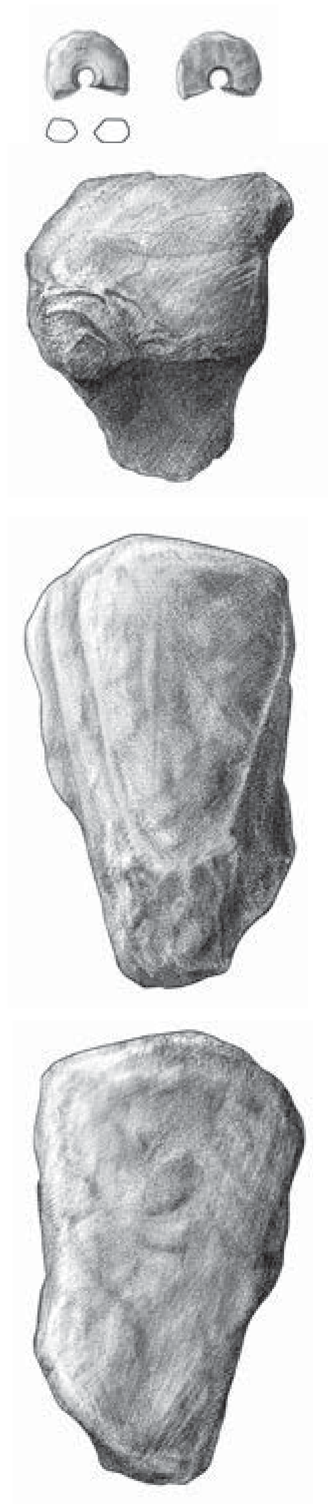


Figure 5.2 Amber bead and hammer stone.

Figure 5.3 Flaking marks observed in the surface of the half bead found at Keinsmerbrug.

[64] Van Gijn 2006.
[65] Piena & Drenth 2001.

**Contact material**

*HM* Hard material
*HI* Hide
*BO* Bone
*WO* Wood
*MI* Mineral
*UN* Unsure

**Degree of use**

- Heavily developed traces
- Medium developed traces
- Lightly developed traces

**Motion**

Transverse / Scraping
Longitudinal
Hafting
Impact
Drilling / Boring

**Technical information**

Bulb of percussion present
Bulb of percussion absent but direction of percussion clear

**Surface**

Burnt
Cortex

Legend of codes in figures of this chapter.

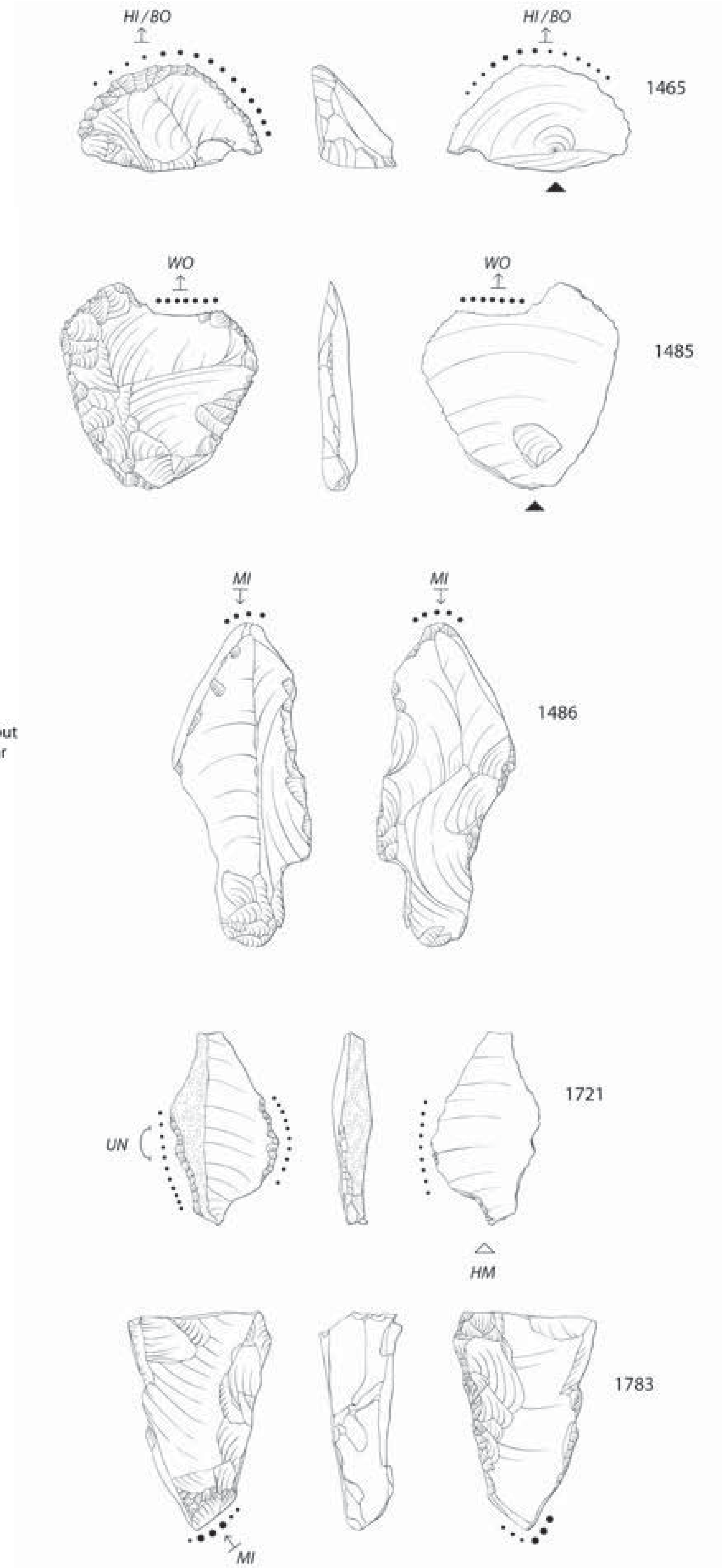



Figure 5.4 Artefacts with traces of different materials (scale 1:1).

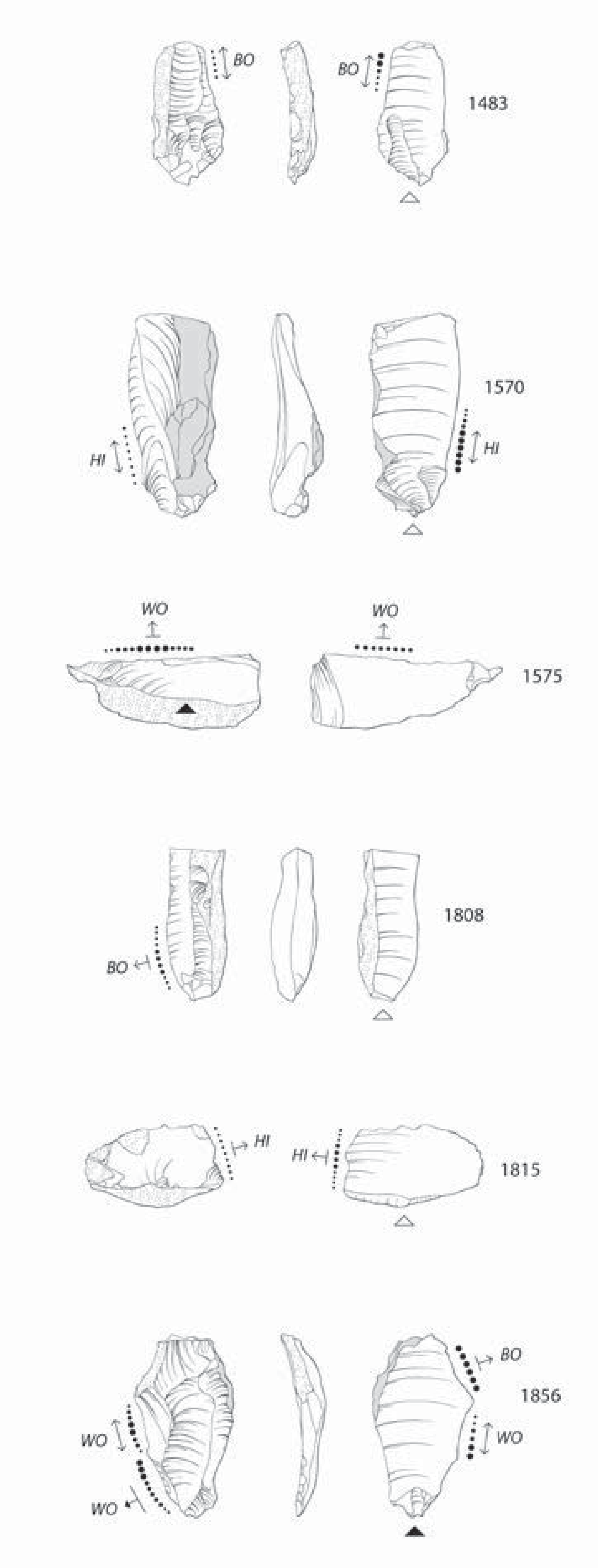



Figure 5.5 Artefacts with traces of different materials (scale 1:1).

**Table 5.6: The relationship between form and function: artifact type versus motion.**

| | | motion | | | | | | |
|---|---|---|---|---|---|---|---|---|
| contact material | | longitudinal | transverse | boring | pounding | hafting | indet | total |
| plant | | | | | | | | |
| | reeds | 1 | - | - | - | - | - | 1 |
| | wood | 2 | 2 | - | - | - | - | 4 |
| animal | | | | | | | | |
| | bone | 1 | 3 | - | - | - | - | 4 |
| | hide | 2 | 2 | - | - | - | - | 4 |
| | soft animal | - | | | | | 1 | 1 |
| | animal unspecified | - | - | 1 | - | - | 1 | 2 |
| mineral | | | | | | | | |
| | pyrite | - | - | - | 2 | - | - | 2 |
| hafting | | | | | | | | |
| | material indet. | - | - | - | - | 3 | - | 3 |
| indeter. | | | | | | | | |
| | indet. | - | - | - | - | - | 7 | 7 |
| | total | 6 | 7 | 1 | 2 | 3 | 9 | 28 |

**Plant processing and wood working**
One blade, two flakes and one piece of flint waste show traces of contact with wood. Three of the tools were used to work hardwood and one flake was used to cut softwood. The interpreted activities also include the sawing and cutting of hardwood. Finally, not one implement shows traces of processing cereals.

**Softwood**
One distal fragment of a flake (1522) shows a very well developed longitudinal wood polish. On both faces polish has a fluid appearance but on the dorsal face it is well delimited by the edge of the tool. The use-wear is very much like the wear traces obtained from contact with softwood, perhaps a hard type of water plant like reed or willow.

**Hardwood**
One blade, one flake and one piece of flint waste were used to work hardwood. The blade (1856) displays three used areas. Two of them show traces of contact with hardwood and the other one, which will be discussed below, shows traces of contact with bone. On the proximal left edge of the blade (coordinate 03), on the dorsal face, small and continuous retouches can be observed along the entire surface of the edge. Around these retouches is a very well developed hardwood polish. However, on the ventral face an isolated polish line parallel to the edge has been recorded. This fact suggests that the working edge of the tool was mostly high, with the dorsal face receiving most of the contact with the worked resource. The apparent transversal directionality seen on the tool further suggests that this tool was used for scraping wood. On the other hand, the left medial edge of the blade (coordinate 04) shows a wood polish with longitudinal motion. Also, on the dorsal face Small geometrical edge damage surrounded by wood polish can also be seen on the dorsal face. This use-wear is indicative of sawing hardwood.

The flake (1485) also shows use-wear of the type caused by sawing wood (Fig. 5.6). The polish is mostly developed on the ventral face so it is possible that the working edge was around 45 degrees. The flake also shows edge retouches

Figure 5.6 From left top to right bottom: 1485: bright surface produced by a contact of the flint implement surface with mineral (50x); rounded edge with linear and small bands of mineral polish (50x); 1471: use-wear displayed in a hide scraper (100x and 200x); 1483: edge damage and polish produced by bone work (50x and 200x); 3-1-71 n1: very well developed longitudinal polish produced by the contact with soft wood (50x and 200x).

on its left side. No use-wear has been documented on this edge, but the retouches may be the result of hafting the tool.

Finally, the piece of waste (1575) displays isolated edge damage in the medial section of the distal edge. The use-wear is not very developed, but shows a clear longitudinal directionality. This probably means that the tool was used for only a short time.

**Animal resources**

Traces of contact with animal resources occur most frequently. A total of 64.7 % (N= 11) of the artefacts were used for working animal resources. Eight tools show clear traces of bone and skin work and three flint tools show possible traces that resemble work on animal resources.

**Hide working**

Three flakes and one blade were used to work hide. Two of the flakes (1815 and 1471) show a transversal motion and another (1583) shows a clear longitudinal motion. One of the flakes is a scraper, with a retouch less than 1 mm wide on the dorsal face. The polish is documented inside and around the retouches on the edge. Moreover, in all cases the polish has a greasy-looking appearance. In all cases the use-wear is not very developed, which made it impossible to infer whether they were used on soft or dry skin. This fact, in addition to the clear transverse directionality documented on these three tools, suggests the use of these tools for cleaning or preparing skins. On the other hand, the blade (1569) displays a well-developed polish with a longitudinal directionality. The surface of the tool shows extensive damage due to burning. However, remarkably enough, on the dorsal side of the blade the damage produced by fire affects only the right side. The damage is clearly marked by a straight line. One explanation for this observation is that this straight line shows where the handle was located.

**Bone working**

Three blades and one scraper were used to work bone. Isolated points of bone polish have been recorded on two of the blades (1483 and 1808). This suggests that other kinds of animal resources (like meat) were worked. However, no polish from contact with meat is visible. One blade shows a longitudinal motion while the other has evidence of a transversal motion. As mentioned above, the other blade (1856) displays bone and wood polish. The bone polish is located on the left distal edge of the tool (coordinate 06) and is only preserved on the ventral face. The motion recorded in the polish suggests that the blade was used as a bone scraper. Unfortunately, the dorsal face of the edge consists of cortex on which it is impossible to distinguish any kind of use-wear. The scraper (1465) shows a very well developed polish from bone working on the ventral and dorsal sides (Fig. 5.7).

**Unspecific animal resources**

Finally, three tools display use-wear that can be related to contact with unspecified animal resources. Two of these tools display substantial alteration due to fire, making it impossible to determine the kind of material worked. However, other tools display some use-wear attributes that make it possible to suggest that the worked material was an animal resource. This is true of a blade borer (1671) and a medial flake fragment (1704). The borer is made of a proximal blade fragment. The surface of this blade is so altered by fire that it is even impossible to distinguish the kind of flint that was used to produce the tool. The proximal part of the blade was prepared in such a way as to form an elongated pointed end. The fire also caused the right side of the proximal part of the blade to break, so it is not possible to obtain any kind of information. However, the left side of the tool (coordinate 01-02) and the point are very rounded. Also, a polish very similar to that caused by working skin has been recorded. Moreover, the flake fragment displays a polish that is very similar to the wear traces obtained from contact with a hard animal material like bone but again, because of the fire and some post-depositional alterations (metal marks from the sieve), the motion and the animal resource cannot be interpreted. Finally, one retouched flake (1721) also displays use-wear but its poor development makes a more detailed interpretation impossible. The proximal and medial left edges of the tool show small and continuous retouches. On the unretouched ventral face, isolated spots of polish without directionality are visible. This kind of polish can be interpreted as the result of handling. On the other hand, the medial part of the right lateral edge also shows small and continuous retouches. Polish from contact with an unspecified hard animal material has been recorded on both sides of the edge, as well as polish from a medium soft material that could not be specified. The poor development of the polish and the post-depositional alterations that cover part of the surface (metal marks probably related to sieving) make it impossible to identify the use-wear. However, all the evidence seems to point to tools used to work both a hard animal resource (such as bone) and a softer one (meat and perhaps skin). This observation suggests that this implement was involved in butchering activities.

**Mineral resources**
Two pieces of flint waste were found at Keinsmerbrug (1486 and 1783), displaying one elongated side where use-wear was observed. The use-wear is very well developed and is characterised by small impact fractures and a rounded edge with small linear bands of mineral polish. This observation suggests that these tools were used as strike-a-lights. Both tools have a very bright surface. This fact has been explained by other authors as the result of contact between fine pyrite powder and the flint surface '*that acted as an abrasive on the tool's surface*'[66], most likely during handling and while carrying the tool around. This characteristic also suggests that the tools were probably used for a long time and must be considered a curated item.

**Unknown materials**
This category contains seven tools that display ambiguous and poorly developed traces. Unfortunately, the bad preservation of the surface of the tools makes a functional interpretation impossible. All of them have been altered by contact with fire and only some edge damage can be observed. The vast majority of the tools are complete and fragmented flakes. However, it is worth pointing out the presence of a complete blade (1871) and a medial blade fragment (1769).

**Hafting traces**
The study of hafting traces is not very well developed, and this phenomenon tends to be overlooked in use-wear analysis. However, some recent experimental work has shown that hafting can leave substantial traces.[67] The authors stress that the absence of experimental references and the resulting lack of experience with hafting traces is responsible for the fact that some hafting traces, such as the bright spots, are often interpreted as post-depositional alterations.

At Keinsmerbrug, just three implements showed any polish or retouches that suggest that they were hafted. In two cases, the use-wear recorded on the tools can be defined as bright spots. These bright spots are considered '*indubitable evidence for assessing that a tool was used in a haft*'.[68] On the other tool, the position of the fire alterations, clearly marked by a straight line in its surface, suggests that the tool was hafted when it came into contact with the fire. In any case, the incidence of hafting is not very high. This can be explained as the result of a high level of alteration in the flint implements, but also because most of the tools were probably used without hafting.

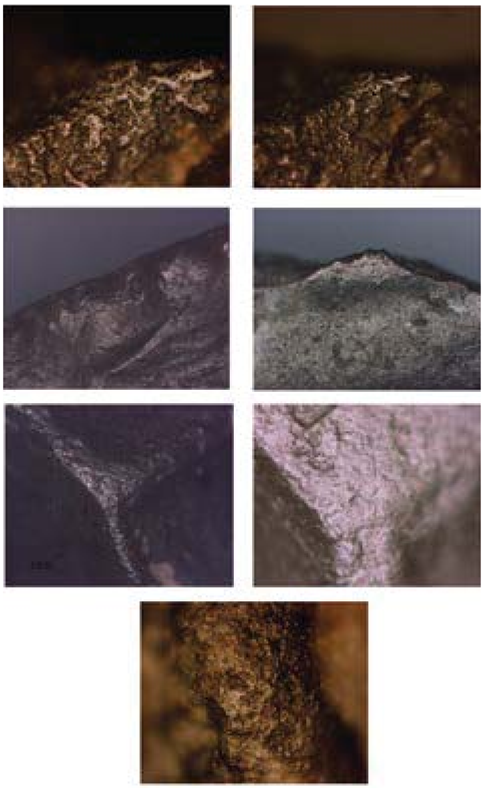


Figure 5.7 From left top to right bottom: 1586: use-wear displayed in a hide scraper (50x and 50x); 1465: use-wear displayed in a bone scraper (50x and 50x); 1783: bright surface produced by a contact of the flint implement surface with mineral (50x and 50x); 1671: polish very similar to the one that develops after boring skin.

66 Van Gijn *et al.* 2006, 155.
67 Rots & Vermeersch 2004; Rots 2008.
68 Rots & Vermeersch 2004,

## 5.7.2 Use-wear on stone tools

Use-wear analysis of stone tools is not an easy issue because of the state of preservation of the stone in the archaeological record. The level of fragmentation is often very high and different kinds of post-depositional alteration (like patination, rounding or weathering) are also very frequent. The fact that in some instances the stone tools are used without previous modification also makes the recording of production traces more difficult. Unfortunately, the stone tools from Keinsmerbrug are no exception.

The level of fragmentation is so high that just 6.3% of the tools show their original shape and volume. This fact hampers the detection of traces not only of production, but also of use. Just one hammer stone displays use traces (Fig. 5.8). The rest of the implements show no modifications related to their functionality.

The traces that have been recorded in the tool are located on only one of the edges. The analysis of the distal edge of the tool revealed traces of pounding and percussion. Unfortunately, the worked material could not be inferred. Nor could any evidence of hafting or handling be detected.

The hammer stone was selected for phytolith analysis. Even though the surface of the hammer stone shows some phytolith remains, the plant species could not be determined.

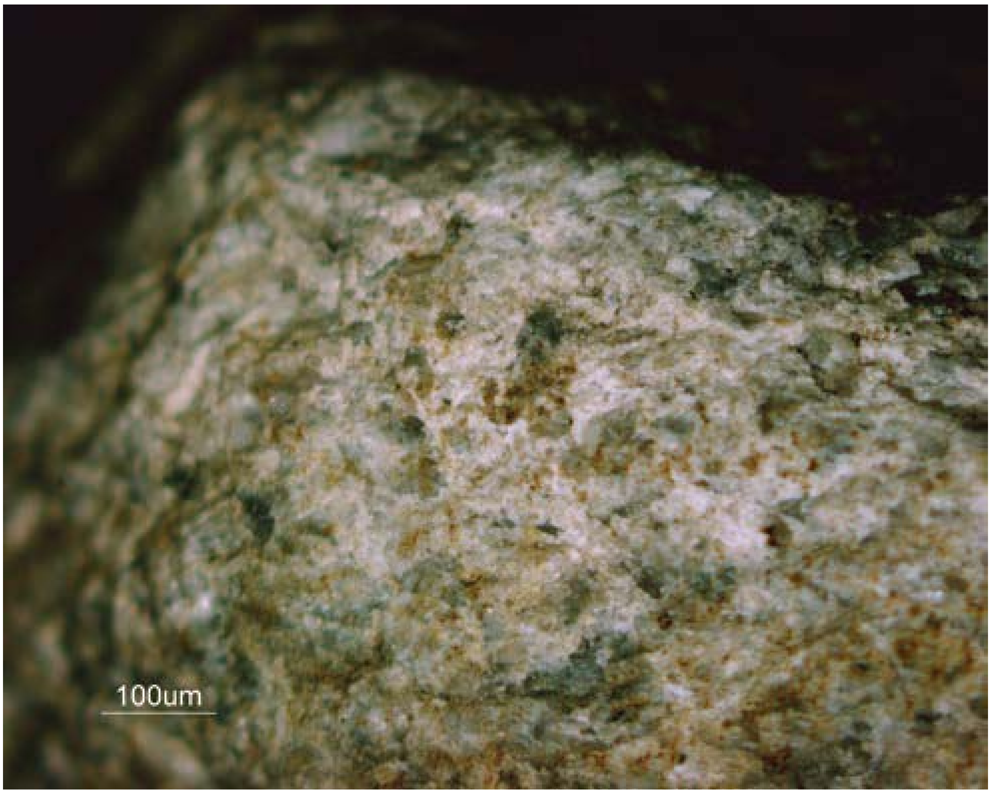



Figure 5.8 Traces of pounding and percussion (10x).


Figure 5.9 Wear traces along the rim of the perforation of the half amber bead.

### 5.7.3 Amber use-wear

Microscopic analysis can provide interesting information about the use of beads, such as the intensity of wear or the lack thereof. Sometimes, friction between the cord and the surface of the amber gives some idea of its use as part of a pendant. The half amber bead found at Keinsmerbrug shows wear traces along the rim of the perforation, indicating that it was worn on a cord (Fig. 5.9).

## 5.8 Spatial patterning

Following the work of Nobles[69], seven activity areas were recorded by the analysis of Keinsmerbrug. The relationship between these areas and the flint, stone and amber implements will be presented in the following chapter.

### 5.8.1 Spatial distribution of flint

As mentioned by Nobles the flint distribution analysis was based on 354 of 416 pieces.[70] These flints come from the cultural layer and from features.

The map of the flint spatial patterning shows a general distribution of the flint along the site (Fig. 5.10). However, some concentrations of flint are recorded, mostly in the northern part of the site, and also in the south (Fig. 5.11). These concentrations are related to the activity areas which Nobles designated Areas 1, 2, 3 and 4.

Areas 1, 2 and 3 are related to the use of structure number 2. Other remains, including mammal and bird bones, have been found in these distribution areas. These areas seem to be associated with household activities. Unfortunately, the use-wear distribution does not allow us identify them as specialised areas (Fig. 5.11). In Area 1, use-wear related to skin processing is the most common, though work with bone and wood is also represented.

[69] Nobles this volume (chapter 10).
[70] Nobles this volume (chapter 10).

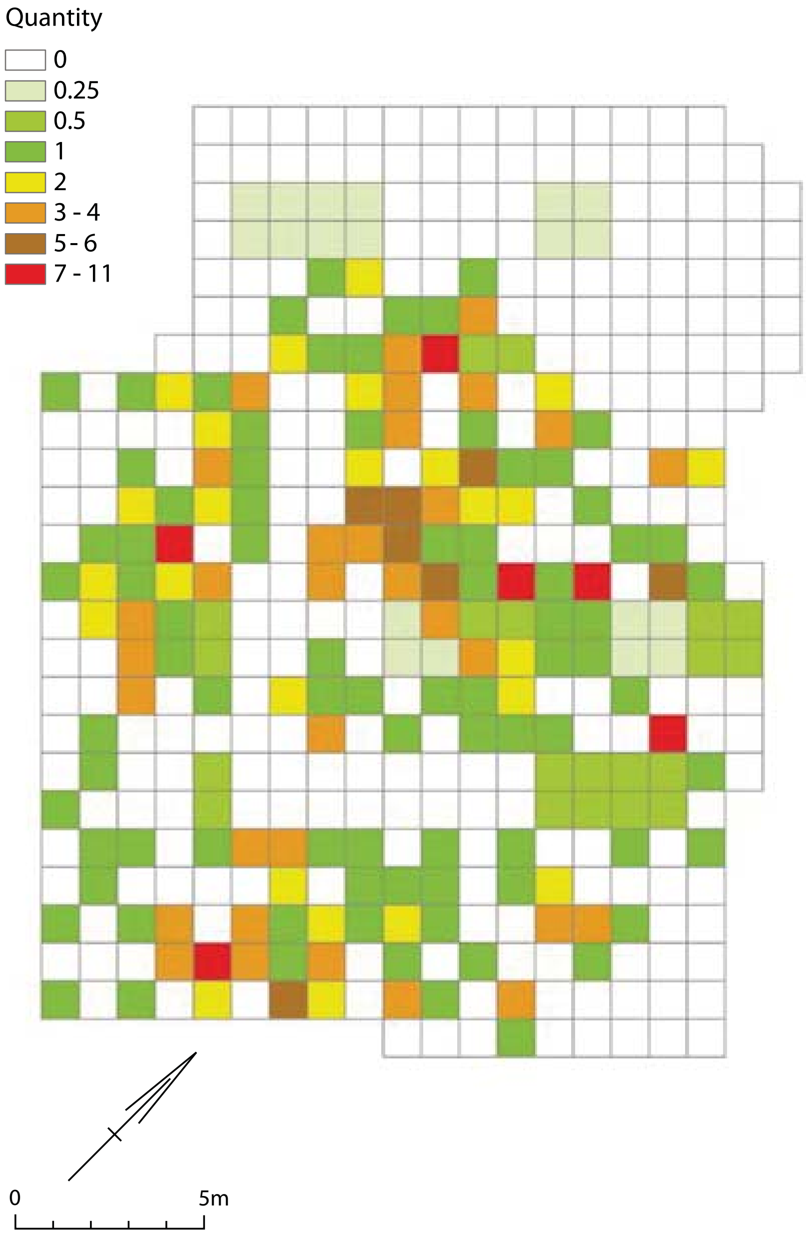



Figure 5.10 Distribution patterns of flint implements.

Moreover, activities related to bone and wood have also been recorded in Area 2. However, activity area 4 yielded mostly flint flakes and waste, indicating that this area could have been used for the preparation of flint tools.

The burnt flint distribution shows a random spread all over the site. Even though some hearths were found during the fieldwork the wide distribution of burnt flint does not seem to be related to the intentional preparation or modification of the tools (Fig. 5.12).

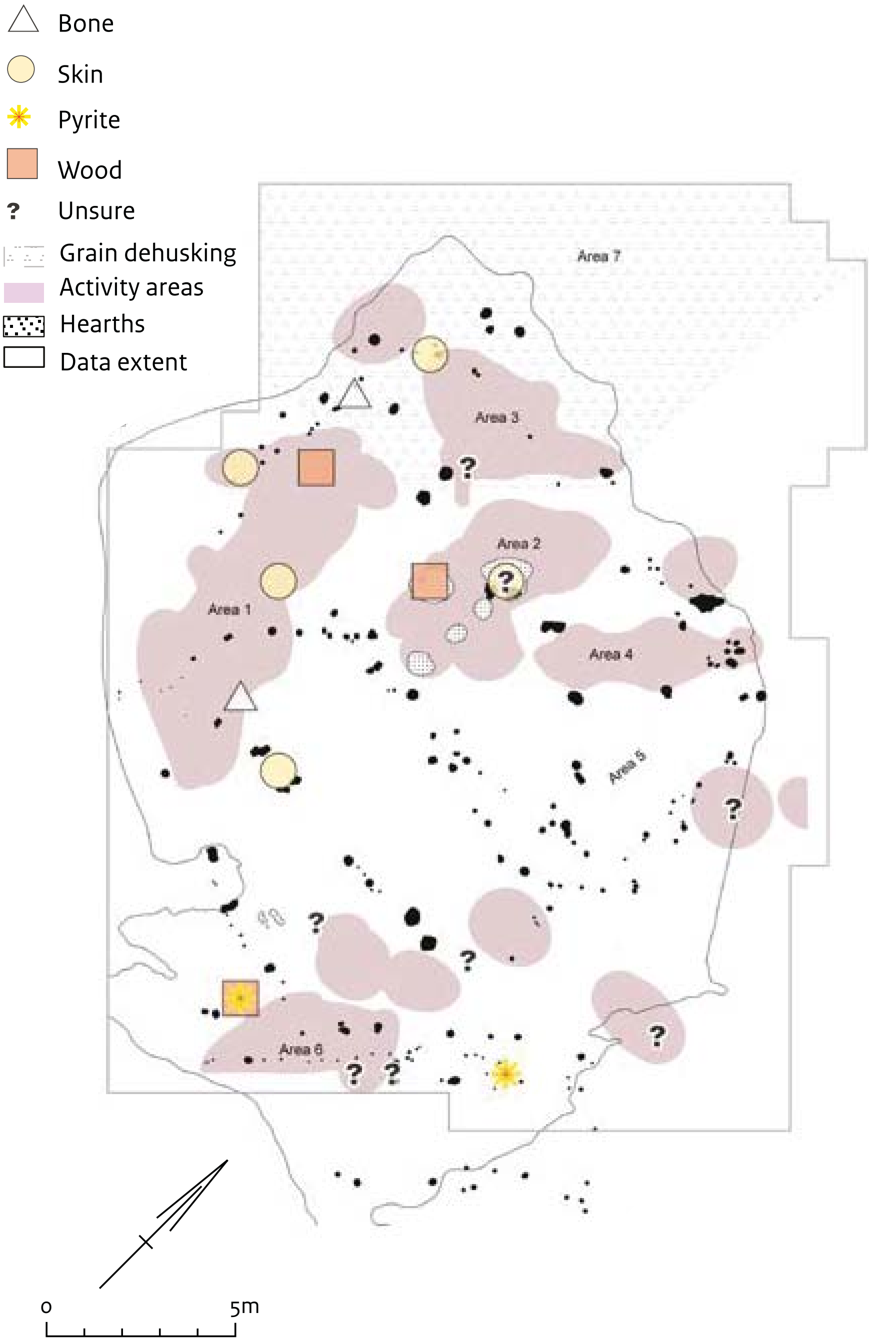



Figure 5.11 Distribution patterns of use-wear on flint artefacts.

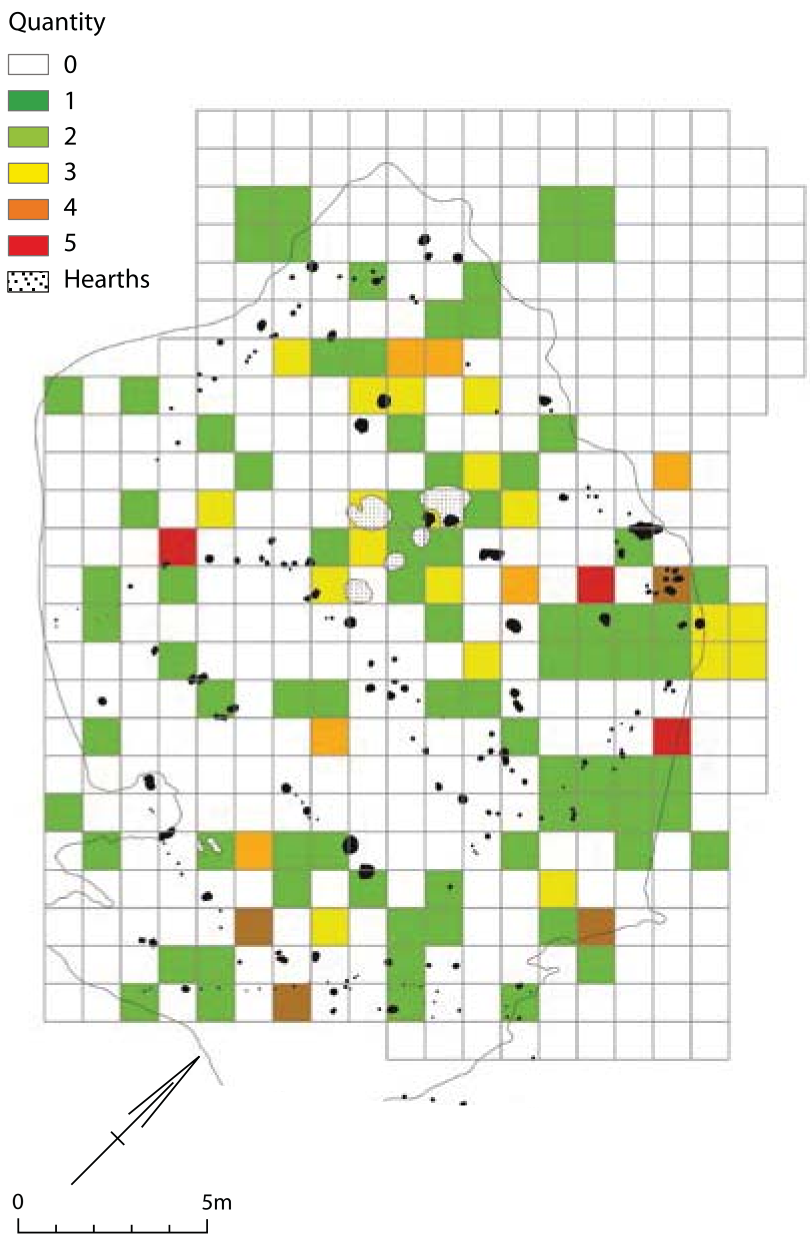



Figure 5.12 Distribution patterns of burnt flint.

## 5.8.2 Hard stone spatial patterning

The distribution analysis of hard stone does not show any clear concentration of implements. Despite a higher presence of hard stones in the central part of the site, the distribution patterns show a random spread (Fig. 5.13). Also, as is the case with flint, the distribution of burnt hard stone implements does not seem related to any intentional modification of the stones (Fig. 5.14). However, the relationship between the hammer stone with the activity Area 2 is worth noting. As mentioned above, this area could be related household activities. The presence of the hammer stone might support this idea (Fig. 5.15).

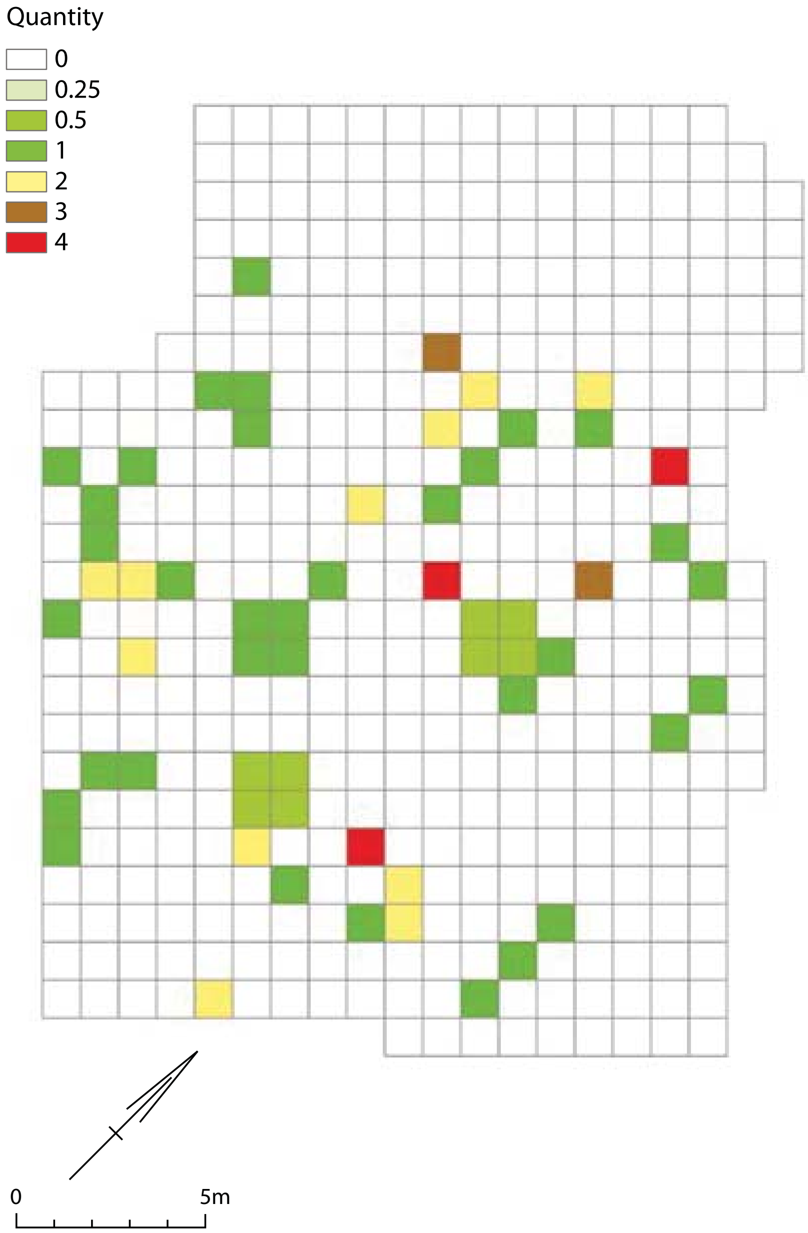



Figure 5.13 Distribution patterns of hard stone.

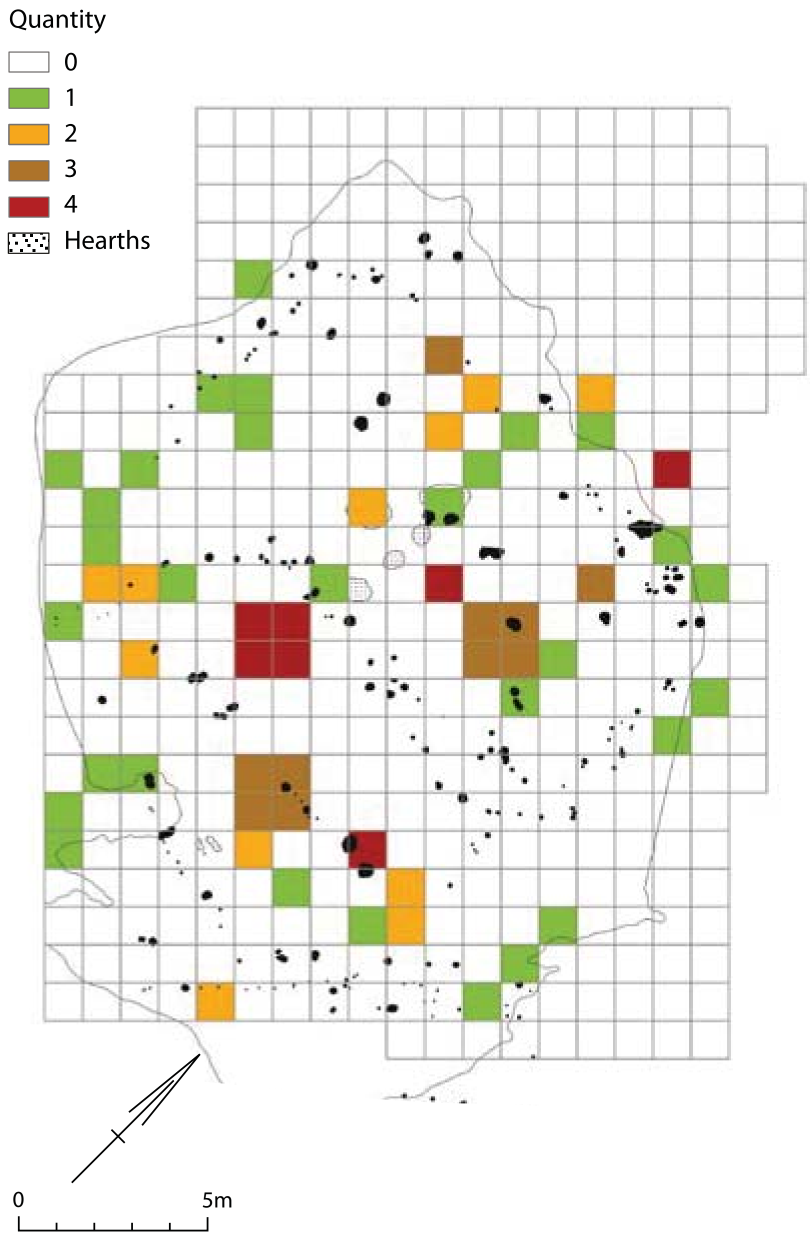



Figure 5.14 Distribution patterns of burnt hard stone.

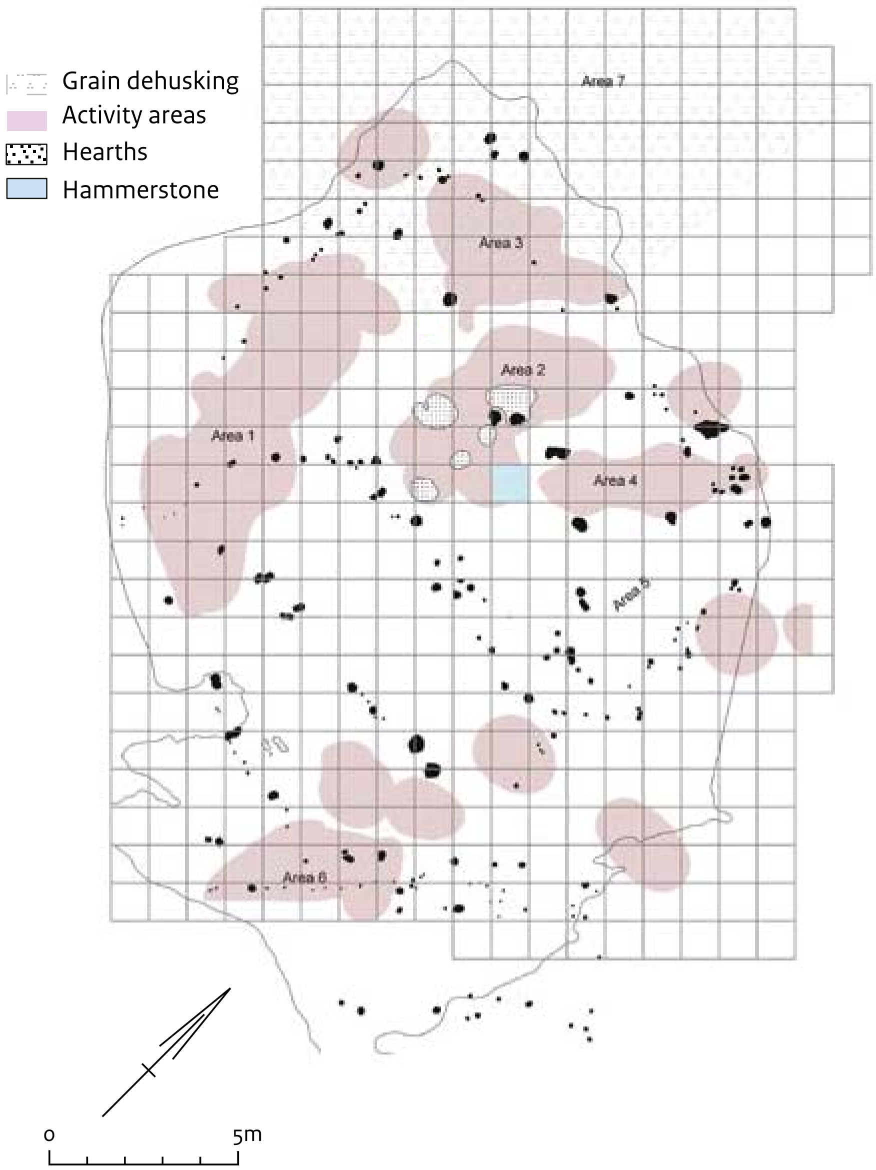



Figure 5.15 Distribution patterns of the hammer stone.

### 5.8.3 Amber spatial patterning

The spatial distribution of the few amber implements does not provide much information. However, it is worth noting that the three fragments were recovered in the northern part of the site, in relation to structure number 2. One fragment was recovered in activity Area 1, while the other was recovered in Area 2 (Fig. 5.17). Finally, the bead fragment was recovered from inside a posthole. This fact suggests that the chronology of this amber bead is posterior.

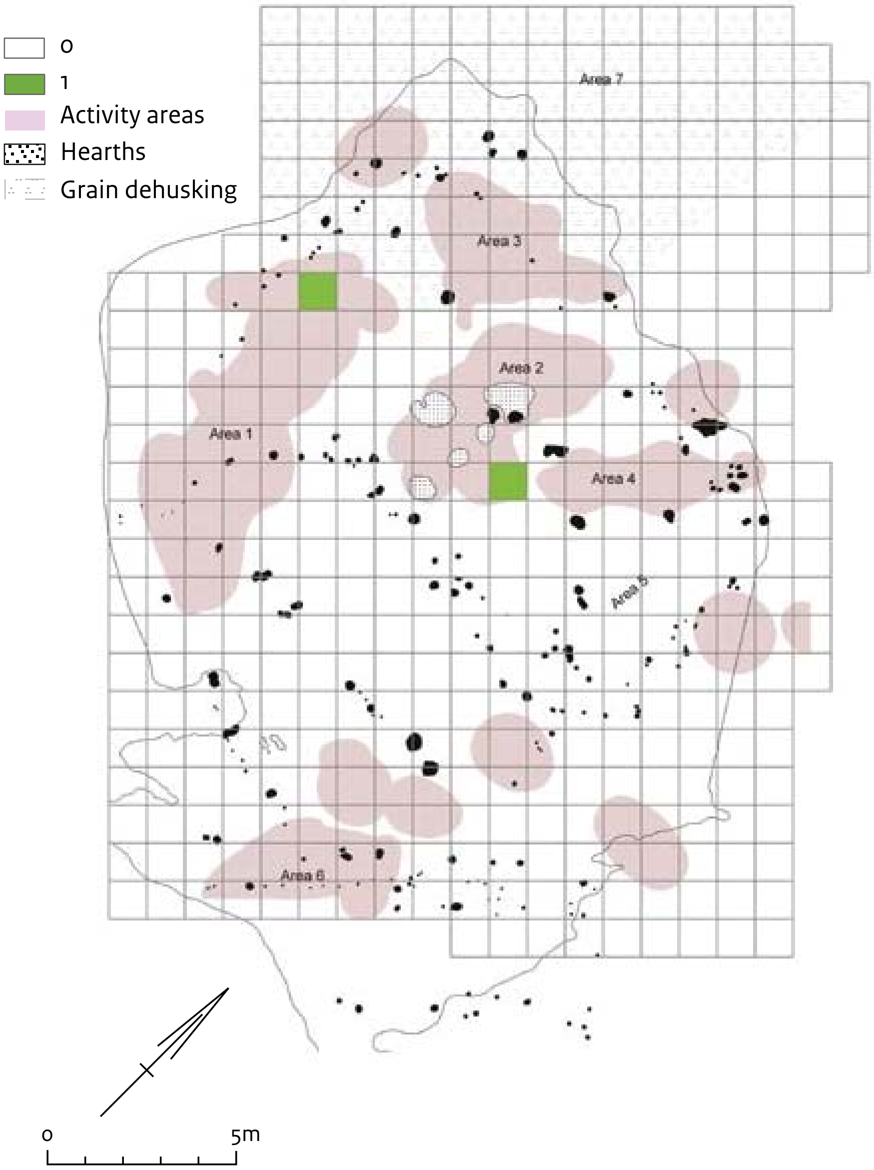



Figure 5.16 Distribution patterns of amber implements.

## 5.9 Conclusions

### 5.9.1 Flint procurement network

Six different groups of raw material could be distinguished, all of northern origin. The most frequently used flint is the one catalogued as R1, which is characterised by the presence of internal fossils. However, other kinds of flint are also important, such as the ones referred to as R2 and R3. Also, rolled pebbles were an important raw material transported to the site. The flint was probably collected from nearby areas, such as beaches or the glacial till deposits at Wieringen. The study of the materials from Keinsmerbrug indicates that the flint was carried to the site in small nodules. The knapping process was performed at the site to obtain the tools needed, as evidenced by the presence of knapping waste, cores, and primary flakes.

### 5.9.2 Flint knapping techniques

The tool production process reveals that people from Keinsmerbrug used the small flint nodules and the rolled flint pebbles to produce the tools they needed. The technological approach seems to be very similar to other Single Grave sites, such as Mienakker.[71] More than 70% of the implements are flakes, with few retouched tools (just five instruments). Scrapers are the most common tool type and the presence of one borer is also interesting. No preparation has been observed in the cores or flakes and blades so, as Peeters concludes in the case of Mienakker and Molenkolk I, the technology inferred at Keinsmerbrug can also be considered opportunistic.[72]

### 5.9.3 Hard stone implements

Fewer than 100 fragments of hard stone were found at Keinsmerbrug. Most of them are igneous and metamorphic rock (granite and quartzite) in a very poor state of preservation due to a high degree of fragmentation, burning and various post-depositional alterations. Because of this fact, traces of production and use are poorly preserved and difficult to distinguish.

Only one granite artefact shows clear traces of use, related to pounding and percussion, which suggests it was used as a hammer stone. Unfortunately, the worked material has not been identified.

### 5.9.4 Amber

Amber ornaments are very common at Neolithic sites and, of course, in Single Grave settlements in Noord-Holland province. Amber represents a large proportion of the material assemblage at several sites, including Mienakker and Aartswoud.[73] However, amber accounts for just a tiny proportion of the assemblage from Keinsmerbrug. Just half a bead and two small fragments were recovered during fieldwork. Amber was probably picked up from the coastal areas of Noord-Holland. Taking into account the small number of amber implements and the absence of production waste, amber ornaments were probably not produced at Keinsmerbrug. The amber bead cannot be considered an intentional deposition. This means that, as is the case with other Neolithic sites (Van Gijn 2006), beads and pendants were taken along when the site was abandoned.

### 5.9.5 Use-wear analysis

Although the number of tools that show use-wear is low (3.8%), some conclusions can be drawn. First, only a small number of tools are related to the subsistence activities of the group. Even though 64.7% of the tools were used to process animal resources, just one of them was probably used for butchering. This can be explained by the various kinds of alteration that the implements underwent, which can obscure the use-wear traces. Still, the absence of flint arrowheads suggests that hunting was not practised at the site or, at least, that they used another kind of technology, such as traps or wooden arrowheads, which have not been preserved. In any case, the absence of

71 Peeters 2001a.
72 Peeters 2001a; Peeters 2001b.
73 Piena & Drenth 2001; Bulten 2001.

arrowheads is a frequently observed fact at other excavated sites in Noord-Holland province. With the exception of Kolhorn, which has never been systematically studied, so the total number of arrowheads is still unknown, just one flint arrowhead was recovered at Mienakker and at Aartswoud.[74] This hypothesis is supported by the existence of four tools that have traces of skin processing and four tools that have traces related to bone working.

Furthermore, it is also interesting to note the absence of tools with traces of harvesting cereals. No sickles were found at Keinsmerbrug. This might reflect the kind of site that Keinsmerbrug was. As in the case of the arrowheads, the absence of sickles is a common phenomenon in the wetlands. Very few flint sickles have been found in Late Neolithic and Early and Middle Bronze Age settlements or graves.[75]

However, traces of craft activities like plant processing and woodworking have been recorded on four tools. Both activities were very important in prehistoric times and both are related to tool manufacture, the construction of houses and other structures, as well as to daily activities like the production of clothing.

The importance of fire in the Single Grave communities is reflected by the two strike-a-lights found at the site. Both of them have a very bright surface and very well developed mineral polish that might be the result of long-term use. This might also reflect the symbolic importance of strike-a-lights that has been observed at other sites. Strike-a-lights are also always curated items that can be considered personal items.[76]

Finally, the stone tools from Keinsmerbrug provide very little information about the function of the site or the social activities of the group. The stones were probably carried to the site from nearby areas. It is possible that they were among the more important tools that the people of Keinsmerbrug used for subsistence activities, but this cannot be substantiated.

Finally, the amber bead fragment shows wear traces along the rim of the perforation, indicating that it was worn on a cord as a personal decorative ornament.

### 5.9.6 Group composition and site function

The results of the technological and functional analysis of flint and stone implements suggest some conclusions related to the group and the function of the site. First of all, considering the *opportunistic* technology and the small number of subsistence practices recorded, it is likely that Keinsmerbrug was a temporary base camp, as other authors have suggested.[77] If this information is compared with archaeozoological remains, and following the interpretations of previous authors which suggest that at Keinsmerbrug the focus was on duck hunting, the absence of evidence of these activities in the flint tools also suggests the existence of other kinds of technology such as wooden traps that have not been preserved at the site. Flint tools would not have been necessary. Finally, even though amber is always related to social identity, it is not possible to base any social interpretations on the Keinsmerbrug assemblage. Unfortunately, the small number of amber ornaments makes it impossible to determine whether there were any social differences in terms of personal ornaments.

74 Peeters 2001a; Van Iterson Scholten & De Vries-Metz 1981; Van Gijn 2010.
75 Van Gijn 2010.
76 Van Gijn *et al.* 2006.
77 Drenth, Brinkkemper & Lauwerier 2008.

# 6 Botany: Local vegetation and plant use

*L. Kubiak-Martens*

## 6.1 Introduction

In the 1980s and 1990s a series of Late Neolithic sites associated with the Single Grave Culture were excavated in the Dutch province of Noord-Holland.[78] Although they are being interpreted as settlements, no satisfactory explanation for their overall function has yet been put forward. It is believed that some of the sites were permanently occupied and represent settlements involved in agricultural practices and animal husbandry, while other sites possibly represent temporarily used specialised camps. To address specific questions about the function of the sites in the tidal environment of Noord-Holland, our current research project is based on archaeobotanical remains from three sites: Keinsmerbrug, Zeewijk and Mienakker.

This section discusses various aspects of local vegetation, site economy and diet, and plant use that emerged from the analysis of botanical samples collected during the excavation at Keinsmerbrug in 1986.

## 6.2 Methods

Four categories of archaeobotanical remains are represented at Keinsmerbrug: (1) seeds and fruits were studied in order to reconstruct the local vegetation on and around the site during the Late Neolithic occupation and to specify the site economy and subsistence strategies. The three following types of analysis were applied to the remains in order to provide more insight into the local diet and methods of plant food preparation: (2) analysis of organic residues on pottery[79], (3) analysis of processed plant food, which involved isolated remains of charred processed plant food and (4) analysis of charred parenchyma. This group included charred remains of roots and tubers and their potential role as a source of human food.

### 6.2.1 Recovery and identification of plant remains

Botanical samples were taken during the 1986 excavation season. With the exception of two samples that were taken from features interpreted as possible wells (Features 1001 and 1003), all other samples derive from the occupation layer. These were collected within a 1m²-grid and in the approx. 20 cm thick occupation deposits (see figure 6.1, sample locations). Only the south-eastern part of the site was sampled more or less systematically (almost every other square was sampled), while other areas were sampled more randomly. Unfortunately, no samples were taken from the hearths, although they were excavated. In total, 87 botanical samples were stored in the provincial repository in Lelystad and were available for the current research. Soil sample sizes range from approx. 1.5 to 3 litres. Some samples had previously been wet sieved at the former ROB (now the Cultural Heritage Agency, RCE). The bulk of the samples were wet-sieved at BIAX *Consult* using a 0.25 mm-mesh.

All 87 samples were qualitatively assessed in order to estimate their botanical value, including their state of preservation and the diversity of plant species present in them. The seed and fruit remains were studied under a binocular incident light microscope at magnifications of 6x to 50x. Particular attention was paid to the presence of any preserved charred parenchymatous tissue and isolated lumps of charred processed plant food. These two categories of archaeobotanical remains have a much smaller chance of being preserved in archaeological contexts compared with those of seeds and nut shells, or the stony endocarps of many fruits. Parenchymatous tissues, for example, are often rich in water and are therefore very susceptible to damage when exposed to fire, and later during the process of recovery.

The assessment phase produced a picture of the distribution of plant species/taxa throughout the site. Assessment data were used in spatial analysis in order to differentiate possibly contemporaneous activity areas associated with plant processing or plant use.

[78] Drenth *et al.* 2008.
[79] Oudemans & Kubiak-Martens this volume.

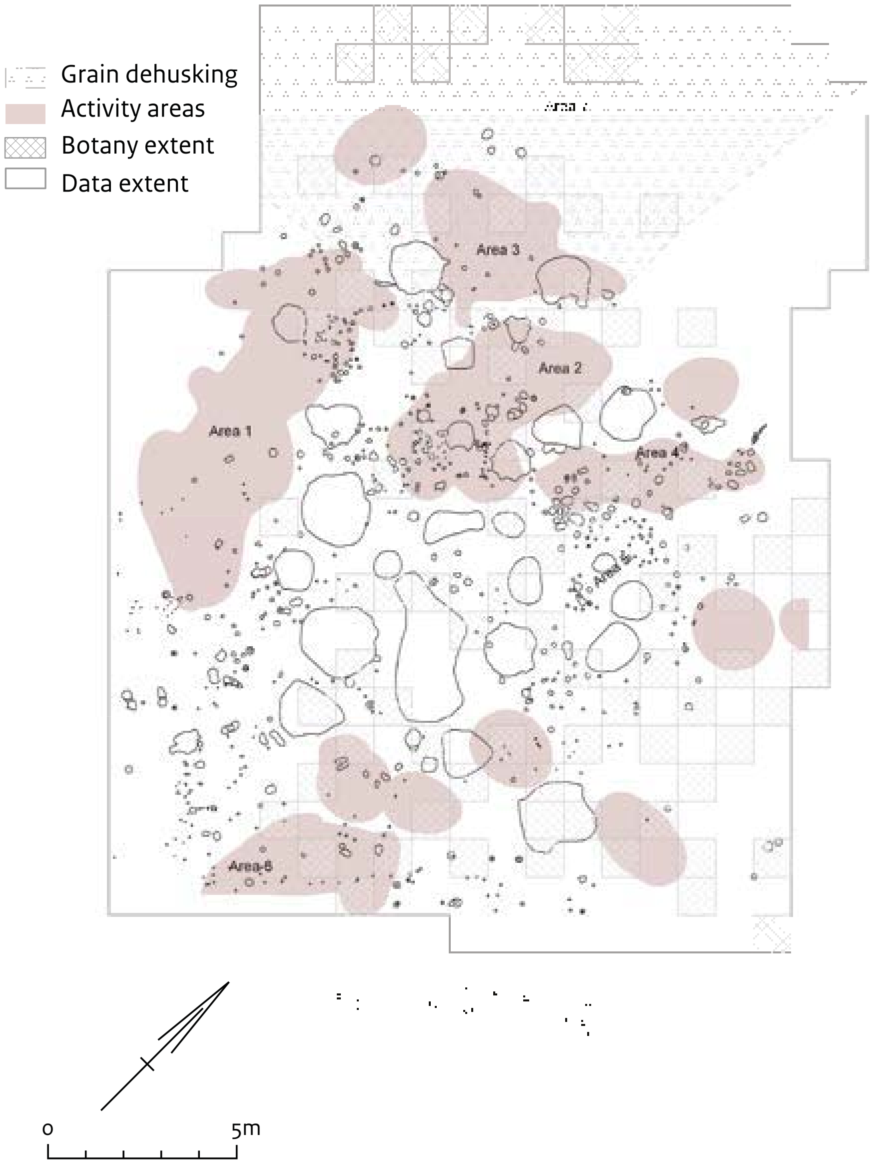



Figure 6.1 Samples grid - position of the botanical samples, including features and activity areas. Maps by G.R. Nobles.

A total of 18 samples were selected for detailed analysis of seeds and fruits, on the basis of combined information on their botanical value and the provenance of the sample within the site. Summaries of the data on seeds and fruits, based on a complete analysis, are presented in Appendix III. With the exception of waterlogged plant remains recovered from the wells (Features 1001 and 1003), all the remains from the occupation deposits had been preserved by charring.

Potentially identifiable charred remains of parenchymatous tissue and isolated specimens of charred processed plant material were subjected to scanning electron microscope examination at the SEM laboratory of the National Herbarium in Leiden. The specimens were mounted on SEM stubs using double-sided carbon tape strips. They were then gold-coated and examined using a JOEL JSM-5300 scanning electron microscope at magnifications between 35x and 200x. The specimens were photographed and described.

### 6.2.2 Approach to the interpretation of archaeobotanical remains

All wild plant species, represented by both waterlogged and charred remains were taken into account in order to reconstruct the local vegetation. In addition to macrofossil analysis, the results of pollen analysis carried out on two samples from the wells, Features 1001 and 1003[80] were also briefly considered. The results of the charcoal analysis were also incorporated, as they provide important information needed to reconstruct the woody vegetation near the site.[81]

When interpreting plant remains from any archaeological site (and hence also those from Keinsmerbrug), one must bear in mind that every botanical sample has been subjected to some degree of human influence.[82]

This influence may be direct – many plants will have found their way into the site having been collected for food, fuel, bedding, tempering or construction material, cut sods etc. and as contaminants in harvested crops; or indirect – through various activities related to animal husbandry, e.g. trampling, grazing or use of dung as fuel. As a result, most archaeobotanical remains represent material of possibly mixed origin.

At Keinsmerbrug, the samples were not particularly rich in plant remains (with the exception of *Atriplex littoralis* and *Atriplex prostrata/patula* seeds)[83] nor did they contain a great variety of species. It is unknown whether this scarcity of plant remains is a primary phenomenon, i.e. that only a few seeds were incorporated in the occupation layer, or a secondary phenomenon, in other words that preservation conditions were responsible and that the Keinsmerbrug assemblage represents only a small proportion of the plant remains originally present and discarded at the site. The latter is much more likely since other Neolithic sites in the coastal area (for example two coastal dune sites, Schipluiden and Ypenburg) have yielded rich assemblages of plant remains.

## 6.3 Local vegetation

### 6.3.1 Salt marsh vegetation

Although various plant species with a preference for brackish habitats[84] are present in the Keinsmerbrug seed assemblage, suggesting the presence of some salt marsh vegetation near the site, there is no clear evidence for the presence of fully developed stands of salt marsh vegetation, with a gradual succession from tidal flats to lower and higher parts of the salt marsh.

One plant characteristic of mud flats and present in our botanical record is glasswort (*Salicornia europaea*). This species often dominates the vegetation on flats that are exposed to tidal movements. At Keinsmerbrug, *Salicornia europaea* would probably have grown on the mud flats bordering the tidal creek (Fig. 6.2).

At slightly higher elevations (the lower and middle salt marsh), above the high tide mark, two other halophytic species of salt marsh grass (*Puccinellia distans*) and lesser sea-spurrey (*Spergularia salina* (=*marina*) would have grown. Both species are characteristic of the coastal plant community (Puccinellietum distantis), which is often associated with human activity. Both plants occur in places where sods have been cut or which are frequently trodden by people and animals.[85] Other plant species that are well represented in this plant community (and found in the archaeobotanical record) are *Polygonum aviculare*, *Plantago major* and *Atriplex prostrata/patula*.

Halophytic plants such as sea aster (*Aster tripolium*), salt marsh rush (*Juncus gerardi*), and also grasses such as creeping bent (*Agrostis cf. stolonifera*) and sea barley (*Hordeum marinum*), would have grown on the higher parts of the salt marsh. This vegetation zone would have been flooded only a few times a year, during spring tides and storm surges. High salt marshes were often used as brackish pasture, offering many possibilities for grazing and hay production. Some plants in this group (*Juncus gerardi* and *Agrostis cf. stolonifera*) are specific indicators of grazing.[86] The brackish grasslands in Keinsmerbrug may have extended to the areas influenced by freshwater conditions.

80 Van Haaster this volume.
81 The original charcoal analysis was carried out by Kooistra 2001.
82 See Therkorn *et al.* 2009, 46; Van der Veen 2007.
83 For scientific English and Dutch plant names see Appendix IV.
84 Schaminée *et al.* 1999.
85 Van Zeist 1974.
86 Körber-Grohne 1992.


Figure 6.2 Glasswort (*Salicornia europaea*): (a) charred seed (find number 3-1-127) and (b) recent plants on mud flats near De Westhoek (prov. Friesland) photographed in May by W. van der Meer.


Figure 6.3. Wild celery (*Apium graveolens*): (a) charred seeds (find number 3-2-1001) and (b) recent plant. Wild celery is characteristic of high salt marsh vegetation and drift deposits. Young leaves and leaf-stalks might have been collected as plant food.

There, two additional grassland species, dandelion (*Taraxacum officinale*) and meadow grass (*Poa pratensis/trivialis*), would have found their most favourable habitats. It is clear from archaeozoological evidence that stock breeding was an important element of the economy of the Single Grave Culture.[87] Grazing may well have been practised on the salt marshes near the site, and also on grassland in a freshwater environment.

[87] Zeiler & Brinkhuizen this volume.


Figure 6.4. Marsh-mallow (*Althaea officinalis*): (a) charred seeds (find number 4-1-16) and (b) recent plants. This species might have grown as arable weed in the fields located on the higher parts of salt marshes.

Species such as marshmallow (*Althaea officinalis*), wild celery (*Apium graveolens*), seablite (*Suaeda maritima*), shore orache (*Atriplex littoralis*), and possibly sea club-rush (*Bolboschoenus maritimus*) and reed (*Phragmites*), may indicate the presence of Angelicion litoralis vegetation nearby (Fig. 6.3-6.4). This particular nitrophilous plant community develops in areas where drift deposits accumulate during storm surges.[88]

## 6.3.2 Brackish and freshwater marsh vegetation

Species characteristic of brackish-water marsh vegetation are sea club-rush (*Bolboschoenus maritimus*), possibly accompanied by reed (*Phragmites*) and false fox-sedge (*Carex otrubae*). This vegetation would have been found along streams/tidal creeks with brackish water. Remains of *Bolboschoenus maritimus* are well represented in the macrofossil record (particularly in charred assemblages, but also in waterlogged conditions), which may suggest that brackish-water marsh vegetation was well established near the site. Away from the brackish creeks, in places where fresh water accumulated (for example backswamps), plants such as reed (*Phragmites*), great sedge (*Cladium mariscus*), rushes (*Eleocharis palustris/uniglumis*), common marsh-bedstraw (*Galium palustre*), water/corn mint (*Mentha aquatica/arvensis*) and various sedges (*Carex acuta/elata* and *Carex riparia*) would have found their primary habitats. Culms of *Phragmites* and seeds of *Cladium mariscus* are particularly well represented in charred macrofossil assemblages. This would suggest that stands of both plants were well developed near the site, either in the freshwater marsh or in slightly brackish locations, since both species tolerate slightly brackish conditions.

At least three plant species from the brackish and freshwater marsh stands (i.e. *Phragmites*, *Cladium mariscus* and *Bolboschoenus maritimus*) may have been used by people for various purposes, such as building material (roofing/thatching) or to furnish their dwellings (bedding, matting, insulation from damp subsoil). This may explain the scatters of charred reed stems, and also the presence of seeds of *Cladium mariscus* and *Bolboschoenus maritimus*, assuming that these derive from houses that burnt down, the seeds representing remains of charred thatch or bedding.

88 Van Zeist 1974; Cappers 1995.

### 6.3.3 Potential arable weeds and ruderals

One group of plants represented in the macrofossil record would have grown both as field weeds and as ruderals at the site. It is often difficult to distinguish true arable weeds from ruderals. This is partly due to the fact that many environments disturbed by people, especially arable fields and ruderal habitats, may have changed over time.[89] Thus, applying present-day classifications to interpret archaeological remains is only possible after some modifications. The preservation conditions of weed seeds may offer some clues, for example whether they have been waterlogged or carbonised. Knörzer, for example, suggested that most carbonised weed seeds in archaeological contexts would have arrived at the site along with crops.[90] Hillman further suggests that charred seeds of typically ruderal species found consistently in association with by-products of the processing of crops are likely to have arrived at the site - and ended up in fires - mainly as contaminants of crops, and are hence to be regarded as field weeds.[91]

In the Keinsmerbrug assemblage, plants that today grow mainly on arable fields are represented by only a small number of charred seed remains, occasionally found together with cereal remains. This group of potential arable weeds is represented by plants such as *Atriplex patula/prostrata*, *Persicaria lapathifolia* and *Polygonum aviculare*. A few other potential arable weeds, such as *Brassica rapa*, *Sonchus asper* and *Stellaria media*, were encountered only in waterlogged remains, which makes their status as field weeds uncertain. *Brassica rapa* (=*campestris*) or field mustard is well known for its oily seeds and edible root (turnips), and also as a weed in arable fields. In Keinsmerbrug it is represented only by waterlogged seeds, suggesting that *Brassica rapa* may have grown on waste places around the site.

Some species in the assemblage of charred seeds, such as *Hordeum marinum*, *Althaea officinalis* or *Atriplex littoralis*, may represent arable weeds, assuming that the fields were located on the highest parts of the levees, as was argued earlier in the case of sandy levees at Aartswoud, or on the beach plain or low dunes as suggested for two Middle Neolithic coastal dune sites, Schipluiden and Ypenburg.[92]

At most settlementsites weed assemblages also include species that favoured places trodden by people and animals (such as paths) or specific locations with nitrogen-enriched soil such as watering places for domestic animals, or places around the houses. In Keinsmerbrug, places rich in nitrogen are indicated by the presence of species such as *Chenopodium ficifolium*, *Chenopodium glaucum/rubrum*, *Atriplex patula/prostrata*, *Juncus bufonius*, *Ranunculus sceleratus*, *Stellaria aquatica* and *Urtica dioica*. The presence of *Chenopodium glaucum/rubrum* points to extremely nutritious locations, such as dung heaps or rubbish dumps. One can imagine cattle wandering freely through the site in Keinsmerbrug, and perhaps even stabled in some of the houses. Consequently, animal dung will have easily become incorporated in site deposits, which would definitely favour nitrophilous plant communities. This assumption is supported by dung evidence from other prehistoric sites in Europe. For example, the frequent occurrence of animal droppings in the Neolithic lake shore settlements in Switzerland and Germany, as well as finds of mineralised coprolites (possibly from cattle) in Middle Neolithic Schipluiden in the Netherlands, suggest that domesticated animals may indeed have been kept in the settlement.[93]

### 6.3.4 Approach to the interpretation of woody vegetation

Before presenting the results of the charcoal analysis performed by Kooistra, a few preliminary remarks must be made.[94] Assuming that the people at Keinsmerbrug collected the firewood for their hearths in areas accessible from the site, the charcoal represents trees and shrubs that would have formed part of the local vegetation. At any site, and hence also at Keinsmerbrug, people would have needed wood for other purposes as well – such as artefacts and construction – for which they may have deliberately selected wood of a specific type and species. After having been used for other purposes this wood may eventually also have ended up as fuel. Finally, at any site located in

89 See for example Bakels 1978.
90 Knörzer 1971.
91 Hillman 1984.
92 Pals 1984; Kubiak-Martens 2006; Van Beurden 2008: more details later in text.
93 Maier 1999; Akeret & Rentzel 2001; Kühn & Hadorn 2004; Van Waijjen and Vermeeren 2006.
94 Kooistra 2001.

the coastal area, and hence also at Keinsmerbrug, we need to consider driftwood as an additional (possible) source of firewood and possibly construction wood. It is quite possible to imagine that driftwood might have been washed ashore or even carried closer to the site through the main tidal channels during high tides or storm surges. This way driftwood would have been available near the site for collecting as firewood and possibly also as construction wood. A single charcoal assemblage may therefore contain a mixture of firewood, which is usually collected near the site, although not necessary deriving from local stands of woody vegetation, and wood collected for other purposes, which may have come from local stands of trees and shrubs but may also have come from a wider area around the site (even collected by people elsewhere or brought to the site by natural causes, for example as driftwood).

Kooistra's identification of oak (*Quercus*) charcoal from Keinsmerbrug occupation deposits indicates that oak trees may have grown in the areas accessible from the site. Kooistra further suggests that the oak charcoal may have derived from thickets of oak trees that may have grown on levees which provided dry (or at least drier) places in otherwise relatively wet surroundings. Oak may have been accompanied by other trees with a preference for drier locations such as maple (*Acer*) and possibly ash (*Fraxinus excelsior*), both of which are present in the charcoal assemblages. There are also a few other (small) trees and/or shrubs which may have been associated with thickets of deciduous 'forest' (as they would be today): hazel (*Corylus avellana*), dogwood (*Cornus* possibly *sanguinea*), elder (*Sambucus* possibly *nigra*) and purging buckthorn (*Rhamnus cathartica*). Such thickets of deciduous trees and shrubs may have grown on the highest locations on levees, provided that they were not flooded by brackish water.

The charcoal assemblages also contain good evidence for wet conditions (influenced by fresh water), where stands of willow (*Salix*) and alder (*Alnus*) and possibly birch (*Betula*) would have found their most favourable habitats, perhaps between levees and backswamps. Wet and possibly mineral-rich soils of low-lying backswamps would have been covered by willow thickets. Interestingly, alder and willow dominated many of the wood charcoal assemblages, even though neither of them is very effective as fuel. They must both have been readily available near the site. Kooistra suggests that the area around the site, which is where the inhabitants of Keinsmerbrug obtained most of their firewood, must have been very wet.[95] Nonetheless, some firewood was also collected from stands/thickets of oak and other deciduous trees, though this vegetation type was probably very limited in extent.

A little charcoal, and also some waterlogged wood (both from trunk wood) of pine (*Pinus*), are represented in the Keinsmerbrug assemblages.[96] Pine is fairly tolerant in terms of environmental conditions but does not take competition with other trees very well. For that reason pine is usually found in marginal habitats such as dry sandy soils or oligotrophic peat. There is no evidence – yet – of suitable locations for viable stands of pine near the site.

One remarkable feature of the charcoal assemblages from Keinsmerbrug is the fact that most of the charcoal derived from trunk wood (with a diameter of over 5 cm).[97] This is clearly observed in the case of oak, ash and maple but also in hazel and birch, yet in the two latter taxons the proportion between trunk and branch wood is less obvious. It is also interesting to note that most of the willow charcoal clearly derived from branches (with a diameter of less than 5 cm), suggesting that willow was collected for purposes other than fuel, possibly as wattle.[98] To conclude, all deciduous trees represented by the trunk wood in the charcoal assemblages – oak, ash, maple, hazel and birch – may have been used as construction wood (for example for making posts and pegs or house frames), while willow branches may have been used as wattle or for binding and tying, due to their flexible nature.

Even though we can suggest now what kind of wood might have been used at Keinsmerbrug and for what purposes, the question of its origin remains somewhat problematic. It seems, however, that any earlier attempts to place deciduous trees such as oak, ash, maple or even birch and hazel near the site are complicated by the results of the pollen analysis. Pollen analysis performed on two samples from the wells has shown that the site at Keinsmerbrug was situated in an open landscape.[99]

95 Kooistra 2001.
96 Kooistra 2001.
97 Kooistra 2001.
98 Kooistra 2001.
99 Van Haaster this volume.


Figure 6.5 Naked barley (*Hordeum vulgare var. nudum*) find number 3-1-127.

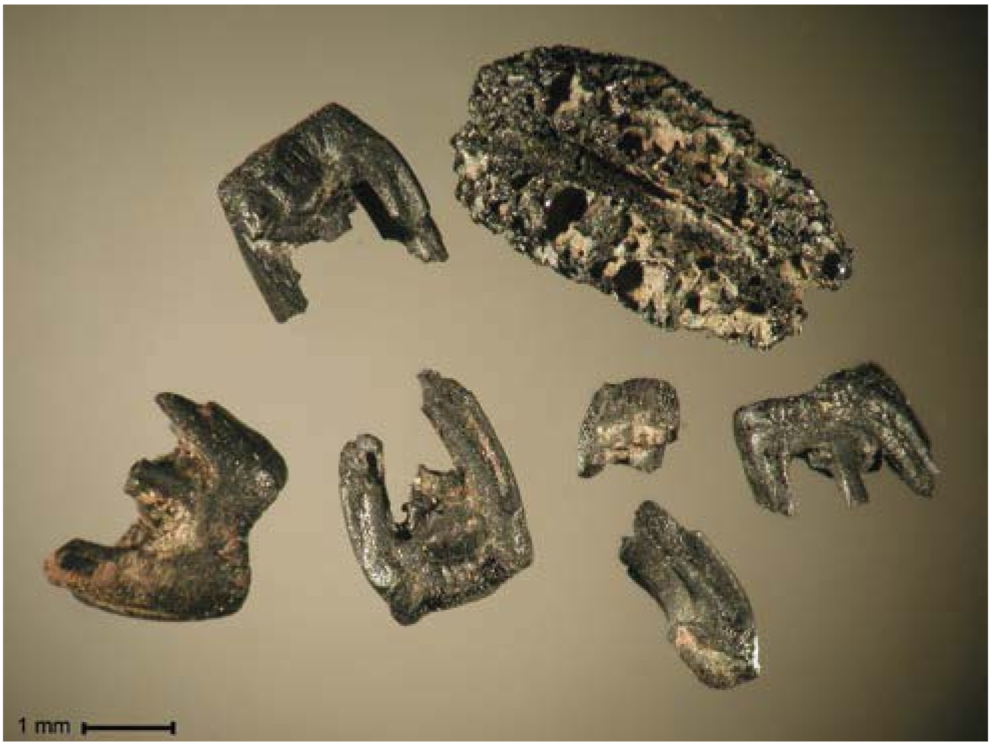



Figure 6.6 Emmer (*Triticum dicoccon*) grain and chaff remains (find number 4-1-416).

Very low percentages of tree pollen suggest that there were no trees nearby, although some may well have grown at higher places further away. One of the possible areas where mixed deciduous forest might have occurred is the Pleistocene sandy soils near Wieringen, some 20 km to the north-east of Keinsmerbrug.[100] Another possible area that might have supported stands of deciduous trees is the peat area south of Zandwerven, some 30 km south of Keinsmerbrug. There is a unique example of a former wetland wood, dating from c. 150 BC to AD 580 at Zwolle-Stadshagen (province of Overijssel, the Netherlands), where open to semi-open woodland with alder, oak and ash, accompanied by willow, elm, maple, birch and hazel, formed on partly mineral and partly organic (peat) substrate.[101] Some measurements – length versus diameter – were taken on waterlogged wood remains from Zwolle (based on remaining trunk length in relation to the trunk diameter). In the case of ash, the maximum trunk length recorded was 8 m, while the maximum diameter was 25 cm; in the case of oak the maximum trunk length recorded was 14.8 m, while the maximum diameter was 30 cm; for alder the maximum trunk length recorded was 6.5 m, with a maximum diameter of 18 cm.

## 6.4 Cereals and other utility plants

### 6.4.1 Cereals

Naked barley (*Hordeum vulgare* var. *nudum*) and emmer wheat (*Triticum dicoccon*) were present throughout the site deposits, and were the only food plants found.

Only small numbers of barley grains were encountered, and except for one charred rachis internode (in square 416), no chaff remains of barley were found (Fig. 6.5). The barley preserved at the site is a naked variety and a free-threshing cereal. Ethnographic studies of crop processing have shown that in the case of free-threshing cereals, threshing by-products from the early stages of crop processing will be found at the sites where this crop was actually grown. The free-threshing cereals would have been transported as naked grain in order to reduce weight and the storage space needed.[102] It seems that transporting whole ears would make sense only when threshing remains were in high demand.[103] The identification of these early stages of crop processing accompanied by the evidence from weed assemblages is crucial in discussions as to whether an archaeological site represents a producer or a consumer site. The absence of barley chaff at Keinsmerbrug suggests that the barley was not processed at the site, which thus favours the argument that it was not grown locally (=in the vicinity of the site). If barley chaff had been present at the site in quantities comparable with grain, this would support the argument for local cultivation.

Naked barley was followed by emmer, but only poorly preserved grains were recorded, and in negligible quantities (single grains in individual samples). Emmer grain was accompanied by chaff remains but again, only a few of these were found (Fig. 6.6). Even though recorded only in small numbers, the chaff remains indicate the presence of semi-cleaned spikelets at the site and suggest that the husking of the grain would have taken place there, presumably before food preparation. The presence of semi-cleaned spikelets of emmer (which unlike barley is non-free-threshing cereal) is not conclusive evidence of local cultivation, but only proves that it was processed at the site.[104] The charring of emmer chaff might be the result of parching the spikelets, but it can also result from occasionally using the threshing residue as fuel.[105]

### 6.4.2 Crop cultivation in brackish environments

Once it had been established that Keinsmerbrug was located in a brackish environment, the question of whether crop cultivation would have been possible near the site had to be addressed. There is experimental evidence to indicate that it is actually possible to cultivate various crops in such an environment.[106] However, a few conditions must be first be met. The fields have to be restricted to the highest parts of the salt marsh, located on natural levees and marsh bars. This location would protect the crops from regular flooding. It would be still difficult,

100 De Mulder and Bosch 1982.
101 Kooistra *et al.* 2006.
102 Hillman 1981, 1984; Jones 1984.
103 Cappers & Raemaekers 2008.
104 Hillman 1981, 1984; Jones 1984.
105 Hillman 1981; Van der Veen 2007.
106 Körber-Grohne 1967; Van Zeist *et al.* 1976.

however, to avoid autumn and winter floods, which are the highest. Therefore, only summer crops (= sown in spring), would have any chance of producing satisfactory yields. The experiments also showed that resistance to brackish influence varies among crop plants. This experimental work has significant implications for the interpretation of archaeobotanical crop and weed assemblages from the Dutch coastal area.[107]

In addition to experimental evidence, archaeobotanical arguments for cultivation of cereals in the coastal area have recently been presented for two Middle Neolithic dune sites, Schipluiden and Ypenburg.[108] At Schipluiden, for example, charred remains of plants characteristic of high salt marshes were found together with cereals and threshing by-products and they were therefore interpreted as potential arable weeds in coastal areas, which in turn suggested that the highest parts of salt marshes or low dunes were viable locations for crop growing.

In the present analysis some individual species deserve additional attention. Plants such as *Althaea officinalis, Apium graveolens*, *Suaeda maritima*, *Aster tripolium*, *Atriplex littoralis* and *Hordeum marinum* are characteristic of high salt marshes and/or drift deposits and are represented by charred remains (though some were also waterlogged). Interestingly, three species from this group (*Althaea officinalis*, *Hordeum marinum* and *Atriplex littoralis*) were found in the same samples that also yielded charred cereal remains, while the other species are not associated in any way with cereal samples. Perhaps these high salt marsh species arrived in the site at Keinsmerbrug together with cereals (as arable weeds). Assuming this to be the case, this would suggest that the fields were located in the high salt marsh area. In the absence of threshing remains of naked barley, however, we have no convincing evidence for local cultivation. This seemingly contradictory evidence might suggest that the cereals found at Keinsmerbrug were not necessarily cultivated locally, albeit still in a coastal environment. The seeds of *Althaea officinalis*, *Hordeum marinum* and *Atriplex littoralis* may have entered the site together with cleaned or semi-cleaned grain products.

### 6.4.3 The spatial distribution of cereals and cereal food products

Since cereal grains and threshing by-products have been found in only negligible quantities, it is difficult to address questions relating to possible activity areas associated with plant processing and food preparation. In two instances, however, the spatial analysis produced some slight spatial patterning that may reflect such activities (see figure 6.7a).[109]

Firstly, there is an area in the extreme north of the site (indicated by squares 353, 416, 417 and 427), where nearly all emmer chaff remains (i.e. husking residues of glume wheat) were found (Fig, 6.7b). They were accompanied by individual remains of emmer grain and charred seeds of potential arable weeds. This area may perhaps be interpreted as a de-husking area for emmer. Emmer wheat was presumably de-husked on a daily basis prior to consumption, and chaff was burnt at the same place.

Secondly, most of the isolated remains of processed cereal food were found in the south-eastern part of the site (the part of the site associated with Area 5a/b and Area 6, see figure 6.7c). This part of the site was therefore perhaps used to prepare plant foods, and cooking and possibly consumption may have taken place in this area.

In the rest of the site cereal remains (mainly grain of barley) are scattered through the site deposits and may represent domestic refuse or cereals lost in food preparation, or perhaps simply settlement noise (as charred remains are dispersed throughout the settlement deposits).

To conclude, the results of the spatial analysis indicate that certain specific activities related to cereal processing and food preparation may have occurred in more than one area of the site; at least the discarded remains of various activities suggest this is so.

107 Van Zeist 1974.
108 Kubiak-Martens 2006; Van Beurden 2008 respectively.
109 Nobles this volume (chapter 10).


Figure 6.7 Botanical interpretation of samples in a spatial context plotted on a map of Keinsmerbrug (a), distribution of cereal grain and chaff (b) and distribution of processed plant remains (c).

## 6.4.4 Wild fruits and nuts, where art thou?

There is a complete absence of wild fruits or berries, hazelnuts or acorns among the remains of both waterlogged and charred assemblages, and there is consequently no evidence for the gathering of wild plant foods. This is surprising, since remains of crab apple, berries, hazelnuts and acorns are present in plant assemblages at a few other Single Grave Culture sites in the area.[110] There may be various reasons for this gap in the remains from Keinsmerbrug. The most obvious reason would be that these plants were not available near the site, though they might have been available within some distance of the site, for example on the sandy soils of Wieringen. Perhaps a better explanation, one that would account for the absence of wild fruits, acorns and hazelnuts, is the possibility that the site was used outside the gathering season for these wild foods (i.e. not during late summer and early autumn). Assuming this to be the case, we may further suggest that this gap in the record might be an indication that the site was not occupied permanently.

## 6.4.5 Gathering of orache (Atriplex spp.) seeds for food?

If an abundance of remains is any measure of the importance of the plant they derive from, then the find of orache (*Atriplex* spp.) seeds deserves to be emphasised. The presence of orache seeds in one of the charred lumps of processed food (see following section) has specific implications for the interpretation of an abundant presence of combined finds of *Atriplex* spp. seeds including *Atriplex littoralis* (Fig. 6.8) and seeds of the groups *littoralis/prostrata* and *patula/ prostrata* throughout the site deposits. It may actually suggest that seeds of various *Atriplex* species were gathered for food at Keinsmerbrug. The dietary potential of the seeds of many chenopods (including *Atriplex* spp.) is enhanced by the fact that they often grow in great abundance, that each plant can produce huge quantities of seeds, and that most of them are also rich in protein. Their potential as food in past human diets has therefore been repeatedly emphasised in the archaeobotanical literature.[111] For example, the seeds of fat hen (*Chenopodium*

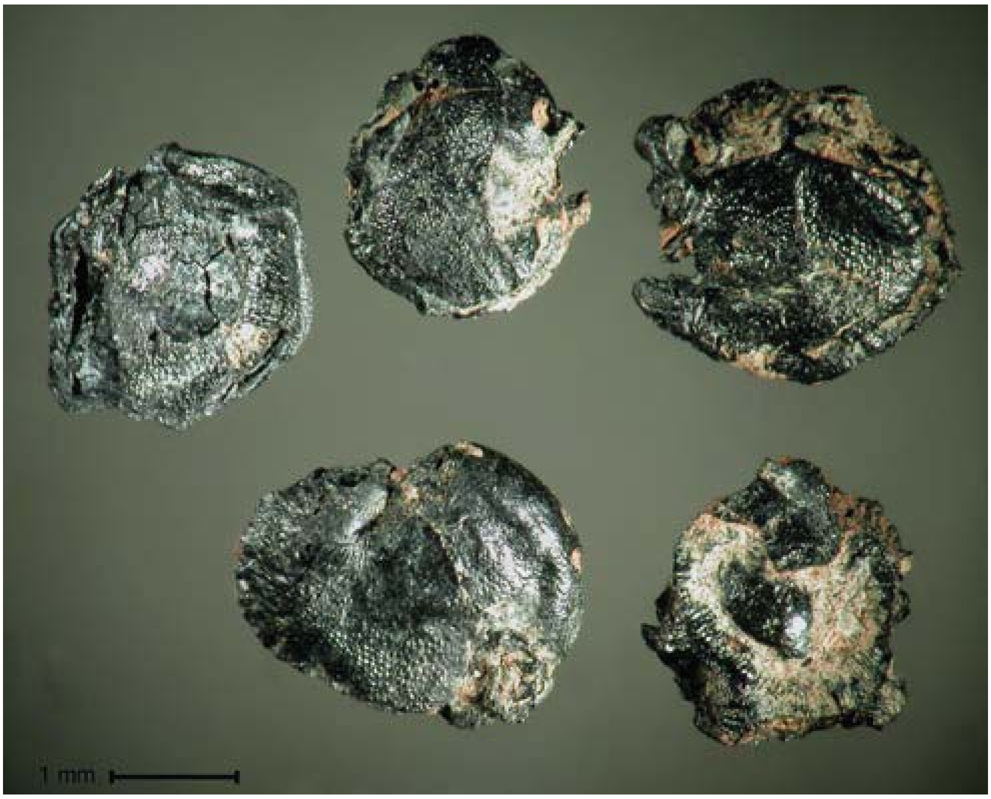



Figure 6.8 Shore orache (*Atriplex littoralis*): (a) charred seeds (find number 3-1-281) and (b) recent plant. Seeds of shore orache were probably gathered for food in Keinsmerbrug.

[110] Pals 1984; Gehasse 2001; Van Smeerdijk 2001.
[111] *e.g.* Moore *et al.* 2000.

*album*), a species related to *Atriplex*, have a high energy yield (414 kcal per 100 g fresh weight) and they are also rich in protein and carbohydrates (16.6 g of protein and 49.6 g of carbohydrate per 100 g fresh weight).[112]

Moreover, many of the chenopods (including *Atriplex*) have succulent leaves, stems and shoots that are also edible. Most of the chenopod seeds (including *Atriplex*) have thick seed coats (testa) which would have to be removed or at least crushed before food preparation. This can be accomplished by parching the seeds in order to make the coats brittle, thus making it easier to release the seeds. After that the seeds would have been ground into flour or mush.[113] In conclusion, the abundant occurrence of charred seeds from the orache group (*Atriplex* spp.) in Keinsmerbrug assemblages, together with their presence in processed plant food (see next section), suggests that various chenopods might have served as a source of food in this Late Neolithic society in a coastal environment.

## 6.5 Processed plant foods

Food preparation in the form of the processing of cereals took place at the site, as suggested by two types of remains: isolated lumps of processed food (Fig. 6.9) and organic residues encrusted on pottery.[114] Two isolated lumps were subjected to both SEM examination and chemical analysis using direct-temperature mass spectrometry (the latter performed by T. Oudemans).

Upon being broken open, one of the organic lumps (find number 3-1-240) revealed embedded fragments of emmer grain (Fig 6.9a&b). Fragmented (crushed?) seeds of orache (*Atriplex*), some identified as *Atriplex littoralis,* were also embedded in the lump matrix (Fig. 6.9c&d ). In addition, stem or leaf epidermis of a herbaceous plant (possibly *Allium*) was also observed in the matrix. The latter could have been used to flavour this mush of emmer grain and orache seeds. Another lump (find number 3-1-289) consisted of cereal grains (possibly barley). Individual grains could occasionally be distinguished. Chemical analysis revealed no traces of organic


Figure 6.9 Processed plant food made of emmer grain and orache seeds (find number 3-1-240), overall view:
(a) SEM micrograph showing fragment of emmer grain embedded in food matrix and;
(b) detail of the grain epidermis showing transverse cell;
(c) orache seed embedded in food matrix;
(d) fragment of seed coat (testa) embedded in food matrix.

112 Kuhnlein & Turner 1991.
113 See *e.g.* Mears & Hillman 2007.
114 Discussed later in Oudemans & Kubiak-Martens this volume.

Figure 6.9 Processed plant food made of emmer grain and orache seeds (find number 3-1-240), overall view:
(a) SEM micrograph showing fragment of emmer grain embedded in food matrix and;
(b) detail of the grain epidermis showing transverse cell;
(c) orache seed embedded in food matrix;
(d) fragment of seed coat (testa) embedded in food matrix.

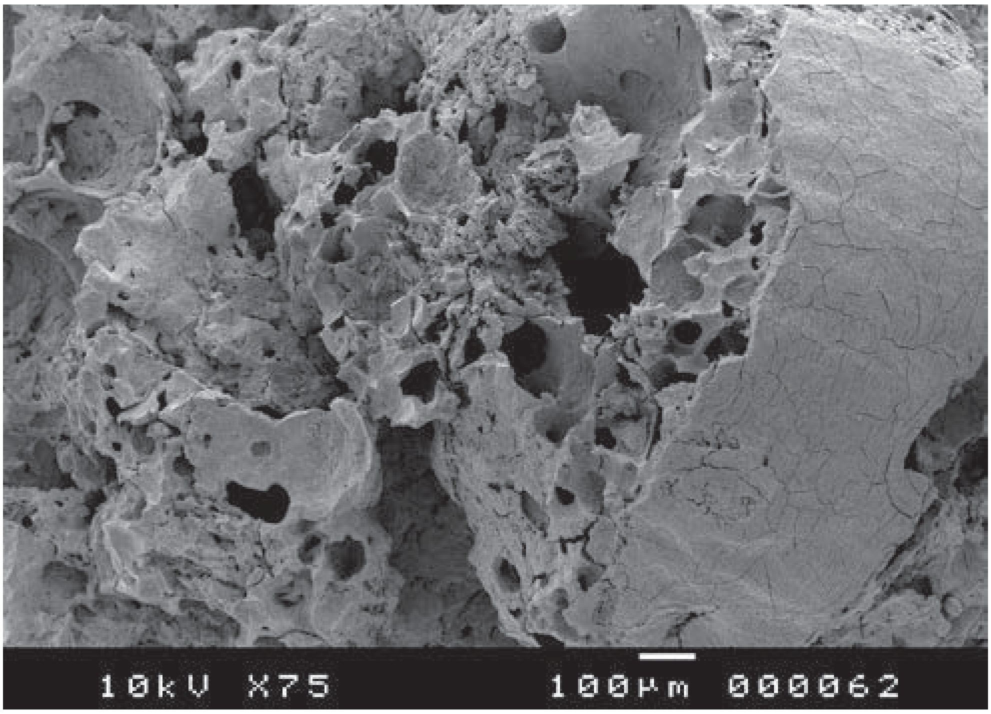



Figure 6.9a

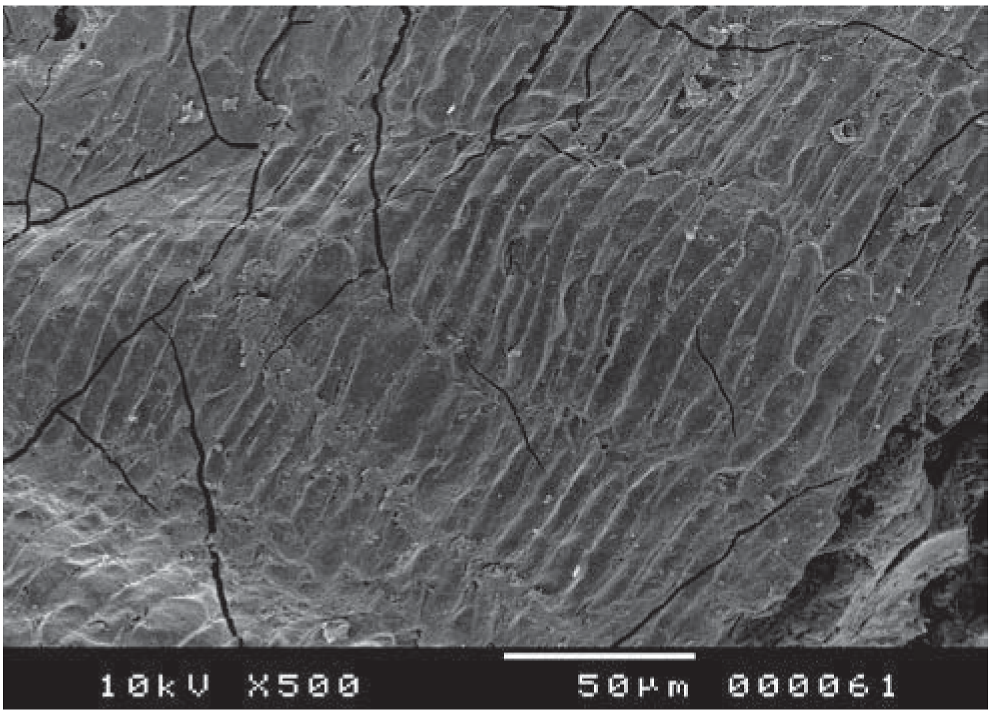



Figure 6.9b

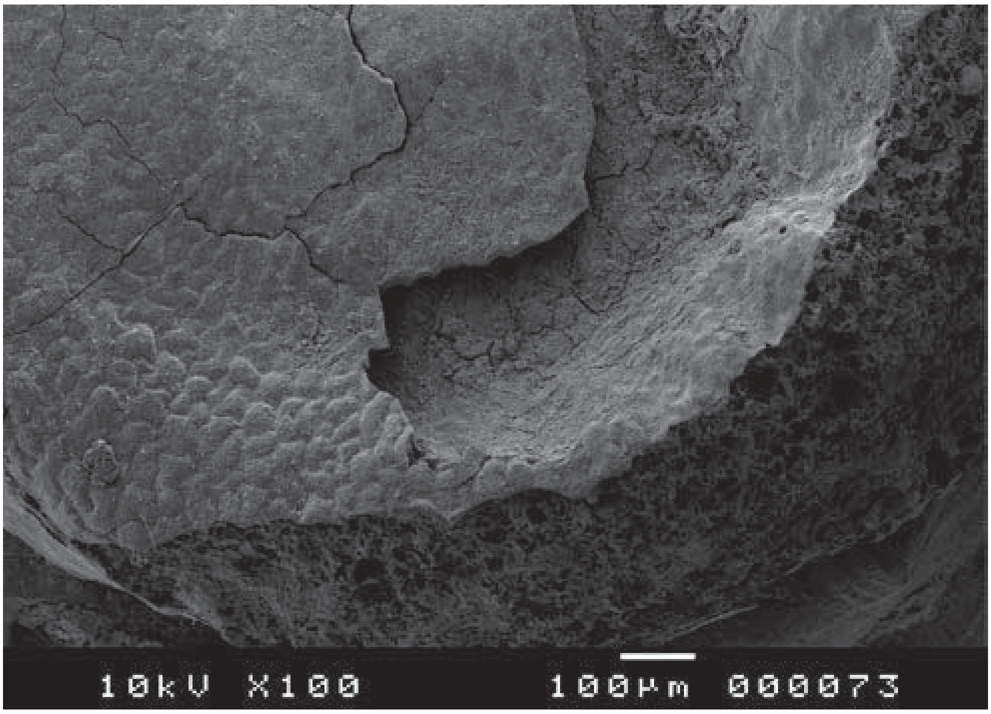



Figure 6.9c

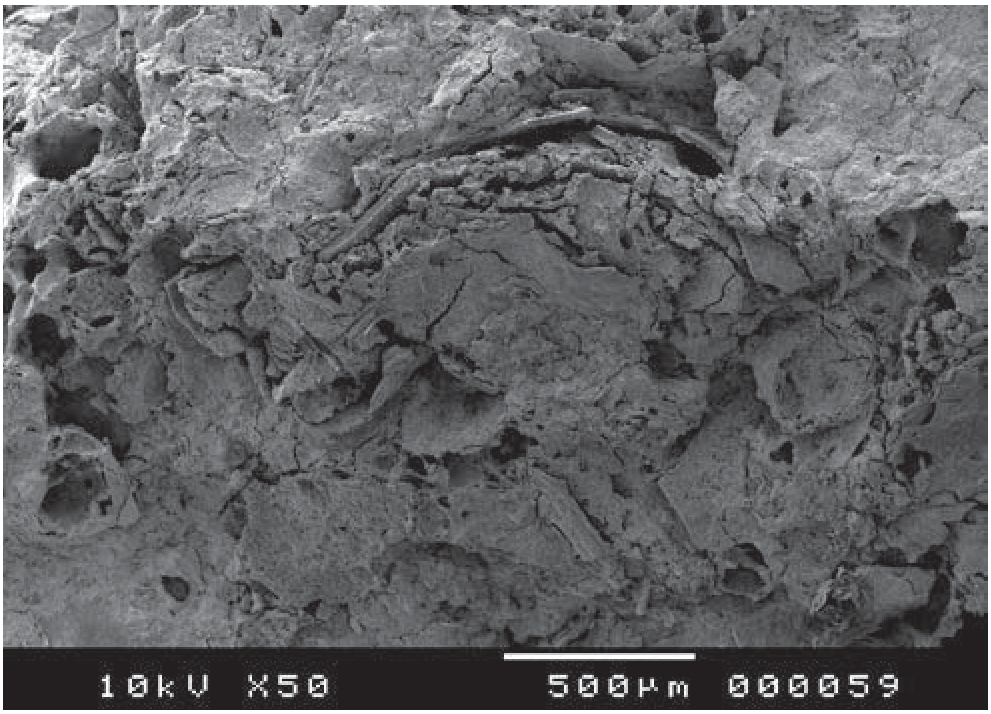



Figure 6.9d

components in these two lumps, or perhaps they were present in quantities too small for a reliable identification of any chemical markers in the samples. This might be explained by the high temperature at which charring had occurred, which was clearly above 250 °C.[115]

## 6.6 Parenchymatous plant tissue

Parenchyma (parenchymatous plant tissue) is a plant storage tissue. It makes up the bulk of soft vegetative organs such as roots and tubers which consist largely of starch-bearing parenchyma. Due to their high concentration of starch, and also other carbohydrates and sugars, roots and tubers are considered a reliable source of human food, and they were gathered for food during early prehistory.[116]

Even though great efforts were made during this project to recover charred parenchyma, they bore little fruit. Charred remains of parenchyma in Keinsmerbrug assemblages derived from plants that were collected for purposes other than food. A number of rhizome fragments studied showed anatomical characteristics of species from the sedge family (Cyperaceae). In the charred remains preserved in sample 3-1-222 (Fig. 6.10 and 6.11), vascular bundles were placed randomly in the stele, and as such they indicate a typical monocotyledonous structure (Fig. 6.11a). Individual bundles were more or less circular in SEM cross section and they were amphivasal concentric in arrangement, with xylem elements surrounding phloem tissue (Fig. 6.11b). The individual bundles were surrounded by fibre tissue (sclerenchyma). In some bundles, phloem tissue was reduced to solid carbon due to the process of charring. Anatomical features of the charred specimens closely matched the characteristics of great sedge (*Cladium mariscus*) rhizomes observed in recent material.

*Cladium mariscus* may have been collected for various reasons. Dry stands may have been collected for fuel but it may also have been used as a material for thatching roofs, for example. Rhizomes that were pulled out together with the stems may have been burnt during accidental or deliberate fires. The seeds of *Cladium mariscus* were also found throughout the site deposits. These may have been brought to the site together with the rest of the plant.

There were a few other remains of charred parenchyma in Keinsmerbrug, but their poor preservation precluded any form of identification.


Figure 6.10 Great sedge (*Cladium mariscus*) charred rhizome fragment (find number 3-1-222).

115 Braadbaart *et al.* 2004.
116 *e.g.* Kubiak-Martens 1999; 2002; 2006; Mason & Hather 2000.

Of some interest perhaps is the fact that although root foods can be collected and consumed throughout most of the year, their highest concentration of stored carbohydrates occurs between autumn and early spring (i.e. before and after the flowering season). It is tempting to speculate whether the gap in root food remains at Keinsmerbrug is due to the fact that site was not used between autumn and early spring.

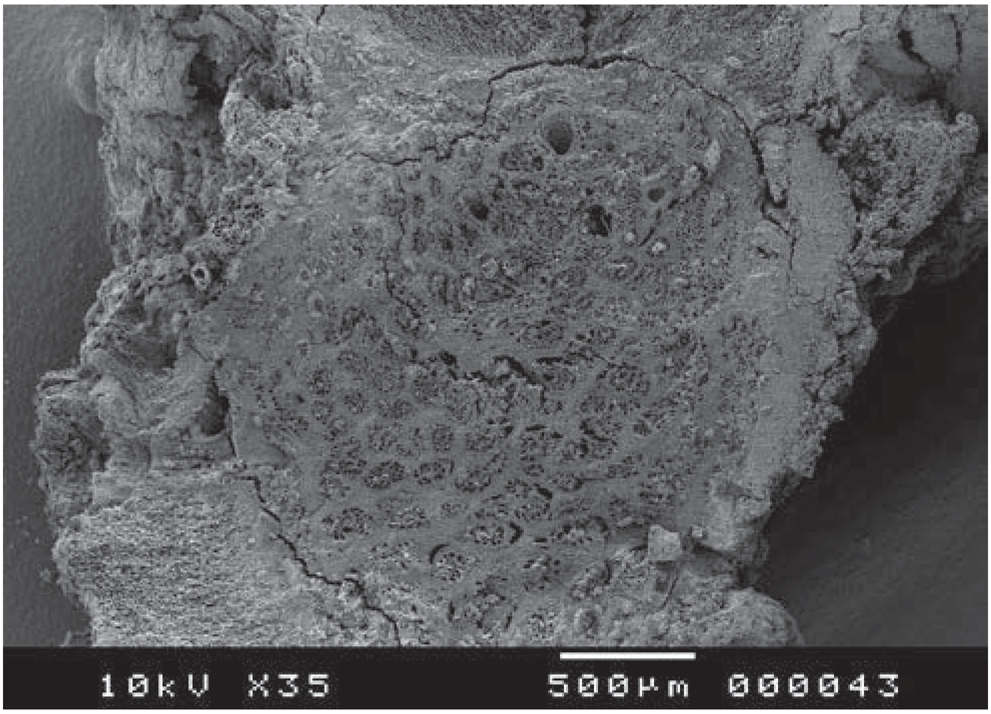



Figure 6.11a SEM micrographs of transverse section through charred *Cladium mariscus* rhizome (find number 3-1-222) :
(a) showing vascular bundles randomly arranged within the parenchymatous tissue;
(b) and individual vascular bundles, amphivasal concentric in arrangement and surrounded by sclerenchyma.

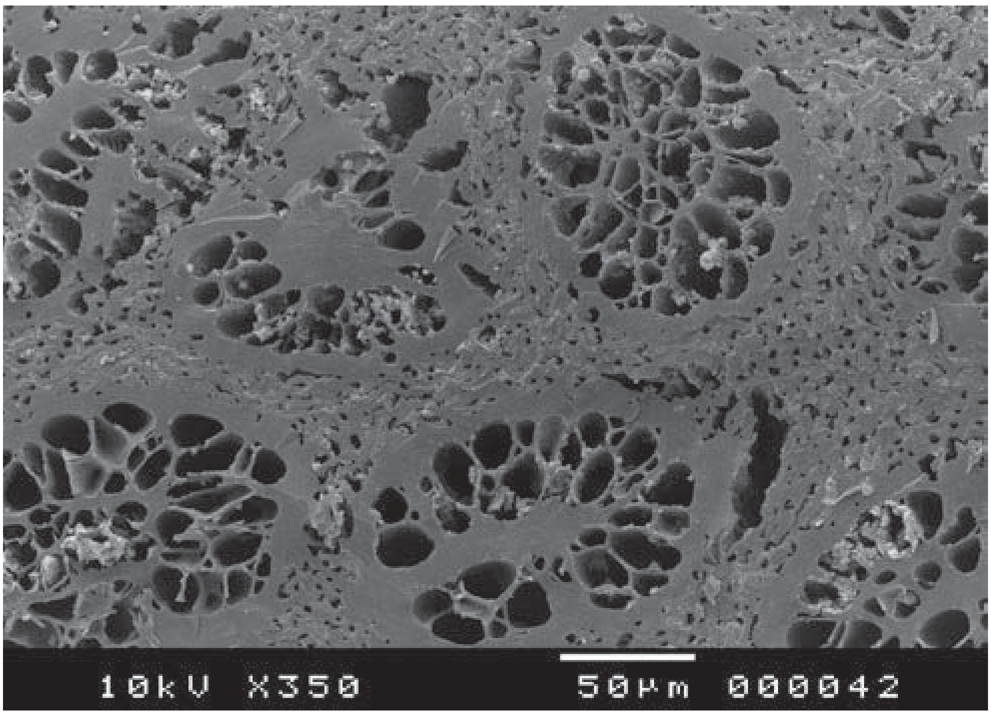



Figure 6.11b

## 6.7 Identifying routes of entry

### 6.7.1 Why did some seeds become charred?

It is not always possible to distinguish the routes of entry for (some) charred plant remains, or an obvious origin.[117] In the Keinsmerbrug assemblages *Salicornia europaea* is an example of a salt marsh plant that is confined to mud flats. The presence of charred seeds found in sampled deposits is puzzling as it is hard to understand how they entered charred seed assemblages. The plant is edible as a green vegetable but must be collected when it is young, long before it forms seeds.

Could *Salicornia europaea*, and perhaps other plants (such as *Aster tripolium*, *Atriplex littoralis*, *Bolboschoenus maritimus*, *Cladium mariscus*, *Phragmites*), have arrived at the site as fuel? The author of this paper would never have considered *Salicornia europaea* as a source of fuel until a recent visit to one of the salt marsh areas in the Dutch province of Friesland where dry, woody-looking stands of *Salicornia europaea* from last season completely covered the lowest part of the salt marsh (Fig. 6.12a). There were also dry stands of other plants, *Aster tripolium* being the most distinctive on the higher part of salt marsh (Fig. 6.12b). This species is also represented in our charred seed assemblage. Could some of these brackish and freshwater-marsh plants have been used as fuel at Keinsmerbrug? It would have been poor-quality fuel, but nonetheless an occasional yet welcome addition to wood, which was far from abundant near the site, located as it was in a tidal landscape.

An alternative explanation would be the use of dung as fuel. There is extensive evidence for the use of dung as fuel in many arid regions, where wood is scarce.[118] In these areas dung is often mixed with straw and chaff and made into dung cakes, which are dried and stored as fuel.

[117] See *e.g.* Van der Veen 2007.
[118] *e.g.* Miller 1984.

No charred remains of dung were found in Keinsmerbrug, however. The question of whether the use of dung as fuel was a tradition in prehistoric temperate Europe as a whole remains open. There are Neolithic sites in Switzerland, Germany and the Netherlands (discussed earlier) where waterlogged or mineralised dung remains were incorporated into settlement refuse. As they were not charred, however, they do not prove that dung was used as fuel, but merely indicate that animals were kept at the site area and were possibly wandering freely through the site. The burning of dung as fuel should not be considered as a possible route of entry for the Keinsmerbrug remains.

Plants such as *Bolboschoenus maritimus*, *Cladium mariscus* and *Phragmites* may also have been collected for various other reasons. Dry stands may have been collected as fuel but also as building material, or for example as thatching for roofs, to make mats, and as insulation material. Eventually these materials may have burnt during accidental or deliberate fires.

## 6.8 Conclusions

The plant remains indicate that Keinsmerbrug was a site where food was consumed, and that it was located in a brackish environment with salt marsh areas nearby. There were also places near the site where fresh water may have accumulated. Pollen spectra have shown that the site at Keinsmerbrug was situated in an open landscape.[119] Very low percentages of tree pollen suggest that there were no trees in the immediate vicinity of the site, although some may well have grown at higher spots further away.

The food crops that were used included naked barley and emmer. Both may have been cultivated in the coastal area, but were probably not grown in the close vicinity of the site. The site has produced assemblages of plant foods composed almost exclusively of cereals. In addition to cereals, the use of orache seeds as

Figure 6.12 *Salicornia europaea* on mud flats near De Westhoek (prov. Friesland), young plants accompanied by last year dry stands (a). And dry last year stands of *Aster tripolium* on the higher part of salt marsh (b). Photographed in May by W. van der Meer.

food has been argued. The presence of food residues encrusted on vessels[120], as well as the isolated remains of processed cereals, indicate that food was prepared and consumed at the site.

Although all samples contained remains of plants of more than one origin, two spatially defined areas within the site appear to have been used for specific activities related to the processing of cereals (de-husking of emmer wheat) and to their preparation and (possibly) consumption. The archaeobotanical data further suggest that Keinsmerbrug represents a site that was occupied seasonally or perhaps even only occasionally, but probably not permanently. This may partly explain the scarcity of plant remains.

If the data from Keinsmerbrug are combined with information generated by other disciplines[121], it appears that the site at Keinsmerbrug was associated with the preparation and consumption of specific foods, namely cereals and meat (principally duck meat), the latter in large quantities. To conclude, Keinsmerbrug may represent a site where specific (social?) activities, accompanied by preparation and consumption of food, took place.

[120] Oudemans & Kubiak-Martens this volume.
[121] Zeiler & Brinkhuizen this volume.

# 7 Palynology

*H. van Haaster*

## 7.1 Introduction

Even though no pollen research was initially planned at Keinsmerbrug, the preservation of waterlogged plant macro-remains in two wells/waterholes (Features 1001 and 1003) inspired the idea of performing pollen analysis on both features. The analyses were carried out with the aim of reconstructing the vegetation around the site during its use and of broadening the information obtained through the analysis of waterlogged plant macro-remains found in both features.

## 7.2 Methods

The pollen samples were prepared by M. Konert of the Laboratory for Sediment Analysis of Vrije Universiteit Amsterdam[122] using Erdtman's acetolysis method, and subsequently analysed under an optical microscope at 400x magnification.[123] Where necessary, identification was carried out at 1000x magnification and/or by phase contrast microscopy. The relative proportions of the various pollen types were calculated on the basis of the total number of pollen grains, including spores of ferns and Sphagnum, the total number of pollen grains and spores counted in each sample constituting 100%. This was done for each type of pollen, spore or other microfossil. The analyses were carried out by M. van Waijjen.

## 7.3 Premises

Palynologists usually assume that pollen analysis of samples derived from anthropogenic features such as wells and ponds will produce results that are less reliable than those based on natural peat deposits. Since anthropogenic features are usually fairly small compared with a lake or other natural water basin, for example, the results of the analysis apply to a much smaller area around the feature (i.e. the pollen catchment area). It is not usually possible to draw reliable conclusions with regard to the composition of the vegetation at distances beyond approx. 500 m of features such as wells. Furthermore, the formation processes responsible for the infill of anthropogenic features can be heavily influenced by human action. All in all, pollen analysis of samples from anthropogenic features is complex and problematic, but in the absence of natural peat deposits or humic soils they are our only source of palaeoecological information. Synthesizing studies of the pollen contents of a large number of wells and ponds in the Eastern Netherlands has shown that, despite these limitations, it is in fact possible to extract valuable information on landscape formation from anthropogenic features.[124]

[122] Faculty of Earth- and Life Sciences.
[123] Erdtman 1960.
[124] Van Haaster 2009.

## 7.4 Results pollen analysis

The results of the pollenanalysis is summarized in the table below (Table 7.1).

Legend:
cf. = resembles (identification uncertain),
+ = found outside the pollen count,
B = identification according to Beug (2004),
P = identification according to Punt *et al.* (1976-2003),
T (followed by number) = Type sensu Van Geel (1976).

### Table 7.1 Keinsmerbrug, results pollen analysis.

| **find number** | **3-2-1003** | **3-2-1001** | **find number** |
|---|---|---|---|
| **BX number** | **4456** | **4457** | **BX number** |
| **totals** | | | |
| sum arboreal pollen (%) | 16.5 | 17.3 | sum arboreal pollen (%) |
| sum non-arboreal pollen (%) | 83.5 | 82.7 | sum non-arboreal pollen (%) |
| trees and shrubs (dry soils) | 11.0 | 14.7 | trees and shrubs (dry soils) |
| trees (wet soils) | 5.5 | 2.7 | trees (wet soils) |
| cultivars | 0.8 | . | cultivars |
| marsh- and wetland species | 2.6 | 2.7 | marsh- and wetland species |
| species of brackish and saline environments | 72.4 | 64.0 | species of brackish and saline environments |
| cryptogams | 7.7 | 16.0 | cryptogams |
| sum arboreal pollen (numerical) | 84 | 13 | sum arboreal pollen (numerical) |
| sum non-arboreal pollen (numerical) | 424 | 62 | sum non-arboreal pollen (numerical) |
| **trees and shrubs (dry/damp soils)** | | | |
| Betula (B) | 3.0 | 1.3 | birch |
| Corylus (B) | 3.1 | 5.3 | hazel |
| Fraxinus excelsior-type (B) | 0.2 | . | ash-type |
| Pinus (B) | 1.4 | 2.7 | pine |
| Quercus (B) | 2.8 | 5.3 | oak |
| Tilia (B) | 0.4 | . | lime |
| Ulmus (B) | 0.2 | . | elm |
| **trees and shrubs (wet soils)** | | | |
| Alnus (B) | 4.7 | 2.7 | alder |
| Myrica gale (B) | 0.8 | . | bog myrtle |
| **cultivars** | | | |
| Hordeum/Triticum-type | 0.8 | . | barley/wheat-type |
| **marshes (freshwater)** | | | |
| Cladium mariscus | 0.4 | . | great fensedge |
| Cyperaceae (B) | 1.6 | 1.3 | sedge family |
| Sparganium erectum-type (P) | 0.4 | . | simplestem/ Branched bur-reed-type |
| Typha angustifolia (P) | + | . | lesser bulrush |
| Valeriana officinalis-type (B) | 0.2 | 1.3 | garden valerian-type |
| **aquatic species (freshwater)** | | | |
| Nuphar (B) | + | . | yellow pondlily |
| **microfossils (water)** | | | |
| Pediastrum | 3.3 | . | green alga, genus Pediastrum |

## Table 7.1 Keinsmerbrug, results pollen analysis.

| find number | 3-2-1003 | 3-2-1001 | find number |
|---|---|---|---|
| **BX number** | **4456** | **4457** | **BX number** |
| Spirogyra (T.130) | 0.2 | . | green alga, genus Spirogyra (T.130) |
| Tetraedron cf. T. minimum (T.371) | 0.6 | . | green alga, Tetraedron cf. T. minimum (T.371) |
| **saltmarsh** | | | |
| Althaea officinalis | 0.4 | . | marshmallow |
| Apiaceae (B) | 0.2 | . | umbellifers |
| Artemisia (B) | 0.2 | . | Artemisia genus |
| Asteraceae liguliflorae | 0.8 | . | ligulate composites |
| Asteraceae tubuliflorae | 1.8 | 5.3 | tubular composites |
| Brassicaceae (B) | 0.4 | 2.7 | crucifer |
| Caryophyllaceae (B) | 0.2 | . | carnation |
| Chenopodiaceae p.p. (B) | 21.1 | 28.0 | goosefoot |
| Cyperaceae (B) (saline thick-walled pollen-type) | 3.5 | . | sedges (saline thick-walled pollen-type) |
| Plantago maritima-type (B) | 0.2 | . | sea plantain-type |
| Poaceae (B) | 25.0 | 24.0 | true grass |
| Poaceae >40 µm | 1.0 | . | true grass, granules >40 µm |
| Potamogeton/Triglochin | 0.6 | . | pond weed/wrrowgrass |
| Ranunculus acris-type (B) (cf. R. sceleratus) | 6.7 | 1.3 | meadow buttercup-type (cf. Cursed buttercup) |
| Senecio-type (B) | 10.0 | 2.7 | ragwort-type |
| Spergularia salina | 0.4 | . | salt sandspurry |
| **microfossils (brackish/saline)** | | | |
| Diatom fragments | 0.8 | ++ | diatoms |
| Hystrichospheridae | 2.6 | 6.7 | cysts of Dinoflagellates (single-celled algae) |
| Podosira stelliger (T.5085) | 7.1 | +++ | diatom of saline/brackish waters |
| **cryptogams** | | | |
| Dryopteris-type | 7.3 | 12.0 | woodfern-type |
| Osmunda regalis | . | 1.3 | royal fern |
| Polypodium | . | 1.3 | rockcap fern |
| Pteridium aquilinum | 0.2 | . | common bracken |
| Sphagnum | 0.2 | 1.3 | peat moss |
| | | | |
| Indet. and varia | 3.0 | . | indet. and varia |
| ∑AP + ∑NAP | 508 | 75 | sum arboreal pollen + sum non-arboreal pollen |

## 7.5 Discussion

### 7.5.1 Environment

Conclusions as to the degree of openness of the landscape around a sampling location are often based on the ratio of tree pollen to non-tree pollen observed in the samples. Experiments involving recent vegetations have demonstrated that the presence of less than 25% tree pollen indicates an open landscape. Rates of 55% and above point to the presence of dense forest, while a score between 25% and 55% suggests open forest cover or a forest edge.[125]

On the basis of these experiments the pollen samples from the wells at Keinsmerbrug, with 16.5% and 17.3% tree pollen respectively, would indicate the presence of an open landscape in the immediate vicinity of the settlement.

Interestingly, in both wells the percentages for most tree species are virtually identical, with those for alder (*Alnus*), birch (*Betula*), hazel (*Corylus*), pine (*Pinus*) and oak (*Quercus*) ranging between 2% and 5%. These percentages are so low that these species are unlikely to have formed part of the vegetation near the settlement. Instead they probably reflect pollen that was transported – by the wind - from a distance of several kilometres away. There were no indications in the samples that transport occurred by water during inundations; in that case more pollen from pine and, more especially, spruce (*Picea*) and silver fir (*Abies*), or pre-quaternary pollen would be expected.

The results of the pollen analysis suggest that herbaceous vegetation near the settlement was dominated by grassland species and a pioneer vegetation, particularly true grasses (Poaceae) and one or more members of the goosefoot family (Chenopodiaceae). Chenopodiaceae are often found in areas affected by human or animal activity, but along the coast, in particular, many species also occur naturally. These include various orache-species (*Atriplex*), annual sea-blite (*Suaeda maritima*), glasswort (*Salicornia*) and saltwort (*Salsola kali*). Unfortunately, their pollen cannot be assigned to a specific species or genus, but macrofossil analysis revealed seeds of common or spear-leaved orache (*Atriplex patula/prostrata*), shore orache (*Atriplex littoralis*), glasswort and annual sea-blite, and most of the *Chenopodium* pollen probably derives from these species (Lucy Kubiak-Martens, this volume). On the other hand, other species identified via macrofossil analysis, such as glaucous goosefoot and/or red goosefoot (*Chenopodium glaucum/rubrum*) and fig-leaved goosefoot (*Chenopodium ficifolium*), are often found in freshwater environments that are affected by the presence of humans or animals. This suggests that not all *Chenopodium* pollen found in the analysed samples derives from natural vegetation, but that some at least was produced by species that prefer anthropogenic environments such as waste dumps and dung heaps, storage facilities and tilled earth.

The grass pollen almost certainly derives from coastal species such as sea barley (*Hordeum marinum*), saltmarsh grass (*Puccinellia* spp.), creeping bent (*Agrostis stolonifera*) and reed (*Phragmites australis*). Macrofossils of all these species were identified (Lucy Kubiak-Martens, this volume). The existence of brackish grassland near the settlement is confirmed by the presence of pollen of marsh-mellow (*Althaea officinalis*), sea plantain (*Plantago maritima*-type) and lesser sea-spurrey (*Spergularia salina*). Pollen of tubular composites (*Compositae Tubuliflorae*) probably derive mostly from sea aster (*Aster tripolium*), and macrofossils of marine diatoms (*Podosira stelliger*) and Hystrichospheridae also suggest a brackish environment. However, *Podosira stelliger* and Hystrichospheridae are not completely reliable indicators of a specific sedimentary environment, since their ability to resist corrosion enables them to remain intact throughout three or even four sedimentation cycles (reworking, sedimentation, reworking etc.). The remains of these organisms may therefore have been embedded in a pre-existing sediment, and they do not necessarily reflect the environmental conditions at the time the site was inhabited.[126]

---

125 Groenman-Van Waateringe 1986, 197.
126 Personal communication by Hein de Wolf.

### 7.5.2 Cultivars and human activity

Only four cereal pollen grains could be identified in the samples (0.8%), possibly from barley and/or wheat (*Hordeum/Triticum*-type). The sample they came from was taken from feature 1003. Although a cereal pollen percentage of 0.8% is very low, most cereals are known to be poor distributors of pollen. The pollen of the two most important prehistoric cereals barley (*Hordeum*) and wheat (*Triticum*) remains trapped inside the husk while the plants are in bloom, only to be released when the grains are being processed. Even pollen samples taken in prehistoric fields usually contain very little cereal pollen. Samples from ard traces in a Bronze Age field, for example, produced a cereal pollen percentage of only 0.28% on average, and samples taken at a distance of 10m from another Bronze Age field produced none at all.[127] Even low percentages such as those at Keinsmerbrug could therefore indicate the presence of agriculture. However, in the case of sites situated in present or former coastal areas this interpretation may be more problematic, since coastal vegetation types tend to include wild grass species that produce pollen identical to the barley/wheat type. Such species include sea barley (*Hordeum marinum*), lyme-grass (*Leymus arenarius*), couch-grass (*Elymus caninus*), sand couch-grass (*Elytrigia juncea*) and marram (*Ammophila arenaria*).[128] Since Keinsmerbrug was situated near the coast, the evidence that the cereal pollen encountered there is the result of local cereal cultivation and/or processing is ambivalent at best.

No pollen of other crop plants was identified. This may not be significant, however, since most Neolithic crop plants such as turnip (*Brassica rapa*), opium poppy (*Papaver somniferum*), pea (*Pisum sativum*) and flax (*Linum usitatissimum*) produce only little and/or atypical pollen.

In short, our pollen analysis has produced no unambiguous evidence of human activity, because most plant species that are usually interpreted as signs of such activity also occur naturally in coastal areas.

## 7.6 Conclusions

Our pollen analysis has shown that the settlement at Keinsmerbrug was situated in a very open landscape. There were no trees nearby, although some may well have grown at higher spots further away. The local vegetation was dominated by grassland and pioneer species, at least in places regularly inundated by brackish water. No reliable evidence of agriculture was produced.

A comparison of the results of our pollen analyses at Keinsmerbrug with those obtained at the Mienakker[129] and Kolhorn[130] sites reveals that the landscape around the site at Kolhorn was also treeless and that the vegetation was dominated by reeds and Chenopodiaceae. On the other hand, the evidence at Kolhorn for a brackish environment nearby was much less convincing than it is at Keinsmerbrug. Unlike the wells at Keinsmerbrug, the single well at Kolhorn did produce a relatively high percentage of cereal pollen (wheat, *Triticum*), i.e. 12%. Interestingly, this well didn't produce any cereal macrofossils. The authors of the Kolhorn publication explain this discrepancy as the result of selective corrosion of any chaff remains in the well. However, other non-carbonised plant remains with similar resistance to corrosion (such as reed, *Phragmites australis*) were well-preserved in the same well. This leaves open the possibility that the 12% pollen of the wheat type derived from a wild grass species that was part of the natural vegetation near Neolithic Kolhorn.

The pollen data from the Mienakker site were based on samples taken from peat deposits near the settlement as well as from habitation layers, both from the same period. These indicated that the landscape around Mienakker was also open. The vegetation near the site seems to have been composed mainly of Chenopodiaceae, grasses and tubular composites (probably sea aster). Chenopodiaceae-type vegetation seems to have been succeeded chronologically by types dominated by grasses and (probably) sea aster. However, these vegetation types also existed side by side, and the people at Mienakker would have lived in a mosaic of freshwater reed marshes, brackish saltwater vegetation (including glasswort) and stands of sea aster, thrift (*Armeria maritima*) and

[127] Van Haaster 2008; Bakels 2000; Hall 1988, 268; Diot 1992.
[128] Beug 2004.
[129] Van Smeerdijk 2001.
[130] Hakbijl, Pals & Troostheide 1989.

common sea-lavender (*Limonium vulgare*). The pollen analyses carried out on samples taken at and near Mienakker produced relatively high numbers of cereal-type pollen. Along a trajectory stretching from Mienakker to the Portelwoid site, 1500 m further to the north-east, an increase in cereal pollen can be observed which suggests that cereals were being cultivated and/or processed at Portelwoid. No evidence was found for cereal cultivation at Mienakker, but the cereals naked barley and emmer wheat may have been stored there.

# 8 Botanical and chemical characterisation of charred organic residues in ceramics

*T.F.M. Oudemans & L. Kubiak-Martens*

## 8.1 Introduction

Ceramic vessels containing encrusted organic residues are an ideal material for archaeobotanical and chemical studies concerning dietary diversity and methods of food preparation. Brown and black crusts are visible on many of the ceramic vessels discovered at Keinsmerbrug. Such residues are studied to find out what foods and non-foods were originally prepared in the vessels. Two powerful techniques are combined in order to obtain the broadest possible range of information on the vessels' original contents. Botanical analysis combined with scanning electron microscopy provides an opportunity to study anatomical features of very small fragments of plant tissue that occasionally survive the process of food and non-food preparation. Chemical analysis can trace components of remaining residues. Lipids, proteins, polysaccharides and plant waxes are among the organic compounds that can be separated and identified using chemical analysis. In the last few years this combined approach has been successfully applied to a number of pottery assemblages from various archaeological sites, resulting in new insights into the site economy and the practices of food preparation.[131] The combination of these two methods helps us understand how people of the Single Grave Culture prepared foods and other materials.

## 8.2 Materials and methods

### 8.2.1 Ceramics

The ceramics from Keinsmerbrug seem to originate from a relatively small number of vessels. Only 19 different vessels could be identified from the count of unique rim fragments.[132] There is a large variety in the ceramics, in terms of wall thickness, tempering materials and decoration. A more detailed description of the ceramics can be found elsewhere in this publication.[133]

### 8.2.2 Sampling the organic residues

The material available for sampling consisted of groups of ceramic fragments packed in plastic bags containing a plastic label indicating a 'pot number' (pot 1 through pot 29). In three bags (referred to here as 'Extra 1'; 'Extra 2' and 'Extra 3') no pot number could be identified. Ceramics had obviously been washed and dried after excavation, and glue could be detected on several fragments. Some bags contained fragments glued together to form partial profiles. Obviously, some earlier work had been done on the ceramics, and fragments had been grouped as individual pots according to the judgement of the researcher. The grouping of fragments was probably based on visual criteria only.

During sampling the original pot number was recorded (Table 8.1). In theory all ceramic fragments given three numbers: pit-number, layer-number and find-number. In practice many of the numbers were unreadable. Sometimes fragments with different numbers are glued together, indicating that that the vessel fragments came from different find numbers. If the original number on the sherd could still be read, it was recorded (Table 8.1). Ceramic studies performed for the purposes of this publication indicated that the original pot numbers were sometimes incorrectly administered, and new vessel numbers were given based on individual vessels based on the rim of base fragments.[134] However, the sampling for residues was performed prior to determination. In addition, all objects from Keinsmerbrug were given a new and unique identification number (UID) as described elsewhere in this publication.[135] The original location where sherds were excavated is indicated (Fig. 8.1). Since the original numbers on the fragments could not always be read, some residues could not be plotted (Table 8.1).

The organic residues were selected after visual inspection by the authors. An attempt was made to obtain residues from as broad a range of ceramics as possible (different pot numbers, from the interior and exterior of vessels, from decorated and non-decorated sherds of the rim, wall and base). The sampled residues are described in Table 8.1, and were photographed prior to sampling (Fig. 8.2 – 8.10).

All residues were firmly adhered to the

131 Kubiak-Martens 2006; 2008; Kubiak-Martens & Oudemans 2008; 2009.
132 Beckerman this volume.
133 Beckerman this volume.
134 New vessel numbers are based on vessel individuals as determined by Beckerman (this volume) see also Appendix II.
135 Nobles this volume (chapter 3) in this volume.

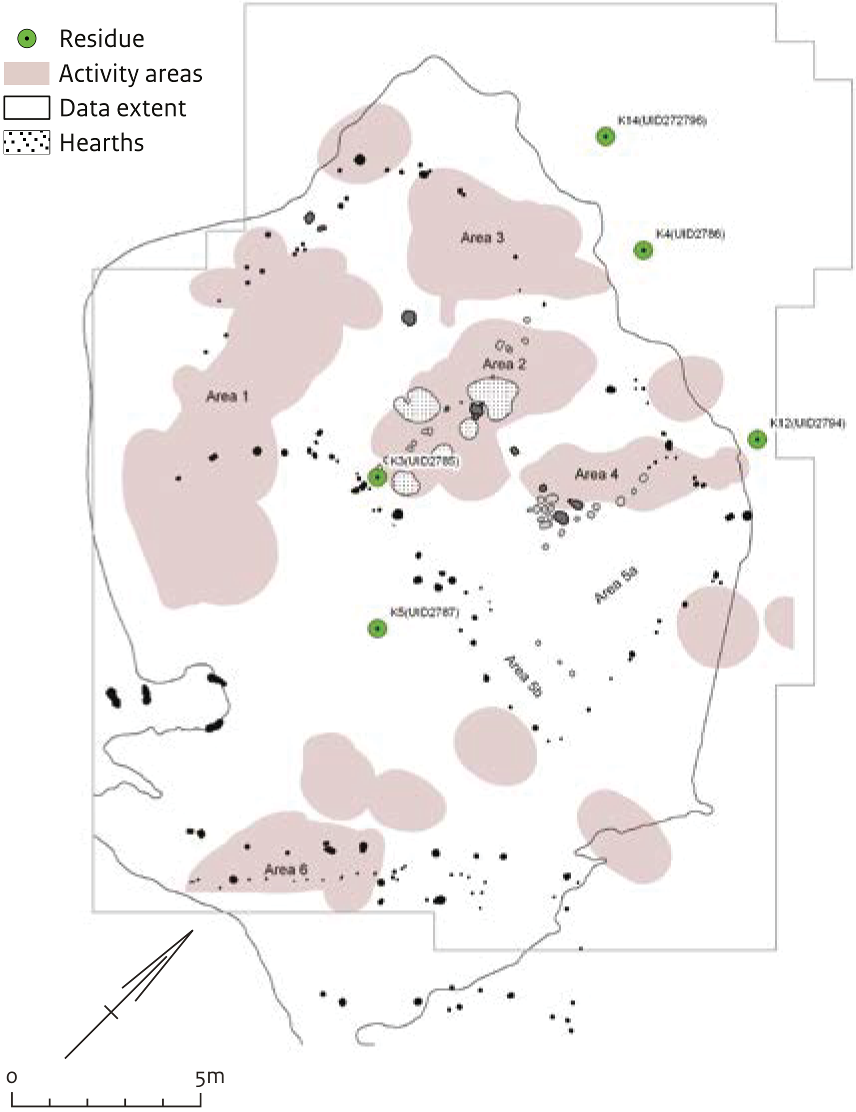



Fig. 8.1 Distribution of sampled residues plotted on a map of Keinsmerbrug.

Fig. 8.2 Residue K1 - view of the interior of a rim fragment from vessel 3 with black residue. The white rectangle shows the location of the sample.

Fig. 8.3 Residue K5 - view of the interior of wall fragments from vessel 21 with black residues. The white rectangle shows the location of sample K5 on fragment 3-1-200 II.

**Table 8.1: Overview of sampled residues from Keinsmerbrug, with description and location of the residues on the vessel. New vessel numbers are based on vessel individuals as determined by Beckerman (Chapter 4).**

| residue nr. | new vessel nr. | orig. vessel nr. | original find nr. | in / ex | rim / wall / bottom | decoration | reside description | UID |
|---|---|---|---|---|---|---|---|---|
| K1 | 3 | 2 | - | in | r | + | soft, brown black (1 mm) | 2783 |
| K2 | 3 | 2 | 4-2-1041 | ex | r | + | hard, black (2 mm) | 2784 |
| K3 | - | 6 | 3-1-140 | in | w | - | soft, black (2 mm) | 2785 |
| K4 | 5 | 10 | 4-1-333 | in | w | + | hard, black (1 mm) | 2786 |
| K5 | 21 | 20 | 3-1-200 II | ex | w | - | hard, black (1 mm) | 2787 |
| K6 | - | 21 | 3-2-1006 | in | w | + | hard, black (<1 mm) | 2788 |
| K7 | 13 | 22 | 4-1-1040 | in | r | - | hard, black (2 mm) | 2789 |
| K8 | 22 | 22 | 01-01-19 | ex | w | - | soft, black (2 mm) | 2790 |
| K9 | 22 | 22 | 01-02-57 | ex | b | - | hard, black (1 mm) | 2791 |
| K10 | 9 | 27 | 01-02-32 | in | r | - | hard, black (2 mm) | 2792 |
| K11 | - | 9+18 | 01-01-10 | in | w | - | soft, brown black (1 mm) | 2793 |
| K12 | 10 | 9+18 | 3-1-136 | in | r | - | hard, brown black (<1 mm) | 2794 |
| K13 | - | extra 1 | - | in | w | - | hard, black (3 mm) | 2795 |
| K14 | 4 | extra 2 | 4-1-384 | in | r | - | soft, black (1 mm) | 2796 |
| K15 | 4 | extra 2 | 3-1-102 | in | r | + | soft, black (3 mm) | 2797 |
| K16 | 8 | extra 3 | 3-1-262 | in | r | + | hard, black (1 mm) | 2798 |

interior wall of the ceramic fragments, and are therefore primarily assumed to reflect an original association between residue and pottery. Whether a residue is truly representative of the original contents of the vessel only becomes apparent after chemical characterisation. Occasionally, remains of soil or plant debris (peat, roots or degraded plant material) firmly attached to ceramic sherds can visually resemble residues. However, such remains are chemically clearly recognisable as secondary contamination. Since no indications of post-depositional contamination were seen, the residues were interpreted as the remains of one of the final use-phases of the ceramic vessels.

Fig. 8.4 Residue K6 - view of the interior of a wall fragment with a black residue. The white rectangle shows the location of sample K6 on fragment 3-2-1006.

Fig. 8.5 Residue K6* - view of the exterior of wall fragments with black residues. The white rectangle shows the location of sample K6* (SEM8 study).

Fig. 8.6 Residue K7 - view of the interior of a rim fragment from vessel 13 with black residues. The white rectangle shows the location of sample K7 (SEM9) on fragment 4-1-1040.

Fig. 8.7 Residue K9 - view of the exterior of various fragments from vessel 22 with black residues. The white rectangle shows the location of sample K9 (SEM11) on fragment 2-1-57.

Fig. 8.8 Residue K13 - view of the interior of various fragments with black residues. The white rectangle shows the location of sample K13 (SEM14).

Fig. 8.9 Residue K15 - view of the interior of three rim fragments from vessel 4 with thick black residues. The white rectangle shows the location of sample K15 (SEM17).

Fig. 8.10 Residue K16 - view of the interior of fragments from vessel 8 with thick black residues. The white rectangle shows the location of sample K16 (SEM18).

**Table 8.2: Overview of botanical results from Keinsmerbrug.**

| sample nr. | SEM nr. | figure | pot | fragment find nr. | in / ex | rim / wall / bottom | results of SEM examination | interpretation |
|---|---|---|---|---|---|---|---|---|
| K1 | SEM 1&2 (ex) | . | 2 | ? | in | r | deteriorated plant tissue | - |
| K2 | SEM 3 | . | 2 | 4-2-1041 | ex | r | deteriorated plant tissue | - |
| K3 | SEM 4 | . | 6 | 3-1-140 | in | w | not clear | - |
| K4 | SEM 5 | . | 10 | 4-1-333 | in | w | very solid crust | - |
| K5 | SEM 6 | 8.11A, B &C | 20 | 3-1-200ll | ex | w | Emmer (Triticum dicoccon) chaff epidermis | cooking emmer grain food |
| K6* | SEM 8 | 8.12 | 21 | 01-02-58 | ex | w | deteriorated emmer chaff epidermis | cooking emmer grain food |
| K6 | no SEM | . | 21 | 3-2-1006 | in | w | . | - |
| K7 | SEM 9 | . | 22 | 4-1-1040 | in | r | deteriorated plant tissue | - |
| K8 | SEM 10 | . | 22 | 01-01-19 | ex | w | not clear | - |
| K9 | SEM 11 | 8.13 | 22 | 01-02-57 | ex | b | deteriorated emmer chaff epidermis | cooking emmer grain food |
| K10 | SEM 12 | . | 27 | 01-02-32 | in | r | very solid crust, not clear | - |
| K11 | SEM 13 | . | 9+18 | 01-01-10 | in | w | deteriorated plant tissue | - |
| K12 | no SEM | . | 9+18 | 3-1-136 | in | r | . | - |
| K13 | SEM 14 | 8.14A & B | extra 1 | ? | in | w | deteriorated emmer chaff epidermis and possible bone remains | cooking emmer grain food |
| K14 | SEM 15&16 (ex) | . | extra 2 | 4-1-384 | in | r | . | |
| K15 | SEM 17 | 8.16A, B & 8.17 | extra 2 | 3-1-102 | in | r | isolated parenchymatous tissue (possible vegetative parenchyma), and possible bone remains(fish?) | cooking (vegetative) parenchymatous food |
| K16 | SEM 18 | 8.15A & B | extra 3 | 3-1-262 | in | w | well preserved emmer chaff epidermis | cooking emmer grain food |

## 8.2.2 Botanical methods

### Scanning electron microscope (SEM) examination

The identification of charred remains of processed plant food such as organic residues encrusted on vessels, remains of bread and cakes, isolated lumps of porridge or mushes made from various plant parts requires use of scanning electron microscopy (SEM). The process of food preparation, which often involves grinding or pounding followed by cooking, destroys much of the morphologically recognisable plant parts. The traditional method of identifying plant macrofossil remains using a binocular microscope is therefore inadequate. An alternative method such as examination under a scanning electron microscope provides an opportunity to explore micro-morphological and anatomical features of very small fragments of plant tissues (for example fragments of epidermis, remains of vegetative tissue, starch granules, elements of vascular tissue) that occasionally survive the process of food preparation and cooking.

### Instruments

The examinations concerned here were carried out at the SEM laboratory at the National Herbarium in Leiden. Specimens of selected organic residues were first detached from the potsherds then mounted on SEM stubs using double-sided carbon tape strips. They were then gold-coated and examined using a JOEL JSM-5300 scanning electron microscope at magnifications of 100 to 2000x. For reliability, different areas of several specimens from each organic residue were examined. The specimens were photographed and described. Sixteen charred organic residues adhering to the interior or exterior surface of ceramic vessels were selected from the Keinsmerbrug pottery assemblage for SEM examination (Table 8.2).

## 8.2.3 Chemical methods

**Organic residue analysis using DTMS**
Direct Temperature-resolved Mass Spectrometry (DTMS) is a powerful tool for the analysis of very small samples of complex solid organic materials. DTMS makes it possible to characterise the complete composition of the material, including both volatile, extractable compounds and non-extractable solid compounds. The chemical DTMS 'fingerprint' gives information about a broad range of compounds interesting to archaeologists, such as:

- lipids (common in fats and oils),
- waxes (as in beeswax or waxy plant leafs),
- terpenoids (major components of resins, pitches and tars),
- poly- and oligosaccharides (components of sugars and starches),
- small peptides and protein fragments,
- polycyclic aromatic compounds (which occur in 'soot' and smoke condensates), and
- a broad range of thermally stable polymeric components (commonly called "charred", or "carbonised" materials).

The DTMS technique basically employs the mass spectrometer to monitor the organic compounds released from a solid sample as the temperature in the sample is increased over time. A very small amount of sample is applied to a platinum/rhodium (Pt/Rh) filament in a suspension and subsequently dried. After the filament is inserted into the DTMS, the sample is heated by passing an electrical current through the filament. The compounds are identified by their masses measured in the MS detector. The DTMS measurement shows the masses of all organic compounds released as a function of time (and thus of temperature, as the temperature is increased during the measurement).

The DTMS measurement lasts roughly two minutes and usually consists of two phases: the desorption phase and the pyrolysis phase.

Desorption phase (roughly scan 25–50): At lower temperatures many extractable, volatile compounds such as lipids (free fatty acids, acylglycerols, waxes and sterols), aromatic compounds (polycyclic aromatic compounds) and resinous compounds (di-and triterpenoid) are released from the solid sample due to evaporation or desorption. Some contaminants such as phthalate-esters and sulphur-containing compounds are also released during this phase.

Pyrolysis phase (roughly scan 55–110): As the temperature increases, non-volatile compounds are released due to thermal fragmentation (breakdown of larger molecules into smaller, indicative fragments). Important compounds that are released in this phase include protein fragments such as small peptides and amino acids. Polymeric compounds of a more condensed nature are also released at this stage. Due to the controlled circumstances in the DTMS (absence of oxygen and controlled temperature increase), fragments are found in a predictable way indicative of the chemical structure of the original compounds.

DTMS techniques have been applied in archaeological research to the study of many complex organic solids such as carbonised grains and pulses,[136] pitches and tars,[137] food remains[138] and other coatings on ceramics.[139] Recent studies performed by Kenaz Consult concern the function of Early Holocene pits at Hattemerbroek,[140] the identification of bark tar in a deposited vessel from a Bronze Age settlement in Wierden,[141] fermented food remains recovered from Roman ceramics in Leidsche Rijn,[142] the determination of birch bark tar as a decorative coating of the shoulder and rim of Gallo-Roman ceramics from Western Belgium,[143] a functional study of an assemblage of early medieval ceramics from Peizermaden[144] and the study of Slavic cooking ware and pitch vessels from the Elbe valley in Germany.[145]

**Sample preparation**
Prior to DTMS analysis a small amount of sample (50 microgrammes) is pulverised and homogenised in a small glass mortar and pestle after addition of 10–50 microlitres of ethanol. A small amount (2-5 microlitres) of the sample suspension is applied to the filament of the mass spectrometer, dried (in a vacuum) and subsequently analysed.

**Instrumental**
The mass spectrometer was a JEOL SX 102-102A tandem mass spectrometer. The following MS conditions were applied: 16 eV electron

136 Braadbaart 2004.
137 Van Gijn & Boon 2006; Kubiak-Martens & Oudemans 2007; Oudemans 2009.
138 Oudemans 2008; 2010.
139 Boon 2006.
140 Oudemans 2007.
141 Kubiak-Martens & Oudemans 2007.
142 Oudemans & Kubiak-Martens 2009.
143 Oudemans 2009.
144 Oudemans 2008.
145 Oudemans 2009.

ionisation voltage, 8kV acceleration voltage, a scanning range of mass *m/z* 20–1000, and a scanning speed of one scan per second. Data were collected and analysed with the use of a JMA7000 data system and appropriate software.

## 8.3 Results

In this paragraph the results from the botanical study are presented, followed by results of the chemical DTMS study.

### 8.3.1 Botany, scanning electron microscope

Six of the selected residues revealed information about their plant composition, which is discussed below. Table 8.2 summarises the results of the SEM examination of all 16 organic residues. Obviously, the plant tissue in the residues has suffered a high level of deterioration. Different charring regimes, and also different methods of food preparation and cooking, can have major effects on residue microstructure and, eventually, on the level of identification possible (an issue discussed later in the text).

**Sample K5 - SEM 6 and 7 (Fig. 8.11 A, B and C)**
A fine layer of organic residue was encrusted on the exterior surface of pottery sherd number 3-1-200 II (originally Pot 20). The crust was fairly solid and had a slightly shiny appearance. Under the scanning electron microscope, small epidermal fragments were observed (approx. 300 x 80 µm in size). They were embedded in a rather fused residue matrix (as presented in Fig. 8.11 C). The epidermal remains show wavy cell pattern characteristic of members of the grass family (including cereals). The individual epidermal cells were approx. 80-120 µm long and approx. 20-25 µm wide (Fig. 8,11 A and B) and as such they match the anatomy of cell patterns observed in recent material from emmer wheat (*Triticum dicoccon*).

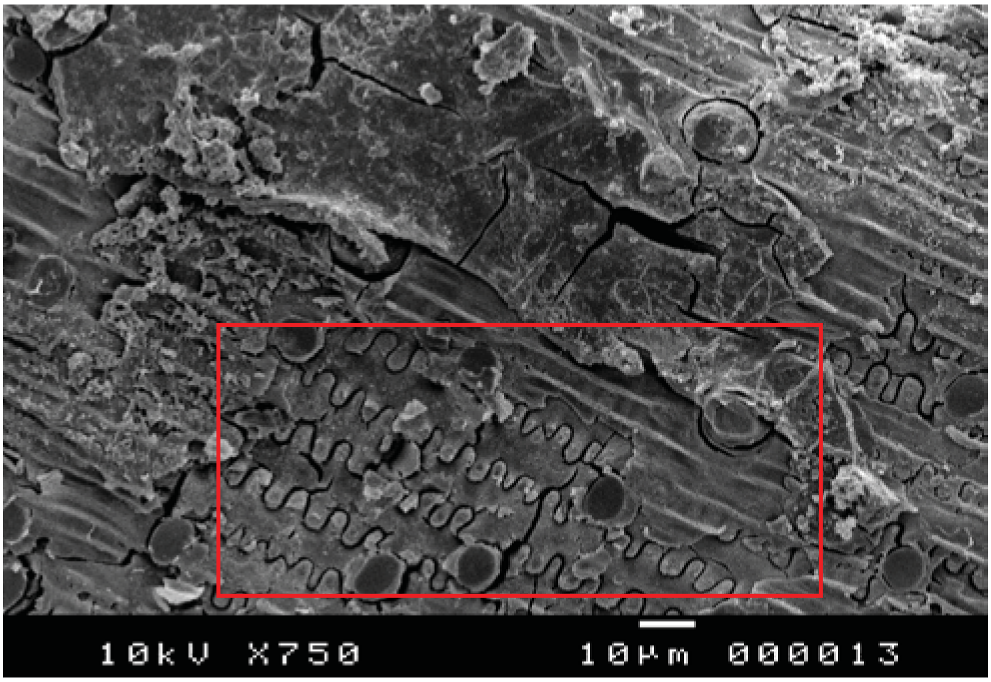



Fig. 8.11 Sample K5 - SEM 6 (find nr. 3-1-200 II, Pot 20). Organic residue showing epidermal tissue of emmer wheat chaff.
A. Overall view (750x);
B. Detail, emmer epidermis embedded in fused residue matrix (1000x).
C. Deteriorated emmer chaff epidermis and fused residue matrix (latter marked by arrow).

Fig. 8.11B

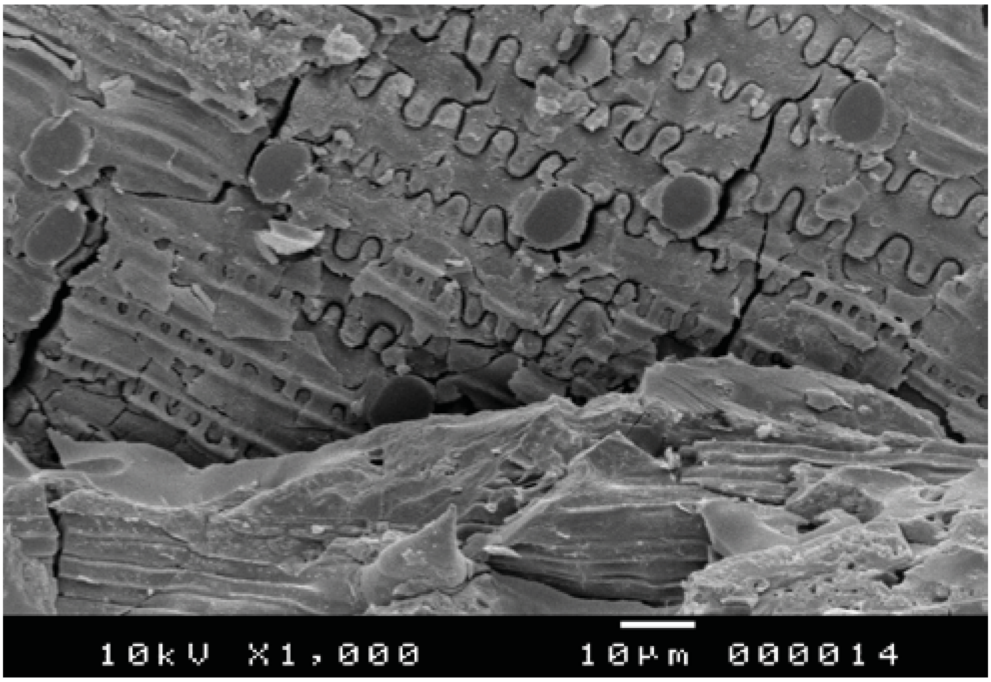
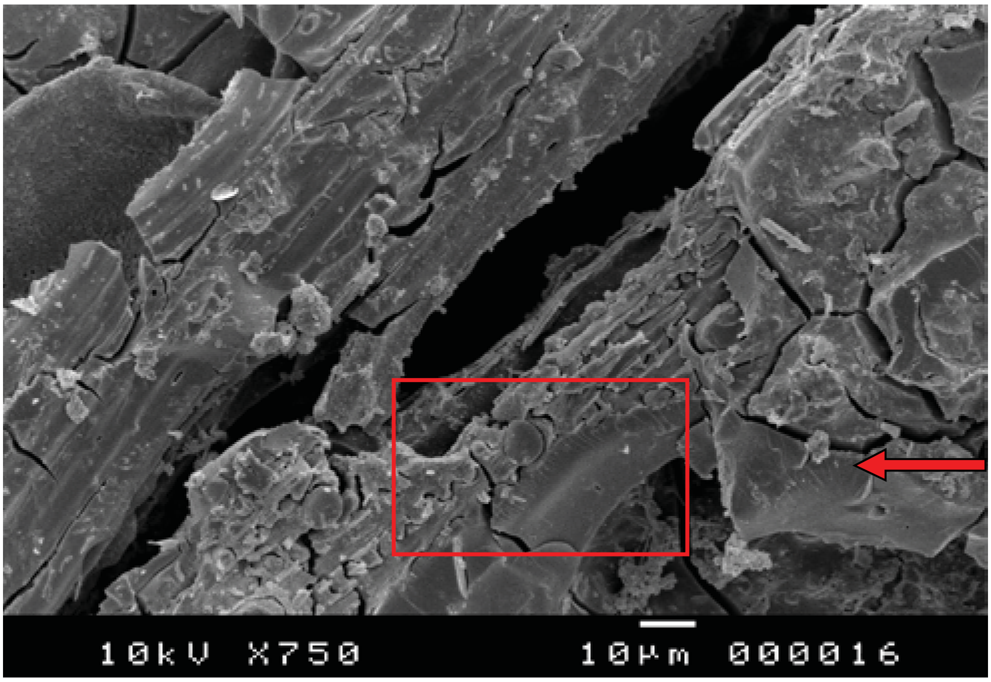



Fig. 8.11C



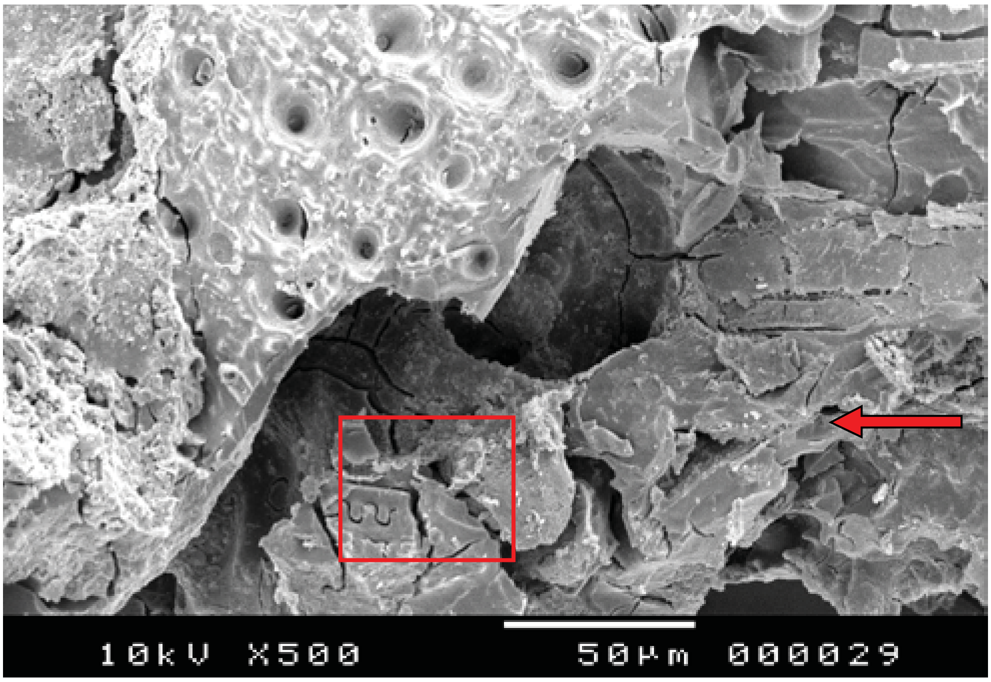



Fig. 8.12 Sample K6* exterior - SEM 8 (find nr. 2-1-58, Pot 21). Organic residue with deteriorated epidermal tissue of emmer wheat chaff embedded in fused residue matrix (latter marked by arrow) (500x). This sample does not originate from the same shard as K6 interior.

**Sample K6* exterior - SEM 8 (Fig. 8.12)**
A thick layer of organic residue was collected from the exterior wall of pottery sherd number 2-1-58 (originally Pot 21). The microstructure of this residue matrix resembles the previous one, being rather solid and somewhat glassy. Plant tissue observed in this residue closely resembles the emmer wheat chaff epidermis embedded in the previous sample, although here poorly preserved epidermal fragments are only approx. 80 x 30 µm in size (Fig. 8.12).

**Sample K9 - SEM 11 (Fig. 8.13)**
A thin layer of fine organic residue, rather solid in structure, was encrusted on the exterior of sherd number 2-1-57 near the bottom (originally Pot 22).

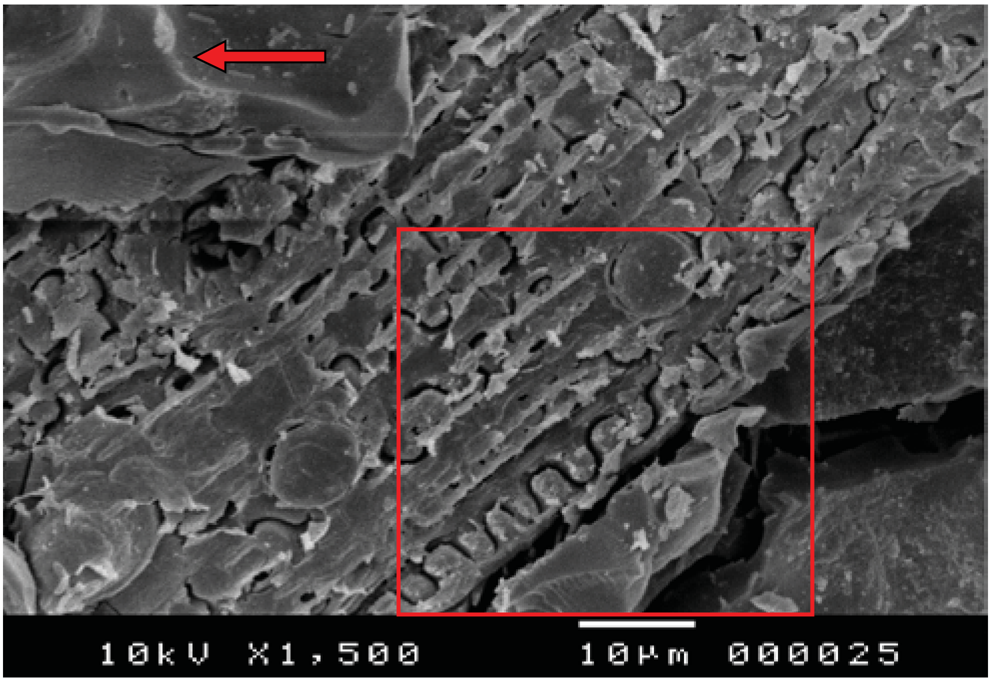
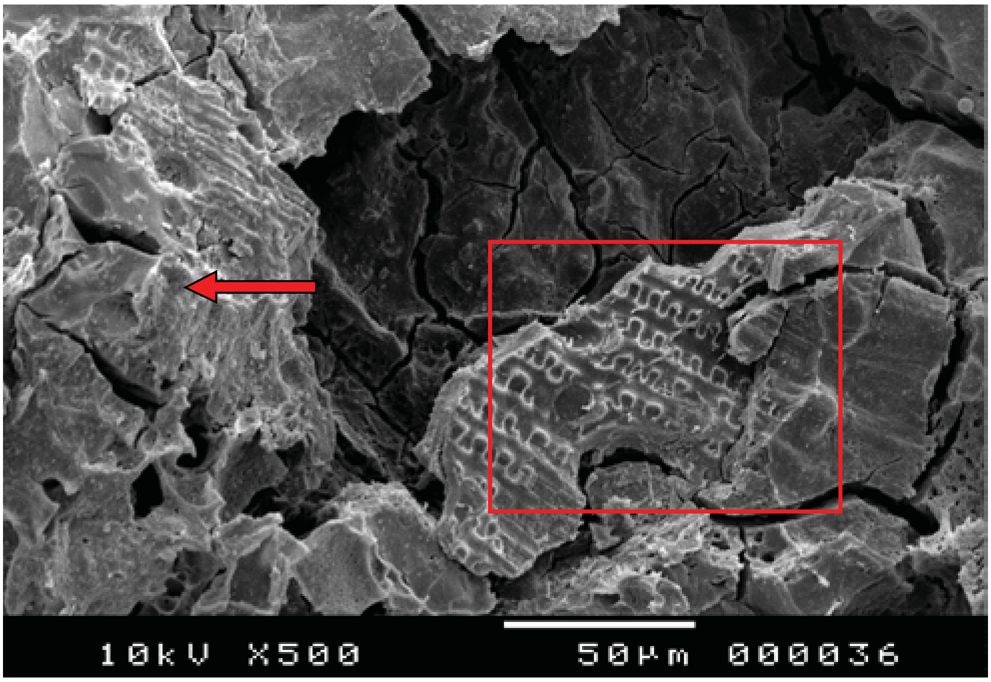



Fig. 8.13 Sample K9 - SEM 11 (find nr. 2-1-57. Pot 22). Organic residue with deteriorated epidermis of emmer wheat chaff embedded in fused residue matrix (latter marked by arrow) (1500x).

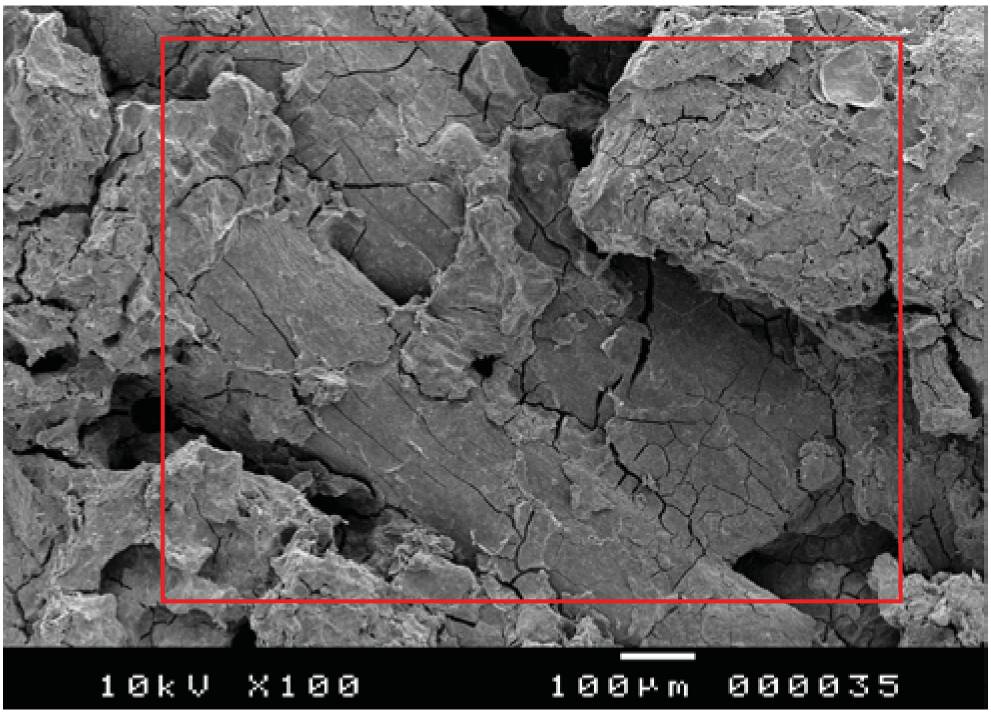
Fig. 8.14 Sample K13 - SEM 14 (Extra Pot 1).
A. Deteriorated epidermal fragment of emmer wheat chaff embadded in fused residue matrix, marked by arrow (500x),
B. Possibly bone fragment embedded in residue matrix (100x).




Scanning electron microscopy found this crust to comprise a featureless fused matrix with small epidermal fragments (approx. 120 x 50 µm in size) of emmer (*Triticum dicoccon*) chaff (Fig. 8.13).

**Sample K13 - SEM 14 (Fig. 8.14 A and B)**
One of the pottery sherds associated with Extra Pot 1 provided a thick organic residue encrusted on the interior surface. Under a scanning electron microscope a fairly solid microstructure of residue matrix was observed with small and deteriorated epidermal fragments of emmer chaff embedded within it (approx. 100 x 80 µm in size) (Fig. 8.14 A). Interestingly, in addition to the

Fig. 8.14B



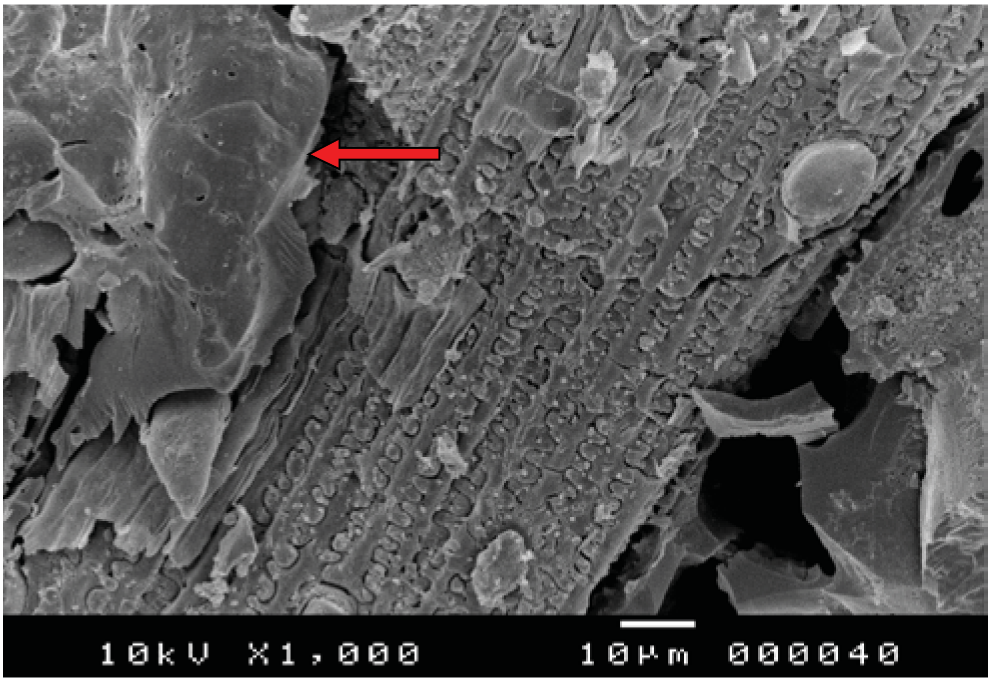



Fig. 8.15 Sample K16 - SEM 18 (find nr. 3-1-262). Organic residue with well preserved epidermal fragments of emmer wheat chaff embedded in completely fused residue matrix (latter marked by arrow).
A. Overall view (1000x),
B. Detail (2000x).

plant component, there were also small fragments embedded in the residue matrix which could originate from (animal/fish) bone (Fig. 8.14 B).

**Sample K16 - SEM 18 (Fig. 8.15 A and B)**
A thick layer of rather solid crust was collected from the interior surface of pottery sherd number 3-1-262 (originally Extra Pot 3). Under a scanning electron microscope this crust was found to comprise a featureless fused matrix with small yet well-preserved fragments of epidermal tissue of emmer chaff (*approx.* 200 x 50 µm in size) (Fig. 8.15 A and B).

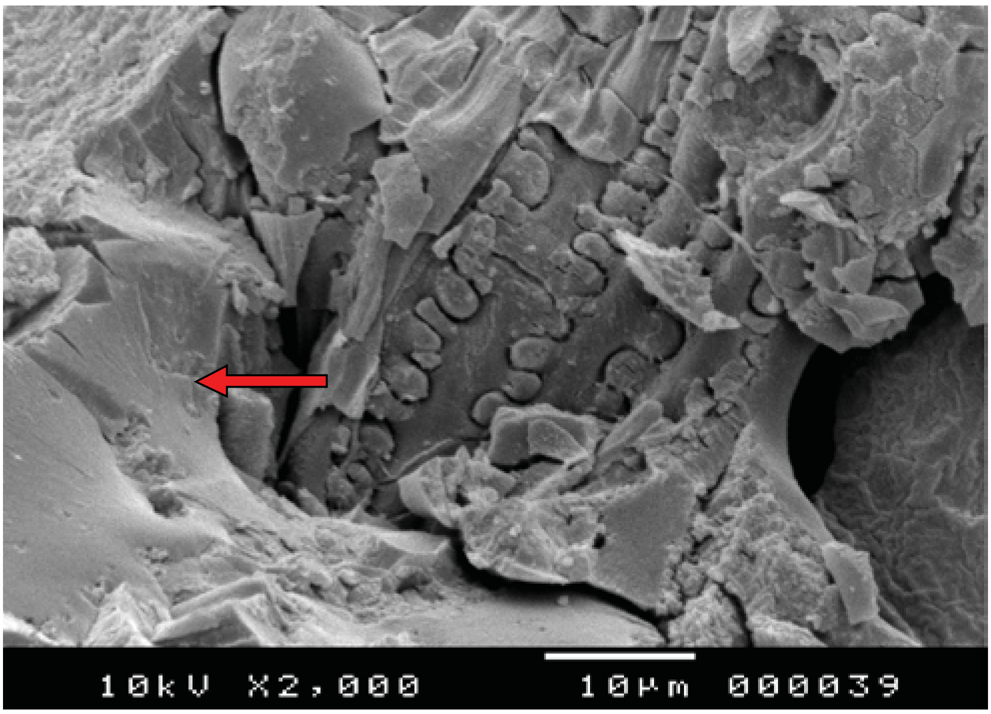
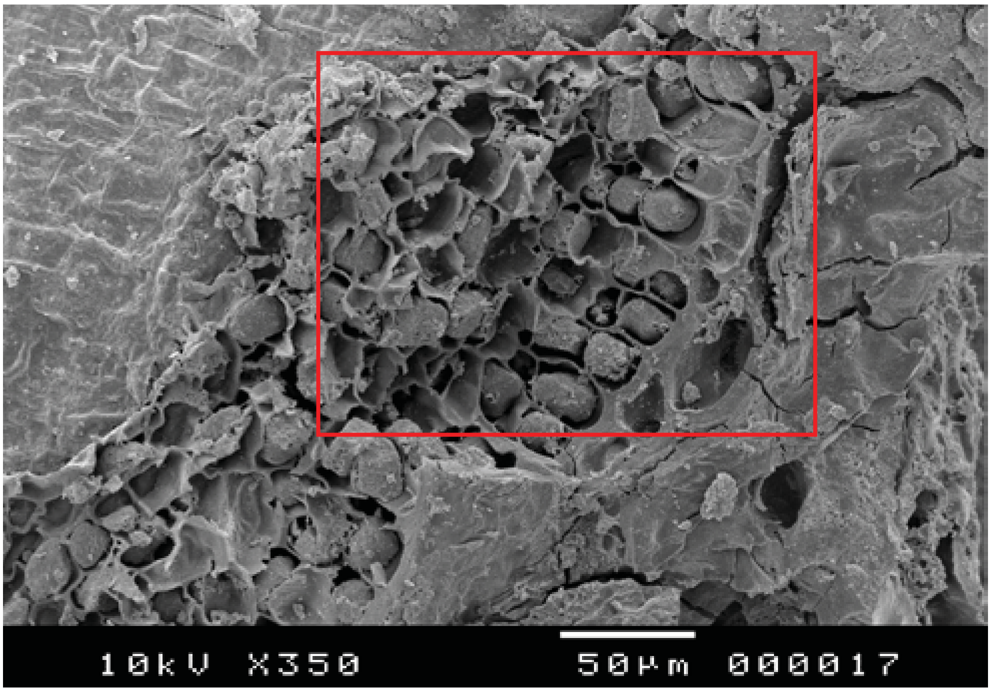


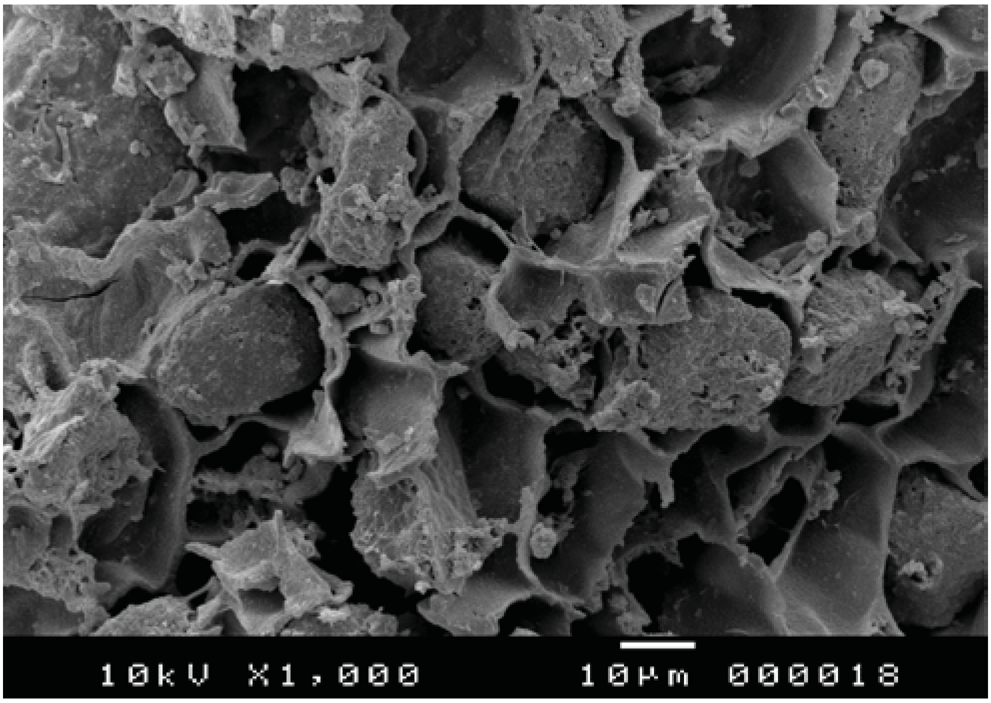

Fig. 8.15B

Fig. 8.16 Sample K15 - SEM 17 (Extra Pot 2). Organic residue with isolated fragment of parenchymatous tissue embedded in residue matrix.
A. Overall view (350x),
B. Detail, parenchyma cells (1000x).




**Sample K15 - SEM 17 (Fig. 8.16 A, B and 8.18)**
A thick layer of rather irregular coarse organic residue was encrusted on the interior surface of pottery sherd associated with Extra Pot 2. Under a scanning electron microscope this residue was found to contain fragments of parenchymatous tissue embedded in the matrix (Fig. 8.16 A and B). In general, parenchymatous tissue (or parenchyma) constitutes the bulk of soft vegetative and non-vegetative plant organs. Many roots, tubers, fleshy stems and also fruits are composed largely of parenchyma. In this residue a small fragment of parenchymatous tissue was preserved as thin-walled, irregular to

Fig. 8.16B



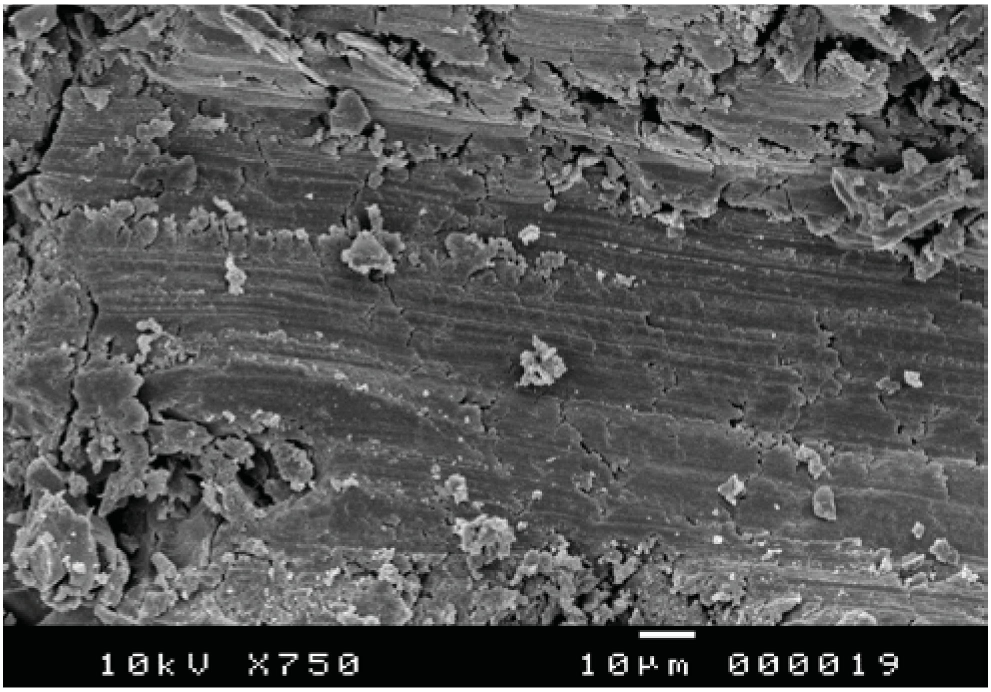



Fig. 8.17 Sample K15 - SEM 17 (Extra Pot 2). Organic residue with possible fragment of fish bone embedded in residue matrix (750x).

rectangular cells 20 to 25 µm across. Unfortunately, isolated fragments of parenchyma cannot be identified to species or even family solely on the anatomical grounds of parenchyma cells. Detailed identification requires the presence of vascular tissue associated with parenchymatous tissue. A different area of the same residue contained fragments of possible fish bone remains embedded in the residue matrix (example shown in Fig. 8.17).

The identification was based on comparison between possible bone surface observed in the residue matrix and the reference material of charred fish vertebra bone recovered from one of the botanical samples with find no. 3-1-186 (Fig. 8.18).

**Discussion of botanical results**

One characteristic feature of the organic residues is the presence of small to tiny fragments of chaff epidermis from emmer wheat (*Triticum dicoccon*) embedded in the residue matrix. It is assumed that these epidermal remains derive from fine emmer chaff rather than from other material such as emmer straw. Perhaps the most plausible explanation for the presence of emmer chaff in organic residues, not only at Keinsmerbrug but also in other assemblages,[146] is the fact that emmer is a hulled (or glume) wheat. In this particular kind of cereal a hard/woody chaff is firmly fused to the grain. A special processing method such as parching or pounding is required to release the grain from the chaff.[147]

It is actually not surprising that even in a 'cleaned' emmer grain product, some fine chaff remains might have survived both grain processing (dehusking) and subsequent cooking. The presence of emmer chaff in organic residues suggests that these residues originate from a food that was at least partly prepared from emmer grain. Emmer and naked barley were the two cereal crops used at the Late Neolithic site at Keinsmerbrug and there is botanical evidence for the dehusking of emmer grain at the site.[148]

A recent study of starch microstructure in experimental and archaeological charred cereal food remains demonstrated that, under some conditions, a distinctive cooked starch structure survives the charring process[149]. Unfortunately, in the Keinsmerbrug assemblage no individual starch granules of emmer grain endosperm survived the cooking and subsequent charring process.[150] The only evidence of their earlier existence is now demonstrated by a completely fused residue matrix. In other words, the residue matrix is made of distorted starch granules which, through the process of cooking (and possible subsequent charring), fused into a consistently glassy matrix (clearly visible in Figs. 8.11 C, 8.13, 8.15A and B).

146 Kubiak-Martens 2008.
147 Hillman 1984.
148 Kubiak-Martens this volume.
149 Valamoti *et al.* 2008.
150 Cereal caryopses (grain) largely consist of starchy endosperm.

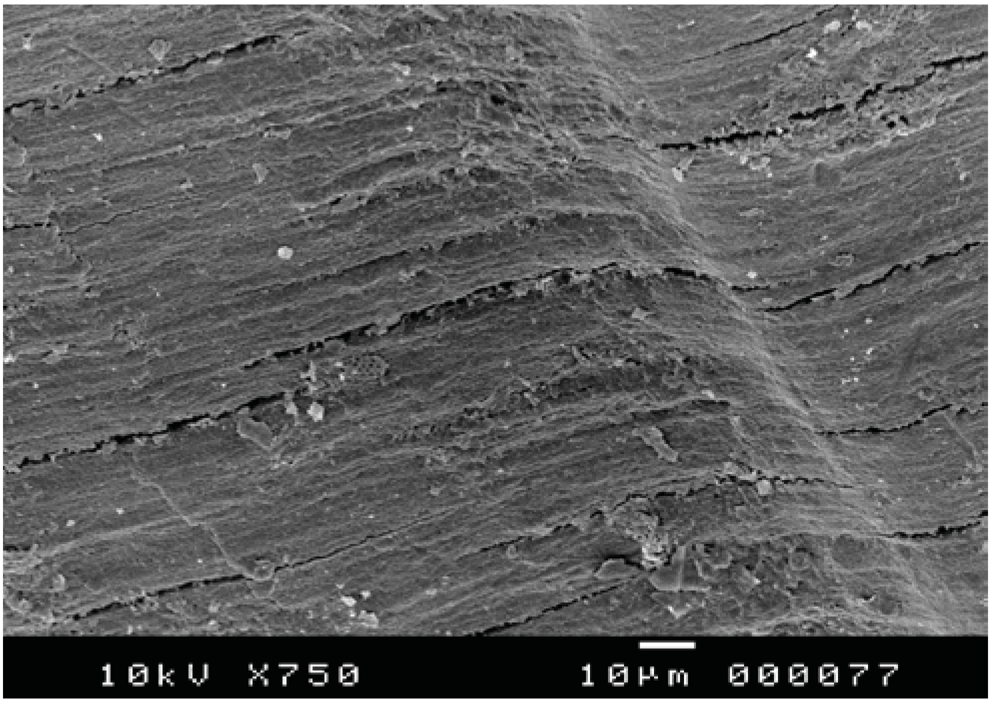



Fig. 8.18 Surface of charred fish vertebra bone. The vertebra bone has been recovered from Keinsmerbrug botanical sample (find nr. 3-1-186) and here used as reference material (750x).

## 8.3.2 Chemical results

The results of the DTMS analyses are presented in mass spectra (Figs. 8.19 – 8.29) and summarized in Table 8.3. Only four of the residues from Keinsmerbrug presented a signal that was high enough to make a significant interpretation of the original material (Table 8.3). Three samples showed a medium-high signal indicating traces of organic compounds. All other residues from Keinsmerbrug presented such low signals that no significant interpretation could be made of the original material involved. Since the organic residues with the highest signals presented a relatively similar chemical profile, only two of the well-preserved samples are discussed in detail below to illustrate the findings.

**Sample K1 (DTMS-code TO11jan2010009)**
The DTMS Total Ion Current (TIC) of sample K1 shows a signal of high intensity (62.106) indicating that the residue contains a relatively large amount of organic material (Fig. 8.19). The TIC shows a peak in the pyrolysis phase area B (scan 70-85) with a large 'shoulder' in the high temperature area C (scan 95-120) increasing in intensity to the end of the measurement. The combined peak in areas B and C is broad and occurs at a relatively high temperature, indicating a complex inhomogeneous polymeric fraction that is highly condensed (due to extensive thermal degradation). In desorption phase area A (scan 30-70), no significant increase or 'bump' is visible in the TIC intensity[151], indicating a lack of significant amounts of volatile compounds in the residue.

The mass spectrum (Fig. 8.20) of desorption area A (scan 30-70) shows mass peaks indicative of various different classes of chemical compounds. Small amounts of free fatty acids (red arrows) are visible in the mass spectrum. Free fatty acids are recognisable as *m/z* 256 and 284 for C16:0 and C18:0 and much smaller peaks at *m/z* 264 and 280 for the unsaturated fatty acids C18:1 and C18:2 or C18:1(OH) respectively. There are no indications of the presence of intact di- or triacylglycerols (*m/z* 551, 579, 607). A small amount of cholesterol can be detected (*m/z* 368, 386). The presence of high peaks (green arrows) originating from sulphur-containing compounds such as elementary sulphur (*m/z* 64, 128, 160, 192, 224, 256) is also significant. The most likely explanation for their presence is contamination with organic compounds from bacterial activity in the soil. The mass spectrum also shows some contaminating compounds such as phthalates (*m/z* 149, 179) and the organic solvent used to apply the residue to the probe (ethanol is shown

[151] The intensity of the Total Ion Current (TIC) is a measure of the amount of organic material present in the sample. H (= high) is defined as a minimum of 80 x the intensity of a base measurement; M (= medium) is 20 to 80 x the value of a base measurement; and L (= low) is less than 20 x the intensity of a base measurement.

**Table 8.3: DTMS results of residues from Keinsmerbrug (The Netherlands). The absence or presence of indicators for various classes of chemical compounds is indicated, and a short description of the original material is given.**

| Sample nr. | DTMS code 11 jan 2010 | TIC | Tot. int. | lipids | | | proteins | | polysaccharides | | sterols | contamination | description of material |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | S FA | U FA | DG TG | PP | P Ch | PS | PS Ch | | | |
| K1 | 9 | 84<br>110 | H (62) | +++ | + | - | +/- | +/- | + | + | +/- A | S | highly carbonised mixture of animal fat and starch. |
| K2 | 11 | 78 | L (1) | ++ | - | - | - | - | - | - | - | - | - |
| K3 | 12 | 79 | L (1) | ++ | + | +/- | - | - | - | +/- | - | - | - |
| K4 | 14 | 79<br>115 | L (6) | ++ | - | - | - | - | - | - | +/- | S, K | - |
| K5 | 15 | 76 | L (1) | +/- | - | - | - | - | - | - | - | - | - |
| K6 | 16 | 78 | L (2) | ++ | +/- | +/- | +/- | + | - | - | + | - | - |
| K7 | 20 | 80 | H (67) | +++ | + | +/- | - | - | - | + | ++ A | S, K | medium carbonised mixture of animal fat and starch |
| K8 | 24 | 76 | L (4) | + | - | +/- | - | - | - | - | - | | - |
| K9 | 25 | - | - | - | - | - | - | - | - | - | - | K | potassium contamination |
| K10 | 26 | - | - | - | - | - | - | - | - | - | - | K | potassium contamination |
| K11 | 32 | 79 | M (15) | ++ | - | + | - | - | - | - | ++ A | K | traces of animal lipid and starch |
| K12 | 33 | 77 | M (16) | ++ | - | +/- | - | - | - | - | + A | K | traces of animal lipid and starch |
| K13 | 39 | 80 | H (42) | ++ | - | - | - | - | - | + | + A | S | highly carbonised mixture of animal fat and starch. |
| K14 | 40 | 81 | L (8) | + | - | +/- | +/- | +/- | - | - | +/- A | K | - |
| K15 | 41 | 80 | M (15) | + | - | - | - | - | - | +/- | +/- A | K | traces of animal lipid and starch |
| K16 | 47 | 79 | H (27) | ++ | +/- | +/- | - | - | + | + | +/- A | K | medium carbonised mixture of animal fat and starch |

by the presence of *m/z* 45).

The mass spectrum (Fig. 8.21) for pyrolysis area B (scan 70-85) still shows indicators of saturated and unsaturated fatty acids (similar to those in the desorption-phase) but also shows an additional series of peaks (pink arrows) associated with mildly heated hexose polymers (*m/z* 98, 110, 126, 144). Such markers have been shown to originate from mildly heated polysaccharides.[152] Residues from archaeological contexts do not often feature these indicators of well-preserved polysaccharides and usually only show the most durable and condensed polysaccharide remains. Clearly, mildly heated polysaccharides were preserved within a matrix of highly carbonised polysaccharides.

Indicators of highly condensed polysaccharides can be seen in the mass spectrum (Fig. 8.22) of high-temperature area C (scan 95-120). In this mass spectrum the same markers for heated polysaccharides (250 – 310 °C)[153] can still be seen (violet arrows) as alkylated benzenes (*m/z* 92, 106, 120, 134), alkylated benzofurans (*m/z* 132, 146, 160, 174) and alkylated phenols (*m/z* 108, 122). Highly condensed aromatic structures indicative of severely thermally degraded polysaccharides (heated to over 300 °C for more than two hours), can be seen as an envelop of masses (even higher than odd masses) above mass *m/z* 200.[154]

Only trace amounts of markers for amino acids or thermally degraded proteins can be seen in this residue (*m/z* 117, 131). Clearly, proteins do not account for a significant proportion of the vessel's contents.

In summary, residue K1 shows a mildly to severely heated polysaccharide matrix, mixed with some saturated (and some unsaturated) free fatty acids, cholesterol and a trace of heated proteins.

Tot. Int.: Total intensity of the TIC signal during the analysis;
SFA: Saturated Fatty Acids;
UFA: Unsaturated Fatty Acids;
DG: diacylglycerols
TG: triacylglycerols;
PP: proteins and peptides;
PCh: indicators for charred proteins;
PS: Polysaccharide markers;
PS Ch: markers for condensed polysaccharides;
Cont: Contamination such as: S for Sulphur containing compounds and K for Potassium.

[152] Pastorova *et al.* 1993 ; 1994.
[153] idem
[154] idem

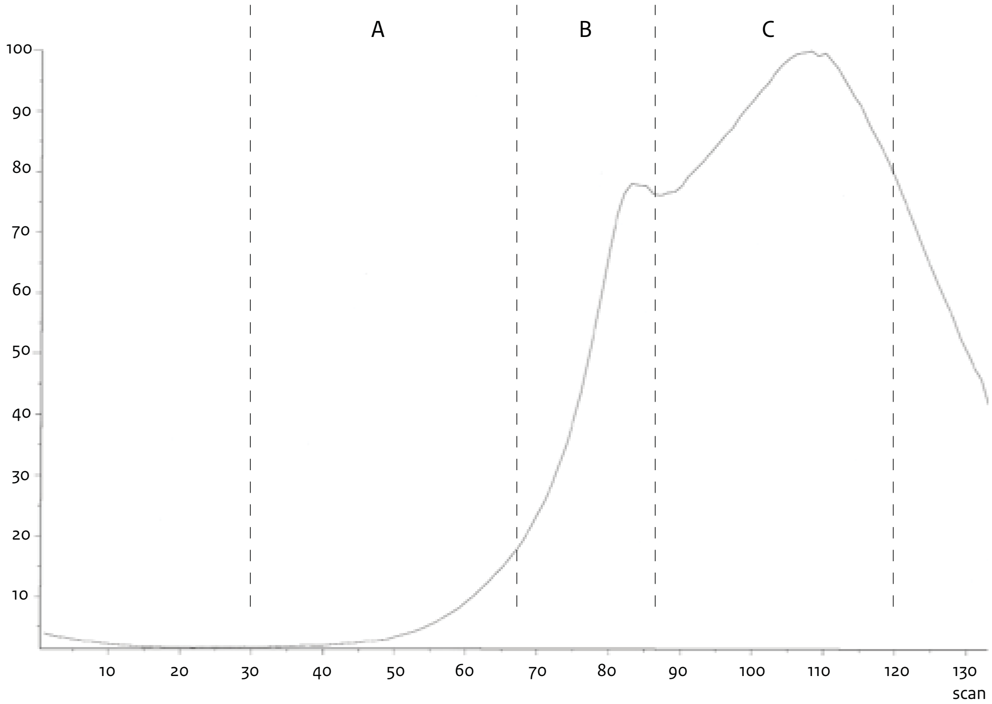



Fig. 8.19 This image shows the TIC of residue K1: showing a combined peak in the pyrolysis-phase (area B, scan 70-85) and the High-temperature area (area C, scan 95-120) and a desorption-phase (area A, scan 30-70) which shows now obvious increase in intensity.

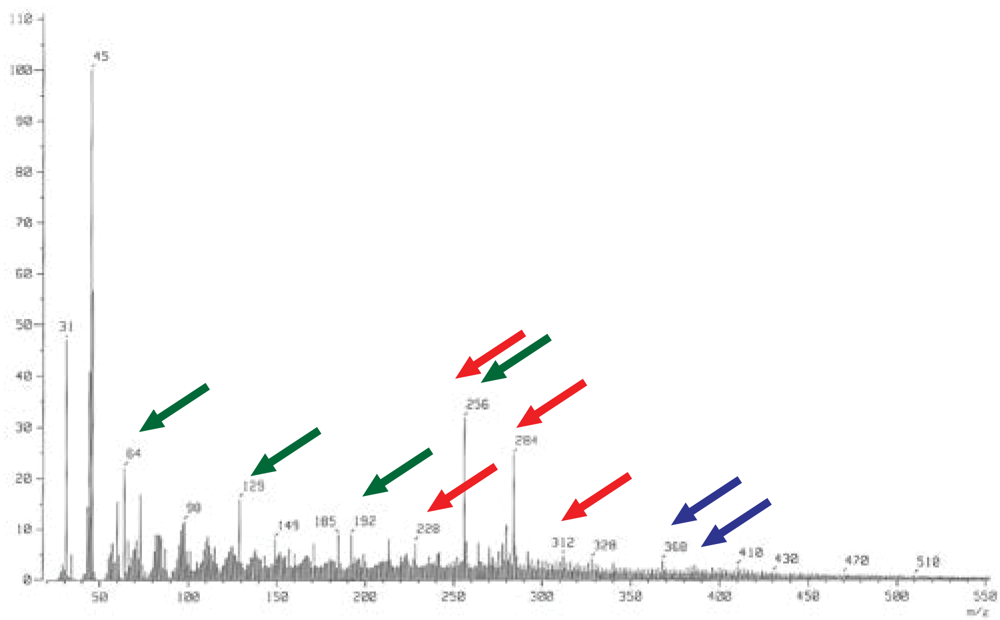



Fig. 8.20 Mass spectra of residue K1: The desorption-phase A is being characterised by the presence of saturated and unsaturated fatty acoids (red arrows), cholesterol (blue arrows) and sulphur-containing compounds (green arrows).

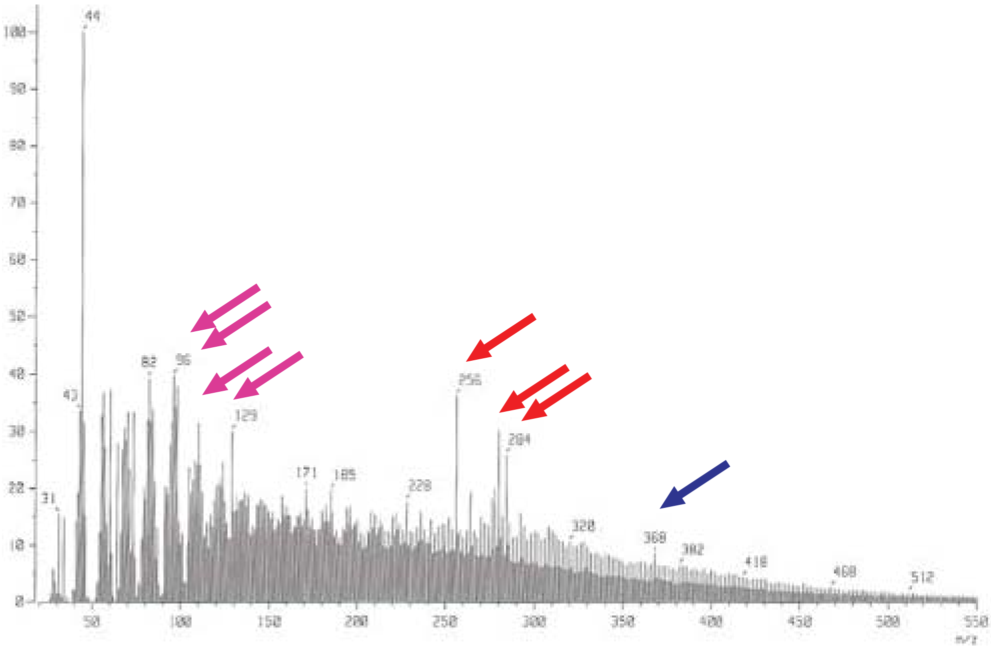



Fig. 8.21 Mass spectra of residue K1 (ceramic fragment UID: 2783): The pyrolysis-phase B (scan 70-85) shows indicators for charred polysaccharides (pink arrows), saturated and unsaturated free fatty acids (red arrows), and cholesterol (blue arrows).

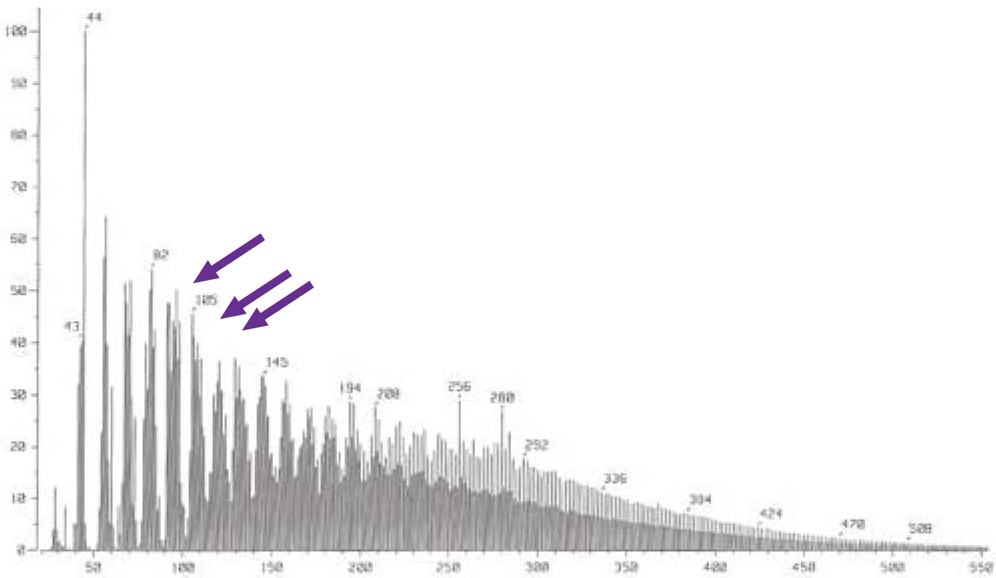



Fig. 8.22 Mass spectrum of residue K1 (ceramic fragment UID: 2783): High-temperature phase C (scan 95-120) shows indicators for a polysaccharide-char (violet arrows).

**Sample K13 (DTMS-code TO11jan2010039)**
The DTMS Total Ion Current (TIC) of sample K13 shows a signal of high intensity (42.106) indicating that the residue contains a relatively large amount of organic material (Fig. 8.23). The TIC is comparable to that of residue K1, but shows a peak in pyrolysis phase area B (scan 75-88) with a much less pronounced 'shoulder' in the high temperature area C (scan 95-120). This indicates that the residue contains less highly condensed material. The peak in area B (at scan 80) is still broad but occurs at a lower temperature, indicating a complex polymeric material of a less condensed nature (due to less extensive thermal degradation).

The mass spectrum (Fig. 8.24) of desorption area A (scan 35-60) shows mass peaks indicative of various different classes of chemical compounds. Small amounts (intensity peaks of 5-10%) of saturated free fatty acids (red arrows) are visible in the mass spectrum. Free fatty acids are recognisable as *m/z* 256 and 284 for C16:0 and C18:0. The indications of the presence of intact di- or triacylglycerols (*m/z* 551, 579, 607) are so low in intensity that they can be disregarded. A small amount of cholesterol (intensity peak of 2-3%) can be detected (*m/z* 368, 386). Peaks originating from sulphur-containing compounds such as elementary sulphur (green arrows) and from contaminating compounds such as phthalates (*m/z* 149, 179) and ethanol (*m/z* 45) are again visible in the spectrum.

The mass spectrum (Fig. 8.25) for pyrolysis area B (scan 75-88) still shows indicators of some small amounts of saturated fatty acids (similar to those in the desorption phase) but also shows an additional series of peaks (violet arrows) belonging to markers for heated polysaccharides. Alkylated benzenes (*m/z* 92, 106, 120, 134), alkylated benzofurans (*m/z* 132, 146, 160, 174) and alkylated phenols (*m/z* 108, 122) overlap to form patterns of high even masses and low odd masses typical of a heated (250–310 °C) polysaccharide matrix.[155] In residue K13 these compounds are better preserved than in residue K1, so the extent of thermal degradation is probably less than in residue K1.

No markers for amino acids or thermally degraded proteins were detected. Clearly, proteins were not part of the vessel's contents, or they have been degraded selectively.

In summary, therefore, residue K13 shows a mildly to severely heated polysaccharide matrix, mixed with a very small amount of saturated free fatty acids and cholesterol.

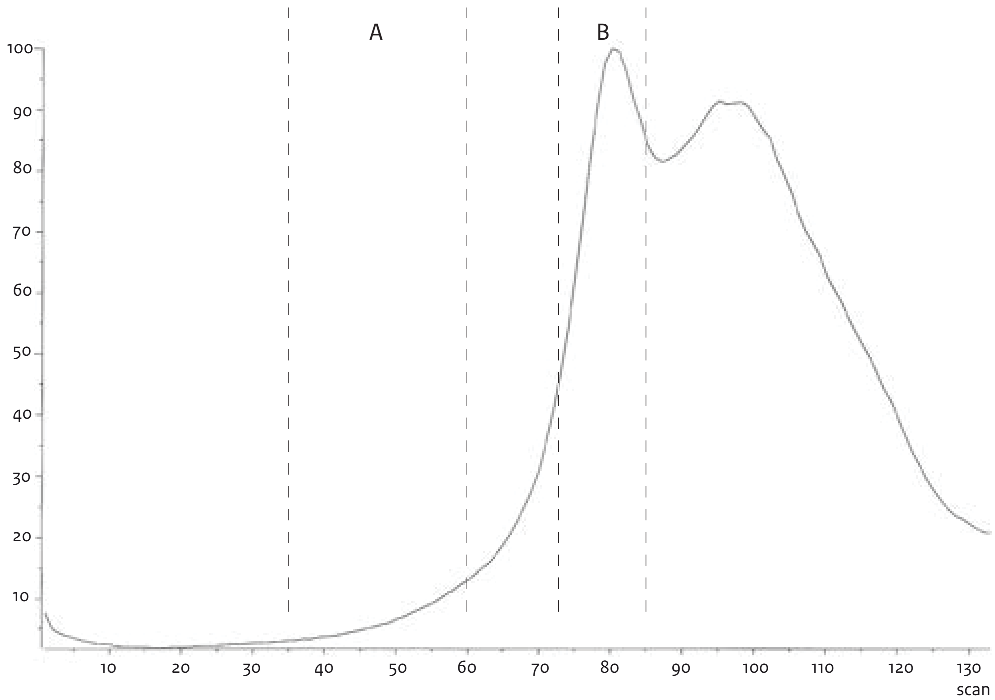



Fig. 8.23 The TIC of residue K13 (ceramic fragment UID: 2795) showing a peak in the pyrolysis-phase (area B, scan 75-88) with a shoulder in the high-temperature area. The desorption-phase A (scan 35-60) shows now obvious increase in intensity. In the desorption-phase area A (scan 35-60), no significant increase or 'bump' is visible in the TIC intensity, indicating a lack of significant amounts of volatile compounds in the residue.

155 Pastorova *et al.* 1993; 1994.

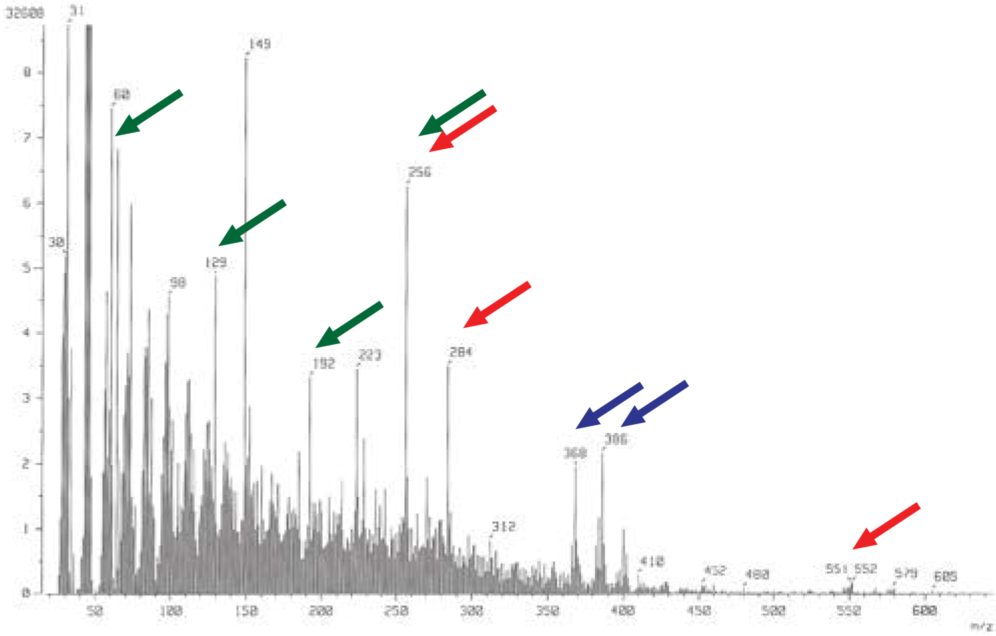


Fig. 8.24 Mass spectra of residue K13 (ceramic fragment UID: 2795): The desorption-phase A is characterised by the presence of saturated fatty acids and a trace of diacylglycerols (red arrows), cholesterol (blue arrows) and sulphur-containing compounds (green arrows).

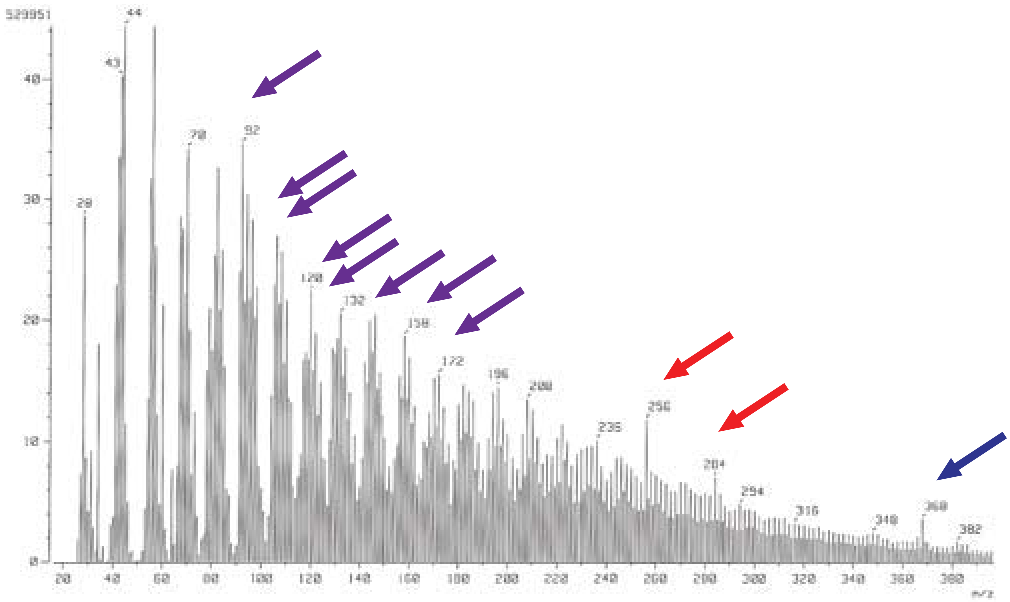


Fig. 8.25 Mass spectra of residue K13 (ceramic fragment UID: 2795): The pyrolysis-phase B (scan 75-88) shows indicators for charred polysaccharides (violet arrows), saturated free fatty acids (red arrows), and cholesterol (blue arrow).

**Sample K16 (DTMS-code TO11jan2010047)**
The DTMS Total Ion Current (TIC) signal of sample K16 is of medium intensity (27.106) indicating that the residue contains an average amount of organic material (Fig. 8.26). The TIC shows one obvious peak in pyrolysis phase area C (scan 79). The peak is fairly sharp and evaporates at a relatively low temperature, indicating a reasonably well preserved, homogeneous polymeric fraction with a limited degree of condensation. In desorption phase area A, no increase is visible in the TIC intensity, indicating very few compounds are released through desorption. Between this area and the full pyrolysis phase C lies a third area of loosely bound, but not yet polymerised, matter in area B (scan 60-70).

The mass spectrum (Fig. 8.27) of desorption area A (scan 30-60) shows mass peaks indicative of various different classes of chemical compound. Lipids (red arrows) are visible in the mass spectrum in the form of molecular ions and fragment ions of free fatty acids as well as intact acylglycerides. Saturated free fatty acids are recognisable as *m/z* 256 and 284 for C16:0 and C18:0. The presence of intact acylglycerols is indicated by small peaks for diacylglycerols (*m/z* 551, 579, 607). No triacylglycerols are visible in this residue. The presence of a high peak for ethanol (green arrow) is a remainder of the organic solvent used for sample introduction and was not part of the original vessel content.

The mass spectrum (Fig. 8.28) for early pyrolysis phase B (scan 60-70) still shows indicators of saturated free fatty acids and some unsaturated free fatty acids (*m/z* 264). Peaks belonging to markers for intact hexose polymers (*m/z* 97, 98, 110, 126) originate from mildly heated polysaccharides (pink arrows).[156]

Charred polysaccharides are also shown (Fig. 8.29) as additional series of peaks (violet arrows) belonging to alkylated benzenes (*m/z* 92, 106, 120, 134), alkylated benzofurans (*m/z* 132, 146, 160, 174) and alkylated phenols (*m/z* 108, 122) typical of a polysaccharide matrix heated to 250–310 °C.[157] In residue K16 these compounds are similar to those in residue K13. But in comparison to residue K13, this residue shows little or no shoulder in the high temperature region (scans 90-120), indicating an absence of severely condensed material. In summary, residue K13 shows a combination of partially unsaturated lipids (including some cholesterol) and mildly heated polysaccharides.

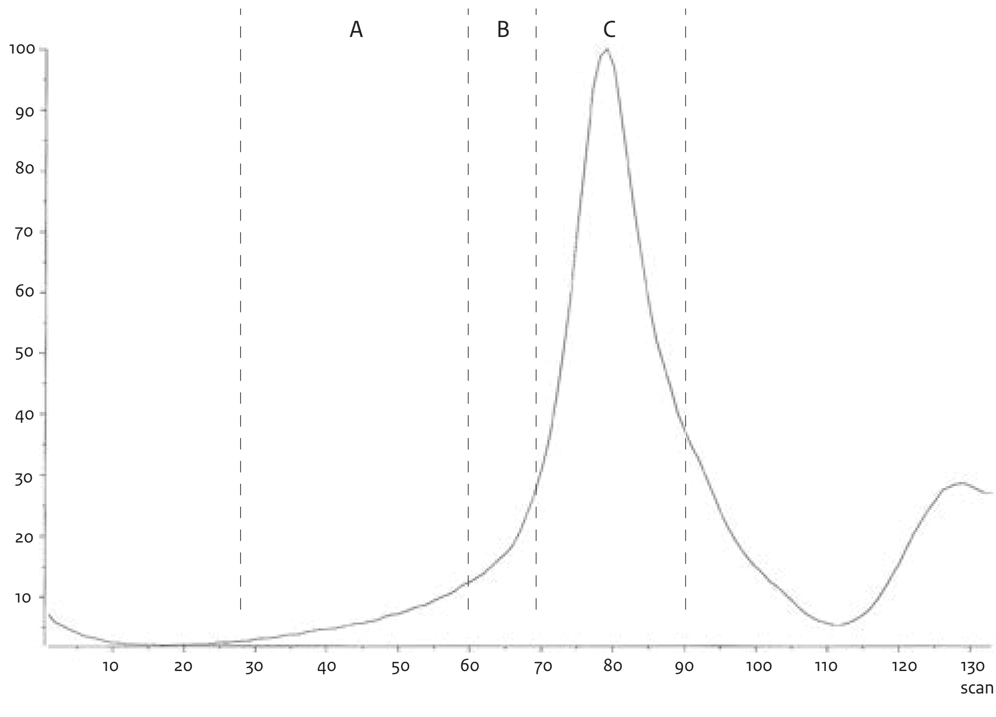



Fig. 8.26 This image shows the TIC of residue K16 (ceramic fragment UID: 2798): showing one major peak in the pyrolysis-phase (area C, scan 70-90) and two other areas of interest: the desorption-phase (area A, scan 30-60) and the early pyrolysis-phase (area B, scan 60-70).

156 Pastorova *et al*. 1993, 1994.
157 Pastorova *et al*. 1993, 1994.

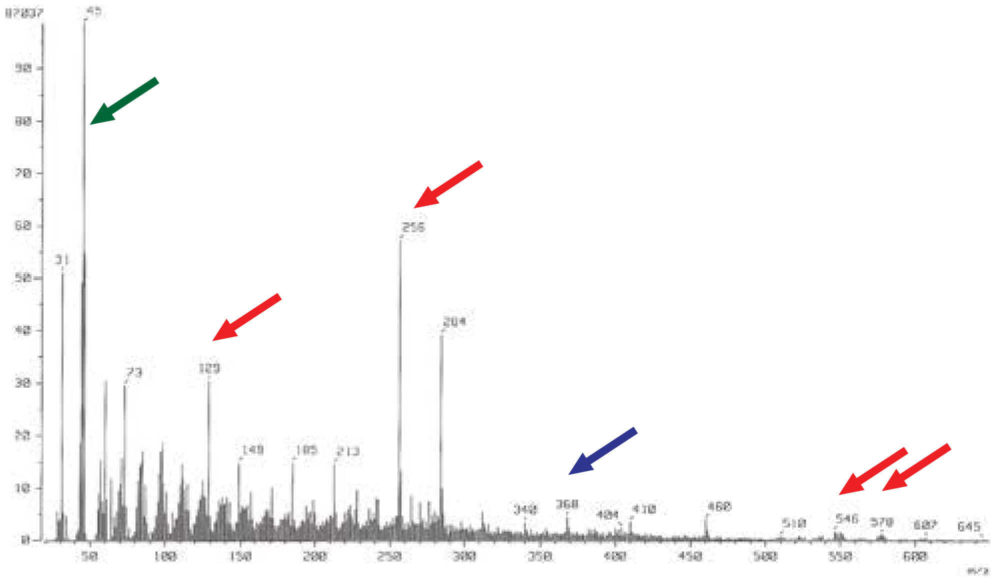



Fig. 8.27 Mass spectra of residue K16 (ceramic fragment UID: 2798): The desorption-phase A is characterised by the presence of lipids (red arrows) and the organic solvent ethanol (green arrow).

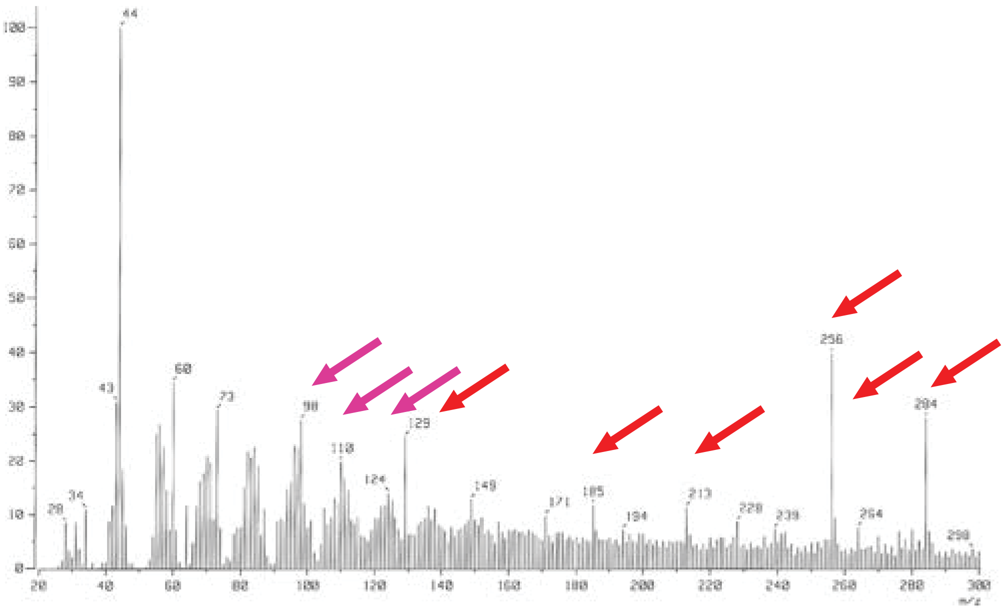



Fig. 8.28 Mass spectrum of residue K16 (ceramic fragment UID: 2798): The early pyrolysis-phase B (scan 60-70) shows free fatty acids (red arrows) and indicators for mildly heated polysaccharides (pink arrows).

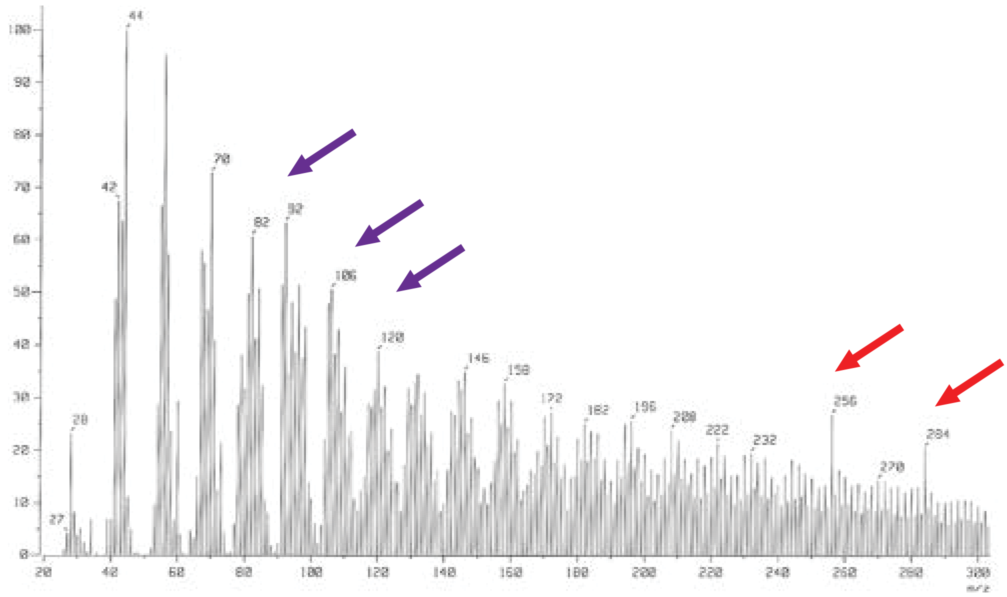



Fig. 8.29 Mass spectra of residue K16 (ceramic fragment UID: 2798): pyrolysis phase C (scan 70-90) shows indicators for a polysaccharide-char (violet arrows).

**Discussion of chemical results**

First, it is significant to note that the organic residues from Keinsmerbrug are relatively low in organic content (Table 8.3 shows low intensities in the Total Iron Currents). This effect is not due to the age of the material. Residues from Dutch Middle and Late Neolithic ceramics regularly show relatively well-preserved organic profiles.[158] The lack of organics in the residues in Keinsmerbrug may be the result of one of two important factors.

One explanation for this phenomenon could be severe post-depositional degradation of the residues after burial. Looking at the organic content of other materials might shed more light on this issue. The only other materials studied chemically were two 'lumps' of organic material collected during the botanical study.[159] Both these lumps – which visual inspection suggested to be organic material – turned out to be extremely low in organic content. This would strengthen the post-depositional theory. The burial conditions at Keinsmerbrug may have allowed severe degradation due to changes in the groundwater level and the presence of relatively high levels of oxygen in the soil.

Alternatively, the low organic content of the Keinsmerbrug residues may be the result of severe thermal degradation during food preparation in prehistoric times. The extent of the thermal degradation observed during cooking depends not only on the temperature and duration of the cooking process, but also on the nature of the food. Some foodstuffs are more sensitive to thermal degradation than others, losing chemical characteristics at lower temperatures and shorter cooking times. Carbohydrates such as sugars and starches are amongst the most easily thermally degradable components of food. At Keinsmerbrug it is precisely these compounds that account for the majority of the remaining organics in the residues.

At this time it is not possible to determine which of these factors is most significant.

The remaining residues consist primarily of carbonised carbohydrates in combination with some lipids (mostly free fatty acids and sterols, sometimes in combination with a trace of intact acyllipids). The Keinsmerbrug residues consist primarily of charred polysaccharides. The presence of heated polysaccharides in residues indicates food preparation. Although other uses may be considered (glue, paint, impregnating materials), consumption as food is definitely the most likely intended result of heating carbohydrates (sugars and starches). The absence of protein markers is significant because heated proteins are relatively resistant to post-

[158] Boon & Oudemans 2007, for lipids from Hazendonk and excavation P14.

[159] Kubiak-Martens this volume.

depositional degradation. Charred proteins (or charred materials with a significant protein fraction) survive longer than charred polysaccharides under most conditions in Dutch soil. In the case of Keinsmerbrug, this means they were obviously not part of the original material prepared in the vessels. The lipid profiles of the Keinsmerbrug residues are poor and seem reduced to their most basic form – almost completely hydrolysed (only free fatty acids are left) and almost completely saturated (no more double bonds can be found). The remaining saturated free fatty acids (C16:0 and C18:0) are all found in combination with cholesterol and therefore indicate animal origins (including fish). It is not possible to say what kind of fat was used in these vessels at Keinsmerbrug.

## 8.4 General discussion and conclusions

Both the chemical and botanical evidence shows a very uniform residue assemblage. The botanical evidence showed that the cooking of emmer grain as a food occurred in five of the six residues containing indicative plant remains (Table 8.4). The presence of fine epidermal remains of emmer chaff was demonstrated in many residues by scanning electron microscopy. This suggests that the origin of these residues can be found in cooking of emmer grain for food. Many residues have well-fused, somewhat glassy featureless matrices (Fig. 8.11 C and 8.12, for example). Their appearance bears a strong resemblance to the highly fused glassy matrices which are known to form under specific heating conditions in the presence of moisture.[160] Consequently, the microstructure of some residue matrices suggests they are derived from cooking cereal grain in some liquid, possibly water, as no chemical markers were found to indicate the presence of other liquids (Table 8.3). It is difficult to specify whether the whole grain was used, or the cereal grain was ground or pounded prior to cooking. What seems clear is that the grain was cooked in liquid. Chemical analysis fully supported this interpretation and revealed a further point of interest. The chemical evidence showed that all of the indicative residues were the result of cooking or heating a starch-rich food mixed with a small amount of animal fat (Table 8.4). Although the amount of fat varies between the residues, it is present in all cases.

Only one of the residues studied – residue K15 (Fig. 8.16) – is clearly different in botanical terms. Here, no evidence of cereal food was found, but there was possible evidence of the cooking of vegetative food, such as roots and tubers or green vegetables, or of non-vegetative parenchymatous food, such as fleshy fruits or green vegetables. As no evidence for the gathering of fleshy fruits has been found in the Keinsmerbrug macrofossil assemblage,[161] it can be assumed that this organic residue derives from the processing of vegetative food. Late Neolithic Keinsmerbrug, there were many plants that could have been used as green vegetables for their edible stems and/or leaves (including orache, wild celery, glasswort and sea aster), and at least one plant that could have been used for its edible tubers (namely *Bolboschoenus maritimus*). This residue also contains fragments that may originate from fish bones (Figs. 8.16 and 8.17), suggesting the preparation of fish for food. The chemical evidence shows that this residue is similar to many others, but does not contradict the botanical evidence. Traces of animal lipid and starch were found during DTMS analysis.

Uniformity in botanical and chemical results as seen at Keinsmerbrug is unusual for residue assemblages from settlement sites. Most of the residue assemblages originating from settlements that have been subjected to chemical analysis were of a later date, but the residue assemblages from Neolithic settlements (Hazendonk, P14, Schipluiden and Ypenburg) studied so far have also shown more internal chemical variation. In combination with the botanical results, this suggests that the residue assemblage from Keinsmerbrug is different from those from other settlement sites. It looks like the residues are the result of one specific activity: heating or cooking a starch-rich food, most likely emmer grain, mixed with a small amount of fat originating from animal or fish. This may suggest that some other functions commonly performed in ceramics were not performed at Keinsmerbrug (for example the cooking of meat or fish), or that these functions were performed without ceramic containers (for instance preparation of meat or fish by smoking, grilling or preparation in ash pits).

160 Valamoti *et al.* 2008.
161 Kubiak-Martens this volume.

**Table 8.4: Summary of combined botanical and chemical results.**

| sample nr. | new vessel nr. | orignal pot nr. | fragment find nr. | in / ex | rim / wall / bottom | interpretation botany | interpretation chemistry |
|---|---|---|---|---|---|---|---|
| K1 | 3 | 2 | ? | in / ex | r | - | highly carbonised mixture of animal fat and starch |
| K2 | 3 | 2 | 4-2-1041 | ex | r | - | - |
| K3 | - | 6 | 3-1-140 | in | w | - | - |
| K4 | 5 | 10 | 4-1-333 | in | w | - | - |
| K5 | 21 | 20 | 3-1-200ll | ex | w | cooking emmer grain food | - |
| K6 | - | 21 | 3-2-1006 | in | w | - | - |
| K6* (only SEM) | - | 21 | 01-02-58 | ex | w | cooking emmer grain food | not measured |
| K7 | 13 | 22 | 4-1-1040 | in | r | - | medium carbonised mixture of animal fat and starch |
| K8 | 22 | 22 | 01-01-19 | ex | w | - | - |
| K9 | 22 | 22 | 01-02-57 | ex | b | cooking emmer grain food | potassium contamination |
| K10 | 9 | 27 | 01-02-32 | in | r | - | potassium contamination |
| K11 | - | 9+18 | 01-01-10 | in | w | - | traces of animal lipid and starch |
| K12 | 10 | 9+18 | 3-1-136 | in | r | - | traces of animal lipid and starch |
| K13 | - | extra 1 | ? | in | w | cooking emmer grain food | highly carbonised mixture of animal fat and starch |
| K14 | 4 | extra 2 | 4-1-384 | in / ex | r | - | - |
| K15 | 4 | extra 2 | 3-1-102 | in | r | cooking (vegetative) parenchymatous food | traces of animal lipid and starch |
| K16 | 8 | extra 3 | 3-1-262 | in | w | cooking emmer grain food | medium carbonised mixture of animal fat and starch |

The botanical and chemical uniformity of the residues also implies that no differences in vessel use can be identified between different kinds of ceramics. Although vessel characteristics such as wall thickness, vessel form, tempering material and decoration were recorded,[162] similar residues were found in vessels of different types. We must therefore conclude that the cooking and heating of emmer porridge with fat has not been proven to be a specialised function of one kind of ceramic.

[162] Beckerman this volume.

# 9 The faunal remains

*J.T. Zeiler & D.C. Brinkhuizen*

## 9.1 Introduction

The numerous and (on the whole) reasonably well-preserved faunal remains from Keinsmerbrug constitute an important source of information in the study of the Late Neolithic occupation of West-Friesland. Yet, despite the research carried out in the 1980s, until recently the potential of the information had not been fully exploited. There were several reasons for this: only some of the fish remains had been studied, and data were available only on paper (some of them handwritten); there was no digital database. The present archaeozoological research was carried out to fill this gap.
The research focused on the following questions:

- subsistence: what was the importance of stock breeding, hunting and fishing? What species were exploited, in what quantities and in what manner? What can be said about the diversity of the fishing activities?
- character of occupation: what information do the species provide on the seasons in which the site was occupied?
- landscape: what information does the faunal spectrum provide on the former landscape (including the aquatic environment) in the vicinity of the site and on the exploited ecozones?

## 9.2 Methods

During the excavation of the site, bone material was collected in two ways: per square metre by means of sieving (4 or 2 mm mesh width) and by hand.[163] Some samples were also sieved through 1 and 0.5 mm meshes. These were used to estimate the total amount of bone material. Part of the material was analysed by F.J. Laarman and G.F. IJzereef, except for the molluscs, which were studied by W.J. Kuijper.[164] In the present research, the fish remains which had previously only been partially studied were analysed in their entirety by D.C. Brinkhuizen. The remains studied in the past by Laarman were re-analysed. Apart from the fact that he had overlooked some vertebra of Cyprinidae, his identifications proved to be correct. The fragment of three-spined stickleback (*Gasterosteus aculeatus*) mentioned by Laarman, the only one of this species he found (find number 3-1-259), could not be traced.

In view of the large amount of fish remains, a selection was made. Only the easily identifiable fragments were selected for analysis. This means that only the number of identified remains is known; the total number of remains was not determined. The remains were identified to species, genus or family level with the aid of the second author's private collection of present-day skeletons of Dutch fish species. In view of their minute dimensions, the fragments were studied under a stereomicroscope at 3.6x, 6x or 12x magnification. Characteristics such as traces of burning were recorded for some of the material.

The data on the remains of mammals, birds, amphibians, reptiles and molluscs were checked in only a few specific cases by J.T. Zeiler (see below). This means that the results presented in this report (except for those on fish) are based on lists and notes made by Laarman and IJzereef, and on the overview produced by Lauwerier.[165] In the original records no clear distinction is made between the different recovery techniques, except for five samples sieved through a 2 mm mesh. For that reason these samples are presented separately from the rest of the material.[166]

The original records mention species (although in most cases duck bones are not specified, only recorded as 'duck/teal'), number and weight (in g). In many cases the skeletal element is not, however, recorded. Information on the age at which the animals were slaughtered and butchering methods is scarce, as are measurements. This will partly be due to the heavy fragmentation of the bones.

The measurements were taken by IJzereef according to the method developed by Von den Driesch.[167] For this report, the data published by Habermehl were used to analyse the information on the ages at which the animals were slaughtered.[168]

In order to have a complete and accessible zoological dataset, the original data were recoded and entered into an Access database according to the specifications developed by the *Projectgroep Archeologie AHR*.[169]

163 Woltering *et al.* 1986.
164 Laarman 1989; Kuijper 2001.
165 Lauwerier 2001.
166 Find numbers 3-1-101, 3-1-120, 3-1-141, 3-1-304, 4-1-348.
167 Von den Driesch 1976.
168 Habermehl 1975.
169 Projectgroep Archeologie AHR 2003.

## 9.3 Results

### 9.3.1 General results

The most striking aspect of the bone material from Keinsmerbrug is the enormous quantity of bird bones. Birds make up 86% of the total number of faunal remains and even account for the greatest proportion of the overall weight (approx. 60%). Mammals come second in weight at approx. 40%, but account for only 2.3% of the total number of remains (Table 9.1).

The heavy fragmentation of the material is reflected in the mean weight: 0.2 g for bird bones and 5 g for mammal bones. These values are slightly higher than those at Kolhorn, where they were 0.1 g and 1.5 g respectively. On the other hand, they are lower than at the Neolithic site of Schipluiden. There the mean weights were 0.6 and 15 g respectively (hand-collected and sieved material taken together), although it must be noted that only identifiable remains were analysed.[170]

Burning seems to have been an important factor in the taphonomic processes, particularly for the bird remains. As there are only a few observations of burning on mammal bones, it is often noted that a considerable proportion (50-100%) of the bird bones are burnt. A quick scan confirmed this to be the case.

### 9.3.2 Mammals

Among the mammal bones, those of livestock are by far the most numerous (Table 9.2). Cattle (*Bos taurus*) exceed pig (*Sus domesticus*) and sheep/goat (*Ovis aries*/Capra hircus) both in number and in weight. The numerous cattle footprints that were seen during the excavation (Fig. 9.1) might be connected with the settlement, but this is not certain.[171] There is no detailed information on the layers or on the level at which they were

Fig. 9.1 Cattle footprints as exposed in the excavation of Keinsmerbrug.

**Table 9.1: Number (NR) and weight (BW, in g) of remains of mammals, birds, fish, molluscs, amphibians and reptiles (the remains in the samples were not weighed).**

| | material excl. samples | | samples | | total | |
|---|---|---|---|---|---|---|
| | NR | BW | NR | BW | NR | BW |
| **mammals** | 591 | 3758.9 | 44 | - | 635 | 3758.9 |
| **birds** | 26 363 | 5465.7 | 1033 | - | 27 396 | 5465.7 |
| **fish** | 2478 | - | 447 | - | 2925 | - |
| **molluscs** | 699 | 84.4 | - | - | 699 | 84.4 |
| **amphibians** | 25 | 0.8 | - | - | 25 | 0.8 |
| **reptiles** | 3 | 0.4 | - | - | 3 | 0.4 |
| **total** | **30 159** | **9310.2** | **1524** | **-** | **31 683** | **9310.2** |

[170] Zeiler 2006a; 2006b.
[171] Woltering *et al.* 1986.

**Table 9.2: Mammal remains (excl. small rodents). NR = number of remains; BW = weight in g.**

| mammals | material excl. samples | | | | samples |
|---|---|---|---|---|---|
| **livestock** | NR | % | BW | % | NR |
| cattle (*Bos taurus*) | 69 | 56.6 | 2771.7 | 92.4 | 1 |
| sheep/goat (*Ovis aries/Capra hircus*) | 6 | 4.9 | 18.0 | 0.6 | - |
| pig (*Sus domesticus*) | 10 | 8.2 | 64.1 | 2.1 | 21 |
| subtotal | 85 | 69.7 | 2853.8 | 95.1 | 22 |
| | | | | | |
| dog (*Canis familiaris*) | 31 | 25.4 | 122.5 | 4.1 | - |
| | | | | | |
| **fur animals** | | | | | |
| wolf (*Canis lupus*) | 1 | 0.8 | 4.2 | 0.1 | - |
| polecat (*Putorius putorius*) | 1 | 0.8 | 0.2 | - | - |
| marten (*Martes* sp.) | 1 | 0.8 | 1.0 | - | - |
| subtotal | 3 | 2.4 | 5.4 | 0.1 | - |
| | | | | | |
| **sea mammals** | | | | | |
| common seal (*Phoca vitulina*) | 2 | 1.6 | 6.9 | 0.2 | - |
| grey seal (*Halichoerus grypus*) | 1 | 0.8 | 11.8 | 0.4 | - |
| subtotal | 3 | 2.4 | 18.7 | 0.6 | - |
| | | | | | |
| **total mammals, identified** | 122 | 100.0 | 3000.4 | 100.0 | 22 |
| | | | | | |
| large mammal | 134 | | 498.5 | | - |
| medium mammal | 201 | | 188.8 | | - |
| mammal, indet. | 34 | | 62.9 | | - |
| | | | | | |
| **total mammals, not identified** | **369** | | **750.2** | | - |

found, which means that they could be either Neolithic or more recent.

At first sight, the strong presence of dog (*Canis familiaris*) is remarkable. However, 12 out of 31 remains (almost 40%) are loose teeth and could come from just one or two individuals. Apart from the skeletal remains, the presence of at least one dog is visible in gnawing marks on a pig bone (tibia).

In so far as data on skeletal elements are available, it is evident that the cattle bones come from almost all parts of the body: head, fore and hind legs (lower legs included), pelvis and vertebral column. This once more corroborates their presence at the site. The same applies to pig. Finds of sheep/goat are limited to a few leg bones (fore and hind) and a loose tooth. In general, the remains of livestock can be regarded as a mixture of consumption and slaughtering waste.

The few age data for cattle suggest that mostly adult and subadult animals were slaughtered. The four milk teeth that were found also come from subadult animals: shedding of milk teeth starts towards the end of the second year of life. The only indication of slaughtering of young(er) animals could come from a pelvis fragment that has been characterised as 'young', though without further specification. It might be that the three parts of the acetabulum had not yet fused, in which case the animal must have been

Table 9.4
p. = proximal;
d. = distal;
FU = (epiphysis) fused = older than indicated age;
UF = (epiphysis) unfused = younger than indicated age.

**Table 9.3: Age class determinations of cattle, sheep/goat and pig, based on the stages of fusion in postcranial bones.**

| | skeletal element/part | age (in months) | FU | UF |
|---|---|---|---|---|
| cattle | pelvis, acetabulum | 7-10 | - | (1) |
| | radius p. | 12-15 | 2 | - |
| | humerus d. | 15-20 | 1 | - |
| | metapodia d. | 24-30 | 2 | - |
| | femur p. | 42 | - | 1 |
| sheep/goat | femur p. | 36-42 | 1 | - |
| pig | phalanx II p. | 12 | - | 1 |

younger than seven months.

As for sheep/goat, in only one case can the age at slaughtering can be established: a femur of an animal more than 3-3.5 years old.

The data for pig suggest that they were slaughtered young. Besides a phalanx II of an animal less than one year old, a jaw fragment has been identified as coming from a specimen approx. one year old. Unfortunately, neither upper or lower jaw is specified, nor the criteria on which the age determination is based. One special case is the partial skeleton of a very young (maybe even unborn) piglet, consisting of cranial fragments, loose teeth, a mandible, two long bones (radius and femur), two phalanges, a pelvis fragment and five vertebrae.[172]

The age data based on the stages of fusion in postcranial bones are specified in Table 9.3.

As far as measurements are concerned, most data are from cattle bones: astragalus, metacarpus and radius (Table 9.4). In this last case the withers height could be inferred from the greatest length (GL): 125.6 cm. In another case (an incomplete humerus) the withers height was estimated at around 130 cm. These values are comparable to those of animals from Kolhorn, Schipluiden and Vlaardingen, with a withers height of 129, 129.4 and 130 cm respectively.[173] The same applies to the measurements of the other bones.

The measurements of a dog mandible (Table 9.4) are also in the same order as those obtained for other Neolithic sites, which confirms once more the moderate size of Neolithic dogs.

Wild mammals (microfauna not included) are scarce and comprise fur animals and sea mammals: wolf (*Canis lupus*), marten (*Martes* sp.), polecat (*Putorius putorius*), common seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*). All are represented by only one or two remains. As for wolf, this is a canine, which was attributed to the species on the basis of its size. In principle, it could come from a large dog, although that is not very likely in view of the moderate size of Neolithic dogs mentioned above. Wild ungulates, such as red deer and roe deer, are absent from the faunal spectrum, which is not surprising given their scarcity at Late Neolithic sites, especially in this region.[174] Some of the pig bones, however, could come from wild boar (*Sus scrofa*), but as no measurements are available this remains uncertain.

### 9.3.3 Birds

The vast majority of the bird bones come from ducks (Table 9.5).[175] Unfortunately, as was mentioned before, in most cases no clear distinction as to species was made and remains were simply qualified as 'duck' or 'duck/teal'. In the samples, however (which were studied by Frits Laarman), the bones were identified to species level whenever this was possible. From this we can see that the majority of the duck bones are from mallard (*Anas platyrhynchos*), followed in number by teal/garganey (*Anas crecca/A. querquedula*) and wigeon (*Mareca penelope*). The ratio between the three species is approx. 4 : 1.5 : 1. Other waterfowl species are present in low numbers: tufted duck (*Aythya*

172 Sample number 3-1-141.
173 Zeiler 1997; 2006a; Clason 1967.
174 See e.g. Clason 1967; De Vries 1996; Zeiler 1997.
175 The numbers are much lower than those published by Lauwerier (2001). This is because Lauwerier used the estimations made by IJzereef. In this report, however, the real numbers are used, as in comparing the handwritten observations and the final computer files made by IJzereef it became clear that sometimes the real numbers were maintained and sometimes the estimated numbers (real numbers multiplied by 6.2) had been used.

**Table 9.4: Measurements (in mm) of skeletal elements and withers height (in cm).**

| species/skeletal element | measurement | value | withers height |
|---|---|---|---|
| **cattle** | | | |
| radius | GL | 292.0 | 125.6 |
| humerus | - | - | (130.0) |
| metacarpus | BD | 55.0; 56.0 | - |
| astragalus | GLL | 73.0 | - |
| | GLM | 64.5 | - |
| | DL | 37.0 | - |
| | DM | 35.0 | - |
| | BD | 43.6 | - |
| **dog** | | | |
| mandible | LP1-M3 | 65.8 | - |
| | LP1-P4 | 35.4 | - |
| | LM1-M3 | 31.1 | - |

Table 9.4 Legend:
( ) = estimated value;
BD = greatest width of the distal end;
DL = greatest depth of the lateral half;
DM = greatest depth of the medial half;
GL = greatest length;
GLL = greatest length of the lateral half;
GLM = greatest length of the medial half;
LP1-P4 = length of the premolar row;
LP1-M3 = length of the cheek tooth row;
LM1-M3 = length of the molar row.

*fuligula*), brent goose (*Branta bernicla*) and greylag goose (*Anser anser*).

Apart from ducks and geese, a number of wader species could also be identified: lapwing (*Vanellus vanellus*), snipe (*Gallinago gallinago*), great snipe (*Gallinago media*), jack snipe (*Lymnocryptes minimus*) and sandpiper (*Calidris* sp.). Of these, the great snipe is not only currently rare in the Netherlands, it is also rarely found in an archaeological context. The Dutch archaeozoological database *BoneInfo* mentions only two more finds: one from a 17th-century context at Rijswijk (province of Zuid-Holland) and one from the Late Neolithic site of Zeewijk.

Two remains of plover (Charadriidae) could not be identified to species or genus level, but might very well come from lapwing.

The white-tailed eagle (*Haliaeetus albicilla*) is represented by four leg bones: three phalanges and a tarsometatarsus (Fig. 9.2). It is very likely that they come from one individual: at least two phalanges (a phalanx I and a phalanx II) do match.

Other bird species found include common gull (*Larus canus*), carrion/hooded crow (*Corvus corone/C. cornix*), great tit (*Parus major*) and thrush (*Turdus* sp.). The presence of the latter two is quite special, as remains of small songbirds (Passeriformes) are rarely found in pre- and early historic contexts.

Most of the bird species will have been consumed. As there are no traces of butchering, we have to look at another source of evidence to support this: the distribution of the skeletal parts, which is best recorded from the material in the samples. From these data it appears that the great majority of the duck remains are wing bones and elements from the pectoral girdle (clavicle, scapula, coracoid and sternum). Wing bones clearly predominate over leg bones (Table 9.6). Although this is a phenomenon often found in bone assemblages, the underlying processes causing it are still not clear. Differential survival of bird remains due to bone density is likely to be a factor, as is human selection. In other words, both cultural and post-depositional factors may play a role. However, the studies which have been performed seem to contradict each other, or at least give inconsistent results. In any case, it is clear that the impact of the individual factors differs from site to site, which means that each site should be treated separately.[176]

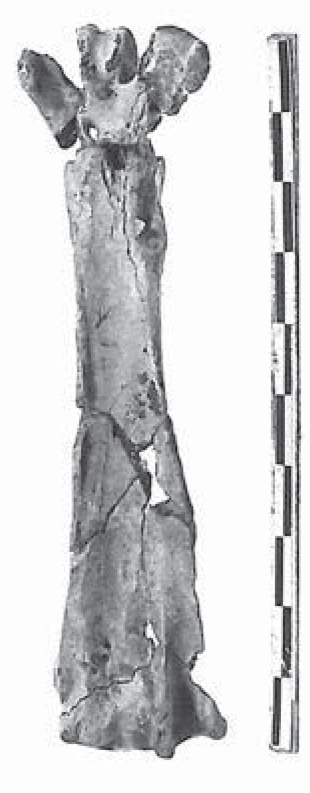


Fig. 9.2 Tarsometatarsus of the white-tailed eagle.

[176] Ericson 1987; Livingston 1989; Bovy 2002; Bochenski 2004; Serjeantson 2009.

Table 9.5
NR = number of remains;
BW = weight in g.;
+ = present, not quantified.
No percentages were calculated because of the preponderance of ducks.

## Table 9.5: Bird remains.

| | material excl. samples | | samples |
|---|---|---|---|
| | NR | BW | NR |
| **geese and ducks** | | | |
| brent goose (*Branta bernicla*) | 1 | 1.0 | - |
| greylag goose (*Anser anser*) | 1 | 0.2 | - |
| goose (*Anser* sp.) | 1 | 4.7 | - |
| mallard (*Anas platyrhynchos*) | + | - | 375 |
| teal (*Anas crecca*) | - | - | 106 |
| teal/garganey (*Anas crecca/A. querquedula*) | + | - | 27 |
| wigeon (*Mareca penelope*) | 90 | 16.1 | 96 |
| tufted duck (*Aythya fuligula*) | 3 | 0.6 | - |
| duck (Anatidae) | 26 228 | 5410.7 | 385 |
| subtotal | 26 324 | 5433.3 | 989 |
| | | | |
| **birds of prey** | | | |
| white-tailed eagle (*Haliaeetus albicilla*) | 4 | 12.0 | - |
| bird of prey (Accipitridae) | 2 | 0.9 | - |
| subtotal | 6 | 12.9 | - |
| | | | |
| **waders** | | | |
| lapwing (*Vanellus vanellus*) | 2 | 0.3 | - |
| plover (Charadriidae) | 2 | 0.1 | - |
| snipe (*Gallinago gallinago*) | 4 | 0.8 | - |
| great snipe (*Gallinago media*) | 2 | 9.6 | - |
| jack snipe (*Lymnocryptes minimus*) | 4 | 0.2 | 1 |
| snipe (*Gallinago* sp.) | 2 | 1.2 | - |
| sandpiper (*Calidris* sp.) | 7 | 1.2 | - |
| subtotal | 23 | 13.4 | 1 |
| | | | |
| **other species** | | | |
| common gull (*Larus canus*) | 1 | 0.2 | 1 |
| great tit (*Parus major*) | 1 | 0.1 | - |
| thrush (*Turdus* sp.) | 2 | 0.3 | - |
| carrion crow/hooded crow (*Corvus corone/C. cornix*) | 3 | 2.1 | 2 |
| subtotal | 7 | 2.7 | 3 |
| | | | |
| **total birds, identified** | **26 360** | **5462.3** | **993** |
| | | | |
| **birds, indet.** | **3** | **3.4** | **40** |

## Table 9.6: Duck remains from samples: skeletal elements of body parts (numbers) versus species.

Table 9.6
(*) 92 phalanges were not specified to fore or hind leg, and were not included for that reason.

| | head | body | wings | | | legs | | | totals |
|---|---|---|---|---|---|---|---|---|---|
| | | | long bones | carpalia/phalanges | total | long bones | phalanges | total | |
| **mallard** | 7 | 148 | 195 | 8 | 203 | 17 | - | 17 | 375 |
| **teal/garganey** | 2 | 60 | 51 | 6 | 57 | 14 | - | 14 | 133 |
| **wigeon** | - | 44 | 44 | 1 | 45 | 7 | - | 7 | 96 |
| **duck** | 17 | 133 | 89 | 41 | 130 | 12 | 1 | 13 | 295(*) |
| | | | | | | | | | |
| **total** | **26** | **385** | **379** | **56** | **435** | **50** | **1** | **51** | **899** |

## Table 9.7: Duck remains from samples: proportions of wing and leg bones (numbers) versus species.

Table 9.7
hu = humerus;
fe = femur;
ra = radius;
ul = ulna;
cmc = carpometacarpus;
tit = tibiotarsus;
tmt = tarsometatarsus.

| | hu – fe | ra/ul – tit | cmc – tmt | tit – tmt |
|---|---|---|---|---|
| **mallard** | 80 – 0 | 53 – 16 | 62 – 0 | 16 – 0 |
| **teal/garganey** | 27 – 0 | 12 – 13 | 12 – 1 | 13 – 1 |
| **wigeon** | 17 – 0 | 13 – 7 | 14 – 0 | 7 – 0 |
| **duck** | 48 – 2 | 19 – 5 | 22 – 5 | 5 – 5 |

The predominance of wing bones over leg bones at Keinsmerbrug is so strong that it must surely reflect human selection rather than survival. The presence of body bones rules out the possibility that only the wings were brought back to the site for the feathers.

Comparison of the frequency of individual wing and leg bones gives the same picture (Table 9.7). The meatless lower leg bone, the tarsometatarsus, is heavily underrepresented compared to the wing bones, which corresponds with the almost complete absence of posterior phalanges. Numbers for the (meatier) tibiotarsus are somewhat higher. Evidently, the lower parts of the legs were cut off before the other parts were cooked and were discarded in a different place from the bones from which the meat had been eaten, or were fed to the dogs.[177] What is surprising, however, is that the other meaty leg bone, the femur, is far less represented than the tibiotarsus. So maybe the carcasses were divided into smaller portions and these parts were consumed elsewhere.

From an overview of natural and human deposits given by Bochenski it appears that the latter feature a predominance of humerus and femur.[178] However, at two Neolithic sites in Estonia, femora are clearly underrepresented among the numerous duck remains, while wing bones prevail. The context of both sites is clearly human. It seems that the pattern is valid for the Baltic Sea shore.[179] The case of Keinsmerbrug shows that it is not restricted to that area.

It is likely that waders were also caught for consumption, although the number of remains is too small to support this on the basis of distribution of the skeletal parts. The white-tailed eagle is generally assumed to have been hunted for its feathers and claws and not – at least not exclusively – for its meat.[180]

The fact that duck bones are found in such large numbers points to mass catches. To get an idea of the number of birds that were caught, the minimum number of individuals (MNI) was estimated for the ‘duck’ category. This was done first and foremost because the numbers are known both for the samples and for the other material. Furthermore, this is one of the most numerously represented categories among the ducks, and both skeletal elements and side are specified in the samples. Based on the data given by Laarman, the MNI is 29. Since the number of duck bones from the samples is only

177 The same pattern was observed at the site at Schipluiden: Zeiler 2006b.
178 Bochenski 2004.
179 Bochenski, pers. comm.
180 See e.g. Amkreutz & Corby 2008; Zeiler 2006b.

1.5% of the total number (385 out of 26 613; see Table 9.5), we could be dealing with the remains of more than 1 900 individuals (1 962, to be precise) in the 'duck' category alone. An even higher number can be presumed for mallard, as Laarman mentions a minimum number of individuals (MNI) of 45 in the samples. For teal/ garganey and wigeon, the MNI in the samples is 17 and 18 respectively. This means that the duck remains represent some 5 000 to 10 000 individuals.

The question arises as to how the inhabitants of Keinsmerbrug could have caught such incredibly large numbers of ducks. IJzereef suggested that a kind of decoy must have been used, as no arrowheads were found and in his opinion the nets needed to catch such large numbers of birds would have been too big to handle. His suggestion, however, was rejected by the excavator, who had found no evidence of such a construction in the features.[181] However, whether a decoy would actually have been constructed *within* the settlement is questionable. Furthermore, the fact that these constructions are not known to have appeared before Late Medieval times also makes it unlikely that there was a duck decoy at Keinsmerbrug.

The answer might lie in the life cycle of the birds. In summer (July-August) ducks and geese moult, and during that period they are unable to fly. This makes them relatively easy to catch, and moreover they can be caught in relatively large numbers. Nowadays, for field biologists studying brent geese in northern Russia, catching birds during the moulting period is the most efficient way. They encircle groups of swimming geese, using small boats, and when they are close enough they throw a net over them.[182] It is not difficult to imagine that the Keinsmerbrug people used the same method to catch moulting ducks in the nearby lagoon. The only species that must have been caught in another way is the wigeon. Nowadays it is a typical migratory and winter bird in the Netherlands, breeding only in very low numbers.[183] Among the Keinsmerbrug ducks, the wigeon is the less frequently represented species, which means that the majority of the ducks may indeed have been caught during the moulting period. There must have been other ways to catch birds, too, most probably using nets placed at well-chosen spots. Waders such as plovers and lapwing could also have been caught in this way. Until quite recently (first half of the 20th century) waders, geese and other birds were caught on the coast of Noord-Friesland using '*staltnetten*', nets that were 15-20 m long and approx. 1.7 m high. They were placed upright in the mudflats right behind the dike, perpendicular to the coast.[184]

Besides practising active fowling, the inhabitants of Keinsmerbrug could also have gathered dead birds that were washed up on the shore after storms – as can still be done today. It is quite conceivable that people gathered such birds for their feathers and down and – if they still were fresh enough – for their meat. Birds that may have been gathered like this include common gull and small waders that are relatively difficult to catch, such as sandpipers and jack snipe.

### 9.3.4 Fish

**The species spectrum**

The fish remains are moderately to well preserved, but almost all are fragmented, some heavily. As a result, hardly any measurements could be taken. Twelve species were identified in the total quantity of fish remains. Tables 9.8 and 9.9 provide a survey of the number of remains and the percentages of the identified species for each of the recovery techniques.[185] 'Material A' refers to the remains from the 2 or 4 mm sieve residues, 'material B' refers to that from the samples (2, 1 and 0.5 mm mesh width). Of the two categories, 2 478 and 447 fish remains respectively were identified to species, genus or family level.

The spectrum comprises fish species from saline and freshwater, some of which migrate between the two. In all the fractions migratory species dominate. Most remains are from one or more species of the Pleuronectidae family (flounder). In the 2 and 4 mm sieve residues (material A) they comprise 84.8% of the total number of remains (flounder, *Pleuronectes flesus*, included). Remains of sturgeon (*Acipenser sturio*) come second at 12.3 %. The combined proportion of the other species is 2.9%. The proportion of each of the other species is less than 1%, except for eel (*Anguilla anguilla*).

Most remains in the samples (material B) are also from Pleuronectidae species. The proportions

[181] Laarman 1989.
[182] Ebbinge 2007, 135-140.
[183] Bijlsma, Hustings & Camphuysen 2001.
[184] Van der Ploeg 1977.
[185] The publications by Nijssen & De Groot 1987 and De Nie 1996 were used for the species' scientific names.

**Table 9.8: Fish remains from 2 and 4 mm sieve residues (material A). NR = number of remains.**

| | NR | % |
|---|---|---|
| **freshwater (stationary)** | | |
| tench (*Tinca tinca*) | 2 | 0.1 |
| carp family (Cyprinidae) | 4 | 0.2 |
| perch (*Perca fluviatilis*) | 1 | 0.0 |
| subtotal | 7 | 0.3 |
| | | |
| **anadromous/catadromous** | | |
| european sturgeon (*Acipenser sturio*) | 306 | 12.3 |
| eel (*Anguilla anguilla*) | 25 | 1.0 |
| flounder (*Pleuronectes flesus*) | 12 | 0.5 |
| flounder/plaice/dab (*Pleuronectes* sp.) | 2090 | 84.3 |
| subtotal | 2433 | 98.1 |
| | | |
| **marine** | | |
| cod (*Gadus morhua*) | 15 | 0.6 |
| codfish (Gadidae) | 8 | 0.3 |
| thin-lipped grey mullet (*Liza ramada*) | 2 | 0.1 |
| thin-lipped/golden grey mullet (*Liza ramada/L. aurata*) | 2 | 0.1 |
| grey mullets (Mugilidae) | 7 | 0.3 |
| bass (*Dicentrarchus labrax*) | 4 | 0.2 |
| subtotal | 38 | 1.6 |
| | | |
| **fish identified, total** | **2478** | **100.0** |

are 72.9%, 90.9% and 96.9% in the 2 mm, 1 mm and 0.5 mm sieve residues respectively.

### Right-eyed flatfish (Pleuronectidae)

Among the total quantity of fish remains, 2 518 were identified as Pleuronectidae. Most of these could not be identified to species level. However, we can be sure that material from the Low Countries will include one or more of the following species: flounder (*Pleuronectes flesus*), plaice (*Pleuronectes platessa*) and dab (*Limanda limanda*). Identification to species level is possible in some cases. For the Keinsmerbrug material this was the case for 379 remains: one pteroticum, eleven specimens of the os pharyngeum inferior and 367 dermal denticles. All are from flounder, thus it is probable that at least a sizable proportion of the other Pleuronectidae remains – and perhaps all of them – derive from flounder, too.

Among the unpaired skeletal elements of Pleuronectidae the os anale is the most frequently represented, with 71 remains. All of these are so heavily damaged that no measurements could be taken. Moreover, there is a chance that two or more fragments derive from the same os anale. So the remains of the os anale represent 71 individuals only in the most favourable case.

The second most frequently found element is the 'first vertebra', with 64 specimens. As most of these are barely damaged, if at all, it is clear that they represent 64 individuals.

### European sturgeon (Acipenser sturio)

Of the 316 remains of sturgeon, 315 are fragments with (on one side) the characteristically reticulate surface. It is not

**Table 9.9: Fish remains from 2, 1 and 0,5 mm sieve residues (material B). NR = number of remains.**

| | NR 2 mm sieve | % | NR 1 mm sieve | % | NR 0.5 mm sieve | % |
|---|---|---|---|---|---|---|
| **freshwater (stationary)** | | | | | | |
| carp family (Cyprinidae) | 1 | 1.7 | - | - | - | - |
| subtotal | 1 | 1.7 | - | - | - | - |
| | | | | | | |
| **anadromous/catadromous** | | | | | | |
| european sturgeon (*Acipenser sturio*) | 10 | 16.9 | - | - | - | - |
| twaite shad (*Alosa fallax*) | 1 | 1.7 | - | - | - | - |
| stickleback (*Gasterosteus aculeatus*) | - | - | 2 | 9.1 | 12 | 3.3 |
| flounder (*Pleuronectes flesus*) | - | - | 14 | 63.6 | 353 | 96.4 |
| flounder/plaice/dab (*Pleuronectes* sp.) | 43 | 72.9 | 6 | 27.3 | - | - |
| subtotal | 54 | 91.5 | 22 | 100.0 | 365 | 99.7 |
| | | | | | | |
| **marine** | | | | | | |
| herring (*Clupea harengus*) | - | - | - | - | 1 | 0.3 |
| cod (*Gadus morhua*) | 3 | 5.1 | - | - | - | - |
| whiting (*Merlangius merlangus*) | 1 | 1.7 | - | - | - | - |
| subtotal | 4 | 6.8 | - | - | 1 | 0.3 |
| | | | | | | |
| **fish identified, total** | **59** | **100.0** | **22** | **100.0** | **366** | **100.0** |

possible to tell how many individuals they represent. Two fragments, one of a pectoral spine and a supracleithrale, indicate an MNI (minimum number of individuals) of one.

As mentioned above sturgeon comes second in terms of number of remains. If the MNI is indeed one, then it is clear that sturgeon is heavily overrepresented. This can be explained by the fact that heavily fragmented bones of the exoskeleton of the species are still identifiable as 'sturgeon' by the reticulate pattern of the surface. However, these remains cannot be identified to anatomical level, i.e. skeletal element. In the 2 mm sieve residues from Keinsmerbrug (material B), remains of sturgeon are well represented, at 16.9 % of the total number of identified remains. By contrast, no sturgeon remains were identified in the 1 mm and 0.5 mm residues.

### Size of the fish caught

In order to estimate the economic importance of the various fish species and to get an impression of the fishing methods employed it is interesting to know the sizes of the most important fish species. The total lengths of one or more specimens of the most important species were therefore calculated or estimated on the basis of the dimensions of certain skeletal elements of recent specimens of a known total length.

It was possible to measure the greatest width (in mm) of the posterior articulation surface of 50 out of 64 'first vertebrae' of *Pleuronectes* sp. (Fig. 9.3). Enghoff gives a formula for calculating the relation between the total length (TL) of *Pleuronectes flesus* and the measurement (W).[186] The regression formula is: TL = 69.7268 x W0.9068. Using this formula for Keinsmerbrug, the lowest value of measurement W yields a total length of 183 mm for the smallest specimen. The highest value yields an individual with a total length of 370 mm. The mean length of the 50 individuals from Keinsmerbrug was 263 mm. Brinkhuizen gives a formula for the relation between the total length and the total weight of *Pleuronectes* sp.[187] From this it appears that the mean total weight of *Pleuronectes* sp. at Keinsmerbrug was 191 g

[186] Enghoff 1989, 46.
[187] Brinkhuizen 1989, 102.

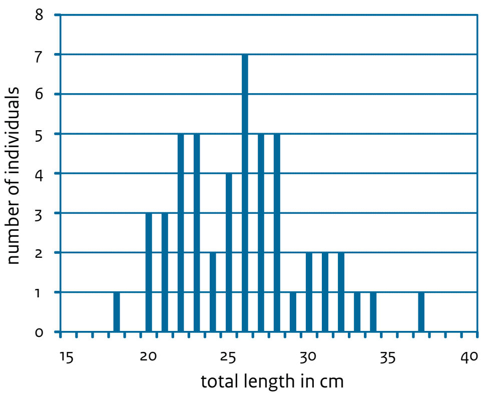



Fig. 9.3 Distribution of total length of flounder (*Pleuronectes flesus*) based on the greatest width of the posterior articulation surface of vertebra I (in mm). Measurements in mm: 2.9; 3.2; 3.3(2x); 3.4; 3.5(2x); 3.6(4x); 3.7; 3.8(2x); 3.9(3x); 4.0(2x) 4.1(2x); 4.2(2x); 4.3(3x); 4.4(4x); 4.5(2x); 4.6(3x); 4.7(2x); 4.8(3x); 4.9; 5.0(2x) 5.3(2x); 5.4; 5.5; 5.7; 5.9; 6.3. n=50; X mean.=4.33; S=0.739; Sm=0.105;var.br.= 2.9-6.3.

Specific measurements could be taken from four remains (an articulare, a quadratum and two praemaxillares) of cod (*Gadus morhua*). These elements could also be measured in a 1003 mm long recent cod. The total length of the specimens from which the four elements mentioned derive could be calculated on the basis of the ratio 'measurement: total length'. The cod in question were 896, 905, 1050 and 1084 mm long. Direct comparison of two excavated, but damaged (and therefore unmeasurable) palatina with the palatinum of the 1003 mm long recent cod made clear that one of these came from a slightly larger individual, and the other from a specimen with the same total length. These values suggest that the cod caught by the Keinsmerbrug people were about 90 to 110 cm long.

Comparison of the size of a damaged praemaxillare of whiting (*Merlangius merlangus*) from the 2 mm sieve residue with individuals of known total length demonstrates that it belonged to an individual with a total length of approx. 38 cm.

One vertebra of herring (*Clupea harengus*) was found in the 0.5 mm sieve residue. It came from an individual slightly smaller than the 82 mm long specimen from the reference collection.

In the 2 mm sieve residue (material B) a first vertebra of twaite shad (*Alosa fallax*) was found. Comparison of the size of this vertebra with that of individuals of known total length (270 mm and 336 mm respectively) suggests that the vertebra belonged to a twaite shad with a total length of approx. 30 cm.

The material from Keinsmerbrug comprises a number of remains of thin-lipped/golden grey mullet (*Liza ramada*/*L. aurata*). Three species of mullet are found in the Netherlands: thick-lipped grey mullet (*Chelon labrosus*), thin-lipped grey mullet (*Liza ramada*) and golden grey mullet (*Liza aurata*).[188] The skeletal elements of thick-lipped grey mullet can be easily distinguished from those of thin-lipped/golden grey mullet. Those of thin-lipped grey mullet and golden grey mullet, however, are very similar. According to Nijssen and De Groot the maximum length of the golden grey mullet is 45 cm, while the thin-lipped grey mullet can be up to 70 cm long.[189] So it is possible to identify a skeletal element as coming from thin-lipped grey mullet if its size indicates that it belonged to an individual more than 45 cm long. In this study the skeleton of a recent 47.8 cm long thin-lipped grey mullet was used. Two remains from Keinsmerbrug (a vertebra and an infraorbitale I) are larger than the corresponding elements in the reference specimen, which means that they can certainly be identified as coming from thin-lipped grey mullet.

A specific measurement could be taken from the infraorbitale I of both the Keinsmerbrug specimen and the reference specimen. A total length of 618 mm was calculated for the Keinsmerbrug mullet on the basis of the ratio 'measurement: total length'.

Finally, it proved possible to measure the height of a quadratum of bass (*Dicentrarchus labrax*). For comparison, the same measurement was taken from two recent bass 410 mm and 681 mm long respectively. A total length for the Keinsmerbrug specimen was calculated on the basis of the ratio 'measurement: total length'. The fish had a total length of 636 mm (based on the data from the 410 mm specimen) or 608 mm (based on the data from the 681 mm individual). Both values make it clear that the length of the Keinsmerbrug bass must have been about 60 cm.

From the calculated and estimated lengths of the fishes caught it appears that the inhabitants of Keinsmerbrug knew fishing techniques that enabled them to catch both very small fish (stickleback, herring) and large fish (cod, bass and large mullets).

188 At present the thick-lipped grey mullet occurs far more frequently in the Netherlands than the thin-lipped/golden grey mullet. It is remarkable that in the past the opposite seems to have been the case. The Dutch archaeozoological database *BoneInfo* (www.cultureelerfgoed.nl; September 2010) mentions 25 finds of thin-lipped grey mullet, ten of thin-lipped/golden grey mullet and only six of thick-lipped grey mullet.

189 Nijssen & De Groot 1987.

### Taphonomy

#### Cut marks

In general, cut marks and surfaces formed by cutting are not usually observed on fish bones. If present, they are usually found on the largest elements of large individuals. The material from Keinsmerbrug yielded no fragments with cut marks.

#### Traces of burning

No records were kept of the occurrence of burning traces, charring or calcination on the identified fragments. The number of unburnt remains far exceeds the number of burnt remains, which suggests that burning was a factor of minor importance in the taphonomy of fish remains. However, it is doubtful that this was indeed the case. Burning has a far more destructive effect on fragile fish bones than, for example, mammal bones. From our own experience we know that thorough burning results in predominantly very fine crumbs. Such minute fragments are easily blown away by the wind.

#### Traces of gnawing

In spite of the fact that many mice were probably present at the site, no traces of gnawing were found. This does not mean that gnawing played no role in the taphonomy of the fish remains. On the contrary: many fish bones will have disappeared completely as a result of gnawing.

#### Pathologies

No pathologies were found.

#### Distortion

When a mammal devours a fish complete with its head and tail, the fish's bones may suffer distortion during their passage through the gastrointestinal tract.[190] Wheeler and Jones illustrate this with some photos of distorted vertebrae from Medieval cesspits. They assume that the bones were flattened during the time they spent in the stomach and intestines. In such cases, Beerenhout refers to vertebrae showing 'metabolic distortion'.[191]

Many of the pleuronectid vertebrae from Keinsmerbrug show traces of metabolic distortion, which would mean that they passed through the gastrointestinal tract of a mammal. However, this explanation for the deformation of vertebrae is doubtful. At other sites the second author has seen distorted complete vertebrae, i.e. with spina dorsalis and spina haemalis still attached. The consumer would certainly have experienced problems as such vertebrae passed through the gastrointestinal tract. Moreover, the author studied fish remains from recent spraints of otter (*Lutra lutra*).[192] Apart from gnawing traces on larger bones, not a single vertebra showed metabolic distortion. Thus it is probable that metabolic distortion is not a result of passage through the gastrointestinal tract. In our opinion, it occurs in vertebrae embedded in clayey sediment that is frequently trodden (trampling). Examination under a binocular microscope clearly shows that many fragments from Keinsmerbrug are heavily rounded. It is therefore more appropriate to speak of distortion rather than metabolic distortion.

#### Fishing and fishing methods

It is clear that fishing activity focused on catching flounder/plaice/dab. In view of the other species caught, the Keinsmerbrug people must have had a range of fishing techniques. It is likely they fished with (semi-)permanent fishing gear in a tidal creek (a fish trap) and/or with a weir or fence on a sandbank that fell dry at low tide. Nor can we exclude the possibility that the inhabitants waded barefoot through the water, feeling the fish dug into the sediment and catching them by standing on them (known as 'bottrappen' in Dutch, or 'flounder treading').

The marine species sturgeon, mullet and bass that regularly forage in shallow waters could have been caught using a weir (possibly permanent) on a sandbank that fell dry at low tide. Fishing with a fish trap is indicated by the presence of species like eel. A fish trap consists of an outer casing and a throat. A fish trap made of willow or cornel twigs, for example, is called a wickerwork fish trap. Both the outer casing and throat are built up of 'wickers' that run more or less parallel to one another in the longitudinal direction of the trap. The distance between adjacent wickers is usually 0.5-1.5 cm. The wickers are connected at regular intervals by means of cord, which forms 'cross-strips'. The distance between these cross-strips is usually 6-10 cm and they run around the fish-trap in the form of circular or spiral bands.

Remains of wickerwork traps have been found at a number of Mesolithic and Early Neolithic inland sites like Hardinxveld-De Bruin,

[190] Wheeler & Jones 1989.
[191] Beerenhout 1996.
[192] Brinkhuizen 1992.

Hoge Vaart and Bergschenhoek, as well as at more recent prehistoric inland sites like Emmeloord. All were 'light traps', in which the distance between the adjacent wickers in the outer casing was very small. In some traps, the throat was still present. If the diameter of the rear opening of the throat was less than 5 cm, the trap can only have been used for catching eel, with very small fish such as sticklebacks as bycatch.

Larger cod are found in deeper waters. These fish could have been caught from a small boat, using a line and hook. From his study of the fish remains from Mienakker Beerenhout concludes that the fishery techniques of the Neolithic fishermen were sufficiently well developed to enable them not only to catch cod in fairly shallow waters, but also the fish of the inshore waters.[193]

**Seasonal evidence**

If we assume that, in prehistoric times, the annual cycle of Dutch fish in general, and their migratory behaviour in particular, was comparable with their behaviour in present and historical times, we can draw conclusions as to the season in which certain fish species were caught. From the following it can be concluded that the inhabitants of Keinsmerbrug fished during the summer, at any rate.

The sturgeon is an anadromous fish that spends the greater part of its life in the sea and temporarily exchanges saltwater for freshwater only in order to reproduce. In late spring sturgeons swim upriver to spawn. However, the presence of sturgeon remains can be used as a seasonal indicator (spring, summer) at inland sites such as the Neolithic Swifterbant and Hazendonk sites. Since Keinsmerbrug was a coastal site, the presence of sturgeon remains cannot be used as a seasonal indicator.[194]

The most common species of flatfish on our coast is flounder. It lives close to the coast, leaving temporarily during severe frosts and in the spawning season (February – May). The spawning areas are located in the North Sea at depths of 40 to 100 m. In principle, flounder are catadromous. After reproducing in the sea in spring they migrate into freshwater if it is freely accessible. They gather in autumn and return to the sea to spend the winter in deeper waters. This makes flounder a summer indicator. Their remains are frequently found among the fish remains from Late Neolithic and Early and Middle Bronze Age sites in the northern part of Noord-Holland.

Two heat-loving species, thin-lipped/golden/thick-lipped grey mullet and bass, provide clear indications of the catching season. Mullet swim into Dutch coastal waters from the south in summer and stay here until October. They are highly adaptable, because they can also be found in brackish and freshwater. The bass is present in the Dutch coastal waters in summer, too. Towards the winter it migrates through The Channel to waters off the southern English coast.

Eels are catadromous. They arrive from the sea in freshwater as elvers. During the winter eels are lethargic and stay in soft substrates. If a fisherman knows where eel hibernate, he can catch them with a fish spear (*elger* in Dutch). In late spring, summer and autumn eels can easily be caught with fish traps. Large numbers of adult individuals can be caught in autumn when they migrate to the sea to spawn.

The three-spined stickleback is an anadromous species. In spring it migrates to freshwater in order to reproduce. After spawning the adult sticklebacks die. They are replaced by the new generation that migrates to the sea in autumn. In spring this new generation swims into freshwater to spawn and die, after which the life cycle starts again.

**Comparison with other sites**

The ichthyoarchaeological data from Keinsmerbrug can to a certain extent be compared with those from the Late Neolithic site of Zeewijk.[195] At this site the material was recovered in squares of 1x1 m, in small layers of approx. 3 cm, after which the soil was sieved by square and by layer through a 4 mm mesh.

The ichthyoarchaeological study of Zeewijk was very broad. The fish remains were weighed (total weight approx. 343 g) but not counted. The proportions between the identified species – sturgeon, eel, cyprinids, pike, cod, haddock, mullet, flounder, plaice and *Pleuronectes* sp. – were estimated. Zeiler also found three-spined stickleback among the material from an earlier survey of the site.[196]

In her 1996 publication De Vries mentions that the estimated numerical proportion of flatfish is the largest, at approx. 90%. Sturgeon and mullet together make up about 8%, which leaves only 2% for the other species. In her

193 Beerenhout 1994, 347.
194 Zeiler 1997, 84.
195 De Vries 1996; 2001.
196 Zeiler 1988.

opinion the species of fish, wild mammals and birds found at Zeewijk show that the site was situated in a tidal flat area. This area consisted of overgrown mud flats with reed marshes behind. Habitation most probably took place on the border between the brackish area and the freshwater area.

The fish data from Keinsmerbrug can also be compared to those of the Early Bronze Age site of Schagen Hoep Noord.[197] The entire habitation layer of this site was sieved (1 mm mesh width). Apart from other faunal remains, almost 6500 fish remains were recovered from the residues. Of these, almost 1400 could be identified to species, genus or family level. At least 19 species (freshwater as well as migrating and marine) were found. The species spectrum points to fishing in an estuarine environment. At Schagen Hoep Noord *Pleuronectes* sp. (including flounder) accounts for the largest proportion, at 85% of the identified remains, a percentage similar to that at Keinsmerbrug. Of the other species, three-spined stickleback is best represented at 2.4%, followed by eel and allis/twaite shad, both on 1.7%. From these percentages it is clear that at all three sites *Pleuronectes* sp. make up the major part of the catch.

### 9.3.5 Background fauna

While most of the bird and mammal remains represent consumption and slaughtering waste, there are species whose remains ended up at the site without human intervention, or secondarily via owl pellets (Table 9.10 and 9.11). These are small rodents and insectivores, amphibians and reptiles. They represent the site's background fauna, indicators of the local environmental conditions. According to Kuijper (2001), molluscs can also be regarded as such (see below).

**Table 9.10: Background fauna: small mammals, amphibians and reptiles. NR = number of remains.**

| | NR | |
|---|---|---|
| | **material excl. samples** | **samples** |
| **small mammals** | | |
| common/French shrew (*Sorex araneus/S. coronatus*) | 6 | 1 |
| shrew (Soricidae) | - | 1 |
| ground vole (*Arvicola terrestris*) | 18 | 2 |
| root vole (*Microtus oeconomus*) | 11 | 6 |
| vole (Microtidae) | 60 | 12 |
| mouse (Muridae) | 4 | - |
| small rodent (Rodentia) | 1 | - |
| subtotal | 100 | 22 |
| | | |
| **amphibians** | | |
| common toad (*Bufo bufo*) | 11 | - |
| toad (*Bufo* sp.) | 8 | - |
| frog (*Rana* sp.) | 3 | - |
| toad/frog (Anura) | 3 | - |
| subtotal | 25 | - |
| | | |
| **reptiles** | | |
| grass snake (*Natrix natrix*) | 2 | - |
| grass snake/adder (*Natrix natrix/Vipera berus*) | 1 | - |
| subtotal | 3 | - |

[197] Zeiler, Brinkhuizen & Bekker 2007.

Almost 90% of the small mammal remains come from voles. In so far as they could be identified to species level they derive from ground vole (*Arvicola terrestris*) and root vole (*Microtus oeconomus*). Insectivores are represented by common or French shrew (*Sorex araneus/S. coronatus*). Four remains of mice, including a molar and an incisor, were described as 'small house mouse', which could mean that they are in fact from the harvest mouse (*Micromys minutus*). The plan to check these identifications did not come to fruition, as the remains in question could not be found.

Most – probably all – amphibian remains come from toads, eleven from the common toad (*Bufo bufo*). Reptiles are represented by grass snake (*Natrix natrix*). The presence of adder (*Vipera berus*) remains uncertain, as these remains also appear to have been lost.

All mollusc species are indicative of a marine or brackish environment. The presence of the edible cockle and the lagoon cockle (*Cerastoderma edule/C. glaucum*) indicates that the water had a lower salinity compared to seawater, but was saltier than brackish water. The environment can be described as a shallow lagoon where gradual changes in salinity took place, with annual amplitude.

According to Kuijper, the presence of doublets indicates that the molluscs come from natural deposits molluscs, and hence – contrary to what has been found at other Late Neolithic sites in the region (e.g. Mienakker) – must not be regarded as consumption waste.[198]

**Table 9.11: Background fauna: molluscs. + = regularly present; ± = occasionally present.**

| | presence |
|---|---|
| mussel (*Mytilus edulis*) | ± |
| edible cockle (*Cerastoderma edule*) | + |
| lagoon cockle (*Cerastoderma glaucum*) | + |
| baltic tellin (*Macoma balthica*) | ± |
| peppery furrow shell (*Scrobicularia plana*) | ± |
| common periwinkle (*Littorina littorea*) | + |
| lagoon periwinkle (*Littorina tenebrosa*) | ± |
| mud snail (*Hydrobia ulvae*) | ± |
| blunt bubble shell (*Retusa obtusa*) | ± |

## 9.4 Discussion

The archaeozoological data make it clear that subsistence at Keinsmerbrug was based on fowling, stock breeding (mainly cattle) and fishing. The large number of fish remains indicate that, apart from birds and livestock, fish was an important part of the diet of the Keinsmerbrug people. The species and their frequencies reveal that fishing mainly occurred in the salty and brackish waters of a tidal flat area. The few remains of freshwater fish indicate that these species (cyprinids, perch) were caught incidentally either in places with very slightly brackish water (where a freshwater stream flowed into saltwater) or in freshwater. Likewise, 'real' marine fish species avoiding brackish water were only caught on a small scale. The most important catch was flatfish: flounder/plaice/dab.

The high frequency of bird remains (mainly ducks) can be regarded as unique for the Neolithic. At no other site, either in the region or in any other part of the Netherlands, did fowling play such an important role as it did here.[199] Although in the Neolithic large numbers of bird bones are quite common at coastal sites, nowhere – even at sites where extensive sieving took place – is their preponderance as great as it is at Keinsmerbrug.[200] At Kolhorn, for instance, bird and mammal bones make up 60% and 40% of the total number of remains respectively; in terms of weight, mammal bones (especially those of cattle) are far more important.[201] At Keinsmerbrug, such large numbers of ducks have been caught that even in weight their remains exceed those of mammals. So, apart from cattle herding and fishing, fowling seems to have been the main activity. This raises questions as to the nature of the site: was it permanent or seasonal?

In general, information on human activities in specific seasons can be inferred from the presence of certain species of mammals, birds and fish (Fig. 9.4). At Keinsmerbrug, the only mammal providing seasonal evidence is the grey seal. Since it leaves the coast in winter, in search of deeper water, it must have been caught sometime between spring and late autumn.

The bird species are either resident or migratory/winter birds. The first category provides no helpful information on seasonality.

[198] Kuijper 2001.
[199] See e.g. Drenth, Brinkkemper & Lauwerier 2008.
[200] Zeiler & Clason 1993; Drenth, Brinkkemper & Lauwerier 2008.
[201] Zeiler 1997.

As for the latter, nowadays nearly all species present at Keinsmerbrug spend a large part of the year in these areas and are truly absent for only a few months. Good winter indicators, such as swans, are absent. The same applies, in reverse, to summer indicators. Even the lapwing cannot be regarded as a summer indicator: in winter it migrates according to the frost line, which means that it stays here as long as the winter is mild. The great snipe is a rare species nowadays, only present in July-October, but it may have bred here in former times.[202] The white-tailed eagle, at present mainly a winter visitor, may well have bred in the Netherlands in the Neolithic.

There is some seasonal evidence from the fish remains, with mullet and bass pointing to fishing in summer.

The strongest indication of summer activity, however, is the enormous quantity of duck bones. At present, the most probable explanation for this is that ducks were caught during the moulting period, in July and August. All archaeozoological evidence therefore points to summer activities. But that may not be the whole story. Catching ducks in such large numbers suggests a winter store was prepared, i.e. that the birds were salted, dried or smoked in their entirety (i.e. without intestines). However, this is hard to prove. At least part of the catch was consumed at the site, and the large quantity of duck bones could well be the result of accumulation over the years. The under-representation of the femur might be an indication that the carcasses were divided into smaller portions (probably after preservation), and that these parts were consumed elsewhere, probably the winter camp. However, it is hard to explain why these parts in particular should have been taken, as they are not the meatiest.

The strong preponderance of wing elements, representing consumption waste, show that the lower parts of the legs were cut off before the conservation process or in preparing the birds for consumption, and discarded outside the settlement (or given to the dogs). The leftovers of the meal, however, were discarded within the site, as is clear from the high percentage of burning on the bones.

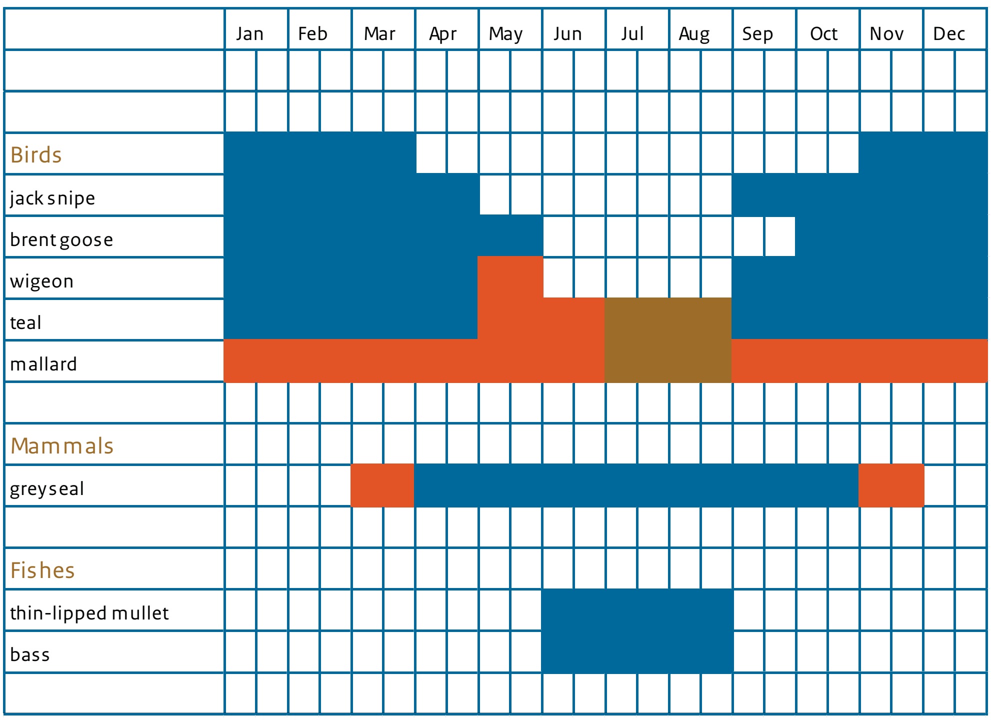



Fig. 9.4 Seasonal presence of bird, mammal and fish species at Keinsmerbrug (adapted from Zeiler 2006a, 2006b; Brinkhuizen 2006). Dark blue = largest numbers; green = largest numbers/easiest to catch.

202 Van den Berg & Bosman 2001.

## 9.5 Conclusions

In conclusion, the research questions mentioned in section 9.1 can be answered as follows:

- subsistence at Keinsmerbrug was based on fowling, stock breeding and fishing, with ducks, cattle and flatfish as the most important species. The most probable explanation for the large number of ducks – mainly mallard and teal/garganey – is that they were caught in the moulting period (July-August), when they are unable to fly. The presence of wigeon, however – nowadays a typical migratory and winter bird in the Netherlands – makes it clear that this was not the only way (and time) to catch birds. Nets placed at strategic spots were most probably also used. Fishing occurred in brackish waters, given the preponderance of flatfish and the low numbers of both freshwater and marine species. Several fishing techniques were probably used, such as fish traps and fish weirs or fences in tidal creeks;
- the archaeozoological information on the character of the site mainly points to summer activities. This applies to the presence of mullet and bass as well as to the large numbers of mallard and teal/garganey that were most probably caught during the moulting period. Some species, like wigeon, could have been caught in spring or early autumn. 'Real' winter indicators are absent;
- the faunal spectrum is indicative of an open landscape with a strong marine influence where some freshwater was present. The latter is demonstrated by the presence of freshwater fish (carp, pike, cyprinids), frogs, toads and grass snakes. The salt marshes must have provided good opportunities for pasturing cattle as well as for fowling. Fishing was concentrated in the brackish water of tidal creeks.

# 10 Spatial analysis

*G.R. Nobles*

## 10.1 Introduction

The features failed to reveal any information regarding the structures at the site. It is possible that no large structures existed and that people lived in small 'lean-to' shacks. Alternatively, it may be that the postholes of the structures are too similar to the others to be recognised visually.
This chapter explores the extent to which any information can be reliably extracted from a dataset gathered using an inconsistent methodological approach and recording techniques which were specific to the time.

Can assessment of the spatial relationships between finds from a legacy dataset provide any insight into the internal functions of the site? In essence: is the original interpretation of a settlement without any clear structural elements still valid? Can spatial analysis of find categories improve our understanding of the activities conducted at the site beyond the interpretation of the features?

This chapter will attempt to identify spatial patterns in a multitude of different datasets; care has been taken to apply the appropriate analysis to each data type. A computational statistical approach was adopted as a way of investigating whether such an approach can yield additional information. This therefore goes beyond the visual interpretations made since the original excavation. It applies some techniques which are relatively new to archaeology but have been tried and tested in ecology and remote sensing.

Milco Wansleeben and Leendert Louwe Kooijmans recently attempted to apply spatial analysis to the Middle Neolithic settlement of Schipluiden.[203] This report has been heralded as a case study for spatial analysis in the Netherlands, and might seem the obvious to attempt to emulate. A new approach was nevertheless taken, since their methodology has prompted a number of concerns. It includes a moving average method whereby the data is smoothed from a one cell neighbourhood to another; in this case, to a 3 x 3 cell neighbourhood and then further to a 5 x 5 followed by a 9 x 9. The authors used only a visual spatial assessment as they made no attempt to quantify their results. This method therefore only smoothes the data to give visually pleasing results. Furthermore, no reasons were given as to why these scales of smoothing were appropriate. This method of visual analysis is not inherently bad but, if it is used at all, it should merely be as an initial exploratory technique, and acknowledged as such.

The problem with their method is visible in the results throughout the published images. For example, their Figure 4.6 on page 74 has a series of what are known as data artefacts. Not to be confused with archaeological artefacts, these data artefacts are a direct result of their technique. In this case, one cell has a much higher value than the surrounding ones. When the moving window passes over it, the target cell is averaged out over the area of the neighbouring cells. Due to this one anomaly the result is a pixellated square which distorts the cells surrounding it. This effect is illustrated below (Fig. 10.1). If this method is adopted then a single cell can cause a pseudo-clustering effect within the wider area of that cell, thus creating major problems for archaeological interpretation. In this case of Schipluiden, area D could be interpreted as a large cluster solely because of the presence of a data artefact in the analysis. If this technique is employed then it should only be used in an investigative manner, with further supporting analysis, rather than in isolation.

However, apart from this criticism, the authors must be commended for their attempts at spatial analysis. They were able to show that distribution maps of artefact types should no longer be considered adequate for a full site interpretation. They realised that investigative techniques need to be applied to the distributions to identify the spatial patterning of Neolithic remains. Unfortunately, in this case, their method was inappropriate for their dataset. A more suitable technique for their data might have been kernel density estimation (KDE), which has been applied previously in archaeology and indeed will be used to some extent in the latter stages of this report.[204] This has a few implications for the Schipluiden settlement; it does not necessarily mean that the final interpretations are incorrect, only that they must be considered exploratory. In this authors opinion these areas should be regarded with some degree of scepticism requiring further detailed analysis to justify them fully.

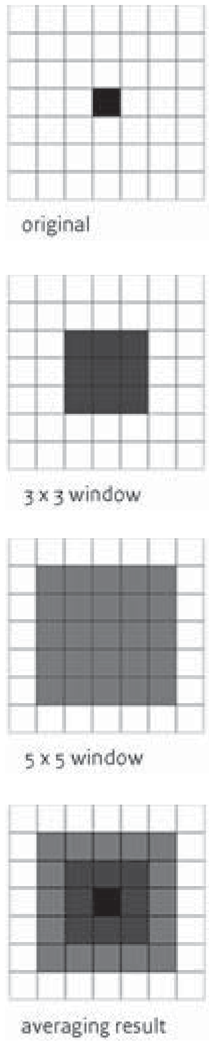



Figure 10.1 Data Artefact effect upon cells with high values.

[203] Wansleeben & Louwe Kooijmans 2006.
[204] For archaeological examples of the use of KDE's see Baxter, Beardah & Wright 1997 as well as Baxter & Cool 2010.

Given the above criticisms, a new direction was sought for this report. It is hoped that this study will help archaeologists appreciate the role of spatial analytical techniques that go beyond the standard Geographical Information System (GIS). This study should be seen not as a 'how to' but more as a 'what is possible'. The author would strongly argue that there is no such concept as a universal method which can be thrown at archaeological data. Each dataset is different and each analysis should be chosen on the basis of methodological considerations, as well as the proposed research agenda. Before arguing 'this is how they did it, therefore we will do the same' one should consider the underlying data. Perhaps 'this data was gathered with a similar methodology as site x, so maybe we can implement similar analyses to answer similar questions?' might be a better argument. Take particular note of the use of the question mark here. In any case, each analytical method used should be subjected to serious thought prior to its implementation based upon the underlying dataset. The analysis here by no means constitutes a complete set of conclusions, merely results which can be assessed, criticised and theorised further.

However, if this methodology is replicated, it should only be when the data allows it, when it is applied to material gathered in metre squares. It is not known whether this is the best methodological approach for intra-site analysis at Neolithic sites. Further research is required to pursue this issue, although some investigation of flint scatters has been conducted.[205]

Computational spatial analysis is a relatively new as a method in archaeology, dating back only as far as the 1970s. Hodder and Orton's[206] publication highlighted its potential in archaeology, the past 40 years or so have seen a great deal of methodological development within this multidisciplinary field. This is still continuing as this study employs some techniques which are relatively new to archaeology and, until recently, the only examples have related to other social science disciplines.[207]

## 10.2 Aims and objectives

The aim of this research is to assess the datasets individually and as a whole. In some cases it is appropriate to look within the single dataset and further subdivide it to try and identify past activity areas. In such a large and wide-ranging project, several objectives are required to encapsulate the datasets. Before starting any analysis it is important to quantify the remains to get a proper grasp of the data before analysing it. Statistical datasheets were created which include basic spatial and statistical information with a graphed summary.[208] This defines the general character of the data so appropriate analysis can be employed.
From this, the following objectives can be defined:

- Assess the global trends in the data.
- Identify underlying factors influencing the spatial distributions.
- Identify any temporal relationships.
- What are the local spatial configurations of the data? Can they help to identify activity areas?
- Interpret how these areas were being used by the people inhabiting the settlement.
- Identify areas of future research which can further enhance this study.

Although we are talking about 'data', it should never be forgotten that the entire premise of this analysis is to try and identify what people were doing in the past, how and why.
Furthermore, returning to the idea of activity areas, in this study they are defined as areas of clustering, be this positive or negative (presence versus absence).

## 10.3 Guide to this chapter

This chapter is intended to be accessible to archaeologists with or without technical knowledge of spatial analytical techniques. A full technical summary has therefore been provided in appendix 10.1 for those who wish to explore the processes used in greater detail. It is expected that readers will proceed to the sections of this chapter which are of interest to them and only a few will read it in its entirety.

205 See Spikins, Ayestaran & Conneller 1995.
206 Hodder & Orton 1976.
207 For instance Anselin's (1995) use of the $G_i$* and $I_i$ statistics (spatial clustering) in regards to African conflict 1966-1978, or tree contact zones as in Swenson and Howard's (2005) paper. Premo 2004 and more recently Crema, Bevan & Lake 2010, 1122-1123 as well as Lasaponara & Masini 2010 have applied these techniques to archaeological questions. However these are the only uses of these techniques to archaeology but specifically related to landscape archaeology. No instances appear in regards to intra-site analysis.
208 See appendix VI.

The chapter is therefore divided as follows:

- 10.1 to 10.3 Introduction
- 10.4 to 10.12 Digitising methodology and initial analysis of the separate datasets
- 10.13 Results
- 10.14 Discussion
- 10.15 Conclusions

Even though it is divided into sub-sections this should not detract from the importance of all the sections in this chapter as a whole.

## 10.4 Critical analysis of the dataset and the recovery process

Prior to any analysis it is essential to evaluate the data from its current state and the procurement strategies which were employed for its retrieval.

### 10.4.1 Criticisms from a spatial approach

The dataset is constructed from the physical remains, documented evidence and general deduction. It consists of:

- *Digitised site drawings*
- *Documentation*
- *Animal remains*
- *Botanical remains*
- *Flint artefacts*
- *Stone artefacts*

Pottery (some with surviving residues)

The main criticism of the excavation is the methodologies which were employed. It is the pluralisation of the methodology which causes the most problems and concerns. Initially the methodology was ideal for detailed two-dimensional spatial analyses, the plotting of each and every artefact with x and y coordinates, but with no z (height). This would have allowed for detailed density analysis and, more especially, multi-scalar point pattern analysis, amongst other techniques. However, the methodology was altered to a grid collection method, although this does still allow for grid-based analytical techniques. As the site was excavated in 5 cm layers some three dimensional information could be attributed to the data. However, these layers could not be located in the archive. The only height measurements which could be accurately reproduced were the top and base of the cultural layer and a contour diagram of the underlying shell bank.

The second criticism is the lack of documentation, an incomplete unpublished site report and several unordered sheets, including scraps of paper with annotation. There are no context sheets or drawing indexes, and all the context information and interpretation is stored on the original drawings. Some drawings and annotations have been inked over, and some of the pencil has faded and is now unreadable.

### 10.4.2 Retrieval of finds

As previously stated, finds were collected in metre squares. However, some lay within features. They have no square number and are instead associated with the feature in which they were excavated. A proportion of the finds have been examined since their deposition but no published results can be found. Some artefacts had indecipherable numbering in which the square number could occasionally be identified, but in other cases only the trench or layer number was identifiable. These finds without any spatial reference had to be omitted from the analysis; they are identified at the start of the appropriate section. Table 10.1 shows there were 37 sheets consisting of 65 drawings (plans and sections) in total.

**Table 10.1 The archive of Keinsmerbrug.**

| type | count |
|---|---|
| sheets | 37 (65 drawings) |
| flint | 416 |
| stone | 94 |
| animal bones | 31683 |
| samples | 83 |
| residues | 16 |
| pottery | 458 |
| ornaments | 3 |

### 10.4.3 Original collection methods

In the original excavation the finds were collected by hand as well as by sieving. Only in the case of the animal bones do we know which were found by each method. This is discussed in section 10.6.

## 10.5 Methods

### 10.5.1 Data acquisition

All the data was digitised, including the plans and sections as described in the previous chapter. The finds specialists used databases and spreadsheets to record their data, which were incorporated into a single database ready for analysis. Every find, sample and residue was assigned a unique identifier starting at 1 and ending at 2851 (see table 10.2). This ensures that each reference is unique. Many items had duplicate numbers as they all came from the same square, so each specialist used different methods to identify each item. Both the specialist recording method and this unique identifier have been entered in the resulting database to ensure future research is possible.

The botanical remains required two sets of numbers, one for each sample and the other (in parentheses) assigned to each species within a sample to enable the joining of the database tables. Once all the various data sets had been imported and converted for compatibility, spatial analysis could take place.

### 10.5.2 Outline of analysis

Several analyses were conducted on these datasets. As stated above, distribution maps with basic statistical quantification have been produced for each type and class. These include an overall plot for all of the animal bones, and also plots for the classes, birds, mammals, etc. Global analysis has been applied to these types, but not the classes. This initially takes the form of exploratory trend surface analysis,[209] which visualises any general trends in the data and suggests directions of trends or areas of clustering (Fig. 10.2-10.5). Getis and Ord's General G and Moran's *I* were employed to describe any clustering within the dataset.[210]

Where clustering is apparent and where appropriate, Getis and Ord's $G_i$* statistic and the Local Moran's $I_i$ statistic have been used to investigate the phenomena further.[211]

**Table 10.2 Unique identification numbers.**

| | |
|---|---|
| **animal remains** | **1-1457, 2799** |
| flint | 1458-1873 |
| stone | 1874-1967 |
| botany | 1968-2048, 2800-2805 (2049-2324, 2806-2851) |
| pottery | 2325-2782 |
| residues | 2783-2798 |

[209] See Grohmann 2005 and Sutterlin & Ghastings 1986 for further uses. No statistical analysis was applied to these results.

[210] See Getis & Ord 1992 and Moran 1948. A detailed explanation of these techniques can be found in appendix V with a summary in the main text prior to its implementation.

[211] Key references are Getis and Ord 1992 and Anselin 1995.

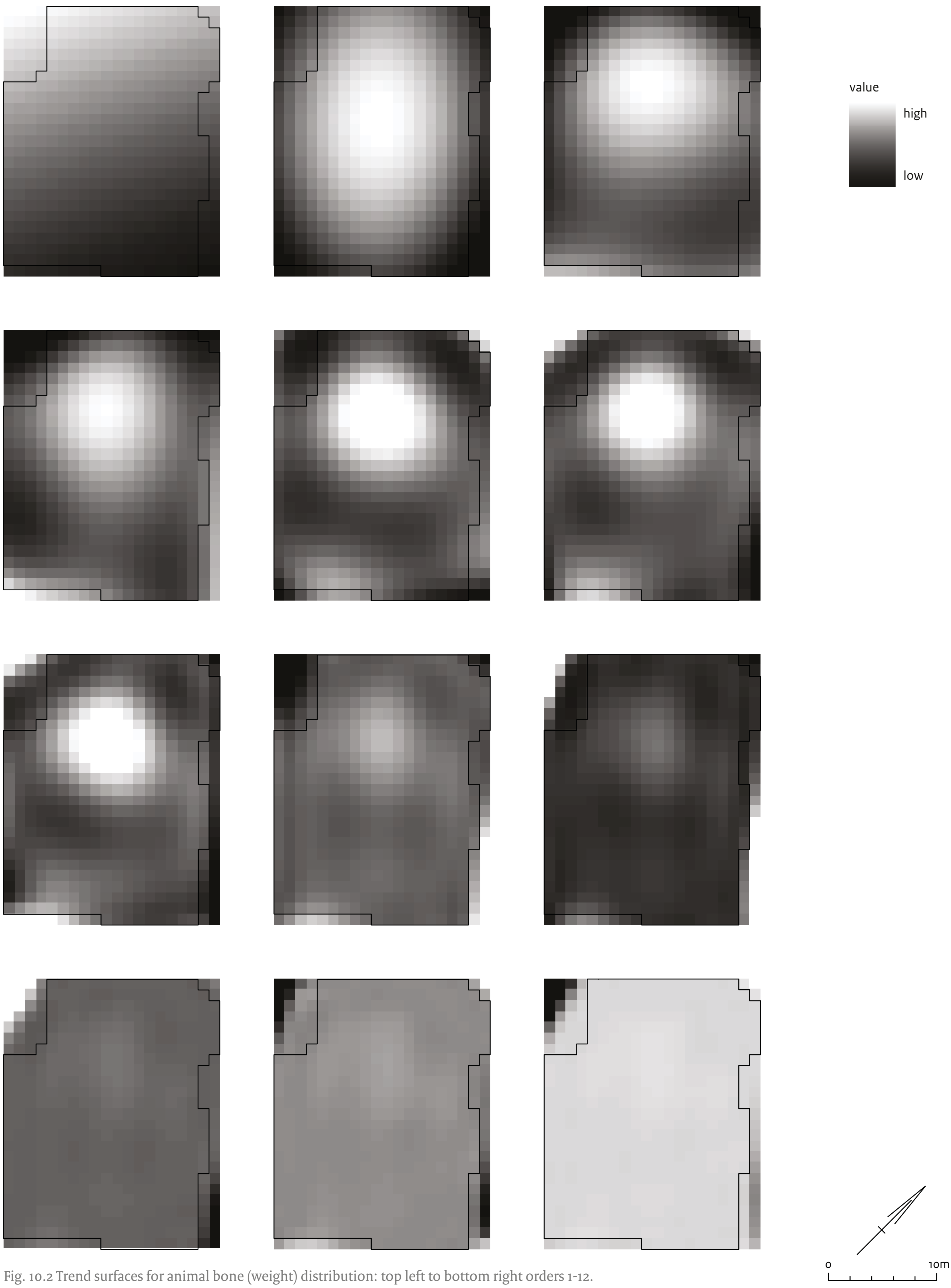



Fig. 10.2 Trend surfaces for animal bone (weight) distribution: top left to bottom right orders 1-12.

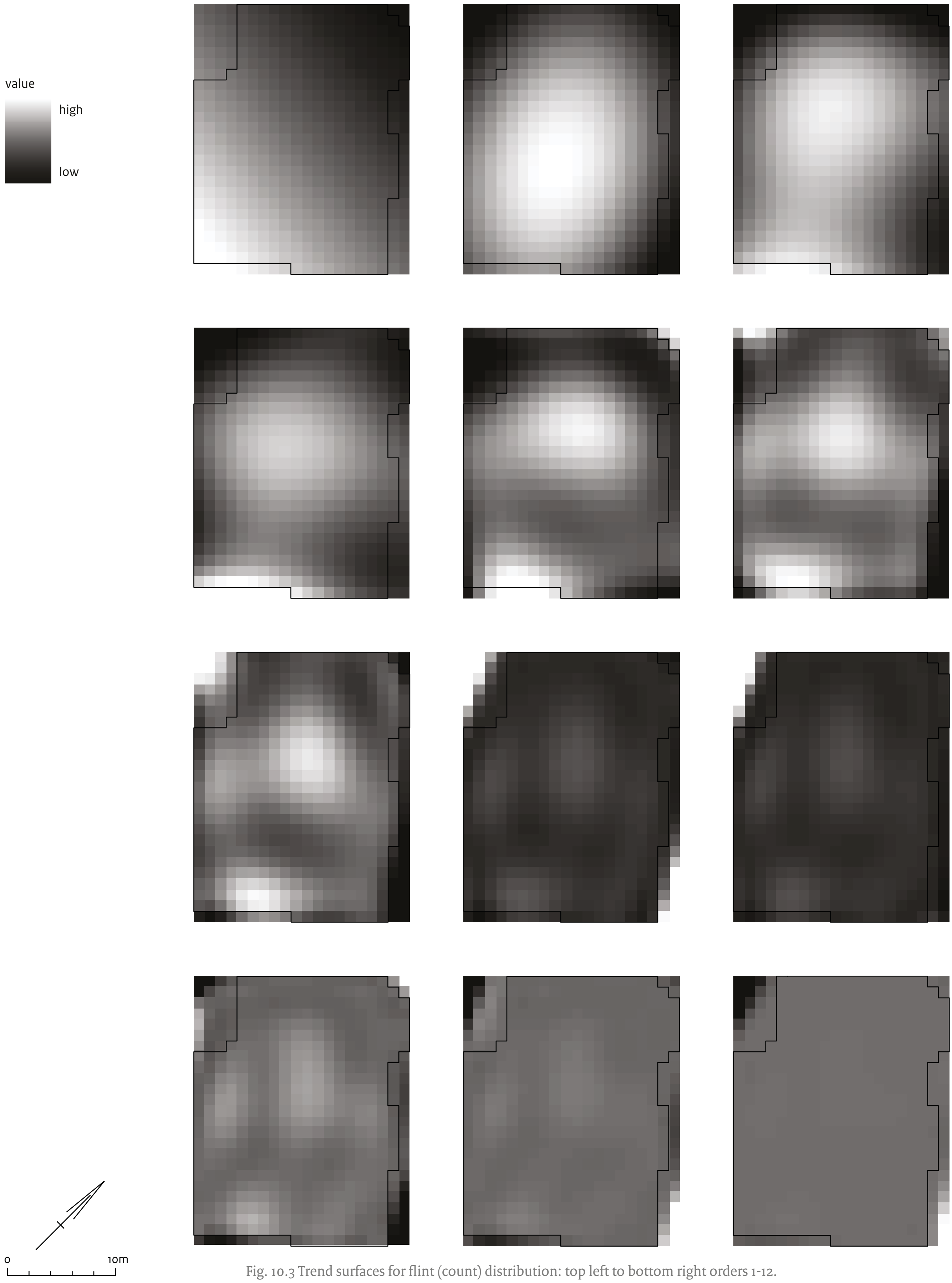



Fig. 10.3 Trend surfaces for flint (count) distribution: top left to bottom right orders 1-12.

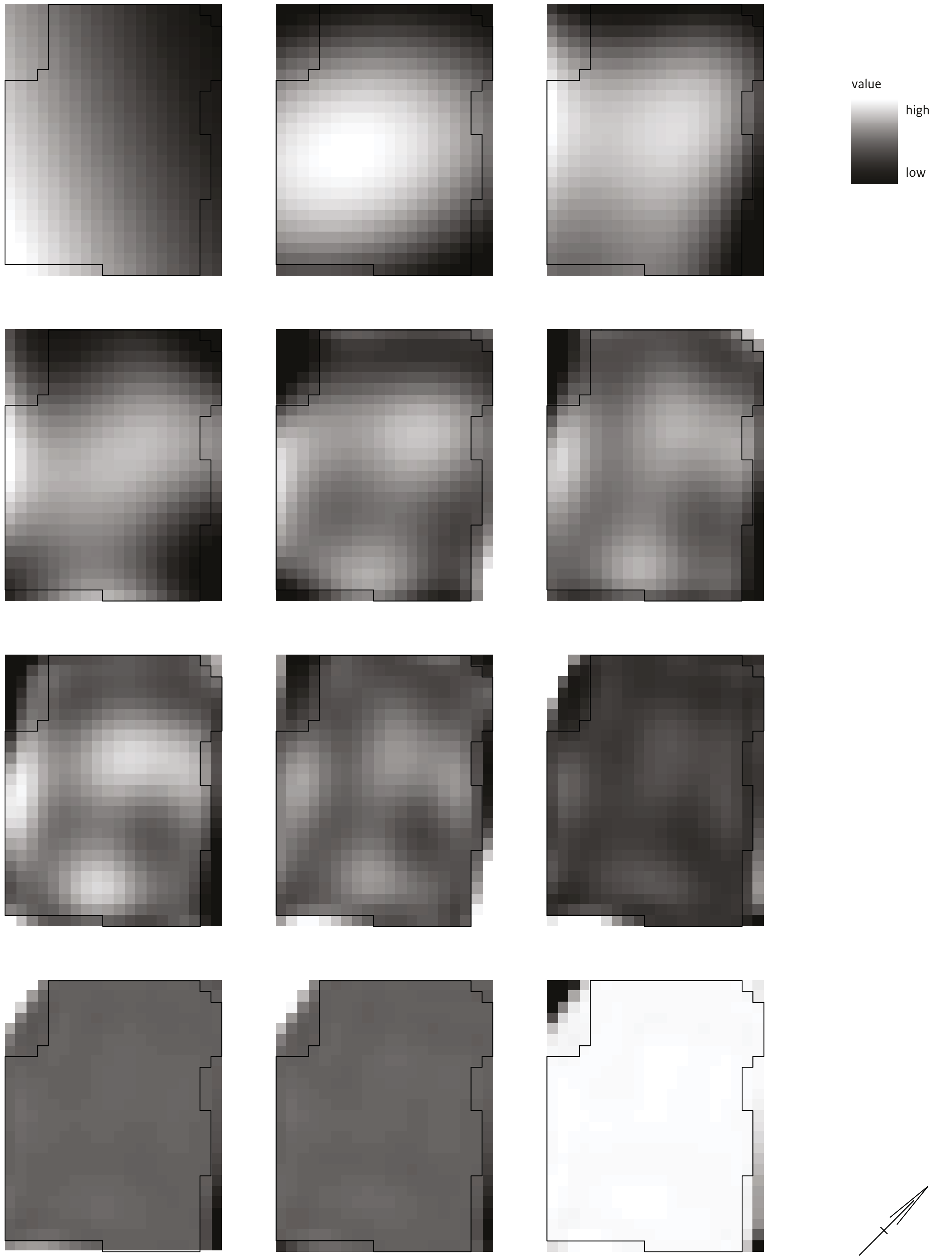



Fig. 10.4 Trend surfaces for stone (count) distribution: top left to bottom right orders 1-12.

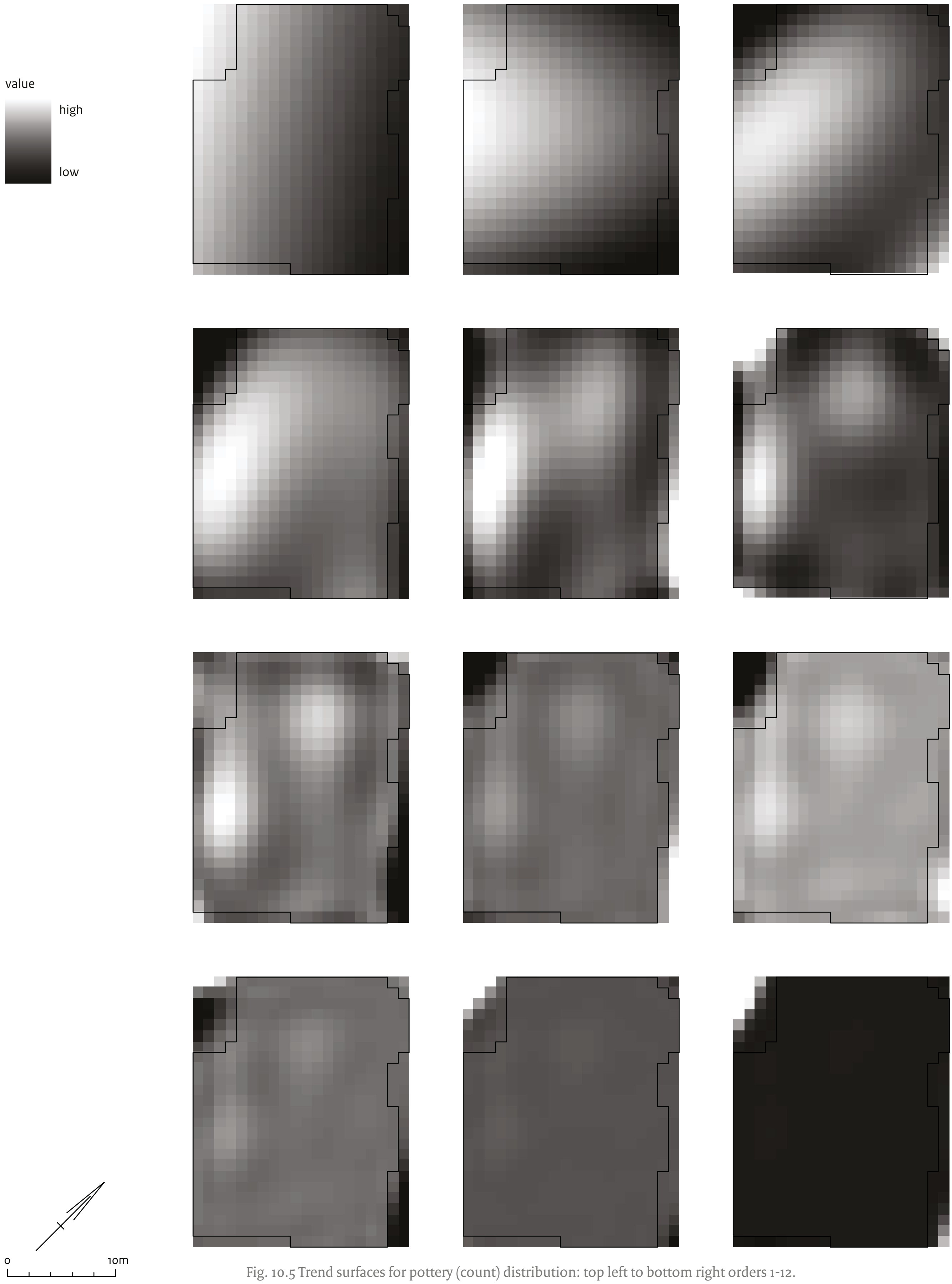



Fig. 10.5 Trend surfaces for pottery (count) distribution: top left to bottom right orders 1-12.

### 10.5.3 Presentation

All the maps which utilise a stretched colour ramp do so by means of the standard deviation of the underlying data. Categorical maps such as the distribution maps were classified depending on the data source, with items which could be classed as single entities. In the case of flint, for instance, whole numbers were used.[212] In cases where actual weights were used as the unit of distribution the standard deviation was applied to the colour ramp. To represent the spatial cluster analysis the standard deviation technique was also used as it relates to the significance levels and can provide a visual aid for the reader. A three tone ramp was used which is best presented in colour, in this case red – white – blue. Some plots are represented by symbols; the botanical distributions are sized by their rank (Fig. 10.6).

The pottery pie chart symbols in Figure 10.25 were also sized in diameter by the weight of sherds in a square. In this case using the actual weights was impractical as it caused ambiguous and chaotic representations. The weights were therefore normalised, restructured from 0 to 1 using the following equation:

$$\textit{normalised value} = \frac{\textit{(value – minimum)}}{\textit{range}}$$

Where:
*range = maximum - minimum*

This means that the smallest weight is not represented as it is classed as 0; the highest weight value is now classed as 1, and all the remaining weight values fall within this range of 0 to 1. Upon these graded circles pie charts denoting the occurrences of fabric types were plotted, after discussion with the pottery specialist[213] the indeterminate sherds were discounted from analysis. Sand fabrics were also excluded from one of the plots as it was agreed that sand could be found locally within the natural clay matrix. Where appropriate this method was also applied to the botanical figures, although without normalisation, as it is ranked data.

### 10.5.4 Brief outline of the statistical analyses

Various statistical spatial analyses were performed on the datasets.[214] These techniques are very briefly discussed below in the form of a non-technical summary.

Global methods return a single value for the study area, in this case the excavation area. The global Moran *I* gives a value which describes whether the artefacts are clustered, randomly distributed or dispersed. The General G describes the degree of clustering. The local methods are the most relevant for this study. Unlike the global ones, they look at the artefact distributions and suggest areas of clustering within the excavation. For instance, the global method may suggest there is one cluster whereas the local analysis may suggest two areas of clustering. The local methods employed were $G_i$* and *Ii*. The $G_i$* is the local version of the General G method, which looks at the quantity of artefacts from a metre square and applies a mathematical formula, resulting in a positive or negative number which is then assigned to this square. The analysis moves to the next square and the process is repeated. This continues until every excavated square has been analysed.[215]

The $I_i$ method is very similar to the process described above, although in this case rather than averaging the surrounding squares the quantities of artefacts from a square are compared with the quantities of those surrounding it, again at a set distance. This time the focus is on the differences between the quantities: how similar or dissimilar they are. If they are similar then a high value is given to the square; if dissimilar, a low number.[216]

Density analysis (KDE) takes the central point of each square and compares the quantities of finds from each square. This is an averaging technique based on the character of the data, which shows where there are high and low densities of artefacts.[217]

Hierarchical cluster analysis (HCA)[218] creates a tree graph (dendrogram) of associated squares at different distances. In this case it was used only for the ceramics dataset, each sherd of pottery being described as a cluster at a distance of 0m. The distance is then altered until two sherds fall within the smallest distance. These then constitute a

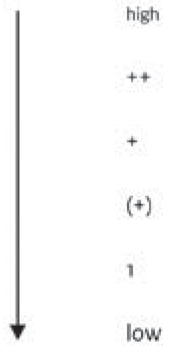



Figure 10.6 Botany ranked order.

[212] Except for generalisation, for instance some flints were from 1 of four squares, but it was not known which one, therefore 0.25 of a flint was attributed to each of the four squares. Although a source of error these flints were few in number.
[213] Personal communication Sandra Beckerman (2010), for further details see chapter 4 in this volume.
[214] The techniques are explained in appendix V.
[215] Further reading Getis & Ord 1992.
[216] Further reading Anselin 1995.
[217] See Baxter, Beardah & Wright 1997 as well as Baxter & Cool 2010 for examples.
[218] Connoly & Lake 2006, 168-171.

cluster and the lines of the tree join. These two sherds are then viewed as a single entity, and again the distance is increased until the next two sherds are connected. This continues until all the sherds are seen as a single entity or cluster.

## 10.6 Results

### 10.6.1 Animal remains

**Data quality**
The dataset was relatively high–quality. With the exception of one sturgeon plate every bone came from a specific square or feature. This bone was omitted from any analysis. The animal bone remains were described by weight per location. The weights of animal bone from botanical samples were given an average weight by the bone specialist,[219] as described below. All of the fish bones came from botanical samples. An average weight per bone per species was derived from the total weight. Table 10.3 identifies the average weight for each class type. Since they were from botanical samples the weights of the bone will be quite small, although not necessarily insignificant, as this depends on their location and quantity.

**Characterising the data**
A total of 31683 pieces of animal bone were recovered from the site, as shown in table 10.4. Bird and fish remains make up the majority of the assemblage. Of these remains, 1862 bones were recovered from features and 29820 were from the cultural layer, with one omission.

**Spatial distribution**
All of these results refer to the finds from the cultural layer, rather than finds from features. Some of these finds were recovered by sieving, although a greater weight of animal remains were directly recovered by excavation (Fig. 10.7). The concentrations in the sieved material appear to be relative to the quantities recovered through excavation.

**General**
The overall distribution map for the animal bone[220] shows a general spread of remains across the site with a few high quantities to the south, but the majority to the north and northwest.

**Table 10.3 Animal remains classes.**

| bone species | class | average weight |
|---|---|---|
| **bird** | duck | 0.46g |
| | teal/garganey | 0.30g |
| | teal | 0.15g |
| | wigeon | 0.16g |
| | mallard | 0.15g |
| | carrion crow or hooded crow | 0.10g |
| | bird, indet. | 0.10g |
| | gull | 0.10g |
| | jack snipe | 0.10g |
| **mammal** | ground vole | 0.07g |
| | small rodent | 0.05g |
| | vole | 0.05g |
| | root vole | 0.05g |
| | common/french shrew | 0.02g |
| | shrew | 0.02g |
| | pig/wild boar | 0.10g |
| **fish** | all classes | 0.08549g |

**Table 10.4 Animal bone class summary from all contexts.**

| type | amount | % |
|---|---|---|
| **amphibian** | 25 | 0.08 |
| bird | 27396 | 86.47 |
| fish | 2924 | 9.23 |
| mammal | 635 | 2.00 |
| mollusc | 699 | 2.21 |
| reptile | 3 | 0.01 |
| total | 31682 | 100 |

**Table 10.5 Generalisation of the data (bone).**

| number of squares | probability | number of pieces |
|---|---|---|
| 1 | 1 | 330 |
| 2 | 0.5 | 5 |
| 4 | 0.25 | 16 |

[219] Zeiler & Brinkhuizen, chapter 9 in this volume.
[220] Appendix VI.

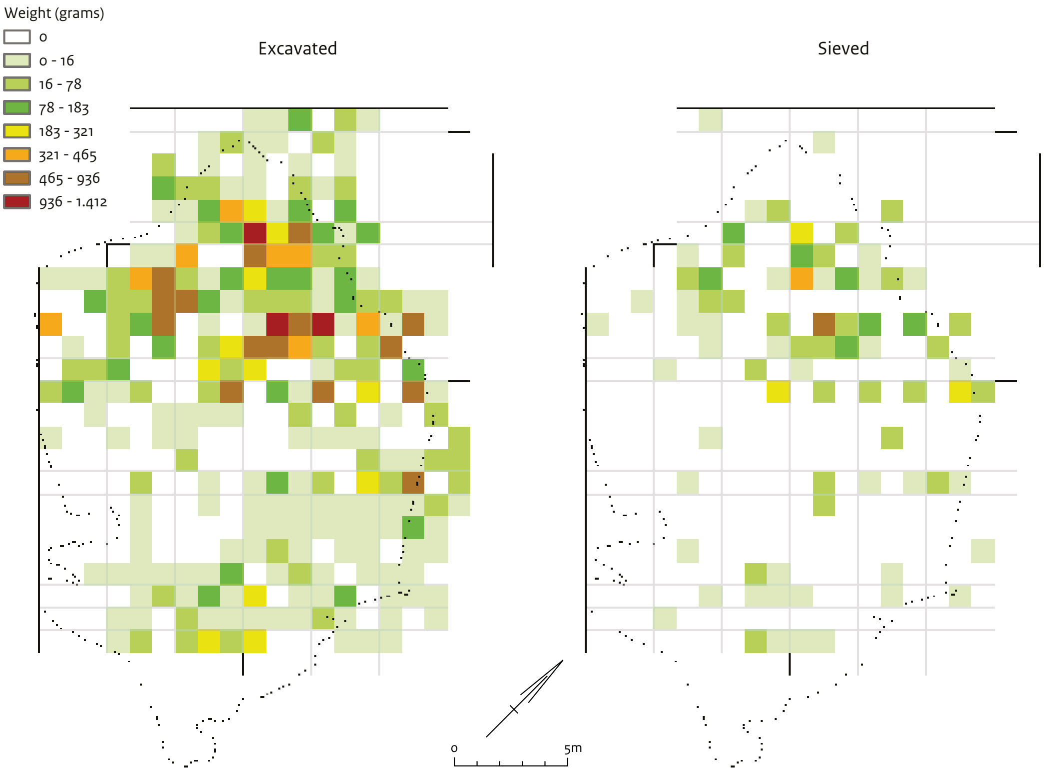



Figure 10.7 Animal remains collection bias.

### Trends

The first-order trend surface identifies a westerly trend. Increasing orders show a central trend which decomposes to a central northern group with possible subdivisions and a potential southern area.

### Global statistics

The global *I* and the general G statistics display a significant global clustering at all of the spatial lags. On a global scale, therefore, the bone exhibits significant clustering, emphasising presence of bone rather than absence. Both tests are complementary and both have a 1% chance of making a type 1 error.[221] It is therefore possible to reject the null hypothesis of complete spatial randomness (CSR) and accept the alternative hypothesis that the distribution is not statistically random. The general G also allows the conclusion that the bone remains are clustered together.

### Local statistics

Local analysis attempts to identify the cluster or clusters on which the global assessment is based. The trend surface suggests two clusters with higher weights of bone to the north. The $G_i$* statistics demonstrate a single cluster which possibly fragments at smaller scales (Fig. 10.8).

Initially three clusters are apparent, to the north, south and west. The western cluster combines with the northern cluster until one cluster remains in the north. The southern cluster is significant at low-scale analysis. However, the northern cluster is the principle factor at all scales with high values of bone

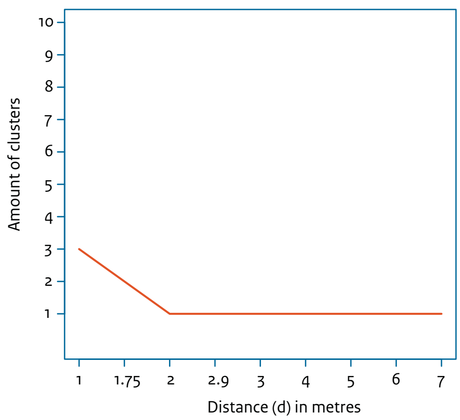



Fig. 10.8 Cluster interpretation of Animal Remains using the $G_i$* statistic at multiple scales.

221 For an explanation of errors see appendix V.

weight clustering together. The local *I* statistic suggests clustering in the northern area dividing into four sub-components (Fig. 10.9).

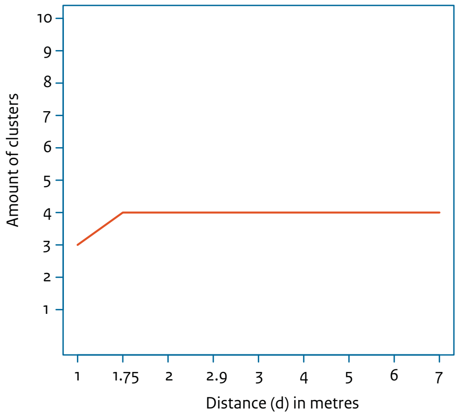



Fig. 10.9 Cluster interpretation of Animal Remains using the $I_i$ statistic at multiple scales.

## 10.6.2 Flint

### Data quality

The flint assemblage was recorded by metre squares. However, on a few occasions, flint finds were recorded within their two by two metre square or a two by one metre square. As a result they had a 25% probability of belonging to any of the four squares or a 50% chance of belonging to one of the two metre squares. A probability was therefore assigned to each square.

The 0.5 class consisted of one core, three waste pieces and one flake. In the 0.25 class there were nine flakes, five waste pieces, one blade and one piece which was unidentified. Twelve pieces of flint were lacking a location within a square or feature. Flints 1458 to 1469 could not be located spatially. Of these twelve numbers 1460, 1461, 1464 and 1465 were from the topsoil, and 1466 and 1467 are from an unknown metre square. The remainder are assumed to have been from the topsoil as they have a trench and a layer number but no square number. Three flints are numbered 2-1-586 but square 586 does not exist. All of the aforementioned flints (15) were disregarded in the analysis.

### Characterising the data

As shown in Table 6, 416 pieces of flint were found at the site. Waste and flakes make up the majority of the assemblage.[222]

Of these flints 354 were found within the cultural layer and 47 in the features. As previously mentioned, 15 could not be assigned a location.

### Spatial distribution

All of these results refer to the finds from the cultural layer, rather than finds from features.

### General

The overall distribution map for the flint finds shows a general spread of remains across the site with a few high quantities to the south and west but the majority to the north and northwest. There is a general lack of finds, except for a few squares, in the southern central area heading east.

### Trends

The first-order trend surface identifies a southerly trend. Increasing orders show a central trend which decomposes to a central northern group and a more responsive southern area. A group can also be seen to the west. The southern high value is not likely to be due to edge effects (Fig. 10.10-10.10.18).

**Table 10.6 Flint type summary from all contexts.**

| type | amount | % |
|---|---:|---:|
| waste | 190 | 45.67 |
| flake | 159 | 38.22 |
| blade | 23 | 5.53 |
| core | 10 | 2.40 |
| unknown | 10 | 2.40 |
| splinter | 8 | 1.92 |
| core fragment | 6 | 1.44 |
| primary flake | 5 | 1.20 |
| pebble | 2 | 0.48 |
| test pebble | 2 | 0.48 |
| nodule | 1 | 0.24 |
| **total** | **416** | **100** |

222 See Garcia-Diaz this volume.

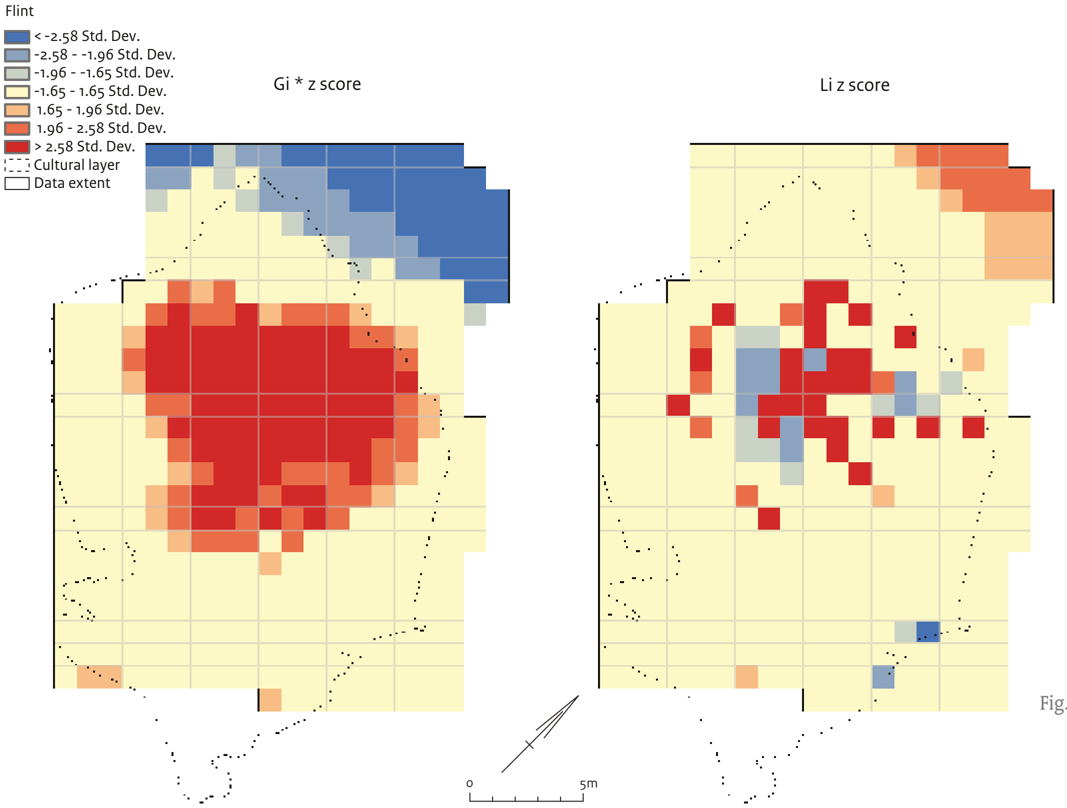



Fig. 10.10 *Gi** and *Ii* plots at a *d* of 7m.

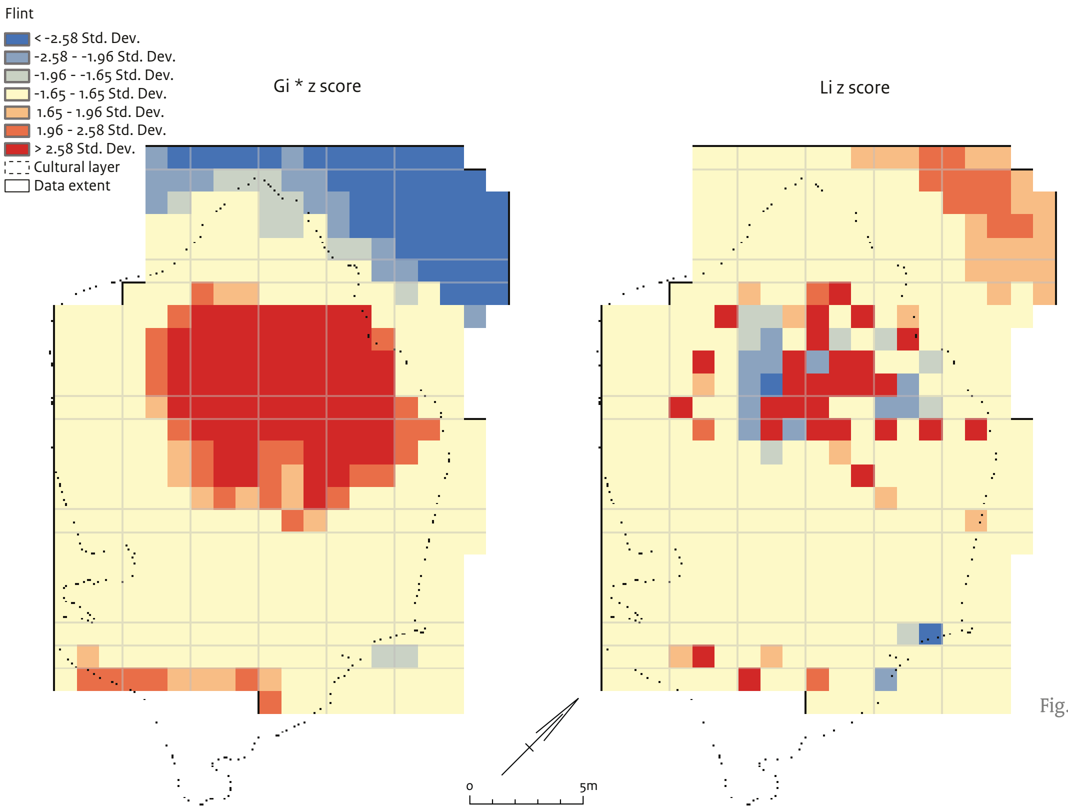



Fig. 10.11 *Gi** and *Ii* plots at a *d* of 6m.

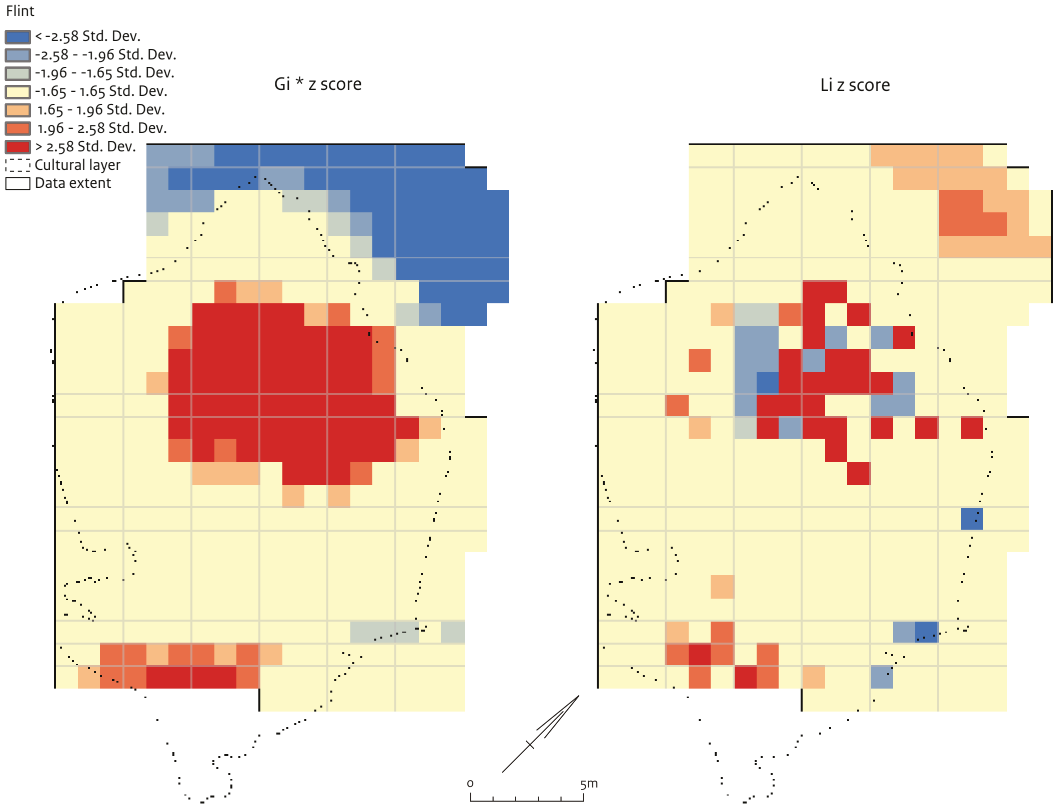



Fig. 10.12 $G_i$* and $I_i$ plots at a $d$ of 5m.

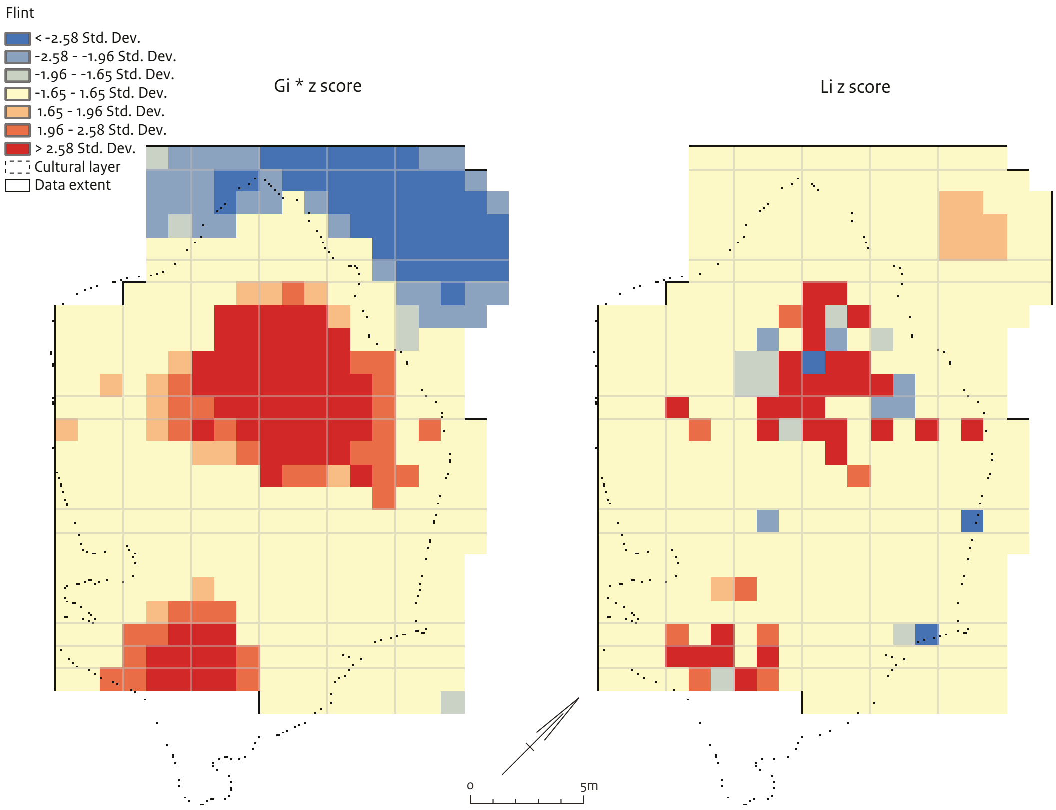



Fig. 10.13 $G_i$* and $I_i$ plots at a $d$ of 4m.

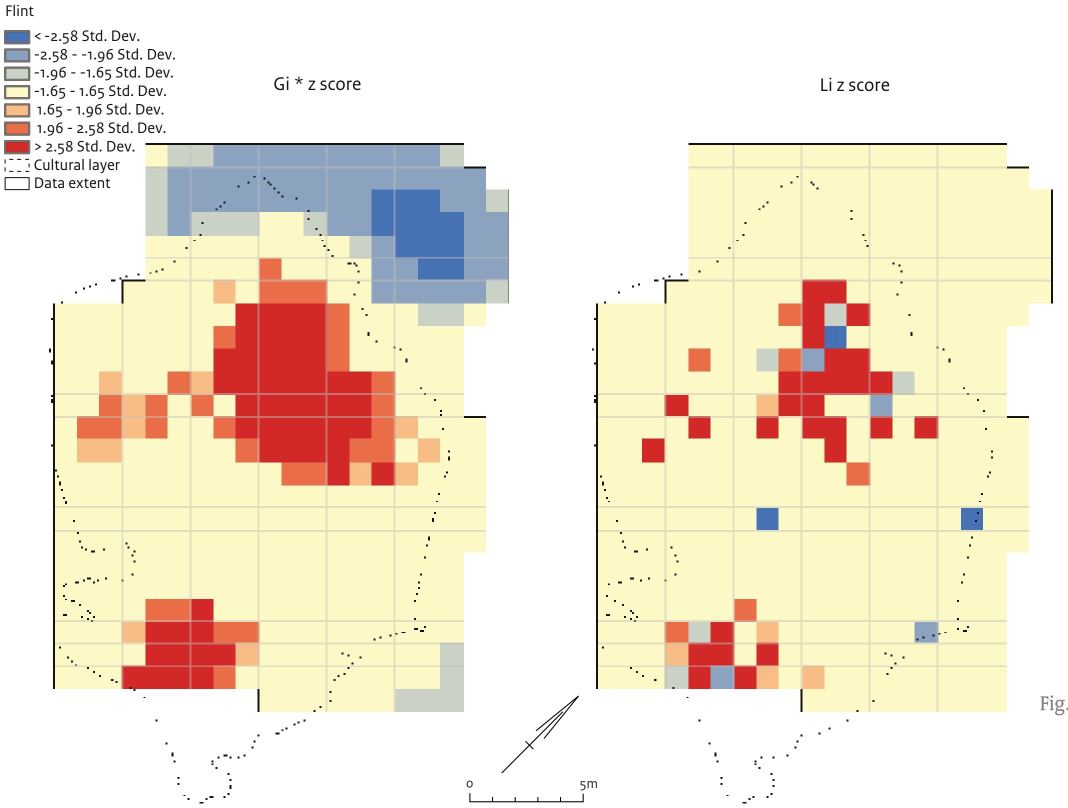



Fig. 10.14 $G_i^*$ and $I_i$ plots at a $d$ of 3m.

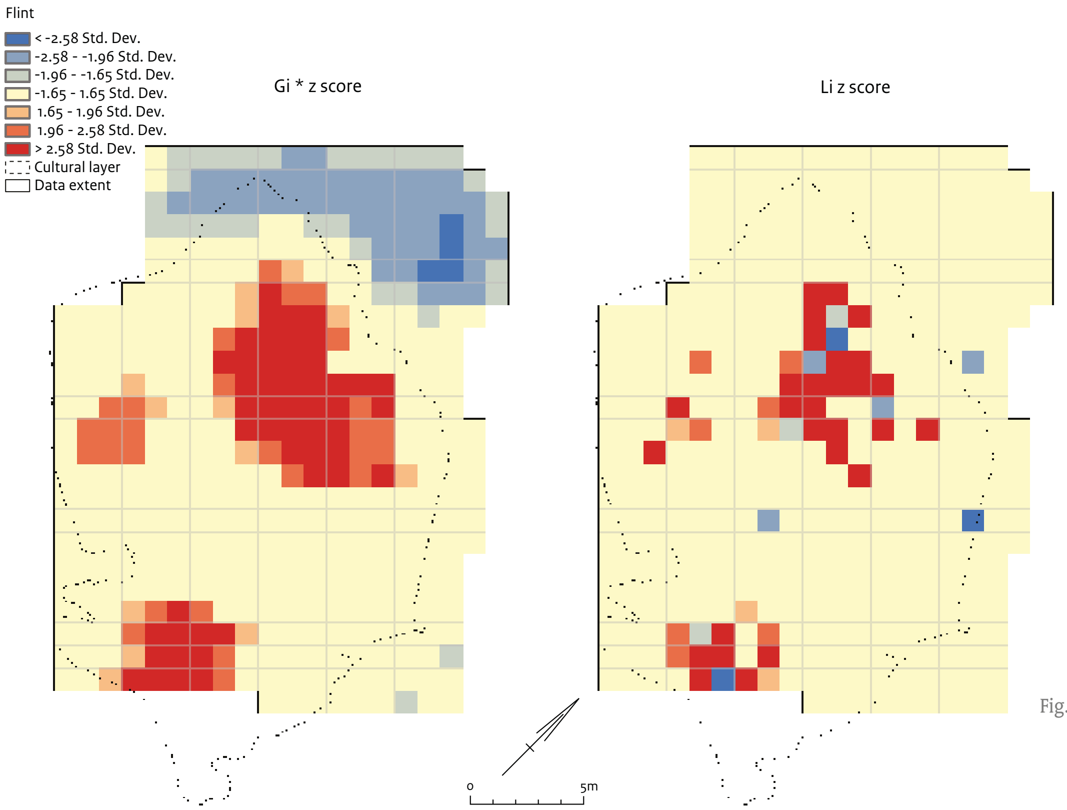



Fig. 10.15 $G_i^*$ and $I_i$ plots at a $d$ of 2.9m.

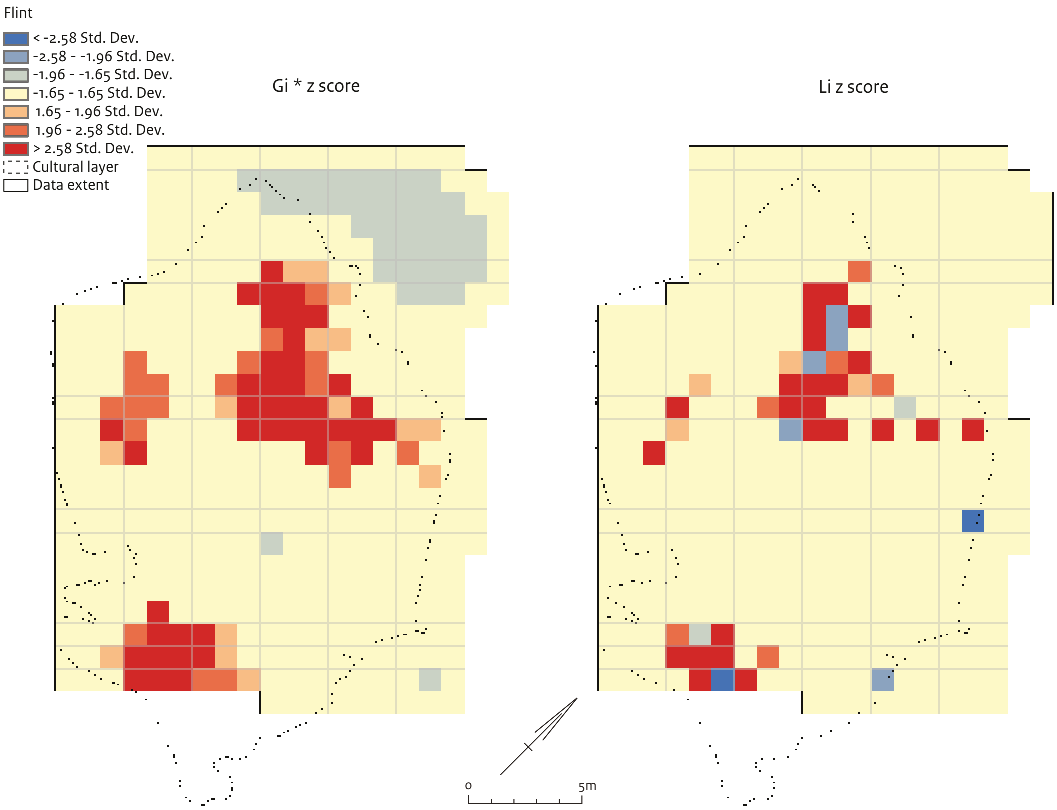



Fig. 10.16 *$G_i$** and *$I_i$* plots at a *d* of 2m.

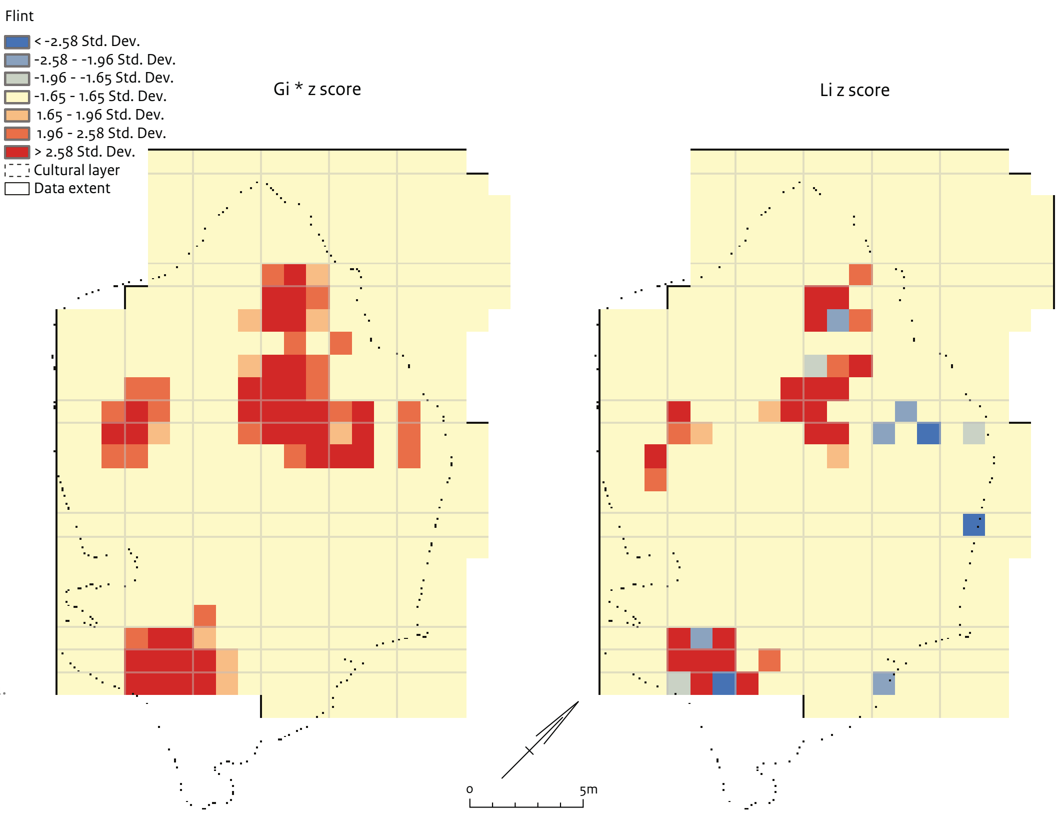



Fig. 10.17 *$G_i$** and *$I_i$* plots at a *d* of 1.75m.

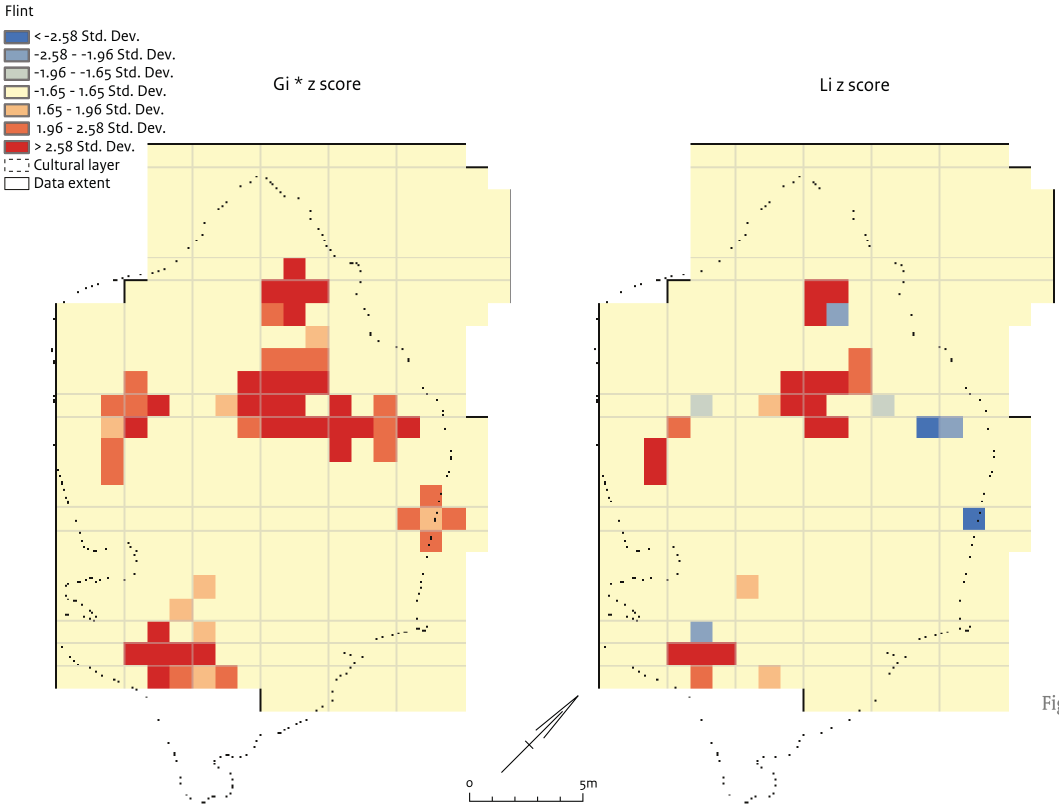



Fig. 10.18 $G_i$* and $I_i$ plots at a *d* of 1m.

## Global statistics

Both the global *I* and the general G statistics display a significant global clustering at all of the spatial lags. On a global scale, therefore, the flint exhibits significant clustering of the presence of flint rather than absence. Both tests are complementary and both have a 1% chance of making a type 1 error. It is therefore possible to reject the null hypothesis of complete spatial randomness and accept the alternative hypothesis that the distribution is not statistically random. The general G also allows the conclusion that the flint artefacts are clustering together.

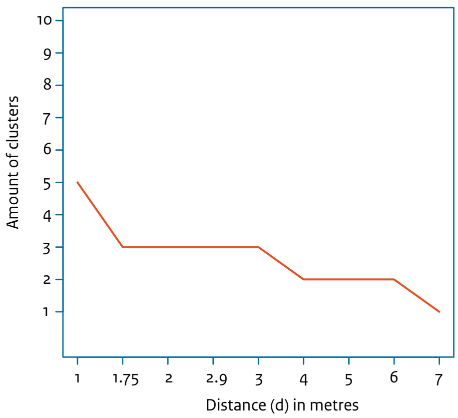



Figure 10.19 Cluster interpretation of Flint using the $G_i$* statistic at multiple scales.

## Local statistics

Local analysis attempts to identify the cluster or clusters on which the global assessment is based. The trend surface suggests two clusters with higher quantities of flint to the south. The $G_i$* statistic identifies one to five significant clusters (5% confidence level), depending on the scale of analysis (Fig. 10.19).

This demonstrates more than one or two clusters as suggested by the global results. Three clusters appear, to the north, west and south. The western cluster lowers in significance with scale, and beyond the 3m scale it combines with the northern cluster, resulting in only two clusters at the 4m scale. At a 1m scale the northern cluster divides into two, splitting northwest to southeast. The southern cluster is significant until the 4 to 5m scale; the northern cluster is significant at all the assessed scales.

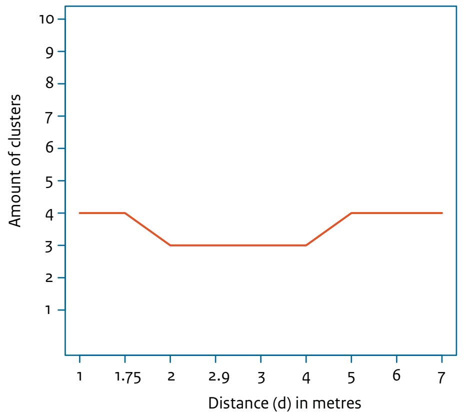



Figure 10.20 Cluster interpretation of Flint using the $I_i$ statistic at multiple scales.

### Local I

The Local *I* statistic illustrates three to four similar groups of high values, using the same confidence levels (Fig. 20). Unlike the $G_i$* a much more static graph is presented. At a 1m scale the northern cluster divides into two, splitting northwest to southeast. At the 2m scale the northern cluster becomes one. At 5m a new cluster appears in the very north, suggesting edge effects are starting to distort the analysis, especially as no finds were found in that area. At the 7m scale it is much more likely that there are one or two clusters with the southern cluster, falling below the significance threshold at the 6m scale. Given the two local results, an analysis at the scale of 1.75m appears to be the most suitable for this dataset.

### Burnt flint waste

During the excavation five hearths and two charcoal patches were discovered, all within metres of each other. As recognised by Sergeant *et al.* it is possible to locate additional non-structured hearths using burnt artefacts as a proxy.[223] Obviously, this assumes that the artefacts stayed within the hearths after burning and were not deliberately burnt for another purpose or moved by anthropogenic processes (for example by cleaning or dumping).

The waste flint was thought to be the most suitable to test this hypothesis, as it should be less susceptible to anthropogenic factors. The majority would be the result of flint knapping,

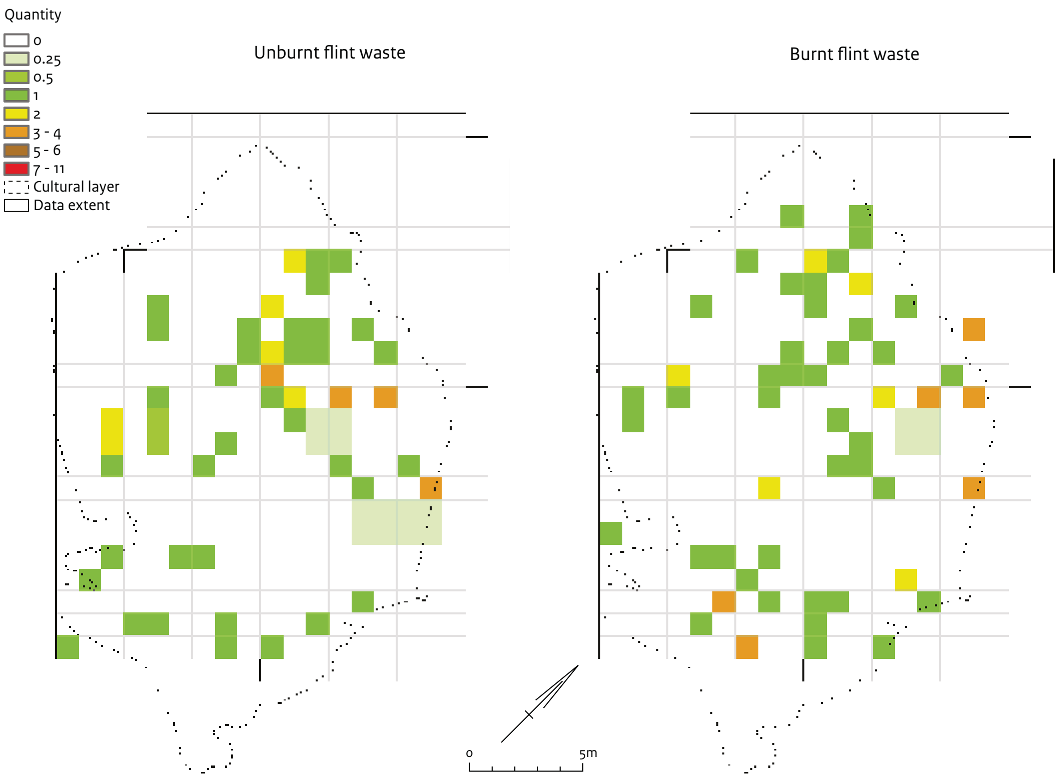



Figure 10.21 Distribution of the burnt and unburnt flint waste, values less than 1 are due to the possibility of multiple locations for a single piece of flint.

[223] Sergeant, Crombé & Perdaen 2006.

and therefore small. Visually, the burnt flint waste appears to be distributed randomly within these three clusters; the unburnt flint also displays a similar pattern in visual terms (Fig 10.21). Significance testing would need to be employed to test if these patterns are statistically random. In this case it does not aid the identification of further hearths, which suggests no other hearths existed. This approach was not explored further.

**Use wear**

The flints showing signs of use wear were plotted (Fig. 10.22).[224] Although there appear to be various groupings at this stage, it is important not to rely too heavily on this distribution for the interpretation of specific activity areas. Only twenty flints showing use wear were located to a square. Four other pieces of flint with use wear could not be assigned a locality. One of these came from the topsoil and the other three had unknown locations.

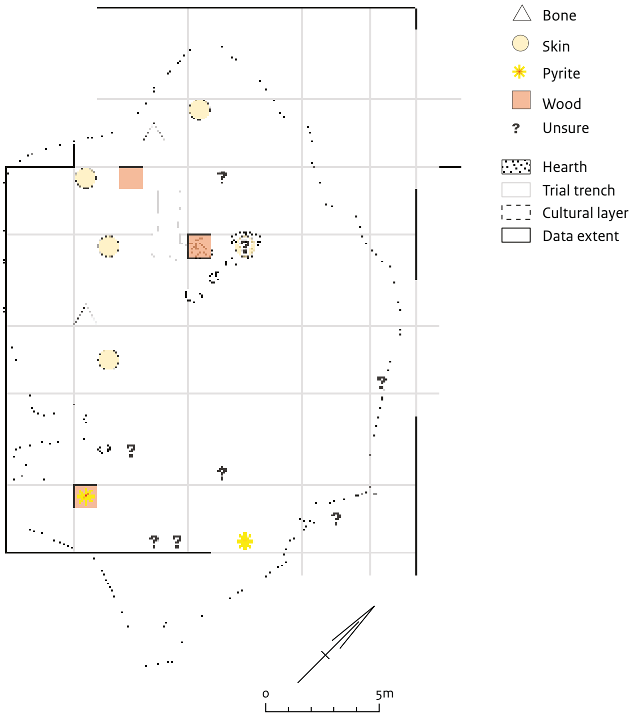



Figure 10.22 Location of the flint with signs of use-wear and interpretation from the lithic specialist.

## 10.6.3 Stone

**Data quality**

The stone was collected by metre squares. As with the flint some items were recorded in a two by two metre square. As a result they had a 25% probability of belonging to any of the four squares (see table 10.7). A probability was therefore assigned to each square. Three pieces of stone were lacking a location within a square or feature (UID1874-6). These were omitted from any analysis.

**Spatial distribution**

General

The overall distribution map for the stone finds shows a general spread of remains across the site, mostly occurring singularly or in pairs, with occasionally three or four in the same square. Otherwise they give a general visual impression of being randomly dispersed.

**Trends**

The trend surfaces initially display a southern bias at the first order. The second order suggests a central tendency; it is not until the 7th order that three areas emerge from the data. No further patterns can be observed beyond this order. None of the surfaces is overly convincing.

**Global statistics**

The stone artefacts display different global spatial characteristics. General G at a 1m scale exhibits a random distribution, which may be because a 1m scale is unreliable (as shown in appendix 10.1). This view is supported by the fact that the other spatial lags exhibit clustering at the 0.05 and 0.01 significance levels. This thus allows rejection of the null hypothesis with a maximum 5% chance of making a type 1 error and acceptance of the alternative hypothesis of spatial clustering. The Moran's I, although agreeing with Global G, does so at a lower significance, all but one scale exhibiting a 5% chance of error and one a 10% chance.

**Table 10.7 Generalisation of the data (flint).**

| number of squares | probability | number of pieces |
|---|---|---|
| 1 | 1 | 70 |
| 4 | 0.25 | 10 |

[224] See Garcia-Diaz this volume.

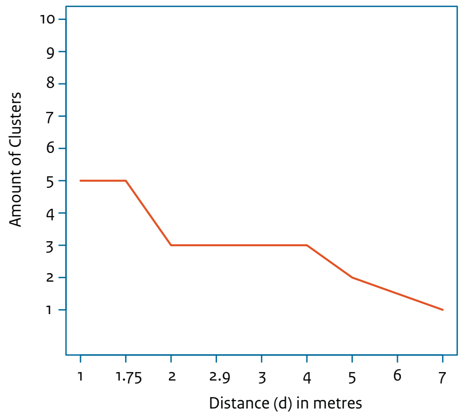



Figure 10.23 Cluster interpretation of Animal Remains using the $G_i$* statistic at multiple scales.

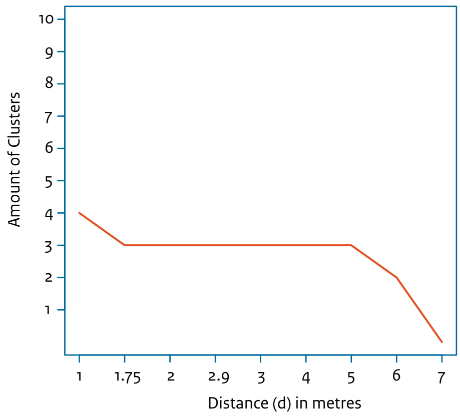



Figure 10.24 Cluster interpretation of Animal Remains using the *Ii* statistic at multiple scales.

The alternative hypothesis is therefore still accepted, albeit with more caution.

**The local analysis**

The $G_i$* statistic identifies one to five significant clusters (5% confidence level), depending on the scale of analysis (Fig. 10.23).

This suggests the three areas depicted in the trend surfaces could be significant. However, this must be viewed with caution due to the relatively low numbers of this type of artefact.

The Local *I* statistic, above, illustrates three similar groups of high values (Fig. 10.24). Using the same confidence levels unlike the $G_i$* a much more static graph is presented. As with the $G_i$* statistic this is likely to be due to the low quantities of artefacts and may be more likely to be a random distribution as identified with the Global *I* (*d*=1m). In view of the two local and global results, further spatial analysis of clustering is not appropriate for this dataset.

## 10.6.4 Ceramics

**Data quality**

The pottery assemblage was recorded by metre squares, although on a few occasions they were recorded within a two by two metre square or a two by one metre square. As a result they had a 25% probability of belonging to any of the four squares or a 50% chance of belonging to one of the two metre squares (see table 10.8).
A probability was therefore assigned to each square. Given the fragmentary nature of the ceramics, the weights are a better indicator of significance rather than the counts.
373 sherds weighing 2900.27g were located to a square or a group of squares, 21 sherds weighing 271.61g were from features, and 77 sherds weighing 562.14g were lacking a location. These 77 sherds were disregarded in the spatial analysis.

**Spatial distribution**

All of these results refer to the finds from the cultural layer rather than finds from features.

**General**

The overall weight distribution map for the pottery finds shows a general spread of sherds across the site, with higher weights occasionally occurring in isolation or in small groups. Slight clustering would therefore be expected.

**Trends**

The first-order trend surface indicates the pottery has a bias to the west of the site, the second order suggests a grouping in the south west, orders 3 to 5 and maybe the 6th order suggest a general band of pottery running from the south to the north (Fig. 10.25).

**Table 10.8 Generalisation of the data (pottery).**

| number of squares | probability | quantity | weight (g) |
|---|---|---|---|
| 1 | 1 | 352 | 2546.03 |
| 2 | 0.5 | 9 | 200.41 |
| 4 | 0.25 | 15 | 153.83 |

**Global statistics**

Pottery has a significant clustering of values based on the Moran *I* statistic, clustering at scales of between 2m to 5m and displaying signs of randomness at the 7m scale. The General *G* statistic defines these clusters as being clusters of high values, suggesting high weights of pottery clustered together.

**Local statistics**

The $G_i^*$ statistic identifies one to three significant clusters (5% confidence level), depending on the scale of analysis (Fig. 10.26). Two clusters are prominent in the 1.75m to 5m analyses.

The Local Moran's *I* suggest that there are one, two or three clusters, depending upon the scale of analysis (Fig. 10.27).

Pottery sherds are difficult to interpret as many sherds can represent one vessel and therefore cluster. Equally, a vessel can smash and scatter. It is possible to assess the clustering of sherds or fabric types. However, this will not aid in the identification of individual vessels. Many vessels can be produced in the same way but have different designs applied to them. With this in mind interpretation might suggest the locations of three vessels.[225] When compared to the distribution of ceramic tempering types, this is even more suggestive of three separate vessels, especially given the fact that all the significant clusters contain a grog and sand tempering. It is likely that a fourth grog tempered vessel is present, in view of the quantity of similar sherds in close proximity.

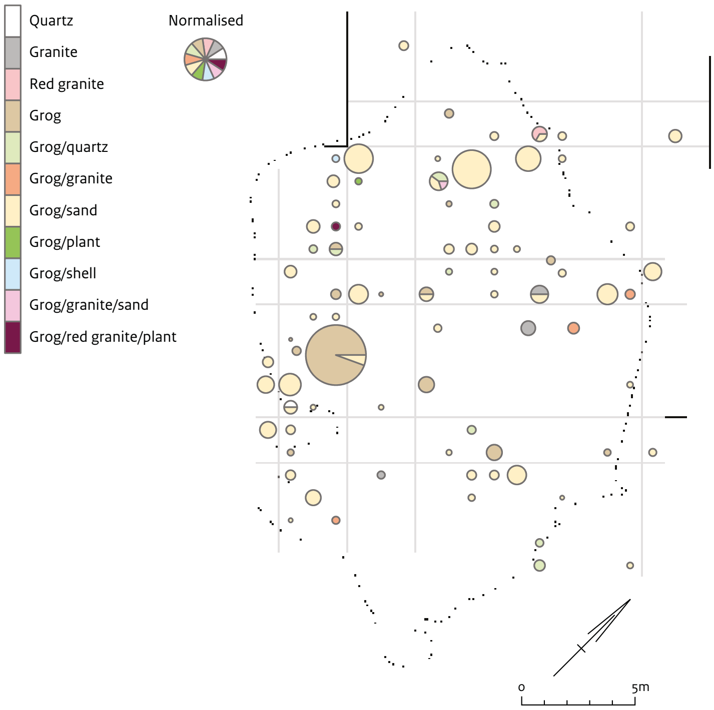



Figure 10.25 A normalised pie chart plot sized by weight of sherds and categorised by tempering as identified by the ceramics specialist.

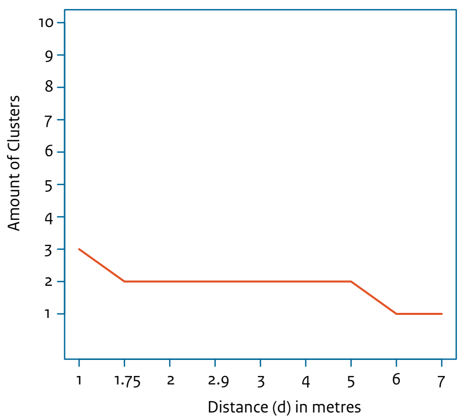



Figure 10.26 Cluster interpretation of Pottery sherds using the $G_i^*$ statistic at multiple scales.

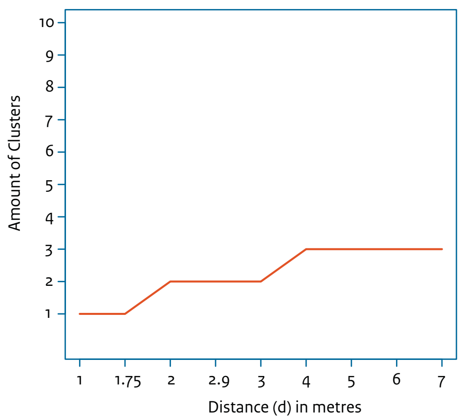



Figure 10.27 Cluster interpretation of Pottery sherds using the $I_i$ statistic at multiple scales.

225 See Beckerman this volume.

## 10.6.5 Ornaments: Amber

### Data quality

Only three pieces of amber were recorded during the excavation, each belonging either to a metre square or to a feature.

### Characterising the data

These three pieces of amber were recovered during the excavation, two of them fragments and the other representing half a bead.[226] General spatial analysis is of little value on such a small dataset, however. Visually, they occur in the north of the site. The broken bead was found in feature 1002 (UID10106), an irregularly shaped posthole below square 85.

## 10.6.6 Botanical remains

### Data quality

Botanical samples were originally collected in a checkerboard pattern. It is therefore assumed that a 50% sampling strategy was employed. On this estimate 83 out of 216 botanical samples survived for processing. This therefore constitutes a 38% sample of the site. It is apparent from the plan of sample locations and the remaining samples that the checkerboard was generally adhered to, but that there were occasional deviations from the pattern. The sample locations were plotted and species distributions calculated. Due to the lack of quantification it is difficult to suggest any broad inferences beyond their distributions.

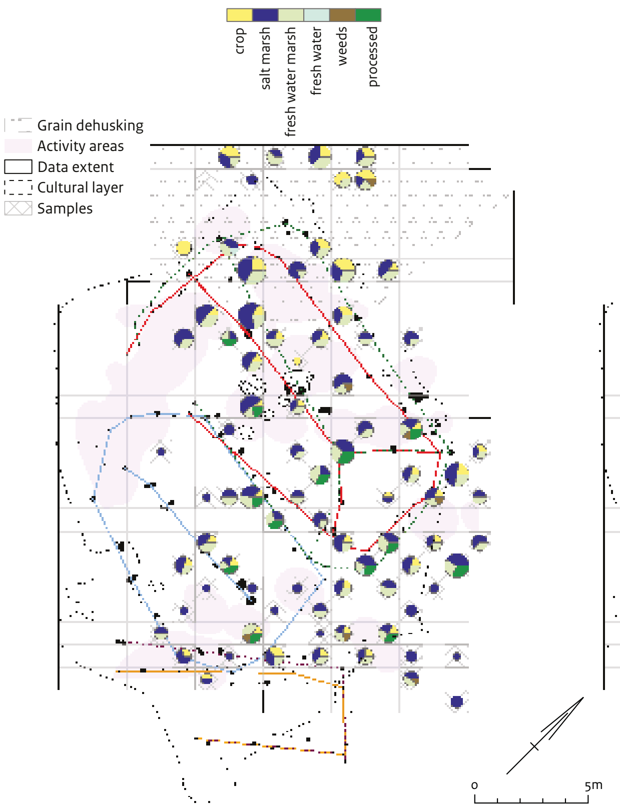



Fig. 10.28 Botanical interpretation of samples in a spatial context.

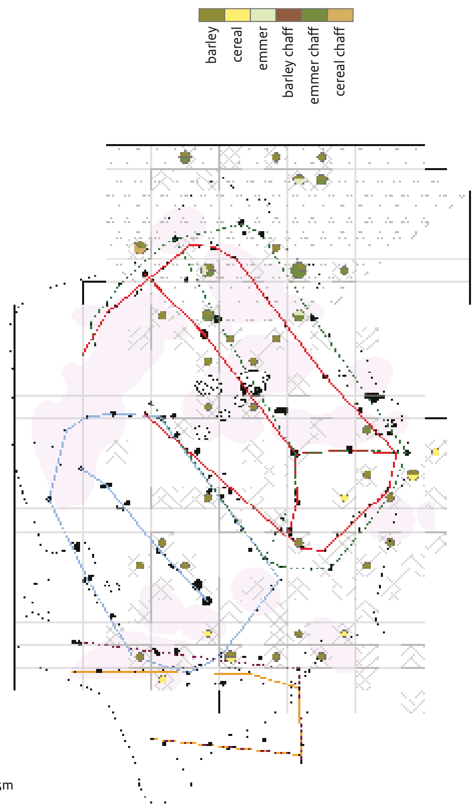



Fig. 10.29 Distribution of cereal grain and chaff.

226 See Garcia-Diaz this volume.

**Characterising the data**

The botanical data were described in a ranked manner, from high to low. The data cannot therefore be characterised in the same way as the other datasets.

**Spatial distribution**

Unlike the majority of the results sections this one only comments on the distributions. The 38% sample is thought to be generally representative of the site, although more samples to the west would have been preferred (Fig. 10.28).

The majority of the chaff from the samples is located in the north of the site, spreading from the cultural layer beyond into the wider landscape. The grain remains, which are predominantly barley, appear to the north but also around the hearths (Fig. 10.29). Three samples just north of the small charcoal areas also contain barley, which also appears in other locations. This possible association of barley to charcoal is interesting, and will become significant later in this chapter.

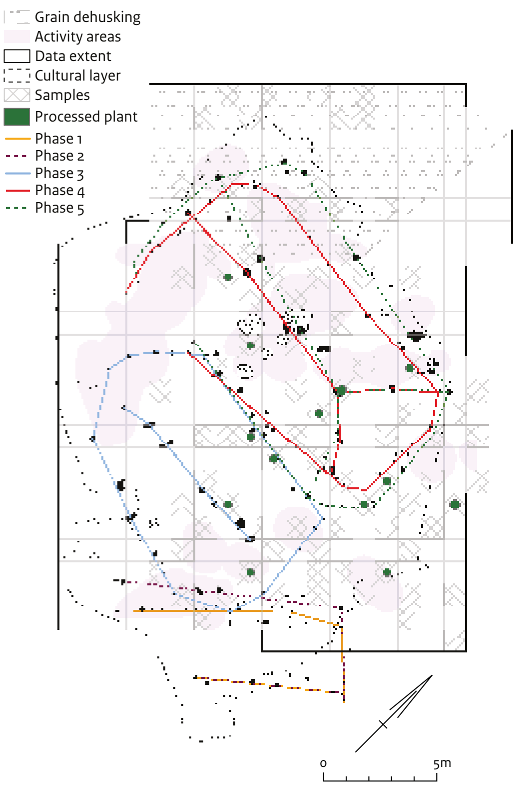



Figure 10.30 Distribution of processed plant remains.

**Table 10.9 Finds from features.**

| find type | quantity |
|---|---|
| pottery | 18 sherds |
| flint | 49 pieces |
| stone | 11 pieces |
| bone | 1,655 grams<br>1862 fragments |
| botany | not quantified |
| residues | 3 residues on 3 sherds |

Processed plant material is also found in samples within the cultural layer, except for on one occasion to the east. It appears visually to be dispersed throughout the samples, albeit more to the south and east (Fig. 10.30). Again, there is a lack of samples in the west.[227]

## 10.7 Finds from features

In view of the recording methodology and the site stratigraphy, finds from features were analysed separately.

Due to the relatively low quantities of finds from the features (compare table 10.9), no spatial analysis was conducted. It is thought that the features, especially the pits, filled rapidly due to flooding and sedimentation. Furthermore, no contextual information is available. It is not therefore possible to isolate finds from the primary deposits from those in the overlying cultural layer.

Due to this inaccuracy only distribution maps of the quantities of finds in each feature were produced and inspected visually. They are not presented here.

A significant majority of the animal bone is found in pit 1041(UID10033), under the cluster from the later cultural layer. This therefore strongly suggests that the bone was intrusive from the overlying layers. By way of further explanation: the cultural layer filled the tops of the pits as seen in the pit sections; during excavation, therefore, the finds from this context could be identified as from a pit rather than associated with the cultural layer, so the association of these artefacts to that pit could be unjustified. This interpretation can only remain a

[227] See Kubiak-Martens this volume.

theory given the lack of information regarding the location of these finds within the pit stratigraphy. This same theory may apply to all of the pits; the other find types are in very low quantities, so no further comparison is possible.

## 10.8 Comparative analysis

The previous section brings the quantification and description of the archaeological remains in isolation to a close. The following section brings the different datasets together and investigates whether any further conclusions can be drawn.

As seen in the previous chapter, the features show no signs of any obvious structures. Although many lines of postholes can be drawn, no convincing structures can be presented. The features were superimposed on the $G_i^*$ plots (Fig. 10.31-10.37). The flint plots, especially at the 2.9m scale, help to identify four lines of postholes which surround the main cluster. When combined they form a rectangular arrangement, and upon closer inspection larger posts can be observed in a rough line through the centre of the cluster on the same alignment as the rectangle of postholes. This is seen as the basis of a structure with the larger central posts forming a central post line supporting a roof and the outer smaller posts forming the external wall.

Turning to the animal bone ($G_i^*$) clusters, a cluster can also be seen in a similar area contained by the proposed structure, and at the same scale (2.9m). All the hearths (5) are within this confined area, except for two areas of charcoal to the southwest of the main hearth group. These are later suggested to represent a hearth.

Having observed the nature of these postholes, similar post alignments can be deduced. In the south of the site there are more lines of postholes, two of which are parallel.

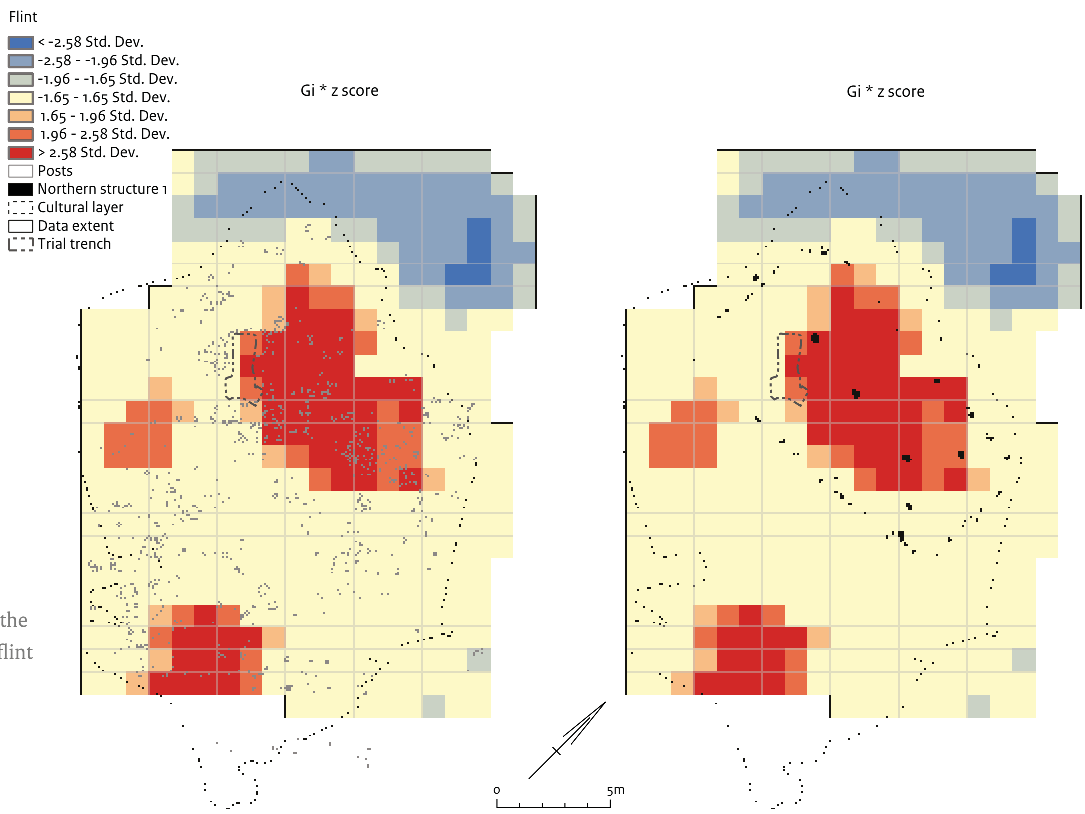



Fig. 10.31 The identification of the Northern Structure 1 from the flint cluster analysis and features.

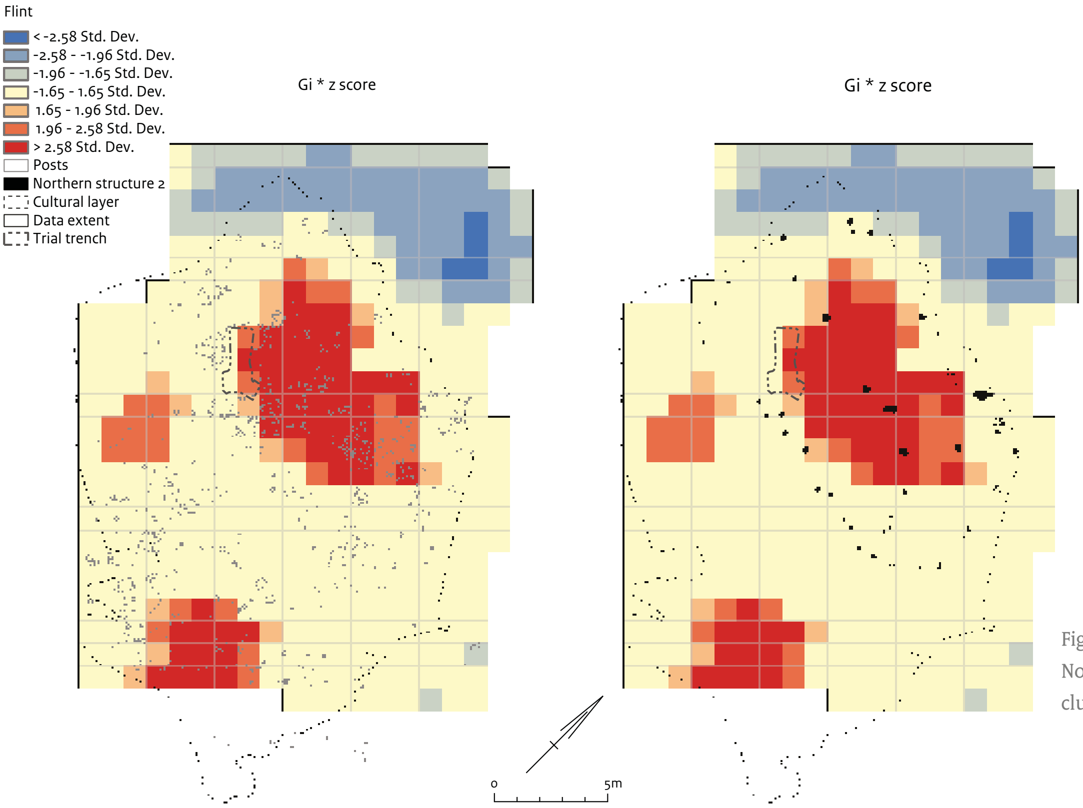



Fig. 10.32 The identification of the Northern Structure 2 from the flint cluster analysis and features.

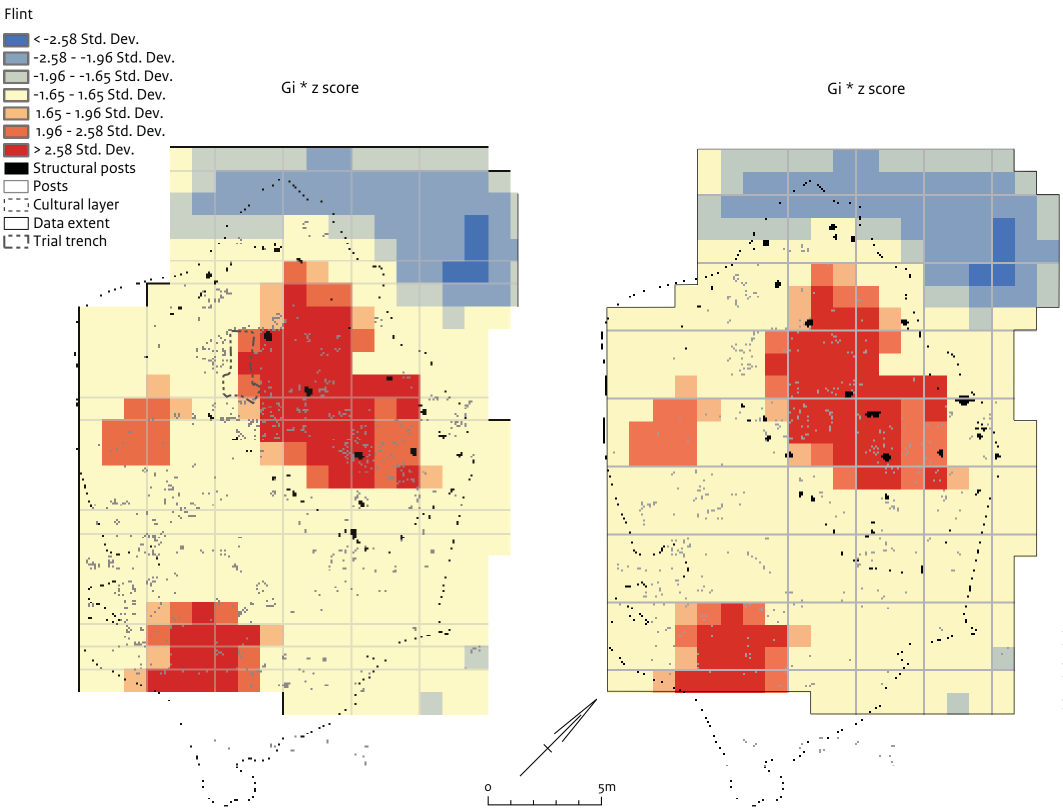



Fig. 10.33 The identification of the Northern Structures 1 and 2 from flint cluster analysis and features.

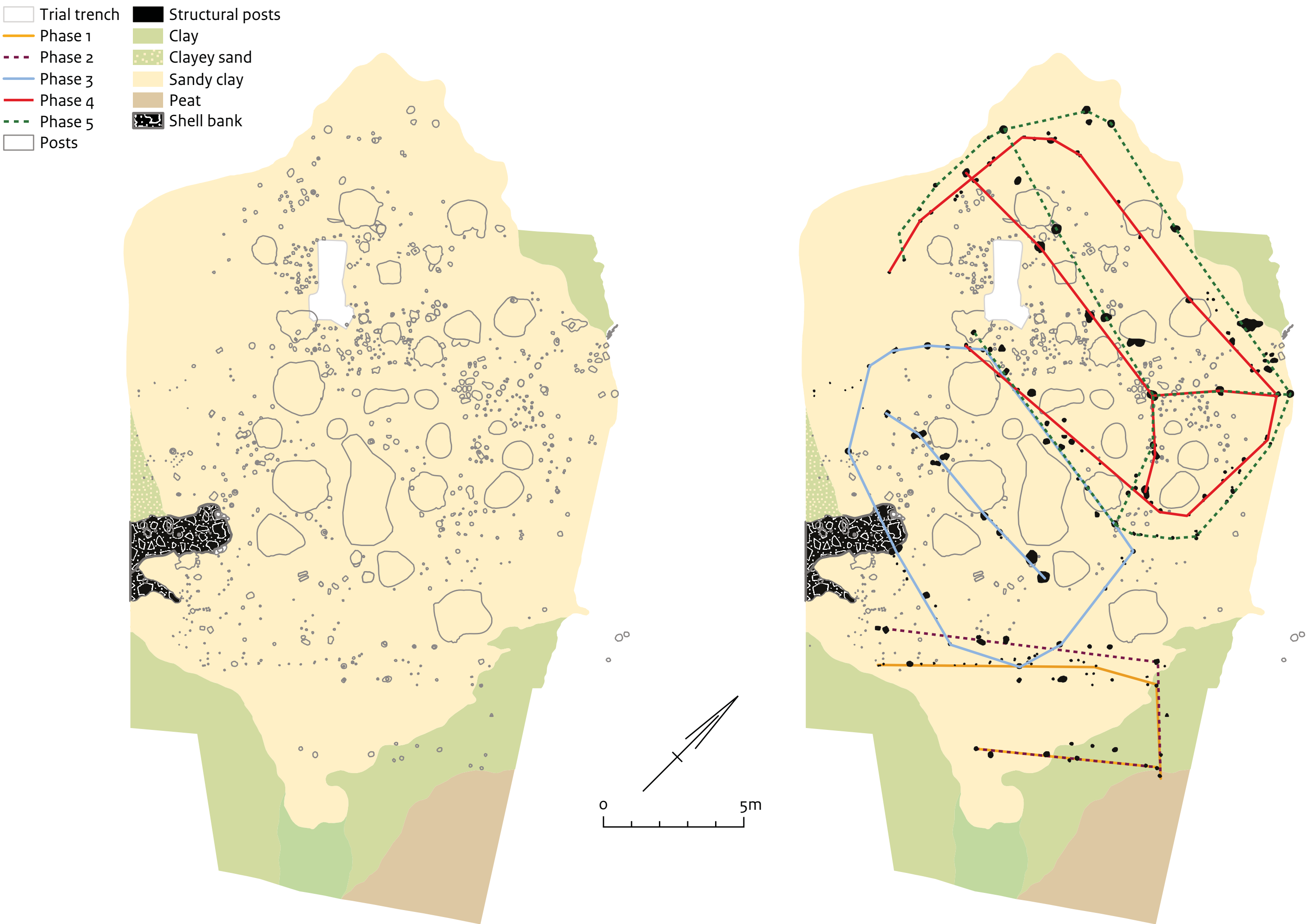



Fig. 10.34 All of the interpreted structural posts before and after interpretation.

One line consists of widely spaced postholes, whereas the other has many small postholes with the occasional larger posthole in the same line. Both lines stop at the northeast where there is possibly another shorter posthole line. If one regards the larger widely spaced post lines as representing a central post line and the smaller parallel postholes as an external wall also comprising the shorter posthole line which is perpendicular in orientation, it is possible to interpret them as a partially excavated structure.

Interestingly, where these posthole alignments cease there is also a change in the soil matrix, to either a clay or peat layer. The clay may either hamper the identification of further postholes, or lie above them. It is more likely that the area required further excavation. Furthermore, the excavation strategy defined this area to be of low importance given the relative lack of finds and was therefore abandoned due to time constraints.

Having isolated these as potential structures, a third posthole alignment becomes apparent. It is located between the two structures on the same alignment as the northern structure. Initially it appears to lack an external wall, but it is in fact within that of the northern structure. A curving line from the Northern structure forms the western wall and a sparser posthole line to the south is proposed as the southern wall, which just overlaps the proposed southern structure.

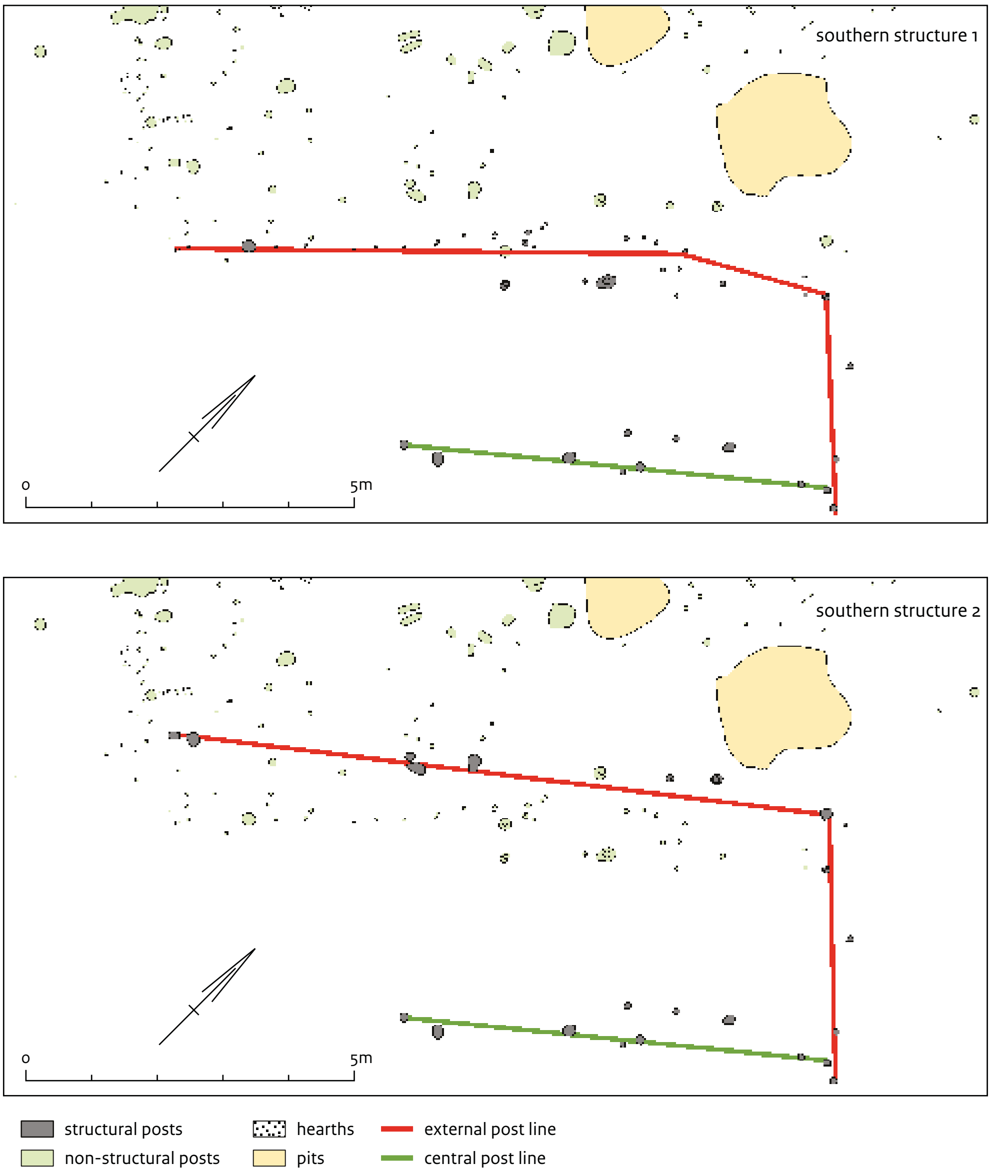



Fig. 10.35 An interpretive outline of the possible limits and features of the Southern Structures.

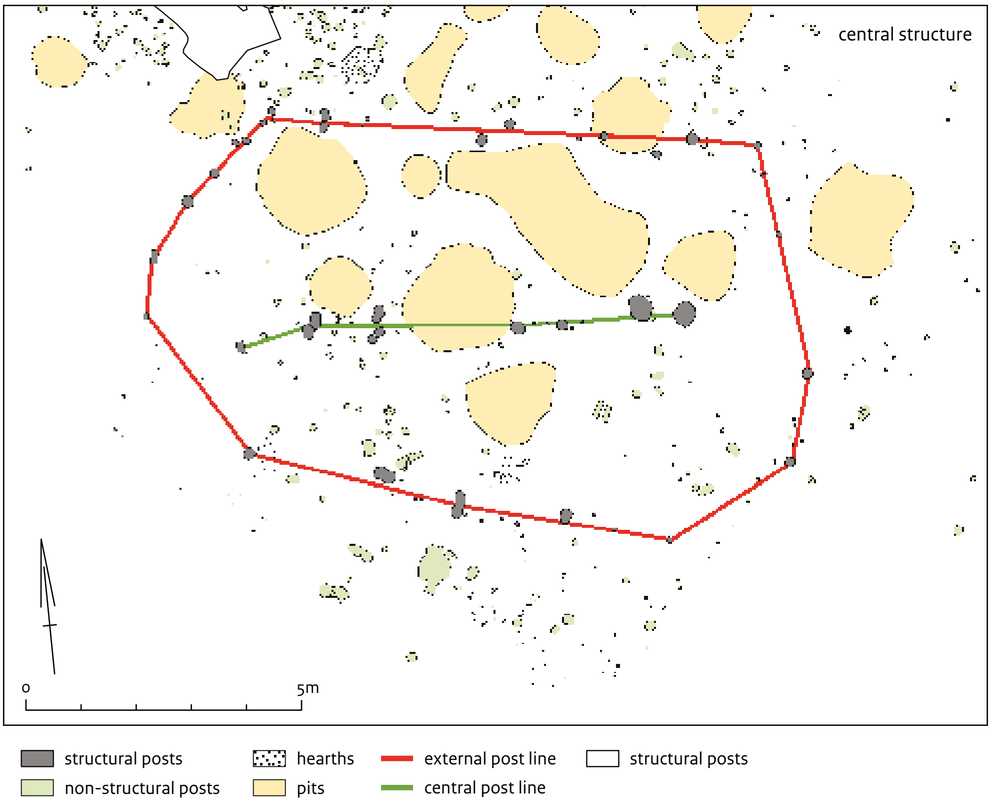



Fig. 10.36 An interpretive outline of the possible limits and features of the Central Structure.

### 10.8.1 Southern structure

The isolation of these structures from the remainder of the postholes means they can be subjected to closer inspection. The southern structures can be divided into two overlapping structures, in which some posts or postholes were occasionally reused. Both structures share the central post line and possibly the northeastern wall. A loose line of larger posts form the northwestern wall of the second structure, set at an angle of 8.2 degrees from the wall of the first.

### 10.8.2 Southern structure 1

The first of the southern structures can be quantified by the presence of 84 postholes, 76 forming the external wall and eight in the central post line. The central posts are generally larger in diameter than the external posts, with three exceptions (Fig. 10.38). The extreme value, as presented in the box plot below, is caused by a large post set within the structure, which might not therefore have formed part of the wall. The outlier is definitely part of the wall, but the third highest value is set within the structure.

The central posts are generally between 0.1m and 0.2m wide and the external wall posts less than 0.1m, with some exceptions (Fig. 10.39).

The rises in these graphs are due to the ordering of the data and do not correspond to any statistical application, they are merely ordered scatter graphs displaying two separate datasets.

It is extremely difficult to characterise the structure, since only a proportion remains. What remains of the exterior measures 13.3m in

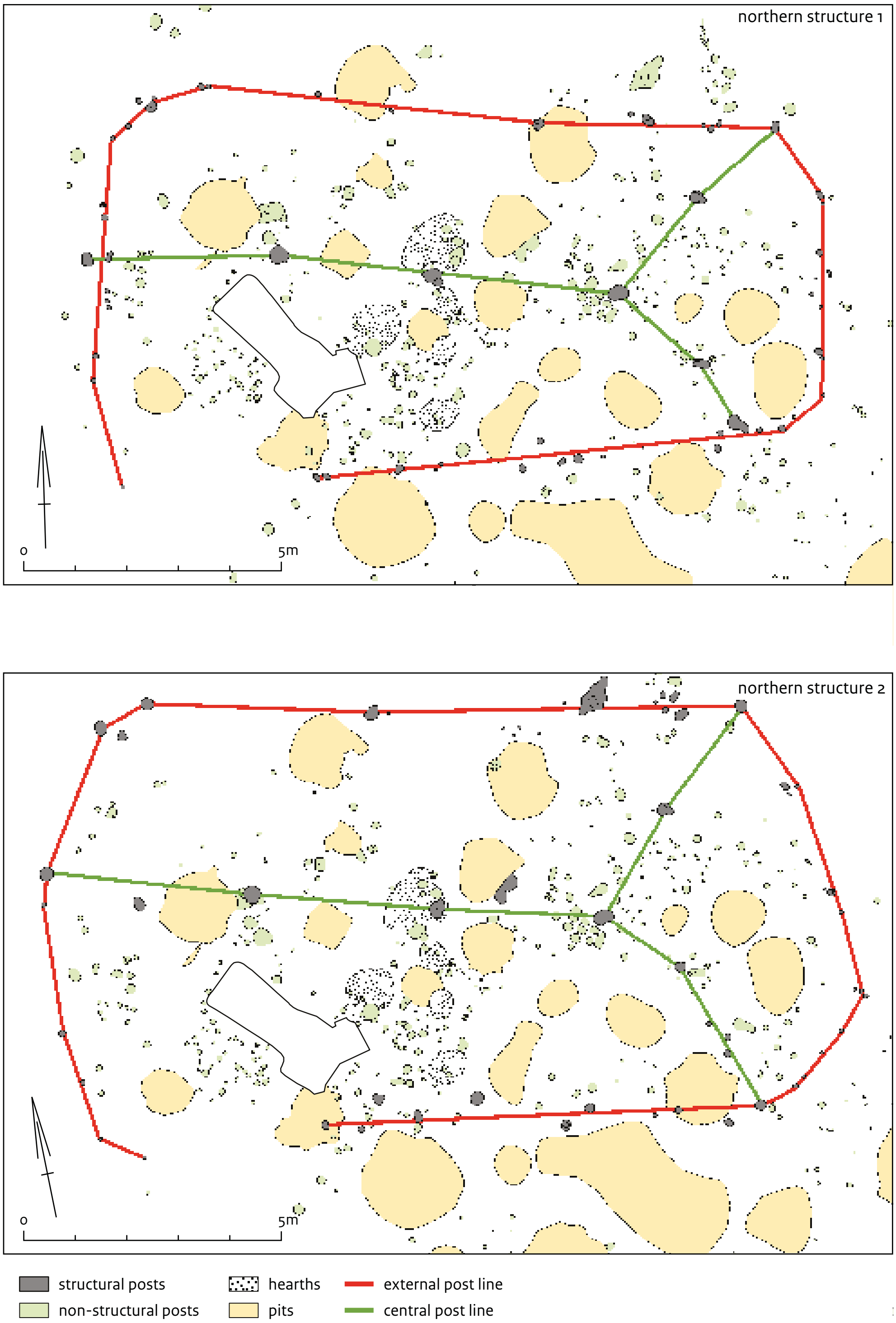



Fig. 10.37 An interpretive outline of the possible limits and features of the Northern Structures.

perimeter, with a central post line 6.6m long. The excavated area is 24$m^2$. There is a possible entrance measuring 1.2m on the northwestern side; a few large gaps appear between the postholes, giving regular spacing up to 0.6m. What remains of the structure measures 10m in length and a maximum of 3.5m from the northwestern wall to the central post line.

### 10.8.3 Southern structure 2

This structure is formed by 32 posts, reusing the central post line (8) of the former structure, with the remainder forming the external wall (15). The diameters of the central post line are the same as in the previous structure. However the external posts are larger, all but one at least near the 0.1m mark, with the majority between 0.1m and 0.2m in diameter, as with the central posts. Three posts are larger, with measurements between the 0.2m and 0.3m threshold. The box plot below illustrates this similarity (Fig. 10.40-10.42).

Again, this structure was only partially identified, so no overall measurements can be given. The remaining perimeter is 14m, with a central post line 10m long, defining an area of 33$m^2$. The distance between the northwestern wall and the central post line is 4m at most. Unlike southern structure 1, two large gaps occur in the wall, 3.1m and 2.8m wide (from southwest to northeast). There is a gap of 1.6m in the same wall, but at the corner, where there was a highly speculative entrance to the former structure.

These two sets of postholes have been interpreted as structures, since the overall form is indicative of a rectangle and can therefore be related to structures of a similar form.[228] Although presented here as structures, it is possible that they are not, however. One alternative interpretation could be a cattle corral, although the cow hoof marks do not correlate with this division of space.

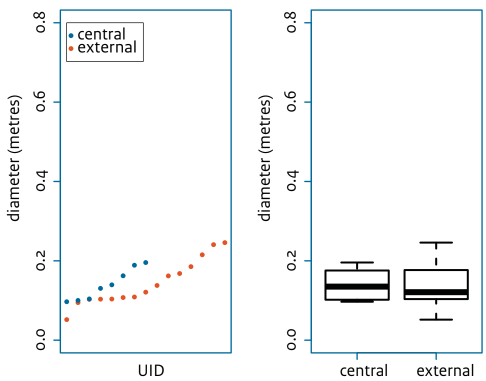



Fig. 10.40 An ordered scatter graph displaying the differences in post hole widths between the central and external posts for the southern Structure 2.

Fig. 10.41 A box plot of the post hole widths from Southern Structure 2.

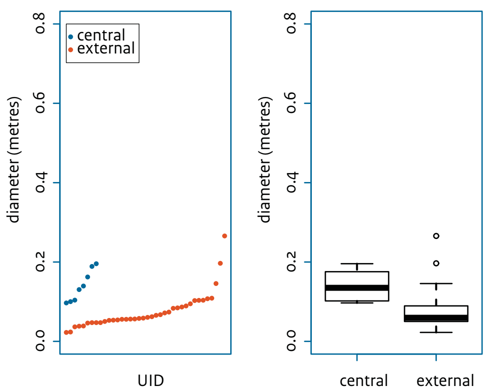



Fig. 10.38 An ordered scatter graph displaying the differences in post hole widths between the central and external posts for the southern Structure 1.

Fig. 10.39 A box plot of the post hole widths from Southern Structure 1.

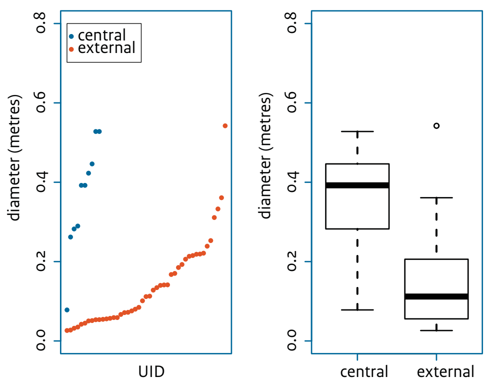



Fig. 10.43 An ordered scatter graph displaying the differences in post hole widths between the central and external posts for the Central Structure.

Fig. 10.44 A box plot of the post hole widths from the Central Structure.

227 Like Zeewijk-Oost and at Mienakker.

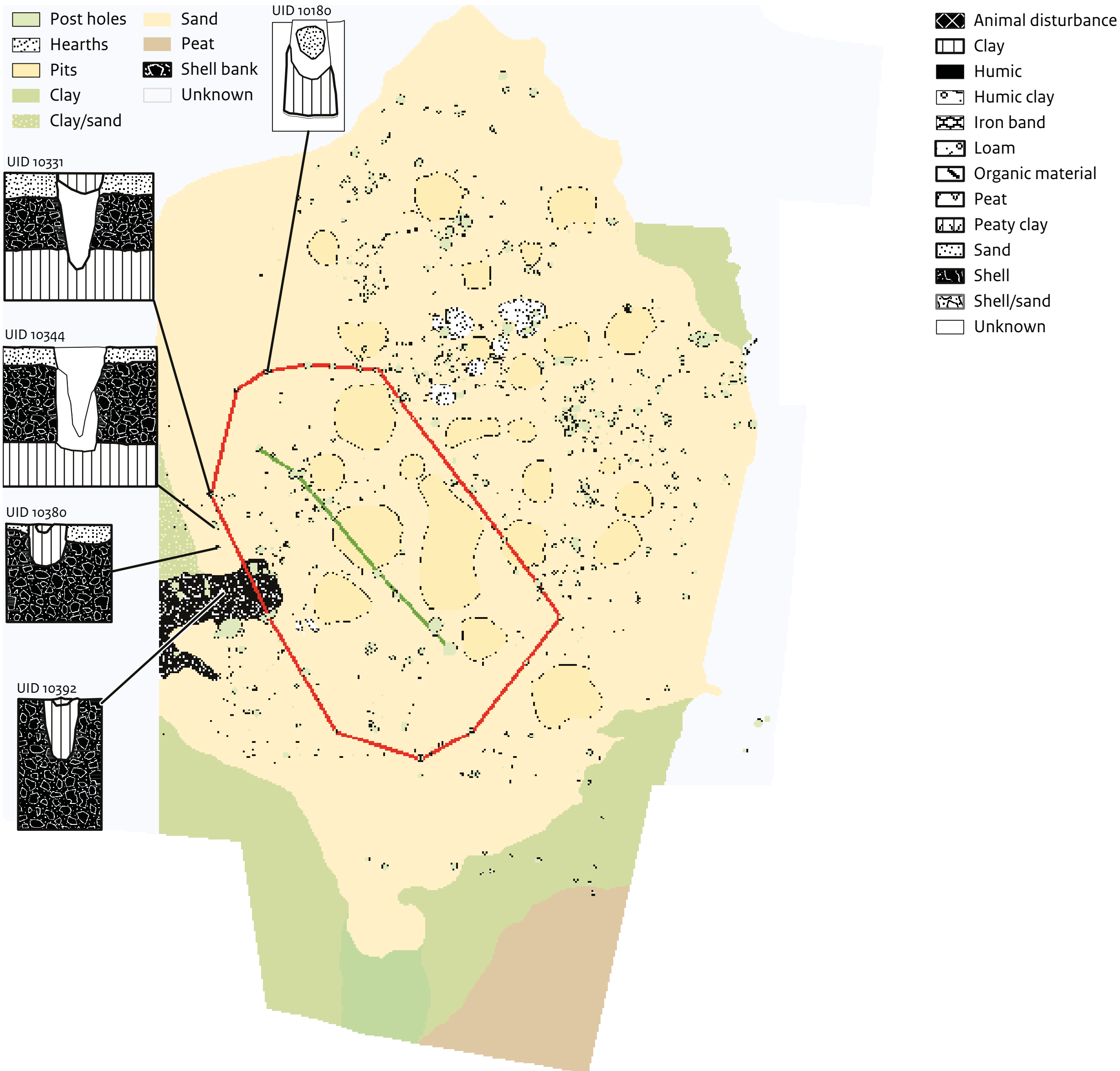



Fig. 10.42 The location of drawn sections for the Central Structure.

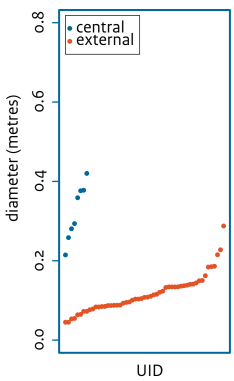
### 10.8.4 Central structure

This structure comprises 60 postholes, five of which have been disregarded in the analysis. They are however on the same alignment, and could be part of internal features. Of the remaining 55 postholes ten form the central line and 45 the exterior wall. Posthole diameters vary from close to zero to nearly 0.6m, seen in both the central and exterior posts (Fig. 10.43). The box plots do however suggest posts of the central line tend to fall in the range 0.3m to 0.45m, whereas the exterior posts are smaller, between 0.05m and 0.2m (Fig. 10.44). Smaller posts are therefore more commonly used in the exterior of the structure. This pattern is also apparent in the more reliable northern structures.

The overall structure measures 11.75m by 7.1m in the east and 11.75m by 5.8m in the west. Although technically trapezoidal, its rounded corners present a more ovoid construction in plan, encapsulating an area of 71.5m². Distances between the central post line and the external wall vary; in the west it is 1.4m, in the south 1.7m and in the north up to 3.9m. From the eastern end the distances are 2m to the east, 2.7m to the north and 3.8m to the south. The larger posts in the exterior wall are spaced between 1 and 2m apart with smaller posts between. There is a larger gap of 3m spanning the southwest corner. Based on the spatial analysis of the flint cluster, this is thought to represent an entrance. The central post line appears to form two groups at each end of the structure spaced closely (up to 1m) with a larger gap between them measuring 2.3m. Most notably, the two largest posts occur in isolation at the eastern end.

### 10.8.5 The northern structure

In the area of the northern structure there appears to be a central line formed by double sets of postholes; these two lines are not parallel but deviate by 10 degrees so that at the western end they are separated by a distance of 1.9m. The external wall also has duplication in differing orientations, one set aligned to one of the central posthole lines and the other aligned to the remaining central line. On this basis they could represent two separate structures, proposed here as northern structure 1 and northern structure 2.



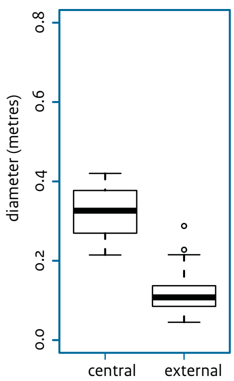




Fig. 10.45 An ordered scatter graph displaying the differences in post hole widths between the central and external posts for the Northern Structure 1.

Fig. 10.46 A box plot of the post hole widths from Northern Structure 1.

### 10.8.6 Northern structure 1

Northern structure 1 is identified by 61 postholes, eight of which constitute the central post line. The diameters of the postholes display a clear division in diameters (Fig. 10.45 and 10.46). All of the central posts are wider than 0.2m and only one is larger than 0.4m (Fig. 10.47). All but three of the external posts are less than 0.2m in diameter.

Gaps between the external posts differ greatly. On the south side they are fairly regular, with a few larger gaps, whereas the northern side has wider gaps. This could be due to unidentified posts or posts which did not impact upon the ground surface to any great degree. The largest gap is 3.72m and, based on the spatial analysis of find distributions, it has been classed as an entrance, because the flint waste and flakes extend through and away from the structure at this point. The gaps between the central postholes are larger, as much as 3.4m, 2.6m and 3.2m from east to west. The overall maximum dimensions of the structure are 14.5m by 6.1 m in the east or, in the west, a trapezoidal shape with rounded corners measuring 14.5m by 7.7m. The area of the structure is 95.2m² at most, with a perimeter of 39.7m. The distances from the northern wall to the central post line are 3m in the west and east but from the southern wall they are 4m in the west and 3m in the east. It is therefore the alignment of the southern wall which results in this trapezoidal shape.

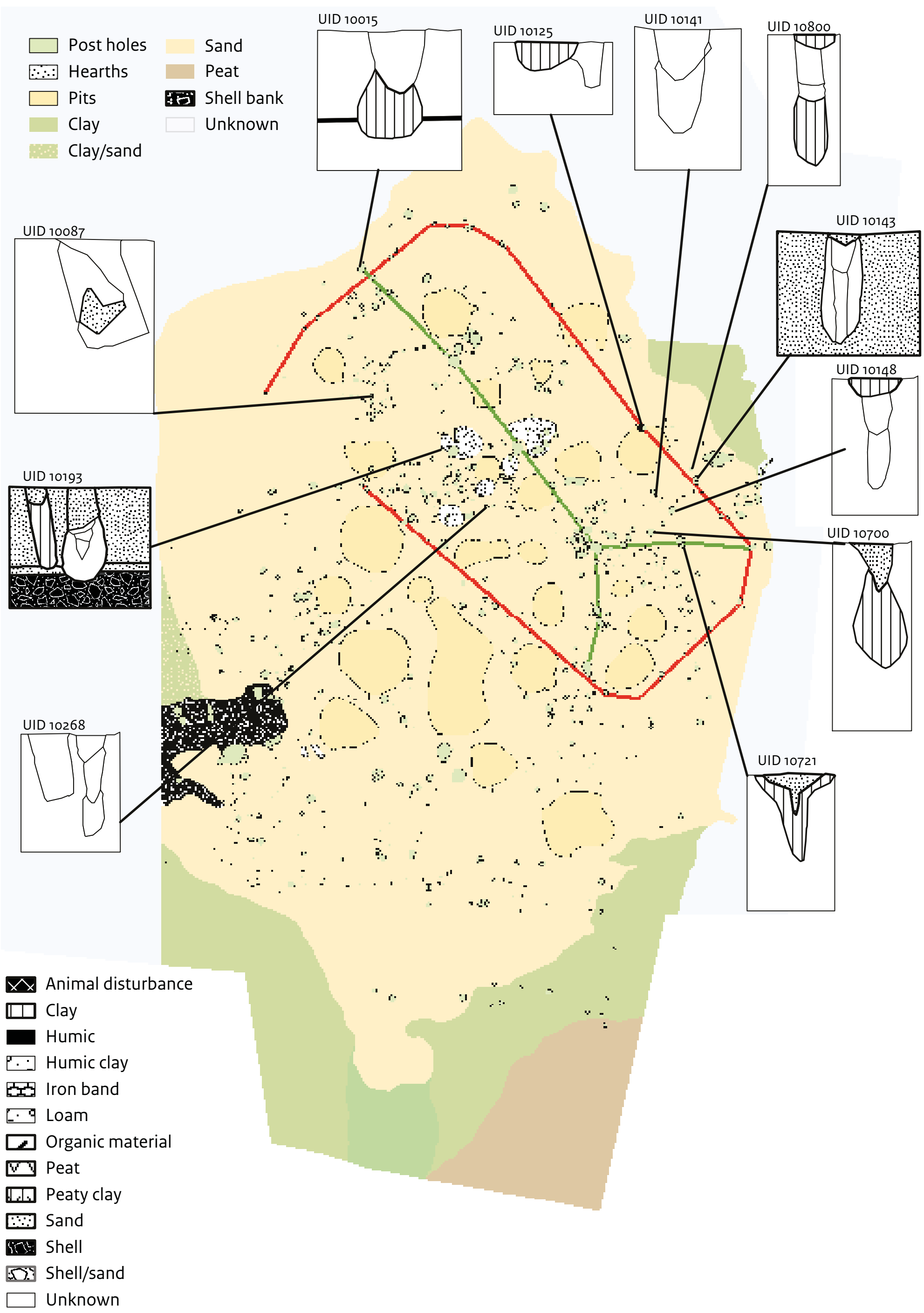
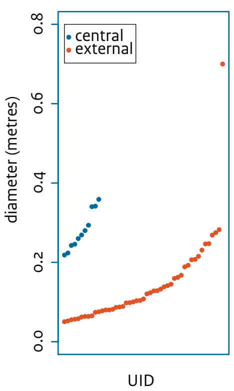



Fig. 10.47 The location of drawn sections for Northern Structure 1.

## 10.8.7 Northern structure 2

This structure comprises 54 posts, 11 central and 43 external. Three posts were excluded from the analysis as they could also be part of an internal feature.

The posthole diameters do not display a clear division between the central and external posts, although the majority of the external posts are below the 0.2m threshold (Fig. 10.48 and 10.49). One posthole is above the 0.7m threshold. This is a very irregularly shaped posthole and it could conceivably have held a post which collapsed, disturbing the area around it, or it could be a tree throw. This outlier can therefore be disregarded. All of the central posts are between 0.2m and 0.4m in diameter (Fig. 10.50). Only three of them are above the 0.3m threshold. These form the main part of the structure.



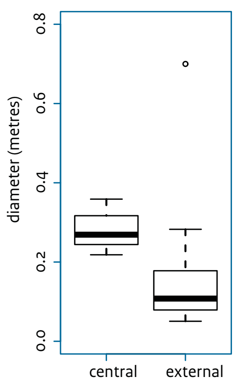




Fig. 10.48 An ordered scatter graph displaying the differences in post hole widths between the central and external posts for the Northern Structure 2.

Fig. 10.49 A box plot of the post hole widths from Northern Structure 2.

The gaps between the posts of the external wall are similar to those in northern structure 1, although the posts are larger, sparse gaps still appear along the northern wall. The entrance is 3.5m wide, fractionally smaller than northern structure 1 but located in the same place based on the same reasoning. Only the three central posts which were above 0.3m were compared in terms of their spacing, which are as follows, from the western wall: 3.68m, 3.3m and 2.88m. The overall maximum dimensions are 15.2m by 8.1m forming a rectangular shape with rounded corners. The central post line is 3.5m from the northern wall and 4.75m (in the west) or 3.6m (in the east), so technically trapezoidal, though this is not visually apparent in plan. It encloses an area of 115.9m².

## 10.8.8 Comparison

Table 10.10 compares the main attributes. Even though few sections were drawn, many depths were recorded; these are illustrated in the previous chapter. The comparative posthole depths are not very informative. The following graphs have however been created by grouping the depths into their structures and then subdividing them into structural elements (external wall and central post line) (Fig. 10.51).

These graphs illustrate how shallow the postholes are. The deepest from the walls are up to 0.35m deep, but all the structures have their deepest posts in the 0.02-0.05m category. Central posts are few in number but have a wider range of depths, from 0.02 to 0.4m. The internal posts mostly fall in the 0.02 to 0.1m range with a unimodal appearance. These graphs could be misleading, as deep posts may have a small diameter despite their depth. The following

**Table 10.10 Generalised comparisons (*incomplete structures-partial measurements).**

| structure | length (max) | width (max) | area (m²) | shape in plan | corners | no. of posts | post diameter, central line (m) | post diameter, external wall (m) |
|---|---|---|---|---|---|---|---|---|
| Kmb SS1 | 10* | 3.5* | 24* | rectangular | sharp | 84(8/76)? | 0.1-0.2 | < 0.1 |
| Kmb SS2 | 10* | 4* | 33* | rectangular | sharp | 23(8/15) | 0.1-0.2 | 0.1-0.2 |
| Kmb CS | 11.8 | 7.1 | 71.5 | ovoid | rounded | 55(10/45) | 0.3-0.45 | < 0.2 |
| Kmb NS1 | 14.5 | 7.7 | 95.2 | trapezoidal | rounded | 61(8/53) | 0.2-0.4 | < 0.2 |
| Kmb NS2 | 15.2 | 8.1 | 115.9 | rectangular | rounded | 54(11/43) | 0.2-0.4 | < 0.2 |

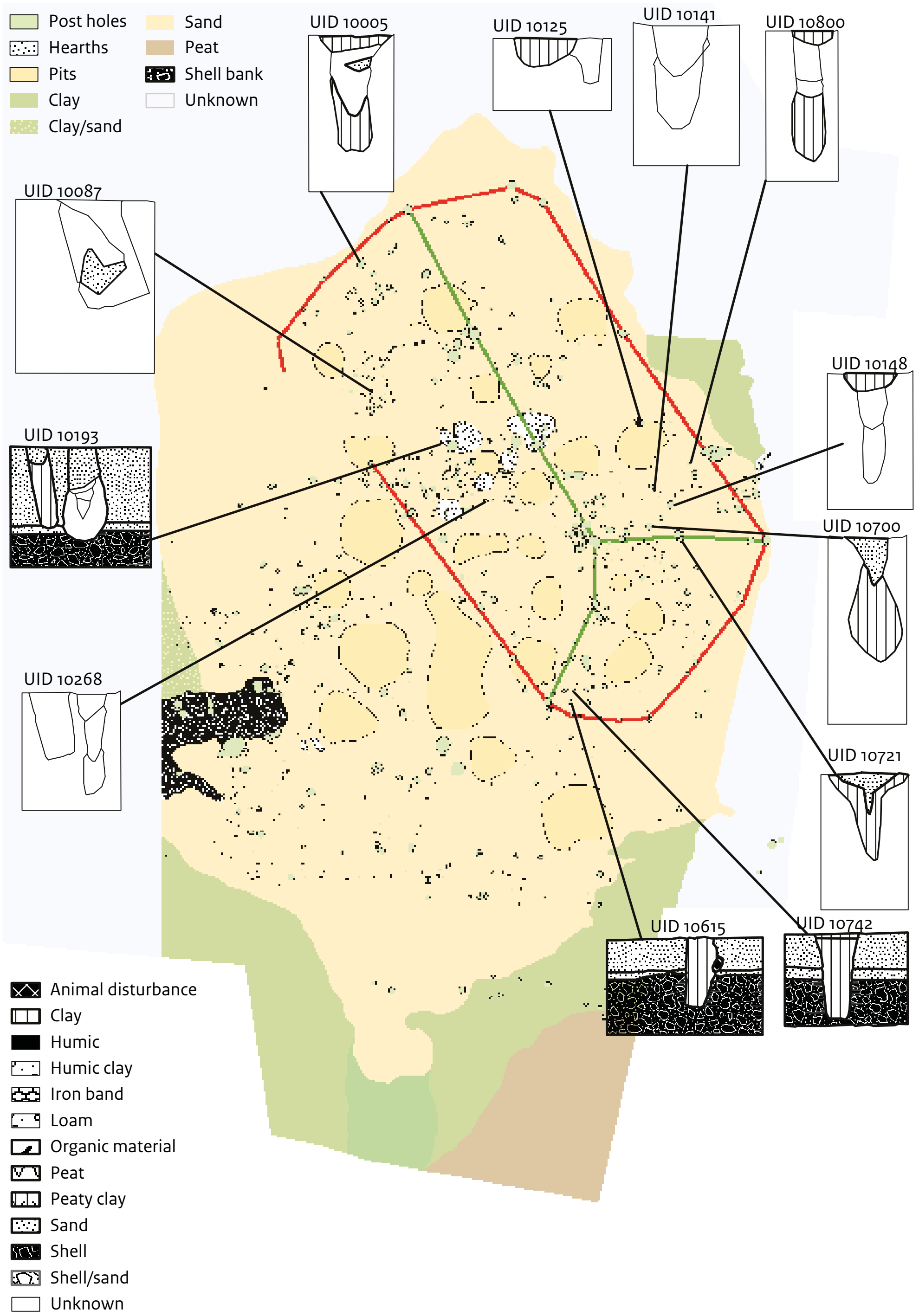



Fig. 10.50 The location of drawn sections for the Northern Structure 2.

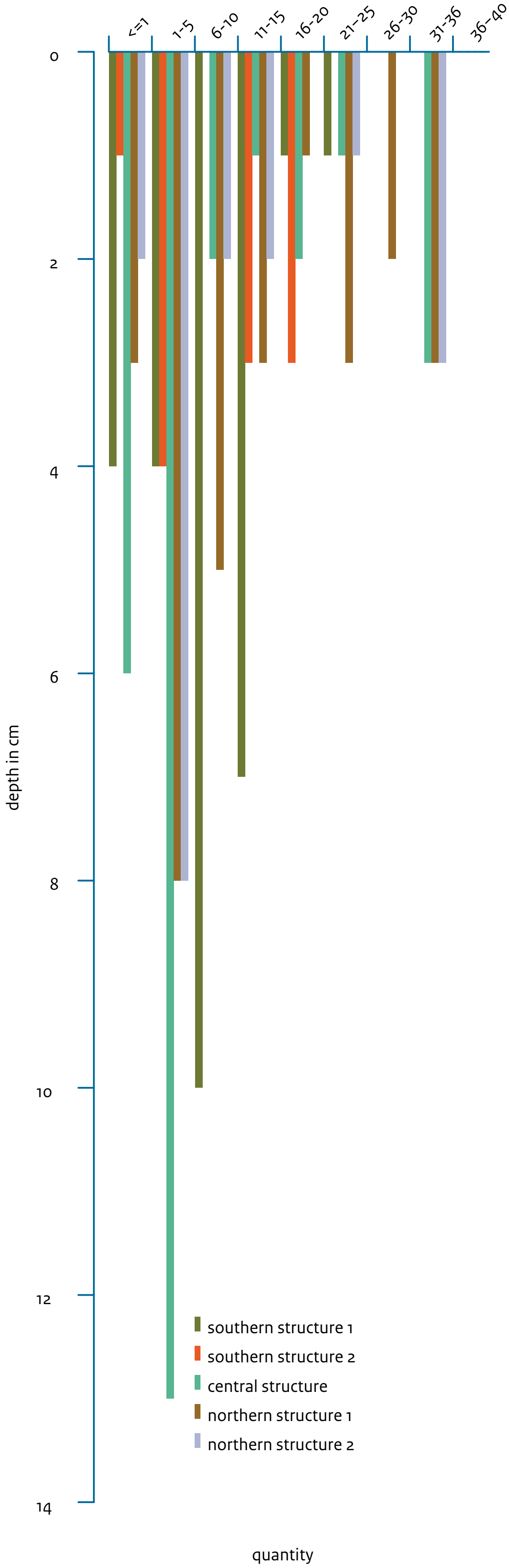



Figure 10.51 A comparison of the number of post holes and post hole depths (in cm) between all 5 structures for the wall post hole.

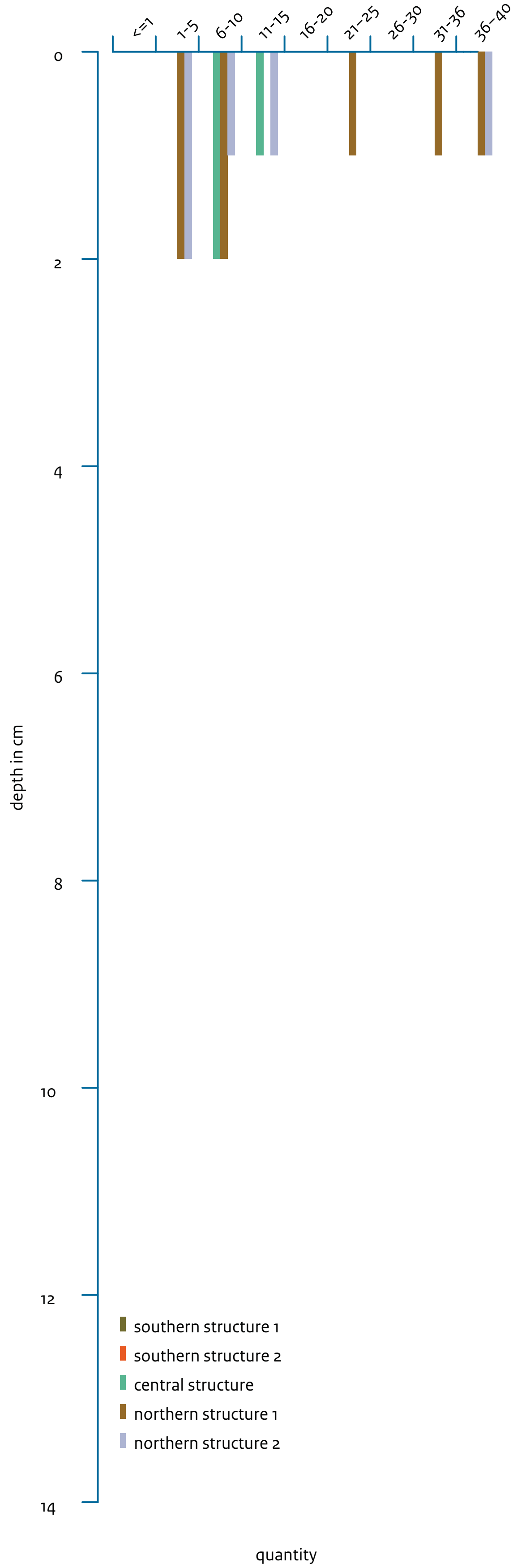



Fig. 10.52 A comparison of the number of post holes and post hole depths (in cm) between all 5 structures for the central post hole lines.

graphs therefore show the depths against diameters, where known. The reader must bear in mind that these represent a sample rather than a complete dataset. The association of posts to individual structures is also largely arbitrary, based on those which best fit a straight line.

The central structure is characterised by shallow yet relatively wide posts in the central post line, whereas the external wall posts range from thin and shallow to thin and deep (Fig. 10.52 and Fig. 10.53).

There is a more obvious break in the data in the case of northern structure 1, where the central line is generally wide in diameter but varying in depth (Fig. 10.54). The external wall posts are thin, ranging from relatively shallow to deep but narrow in diameter. The overlap is caused, in part, by the posts which form the top of the 'Y' configuration.

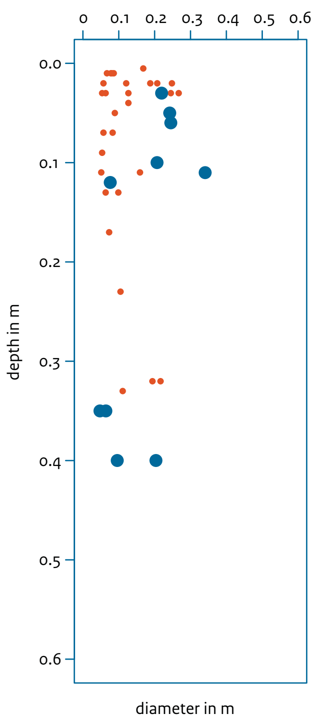
Northern structure 2 displays more of an overlap between the two groups, although the central posts generally fall into two groups: shallow with varying widths or relatively deep but thinner (Fig. 10.55). The wall posts range from thin but shallow to wide but shallow, or shallow and thin to deep and thin in some cases. This overlap could also be due to some of the external wall posts being deliberately wider than their counterparts, as they may have supported cross beams.

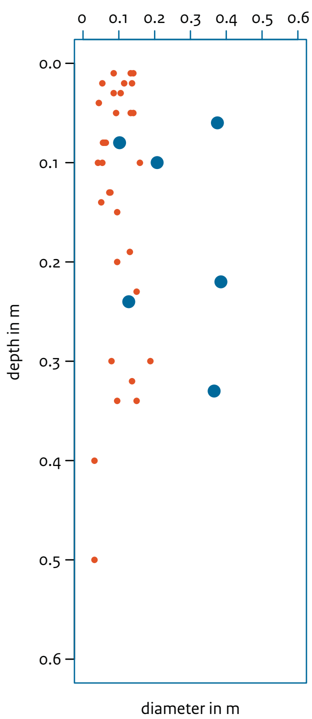
## 10.8.9 Internal analysis

In this analysis, it was not possible to clearly isolate the finds from either of the northern structures, so they can only be observed as a palimpsest. They are nonetheless worthy of assessment.

Kernel density estimates (KDE) were conducted upon the datasets at the find class level, specifically bird, fish and mammal remains as well as flint flakes and flint waste. The other classes were assessed but found to be too few in number to be of use. These densities display several high density areas, which have been designated areas 1-6; area 7 was derived from the botanical evidence and will be discussed in due course (see section 10.8.12).

The identification of these activity areas assumes that the use of the space within the two structures did not change between construction phases. Area 1 is the largest of the assigned areas which can be further subdivided.
The mammal remains, though located in this area, are firmly within the structure located at the entrance side of the central posthole line, but not affected by high degrees of trampling from the entrance. The bird bone density is also



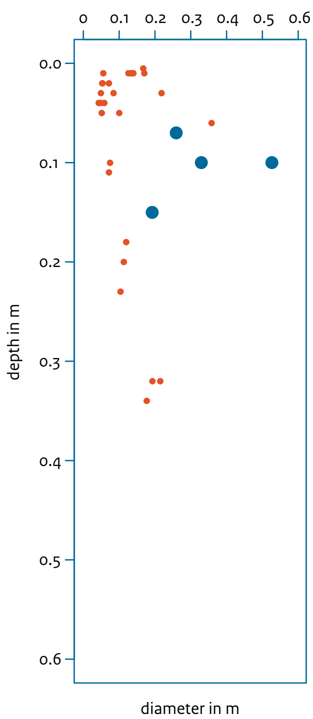




Fig. 10.53 (left) Depth vs diameter (in m) displaying a comparison between the external post hole and the central post holes for the Central Structure.

Figure 10.54 (center) Depth vs diameter (in m) displaying a comparison between the external post hole and the central post holes for Northern Structure 1.

Figure 10.55 (right) Depth vs diameter (in m) displaying a comparison between the external post hole and the central post holes for Northern Structure 2.

in this area and spreads further into the entrance, although it does remain within the structure. The same pattern is seen in the fish bones.

The flint flakes are also located in this area but the density is more elongated, perhaps suggesting two areas which have become merged. Another high density area is found outside the entrances to the northern structures, possibly associated with the central structure. A further high density area lies beyond, located within the central structure, and is possibly associated with that structure. The flint waste has a lower density in the entrance of the northern structures, but a higher density immediately outside, and again within the central structure.

Area 2 is located around the hearths in the northern structures. It has a relatively low density of mammal bones but high densities of both fish and bird remains. The flint flakes and waste also show high densities in this area. Area 3 is located opposite the entrance towards the back of the structures, and contains high densities of bird, fish and mammal remains, flint flakes and waste. Area 4 only has high densities of flint waste and flakes, but also some slight densities of bird remains. Area 5 has no mammal remains, very low densities of bird and fish remains, and very low densities of flint waste and flakes. Area 6 lies beyond the northern structures and has high densities of mammal and fish remains and flint flakes and waste, but is notably lacking in high densities of bird remains. Having defined these activity areas the remaining artefact types need to be assessed on the basis of these areas.

## 10.8.10 Ceramics and activity areas

Pottery sherds do not exhibit any useful patterns. Some sherds do cluster but vessel locations cannot be inferred from this as the sherds contain varying temper matrices, indicating that many of them come from several vessels. Prior to analysis the ceramics specialist identified sherds which relate to vessels using a minimum number of individuals

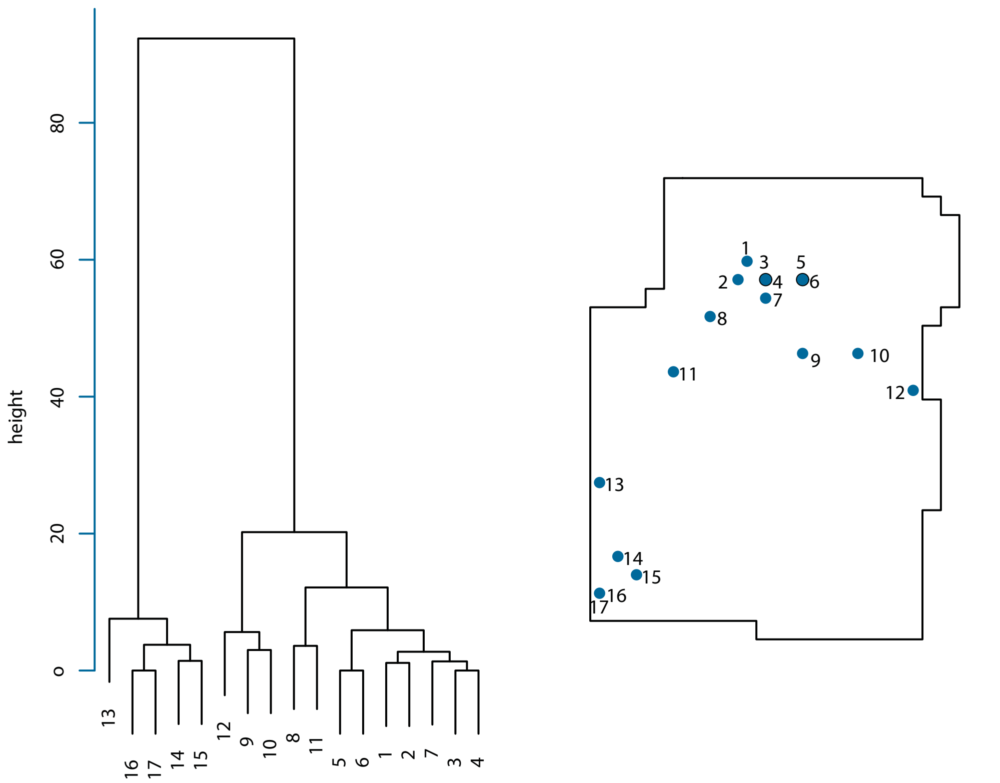



Fig. 10.56 The dendrogram of sherds from vessel 4 and the distribution of sherds by quantity for vessel 4 (values less than 1 are the result of multiple locations of a sherd).

technique based on rim sherds.[229] This revealed five vessels, and one likely further vessel, as the tempering is grog and all the sherds were recovered from a single metre square. On this basis, the distribution of the sherds of these six vessels were plotted and further analysis was conducted to identify the possible original vessel locations.

**Original vessel locations**

Pottery is susceptible to movement around a site. Once a vessel breaks into several sherds it can be very difficult to identify its original location. One can expect sherds which belong to a vessel to cluster around the original discard location, although this depends on the level of disturbance of the sherds prior to natural deposition. This also assumes that the sherds were not deliberately dispersed or grouped together after the vessel was no longer in use. Vessels were classed by the ceramics specialist and then analysed spatially using hierarchical cluster analysis (HCA).

HCA can display levels of clustering at different scales. It first assumes every single sherd is a cluster at zero metres and then groups them together at differing spatial scales. The resulting dendrograms can then be interpreted (Fig. 10.56-10.60). Using these results, it is possible to interpret sherds from vessels 12, 1 and 4 as clustered and vessels 3 and 5 as dispersed in relation to the size of the site. The grog-tempered vessel whose sherds were found solely in square 10 is also clustered, but was not analysed with HCA as the clustering is obvious.

Based on these results, we can tentatively suggest that vessels 12, 1 and 4 have a possible original location from the time the site was abandoned. It must however be noted that these results are highly susceptible to any changes in the numbers of sherds, and it would take only a few extra sherds to drastically alter the picture. The numbers displayed at the ends of these dendrograms or trees represent single sherds from the site and relate directly to the opposing location plot of the square centroids on the right in the figures below. The lower the position of the value the closer and therefore more clustered the sherds.[230]

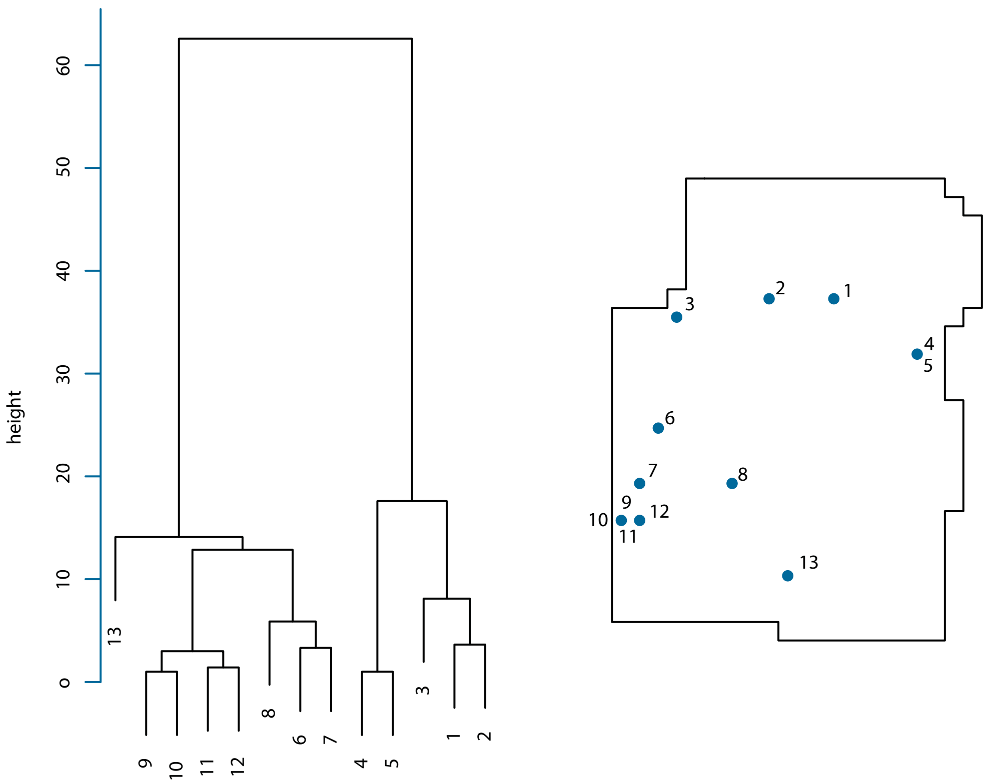



Fig. 10.57 The dendrogram of sherds from vessel 3 and the distribution of sherds by quantity for vessel 3 (values less than 1 are the result of multiple locations of a sherd).

[229] See Beckerman this volume.
[230] All of the dendrograms were constructed using GRASS GIS and R implementing a Ward's case HCA.

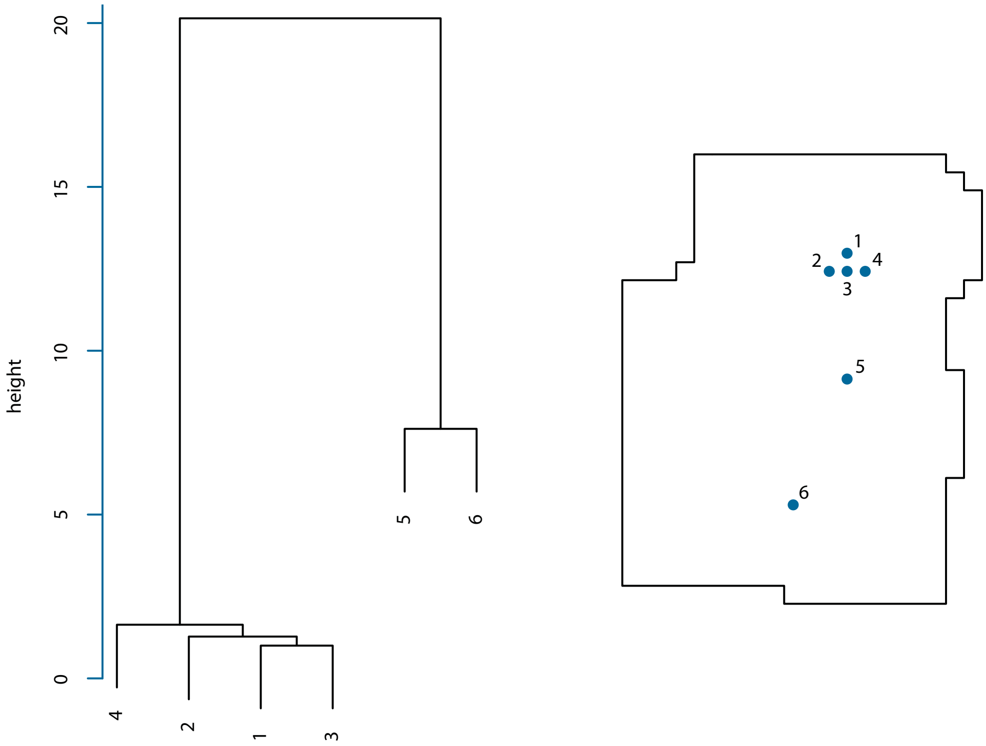



Fig. 10.58 The dendrogram of sherds from vessel 12 and the distribution of sherds by quantity for vessel 12 (values less than 1 are the result of multiple locations of a sherd).

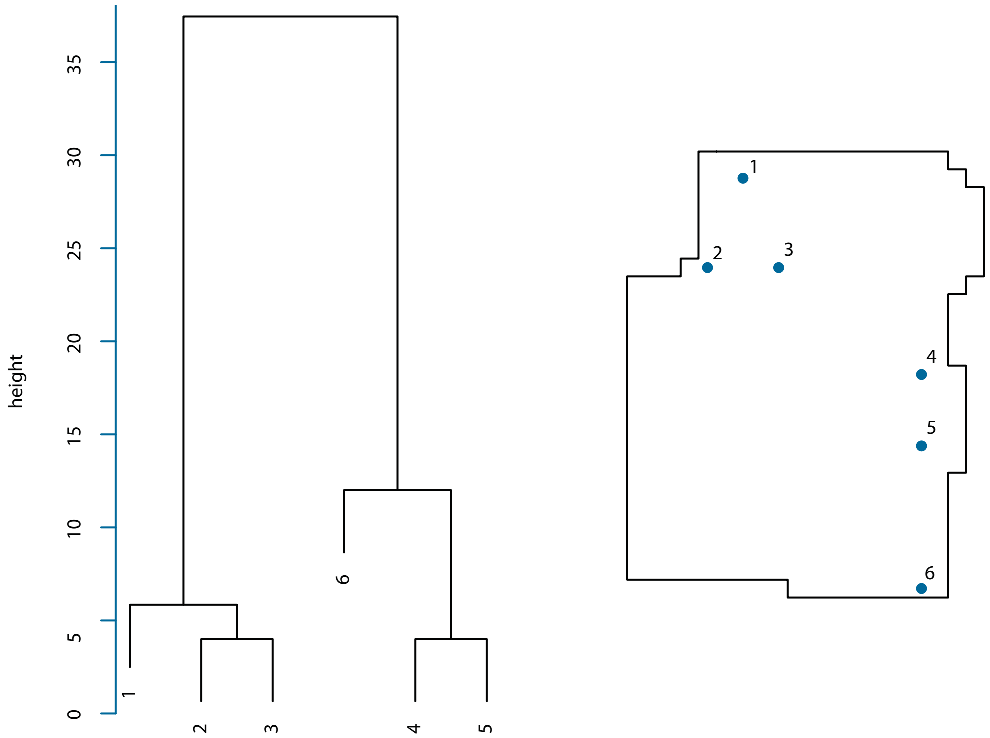



Fig. 10.59 The dendrogram of sherds from vessel 5 and the distribution of sherds by quantity for vessel 5.

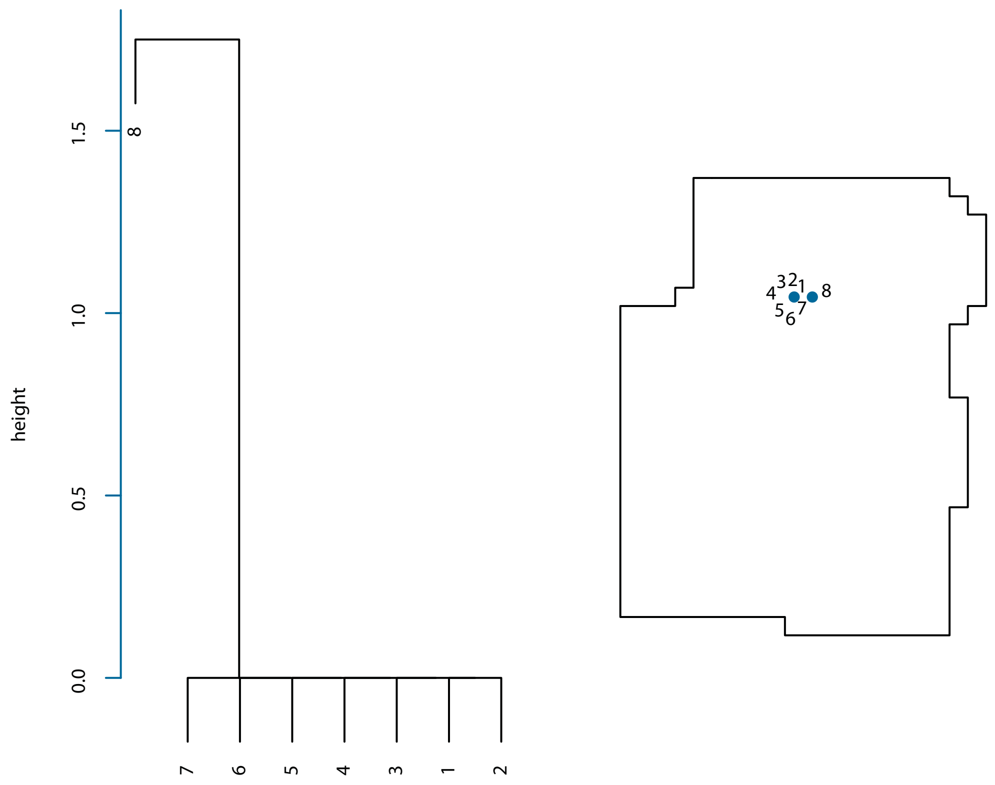



Fig. 10.60 The dendrogram of sherds from vessel 1 and the distribution of sherds by quantity for vessel 1.

## 10.8.11 Residues

Having identified the possible locations of some vessels it may be possible to assign a use to the vessel by analysing the surviving residues. This in turn may aid in the characterisation of these activity areas. Sixteen samples were assessed for their residues.[231] Of these, only nine were on sherds with a context, all of them located in the cultural layer with a square number.

Residues were taken from sherds on which they had survived and it was not, unfortunately, possible to target sherds from vessels in specific areas. As a result, only four sherds were from the cultural layer, and five lay beyond it. Any spatial or temporal extrapolation from these nine residues cannot therefore be applied to the entire site due to the potential underrepresentation in both a geographical and chronological sense, although they can be used to suggest patterns.

## 10.8.12 Botanical remains in activity areas

The cereal and plant tissue remains were plotted over the site and are interpreted here from a spatial analytical perspective.[232] The majority of emmer chaff is located to the north, just beyond the cultural layer, with some emmer grains and barley grains. This suggests a possible grain de-husking area (area 7). The barley at the site occurs with no immediately observable spatial patterns. However, barley is located around the hearths in the northern structures. Crucially, barley is also located near the two charcoal patches in the central structure, an important point which we

**Table 10.11 Results of residue analyses.**

| sample | sherd fragment number | residue UID | vessel number | new vessel number | botanical interpretation | chemical interpretation |
|---|---|---|---|---|---|---|
| K1 | unknown | 2783 | 2 | 3 | none | highly carbonised mixture of animal fat/oil and starch (in) |
| K2 | 4-2-1041 | 2784 | 2 | 3 | none | none |
| K3 | 3-1-140 | 2785 | 6 | X | none | none |
| K4 | 4-1-333 | 2786 | 10 | 5 | none | none |
| K5 | 3-1-200ll | 2787 | 20 | 21 | cooking emmer grain food | none |
| K6 | 2-1-1958 | 2788 | 21 | X | cooking emmer grain food | not measured |
| K6 | 3-2-1006 | | 21 | X | none | none |
| K7 | 4-1-1040 | 2789 | 22 | 13 | none | medium carbonised mixture of animal fat/oil and starch |
| K8 | 1-1-19 | 2790 | 22 | 22 | none | none |
| K9 | 2-1-57 | 2791 | 22 | 22 | cooking emmer grain food | potassium contamination |
| K10 | 2-1-32 | 2792 | 27 | 9 | none | potassium contamination |
| K11 | 1-1-10 | 2793 | 9/18 | X | none | traces of animal lipid and starch |
| K12 | 3-1-136 | 2794 | 9/18 | 10 | none | traces of animal lipid and starch |
| K13 | unknown | 2795 | extra1 | X | cooking emmer grain food | highly carbonised mixture of animal fat/oil and starch |
| K14 | 4-1-384 | 2796 | extra2 | 4 | | none(in) |
| K15 | 3-1-102 | 2797 | extra2 | 4 | cooking (vegetative) parenchymatous food | traces of animal lipids and starch |
| K16 | 3-1-262 | 2798 | extra3 | 8 | cooking emmer grain food | medium carbonised mixture of animal fat/oil and starch |

231 See Oudemans this volume.
232 See Kubiak-Martens this volume.

shall return to below. The plant material is located further to the south, but any further patterning is unclear (see figure 10.28-10.30).

## 10.8.13 Comparative internal analysis

The artefact distributions are mostly within the northern structures, most likely due to better preservation. This suggests that the northern structures were the final construction phases at the site. If habitation or human activity had continued, this distribution pattern would be expected to begin to disperse and erode. Erosion could be the cause of the low quantities of finds associated with the other structures. The northern structures are therefore used for comparison. Even though find densities are low within the other structures some parallels can be identified between the central and northern structures.

Area 1 has high densities of flint flakes and waste. These densities occur in the southwestern area of and outside the northern structures, suggesting an entrance. These high densities also occur in the central structure, again in the southwestern corner. This parallel could therefore also indicate an entrance. It is possible that these densities within the central structure are from later activity associated with the northern structures, but trample is unlikely due to the high densities.

The hearths of the northern structures are located centrally, but also towards the southern wall. The central structure has two areas of charcoal; these could be the remains of a partially eroded hearth, which is also located centrally but towards the southern wall. Barley identified around the northern structures hearths also occurs near to these charcoal patches, as well as elsewhere.

Three vessels were identified as possibly originating in area 3 within the northern structures, located opposite the entrance beyond the central post line. In the central structure a vessel was also identified, albeit tempered by grog. This was located opposite the possible entrance between two posts of the central line. It is therefore possible that the central structure echoes a similar internal layout as the northern structures.

One key observation is the lack of disturbance between the northern structures. This is especially obvious when the fish bone densities are examined. The fact that the density partly lines the wall of the first northern structure indicates good preservation of the spatial distribution. Since the second of the northern structures is built upon the same location but with the wall line placed beyond this density the question arises as to why this previous pattern remained undisturbed. Given the fact that the later structure contains this density one would expect this distribution to have been eroded. There must therefore be a reason why it has been preserved. It may be that the fish bones were embedded in an earthen floor matrix or – perhaps more likely – that a floor was laid, thus unintentionally protecting the spatial distribution. Furthermore, this pattern is not repeated in the later structure. This could be due to a lack of a further floor to preserve the fresher remains, or it is possible that there was a change in the subsistence strategy between the time of these two structures.

## 10.8.14 Summary – why a house?

Before continuing this discussion, a clear explanation is required as to why the structures have been recognised as such. The structures have yet to be defended and no roles have been assigned. They are deliberately referred to as structures rather than anything which suggests a function. All of the presumed structures have the following attributes:

**Central post line**
External post lines (walls) bordering a broadly rectangular space, mostly constructed from stakes but also occasional larger posts. The central and external post lines are fairly parallel or perpendicular to the central post lines.

There is more evidence for some structures than for others, however:

**The northern structures**
- contain hearths (5);
- clustering of artefacts, thus defining a space which fits within the outline of the structure;

the density of the fish bones describes two lines and a corner of the wall of northern structure 1.

**The central structure**

- two patches of charcoal, possibly a former hearth.
- many parallels with the northern structures, in terms of the locations of the hearth and door, the door width and a vessel.
- same orientation as the northern structures
- barley near the charcoal (hearth?)

**Southern structures**

- very little evidence other than the post lines.
- possible door on the long wall near the corner.
- these are the only structures with a possible parallel (Zeewijk-Oost and Mienakker).
- respect the pits.

## 10.9 Discussion

### 10.9.1 A new approach

This monograph has taken a uniquely different approach to post-excavation site analysis of a Neolithic settlement. Traditionally, all Neolithic buildings are interpreted as such by the excavators during the excavation. They are best placed to explain the site as they have a full grasp of the features which have been discovered. It is not currently possible to conduct high-level spatial analysis during the excavation without impacting on cost and time. It is therefore quite possible that Neolithic structures have been excavated but remain in the archives awaiting discovery.

Traditional identification in the field during excavation has been viewed as the most reliable way to identify structures. These identification procedures, as presented in table 10.12, give greater validity to the structures if they are identified during the excavation rather than observed during post-excavation. Following this research, it appears this table should either be revised or another one created for the post-excavation process. Both recommendations will be investigated following the completion of the three site reports of which this – Keinsmerbrug – is the first. The table also suggests that the identification of structures in the post-excavation phase is less reliable, but the author would argue that with sufficient post-excavation analysis this method could be either just as valid or even more so. At present, no studies are adequate from a spatial analysis perspective to allow identification of house plans from Dutch prehistory for the purposes of such a comparison.

**Table 10.12 Classes for houseplan-reliability from Arnoldussen (2008, 73) after Fokkens & Jansen (2002, 10) and Berkvens, Brandenburgh & Koot (2004, 58.**

| Class | Class Description |
|---|---|
| Ia | Very reliable house-plan, recognised and described during fieldwork. Constituent features checked for consistency as being part of the structure within a wider group of features. Preferably exposed and investigated in full. There are no doubts on its validity by the excavator. |
| Ib | Reliable house-plan like those of category Ia, but for which elements are missing due to limited excavation (unit) size or local soil-processes or disturbances. There are no doubts on its validity by the excavator. |
| Iia | Plausible house-plan that was recognised and investigated as such during fieldwork. Some results of the investigation are inconclusive; post are unexplainably absent, or differ distinctly in shape, section or fill. There are some doubts on its exact former nature by the excavator. |
| Iib | Possible house-plan of which the main parts have been discovered during fieldwork, but during post-excavation analysis the structure has been revised, extended or altered. As the association of the posts added during post-excavation analysis was not based on field-observations on their properties, these houses of inherently weaker quality than classes Ia, Iib and Iia. There are some doubts on its exact former nature or overall validity by the excavator. |
| IIIa | Tentative house-plan which was reconstructed during post-excavation analysis. Based on the documentation there is sufficient evidence to suggest that constituent features were once part of a single structure. As the association of the posts during post-excavation analysis is not backed or checked by field observations on their properties, these houses of inherently weaker quality than classes I & II. There are some or ample doubts on its exact former nature or overall validity by the excavator. |
| IIIb | Improbable house-plan which was reconstructed during post-excavation analysis. Based on the documentation there is insufficient evidence to suggest that constituent features were once part of a single structure. As the association of the posts during post-excavation analysis is not backed up or checked by field-observations on their properties, these houses of inherently weaker quality than classes I & II. There are severe doubts on its exact former nature or overall validity by the excavator. |

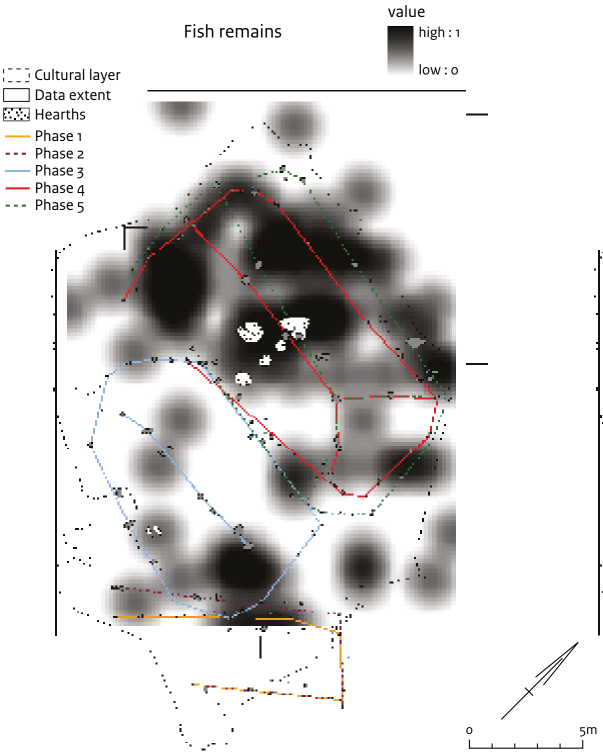



Fig. 10.61 Fish bone densities.

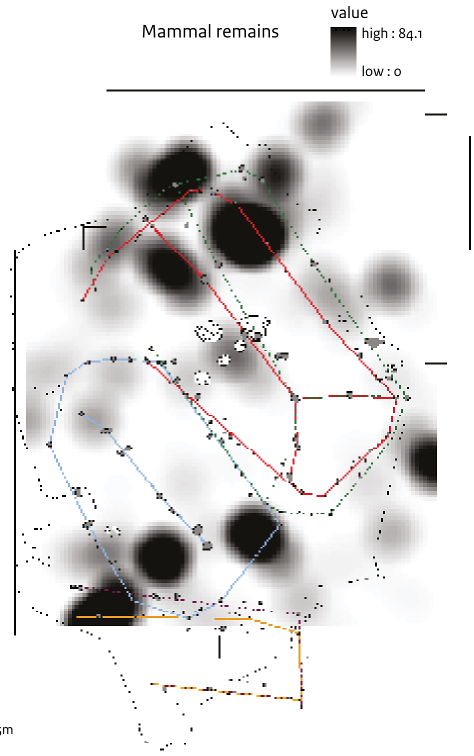



Fig. 10.62 Mammal bone densities.

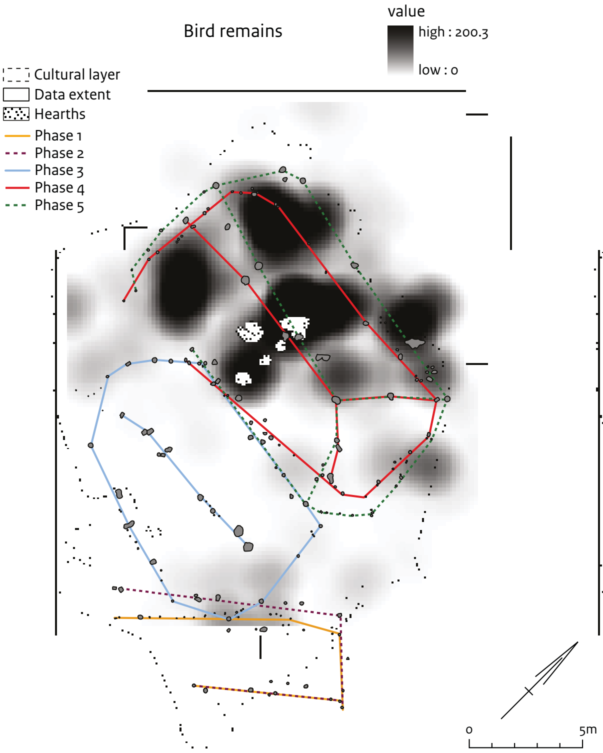



Fig. 10.63 Bird bone densities.

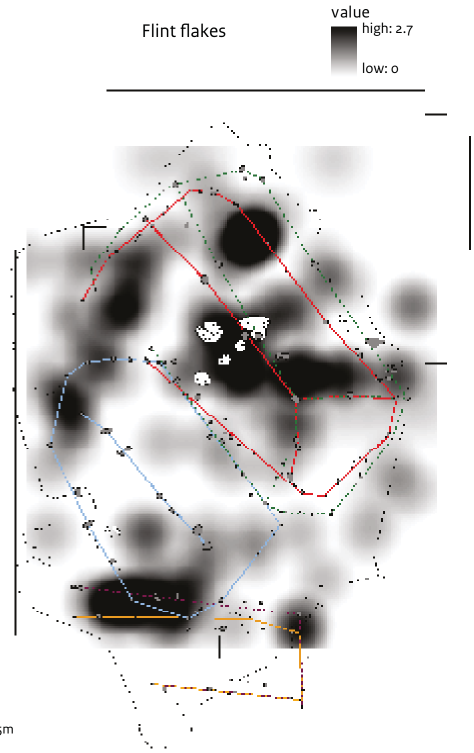



Fig. 10.64 Flint flake densities.

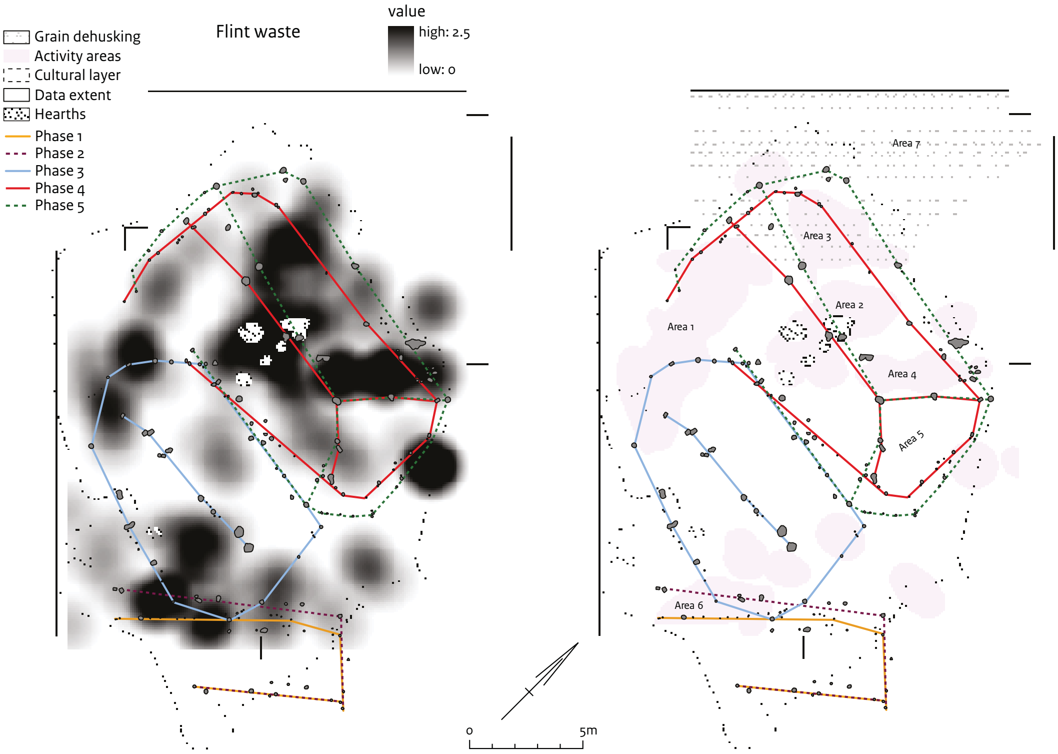



Fig. 10.65 Flint waste densities.

Fig. 10.66 Activity areas based upon the artefact densities, ecofact densities and the botanical evidence.

The dot-to-dot method used in the field is the best way to identify post-built structures from any period in history or pre-history. However, some structures were either not built in a way which impacts upon the soil sufficiently to leave any trace or the structures were temporary, so the postholes appear sparse and not associated. The latter was observed in this case. Other features also distracted from the interpretation of structures, hiding the structures due to the quantity of features in a relatively small area.

This study has taken a uniquely different approach from the traditional, using an artefact to features method, as opposed to a features or features to artefact method. In other words: artefacts are used to define spaces, then the features are assessed relative to these areas, rather than either just assessing the features or assessing the features then incorporating the artefacts. Figures 10.61-10.66 illustrate this with the application of kernel density estimation (KDE).

## 10.9.2 The pits

The majority of this section discusses the structures. However, the pits could have played a crucial role in the early establishment of the site (Fig. 10.67). In some cases it is not certain what type of natural stratigraphical units these pits are cut into. Of the pits with stratigraphic information, (10 of the 15) all but three cut into the natural sandy clay and the shell bank which lies below. They are relatively devoid of finds and contain a number of fills. Some have an upper fill of the later cultural layer, while others lack this information. These pits therefore filled prior to the formation of the cultural layer, which is mostly associated with the northern and central structures. This sand or sandy clay, and especially the underlying shell bank,[233] could filter particles from the water, possibly making it better and safer to drink. It is therefore suggested that at least the majority if not all of

[233] See Nobles this volume (chapter 3).

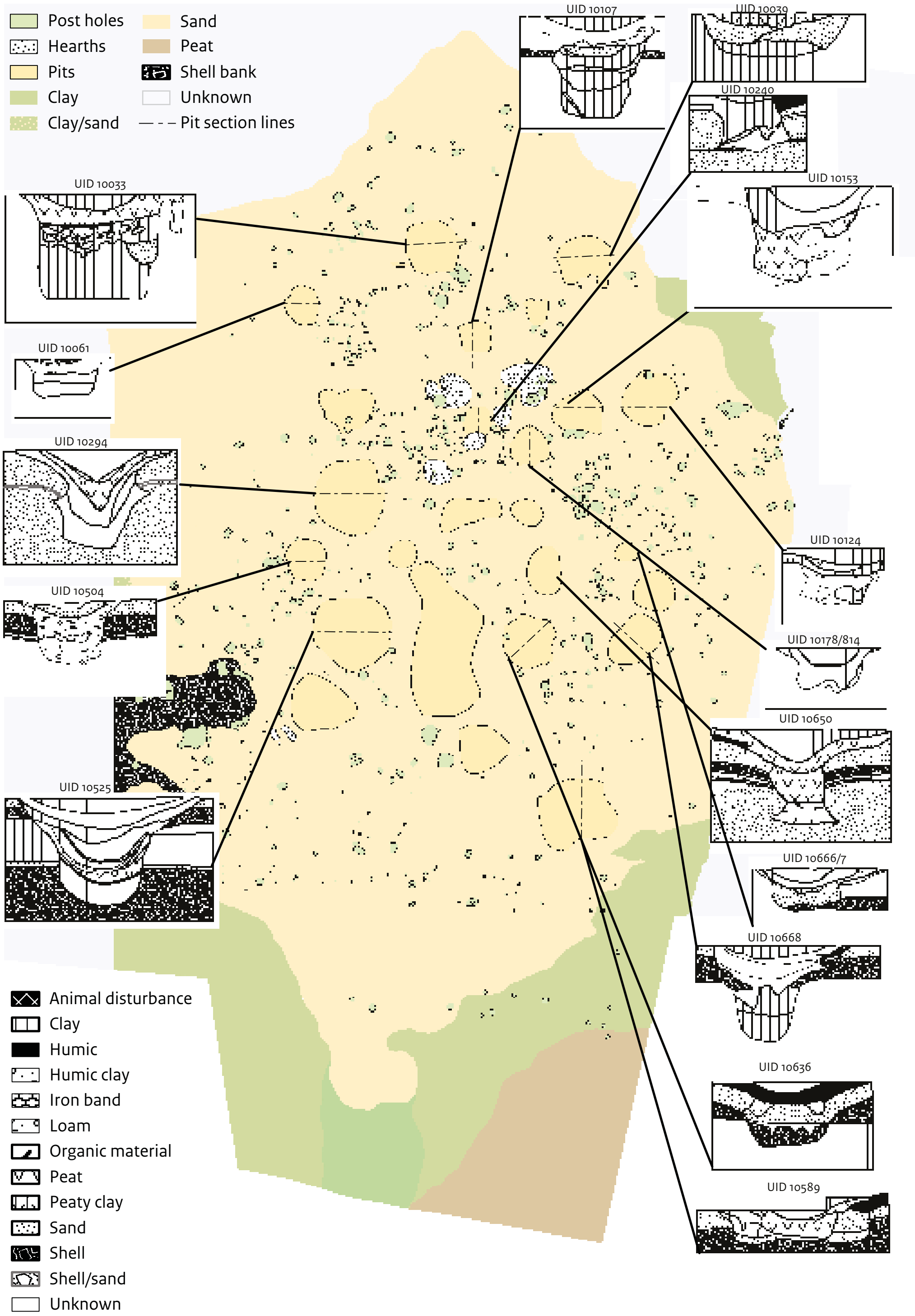



Figure 10.67 The location of pits and sections, note the orientation of the sections are not known.

the pits functioned as water pits or even wells. It is not possible to identify how many of these 'wells' would have been open at any one time, or how many habitation seasons they represent. None are cut by subsequent wells, indicating they were either left open, marked in some way, or it was obvious where they had been. Their phasing is discussed in section 10.14.5.

## 10.9.3 Building methods

There are a few possibilities for how these structures may have been built. Some may be more applicable than others. As has been concluded on the basis of the original excavation, the postholes do not show signs of having been pre-dug. It is therefore assumed that the posts were driven into the ground. If this is the case there are two possibilities: either they were physically hit or forced into the ground, or the structure was placed on the ground surface and sank under its own weight.

Both these arguments are supported to some extent by the diameter-depth graphs for the northern and central structures in section 10.13.8. The wider central posts are shallower than the thin external wall posts. Generally, with exceptions, the central posts do not go deeper than 0.15m. The external wall posts display a greater range. Conceivably, it would be easier to drive the thinner posts into the underlying clay, sand, sandy clay and shell matrix.

These interpretations are tentative, as only a sample of the postholes yielded sufficient information on their depths. Once this frame of central posts and external wall posts were in place cross beams may have been added to lend greater stability. It is possible that these beams would have been attached to the vertical posts using twine, plant fibres or sinew, which could have been applied when wet so it would shrink and tighten as it dried.

Southern structure 1 has regularly spaced stakeholes between the sparsely spaced posts of the external wall. These would have been used to construct a wattle wall, possibly with or without daub (no daub remains). The wall posts in the northern and central structures are widely spaced. No evidence of regular closely spaced stakes for wattle exists. The wattle stakes may therefore have had little impact upon the ground surface and these intermittent stakeholes might not have survived in the archaeological record. Daub could have been added, but no evidence remains.

Botanical evidence supports reed roofs and floors which would have been laid upon the constructions between the central post line and the external wall with some degree of overhang.[234] Again, plant fibres, twine or sinew could have been used to secure the bundles of reed to the frame.

Materials for building such structures could have been found scattered locally, or some resources could have been brought to the site. The heights of the structures are not known. Heights of 2m for the walls and 4m for the central post line were used in the reconstruction images. These measurements are arbitrary and were used as a basis for illustrative purposes. They should not therefore be mistaken for fact.

## 10.9.4 Architectural design

Having accepted these post configurations as structures it is possible to postulate ideas regarding their form. However, some important points should be considered before any attempt at reconstruction.

**Ideas about architectural styles**
A series of postholes can lend themselves to various interpretations of a structure's form, although some configurations are integral to a structures design. In this case, all of the posts have been interpreted as having been driven into the ground; the maximum depths are 0.5m, suggesting a structure at most 1m high (based upon the one third below, two thirds above method). This is not very likely. An arbitrary estimate has therefore been used: 2m for the external walls and 4m for the central postline.

Further attributes which form a structure are doors, windows, walls, roof, stairs, floors and cross beams. Based on the botanical and posthole evidence the walls are thought to be a wattle construction made of willow, as the burnt remains have a diameter of 5 cm.[235] Oak, maple or ash could have been used for the central post line and more structural elements. Hazel and alder might also be considered possible building materials.[236] There is no evidence of daub.

Given the width of the postholes and their arrangement it is not thought that these structures could have supported a second floor. The botanical analysis also suggests the presence of reed, a good roofing and flooring material.[237] When the structures are compared various types of posthole configurations emerge. A number of posthole layouts are presented in figure 10.68 displaying how they

234 See Kubiak-Martens this volume.
235 See Kubiak-Martens this volume.
236 See Kubiak-Martens this volume.
237 See Kubiak-Martens this volume.

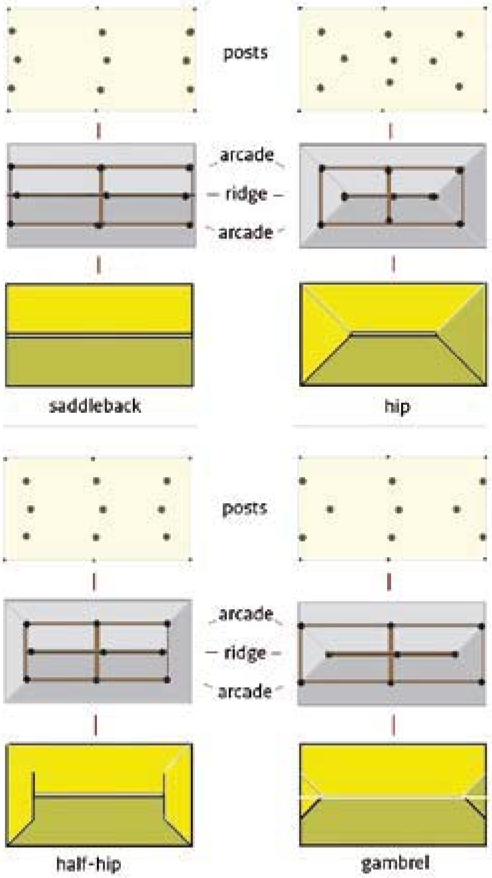



Figure 10.68 Structural forms of LBK Long Houses from Carter (2009) used with permission.

which relate to roof form. Although these relate to LBK houses the posthole distributions are still a good indicator of roof forms.

**The construction of the structures**

All of the structures are thought to have a post construction with wattle walls and reed roofs. Although built using similar building materials they differ greatly in building styles, falling into two or three sub-types.

The southern structures (1 and 2) are of a similar style, the excavated remains measuring 3.5m x 10m and 4m x 10.4m respectively. This is not their full extent, as the widths would have been 7m and 8m, though the full length can only be inferred from a single example, Zeewijk-Oost (see Figure 86), which has a similar width but a length of 22m. These structures could therefore be of that order, though Zeewijk-Oost is very different in terms of posthole diameters and uniformity of configuration.

The structures' floor plans are rectangular with evidence of a sharp corner and a central post line which adjoins the external wall. A possible door is located in the northwestern wall. Based on the posthole configuration the roof is likely to have had a gabled end although possibly set at a slight angle leaning inwards. This gabled end could have been a wattle or reed construction (Fig. 10.69).

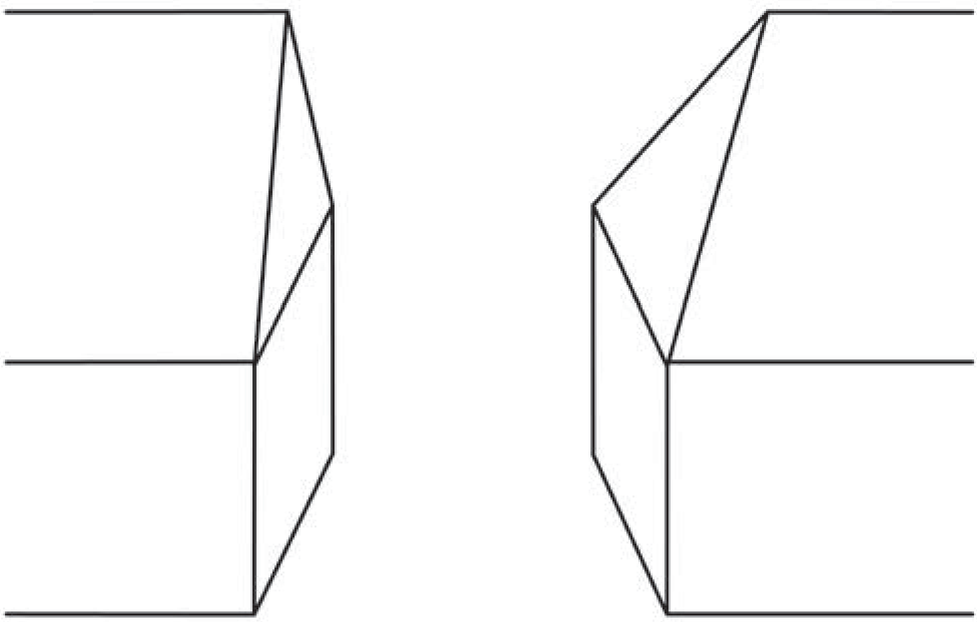


Figure 10.69 Possible roof terminations for the Southern Structures.

The walls of the structures are thought to be vertical or near vertical. Based upon the plans and using an arbitrary measurement of 2m for the walls and 4m for the roof, an illustrative 2.5D representation can be produced (Fig. 10.70 and 10.71).[238]

These models have a slightly sloping roof on the northeastern side with a gabled roof on the southwestern side.

The central structure is vastly different in plan. The central post line does not join with the external wall, the structure has two straight walls which are parallel neither to each other nor to the central post line, and the corners are rounded – so much so that it suggests a more ovoid shape. This suggests a continuous roof covering the structure and therefore no defined 'end' to the structure. Again, a 2.5D representation is shown below (Fig. 10.72).

The northern structures are again different, both from the other structures and from each other. Both have a central post line which splits at an angle of 100 degrees and continues to the 'corners', giving a 'Y' shaped central post line. The two structures share the top of the 'Y' construction but have different main post lines.

Northern structure 1 is trapezoidal in plan and very symmetrical with rounded corners. This configuration yields a unique structure, at least for this period of Dutch prehistory. It is wider in the west than the east and the top of the 'Y' at the eastern end would produce a structure with a hipped roof as seen in Figure 10.76. The roof at the western end may either resemble that of the eastern end, or be completely different. This alternative suggestion is based on a collection of postholes near to the western wall (see Figure 10.38), which could have supported a more 'lean-to' gable-like roof, in this case deviating from the vertical by approx.1m, with an angle defined by the height of the roof (which is unknown). The former roof type is illustrated below (Fig. 10.73).

The next structure, northern structure 2, reuses parts of the former structure, although it undergoes a 10 degree realignment (Fig. 10.74). The roof is similar to that of the previous structure, including two possibilities for the western part of the roof. In this case there is one larger posthole

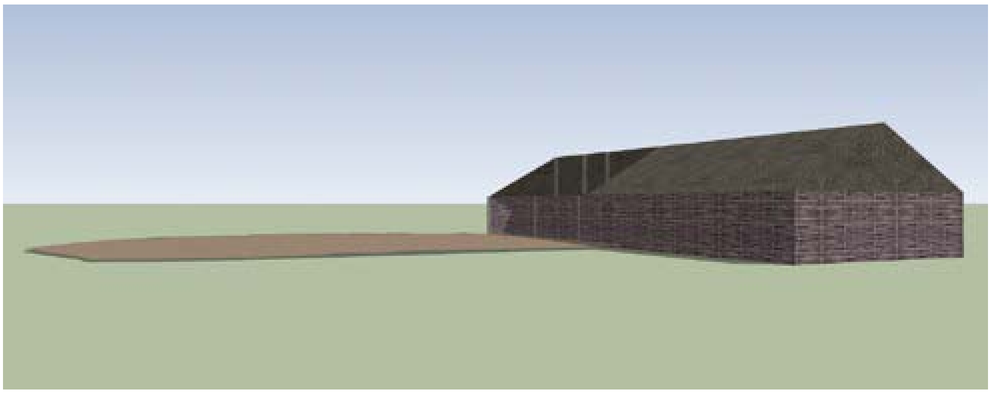


Fig. 10.70 Southern Structure 1 (Interpretation of post hole locations illustrated by the closed roof).

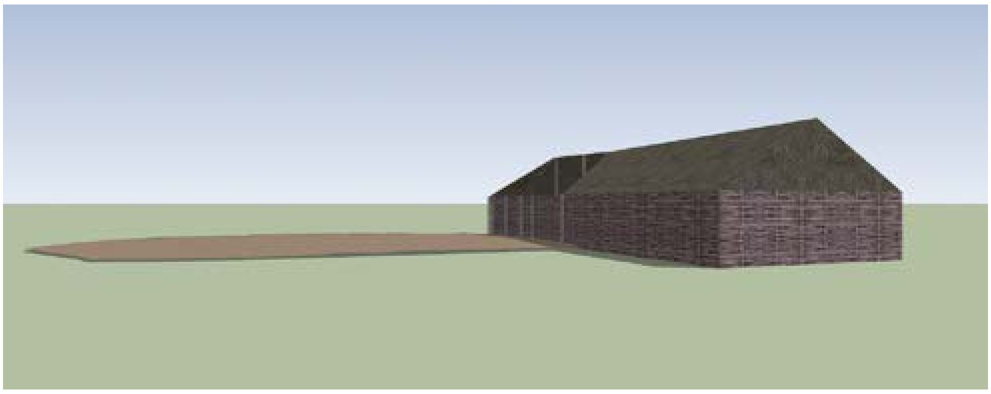


Fig. 10.71 Southern Structure 2 (Interpretation of post hole locations illustrated by the closed roof).

[238] 2.5D means 3D represented on a 2D medium, in this case a 3D reconstruction on 2D paper.

which could have supported a leaning roof at a distance of approximately.1.6m from the wall.

Only two house structures have been identified during excavation in the Noord-Holland area, especially within the palaeo river basin. The discovery of five new structures therefore adds vastly to our knowledge of the archaeology of the area at that time. Now we have seven structures to compare at Keinsmerbrug, Zeewijk and Mienakker, can any typologies be inferred? Each structure has its subtleties, but two or three general observations can be made (Table 10.13). The walls of all the structures include some of the following elements: parallel sides, rectangular, ovoid, trapezoidal, rounded corners, sharp corners, regular post spacing, sparse post spacing, relatively large and small posts. The central post lines are a single line central to the structure, the only deviation from this rule being the northern

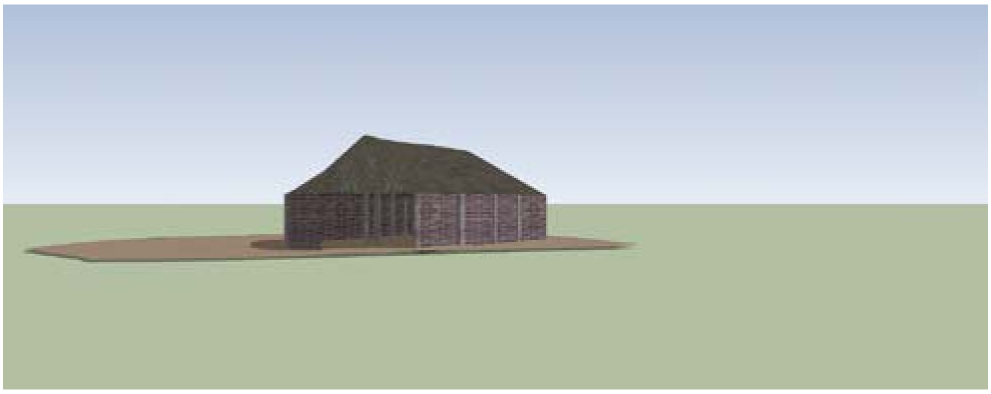


Figure 10.72 Central Structure with a continuous roof.

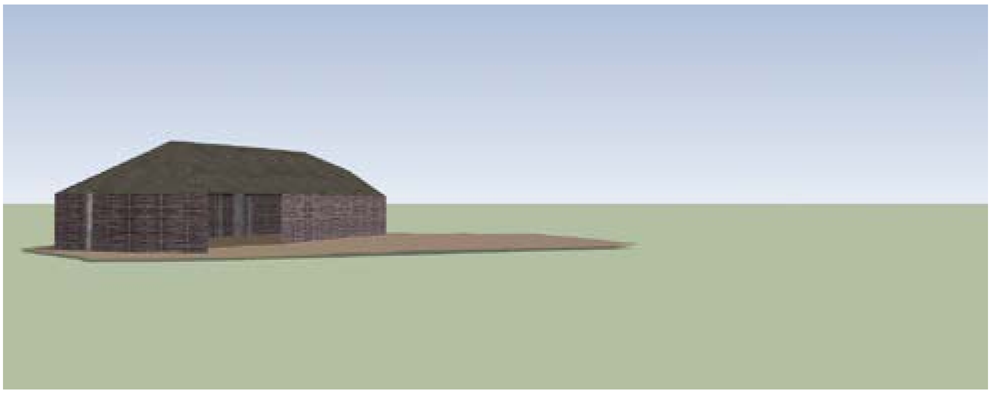


Figure 10.73 Northern Structure 1.

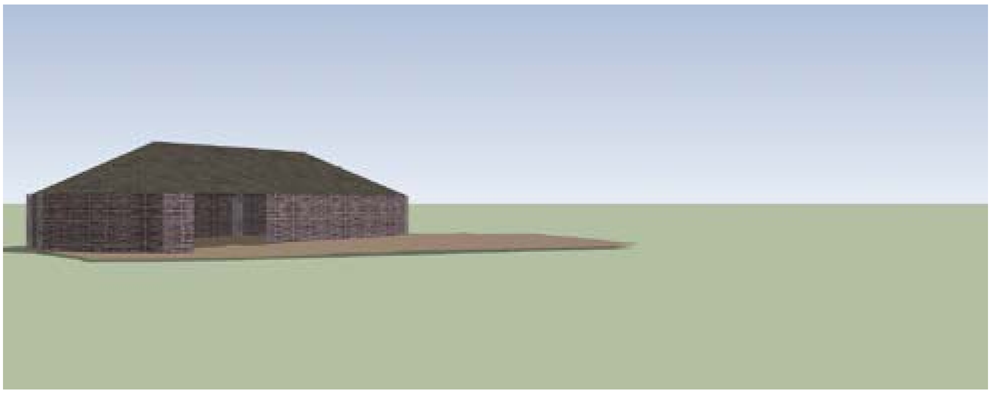


Figure 10.74 Northern Structure 2.

structures at Keinsmerbrug, which have a 'Y' arrangement at their eastern ends.

The table below assesses these attributes at a basic level. Only two pairs of structures – Zeewijk-Oost and Mienakker – share identical attributes. However, Zeewijk is 22m long and Mienakker only 6m. The same applies to Kmb S1 and Kmb S2, although they are not complete. No single distinct building tradition can therefore be observed. This raises a further question: were there any building traditions or were construction techniques dictated by the individuals rather than the rules of the wider society? More structures from different types of settlements are required before any attempt can be made to answer such a question. Stricter social constraints may have applied to construction at long-term settlements than at outlying seasonal base camps. However, this assumes that such long-term base camps existed, an assumption that is yet to be fully investigated.

### 10.9.5 Phasing

Chapter 3 showed a phasing based upon the original excavators' comments. This can now be developed and adjusted (Table 10.14). The first phase saw the building of the first structure, southern structure 1. This is inferred from the fact that the postholes were smaller in the exterior wall prior to their replacement by larger posts for the next structure. This first structure does not interfere with the pits, which are completely separate. However, the pits exhibit a general northeast to southwest alignment, whereas the structure is aligned northeast to southwest. They are therefore set at approx. 90 degrees to each other. Furthermore, two plough marks were found on this alignment. It is not however possible to tell whether these plough marks were in fact ard marks or if they are of a later date. These features neither cut through nor overlap each other. This lack of stratigraphy and respective orientations suggests contemporaneity, which may have led to further development in the next construction phase.

The first structure was replaced either partially or completely. It appears that some posts may have been replaced or reused at the north-eastern extent; this would not have been the case at the opposing end due to the altered alignment. The pits may have continued to be dug during this phase. Construction phases 1 and 2 yielded similar structures built at the same place and on almost the same orientation. The next phase departs from this tradition, however.

The central structure represents construction phase 3, possibly marking a major change at the site. Beyond its obvious change in orientation to east-west, it appears far less formal than the preceding rectangular structures with sharp corners and straight parallel walls. Indeed it is more irregular, tending towards an ovoid shape in plan. The central post line does not interact directly with the external wall, the roof instead acting as the connector. Depending upon the beam configuration it may have been less stable as a result. However, it uses larger posts than the other structures, so both supporting beams and the roof could have

**Table 10.13 Comparison of structural forms between Neolithic structures from Noord-Holland (* Mienakker and Zeewijk are subject to reinvestigation later in this report series).**

| element | wall | | | | corners | | ends | |
|---|---|---|---|---|---|---|---|---|
| Structure | parallel | irregular | trapezoidal | ovoid | rounded | sharp | flat | rounded |
| Kmb S1 | yes | | | | | yes | yes | |
| Kmb S2 | yes | | | | | yes | yes | |
| Kmb C | | | | yes | yes | | | yes |
| Kmb N1 | | | yes | | yes | | yes | |
| Kmb N2 | yes | | | | yes | | | yes |
| Mienakker* | | | yes | | | yes | yes | |
| Zeewijk –Oost* | | | yes | | | yes | yes | |

played an important structural role.

The fourth construction phase (northern structure 1) again shows a change in building method, returning to a more formal symmetrical trapezoidal construction. The 'Y' shaped central post line is a unique technique, no other examples of which have been identified from the SGC period to date (other than the later example in phase 5). It has a similar orientation to the previous structure and either reuses some posts, or is positioned immediately beside the external wall of the central structure, which may still have been in existence.

The fifth and final construction phase builds upon the former, in both technique and location. Northern structure 2 reuses the eastern part of the former central post line but is aligned 10 degrees northward. Crucially, one of the central posts cuts a hearth, providing further evidence to suggest this phasing is correct. The external long walls are parallel with rounded corners and curved ends; the southern wall possibly reused posts or postholes from the central structure or the previous northern structure.

The characteristics of the structures in relation to their phasing suggest two or three temporal phases. Even though only one structure would have been in use at any one time it is not known whether the structures were left standing. Both southern structure 1 and northern structure 1 must have been dismantled in some way prior to the building of southern structure 2 and northern structure 2. Since the central structure overlaps the southern structures it is unlikely that they remained during the third construction phase. However, it is curious to note how both of the northern structures reuse or are at least built upon the former northern wall of the central structure. Could this structure have remained standing in part, or even in its entirety?

The lack of any overlap suggests at least some recognition that a structure was there, be this through physical remains or memory. This notion is further reinforced by the fact that the orientation remains similar, if not the same. This is in great contrast to the southern structures. The northern and central structures, though apparently different in form, share many similarities. They share the same orientation, the doors may have had similar positions, and they are ovoid with

**Table 10.14 Phases of the Keinsmerbrug settlement.**

| phase | construction phase | elements |
|---|---|---|
| 1 | 1 | southern structure 1 |
| | | well pits |
| | 2 | southern structure 2 |
| | | well pits |
| 0 | 0 | none identified |
| 2 | 3 | central structure |
| | 4 | northern structure 1 |
| | 5 | northern structure 2 |

straight sides, similar to northern structure 2.

The southern structures share a different orientation and possibly similar sized entrances. This appears to mark a clear divide in the site, not physically as such, but perhaps temporally. It is possible that two general phases can be identified.

Construction phase 0 is also worth noting. This marks a period when the site was not in use: an abandonment phase, therefore. 0 has been used to make the reader aware that this is a two-phase site (phases 1 and 2), with a hiatus (phase 0).

The main aspect which defines these phases is the orientation of the structures. Since the last three structures share the same orientation and do not overlap (though they do reuse elements), they can be grouped into a separate phase. This places the southern structures in another phase, based on the same arguments.

It is possible that the change of orientation occurred as the former structures were no longer visible and did not therefore serve as a point of reference for new structures. This suggests that some time passed before the site was returned to. Either it was abandoned by one group of people and later adopted by a second group, or abandoned then returned to by the same group after society had changed, specifically in terms of building design.

This change in society, if it occurred, may have been a gradual shift in cultural values, no longer requiring strict formal buildings but allowing the creation of more irregular, less linear structures.

## 10.9.6 Activity areas

The analysis identified activity areas within the area of the site, as well as beyond. The spatial analysis can identify characteristics of these areas but specialist input is required for a full interpretation. Flint waste and flakes are represented in all the areas other than areas 5 and 7. Ceramics are mostly from area 3, although another concentration, interpreted as a single vessel, occurs near area 1. Animal remains show large concentrations in areas 1, 2, 3, 5 and 6, although more informative patterns are observable when assessed at species level.

Fish and bird remains occur in all of the aforementioned areas except for area 6 where densities of bird remains are much lower. Mammal bones are mostly in areas 1 and 3, being clearly underrepresented around the hearths (area 2).

These results suggest that mammal bones are deliberately absent from the hearths or were physically removed from that area by the occupants. This leaves a few possibilities: either the meat was removed from the bones in area 3 and then hung over the hearths for cooking, or alternatively the meat could have been cooked on the bone and then the bones discarded in area 3. This would explain the low densities around the hearth. However, this low density could be caused by activities such as bone working or other activities which require the use of bone. These areas (1, 2 and 3) could be a cooking area, preparation area and discard area. Area 3 would have been for preparation, area 2 for cooking, and areas 1 and 3 for discarding the remains. Area 1 may also have a meat preparation role due to the degree of light. The interpretations posited here are by no means certain; there are currently no comparable sites for this area or period that have been subjected to detailed spatial analysis and further analysis is required to explore these areas.

Very little has been said about any internal elements within the structures, as they represent a palimpsest of activity features within activity areas. Elements could be related to different phases of the site, not associated with the structures solely because of their location.

However, one group of stake holes are of further interest. They are located to the southeast of the hearths, positioned close together to form a straight line, with further stakes perpendicular to the ends. This could represent some kind of rack, possibly for hanging, drying or roasting meat, hide processing or another purpose or purposes.

## 10.9.7 Population estimates

Population estimates based upon floor area are very inaccurate, although they could suggest a representative figure for the settlement. A 2 by 2 metre area was thought to be adequate space for a person to sleep in. This figure is taken from Grogan's paper based on Irish examples.[239] This method has been applied to both the floor area and the proposed sleeping area of the northern house, whereby the sleeping area constitutes 23% and 30% of the area within the overall structures. This ratio has been applied to the other structures using a high, low and medium method: low = 20%, medium = 25%, high = 33%. These span the two values given by the northern structures. This provides an underestimate, overestimate and an intermediate estimate. All are given, since the precise area is uncertain, especially in the case of the southern structures.

If the entire house area was used for sleeping then between 19 and 41 people could have been occupying the site depending upon which structure was there at the time (Fig. 10.75). It is not proposed that the whole floor surface was used for sleeping at this site. A smaller area of the structures is more likely to have been used. This brings the minimum and maximum figure to between 4 and 14 people (Fig. 10.76). If the size of the structures relates to population size, a general description may be more appropriate.

The construction of the second southern structure would suggest the population increased slightly from its original size. The construction of the central structure indicates a drop in the population below that of the original structure (southern structure 1). Northern structure 1 suggests an increase in population, with a further increase for northern structure 2. This last population estimate is higher than that associated with all of the

[239] Grogan 2002, 520-521.

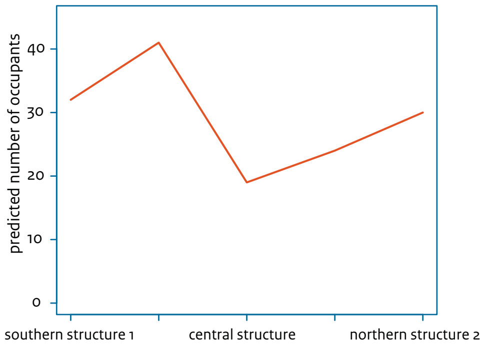



Fig. 10.75 Estimated supported population if the entire house floors are used (Southern structures use predicted floor areas).

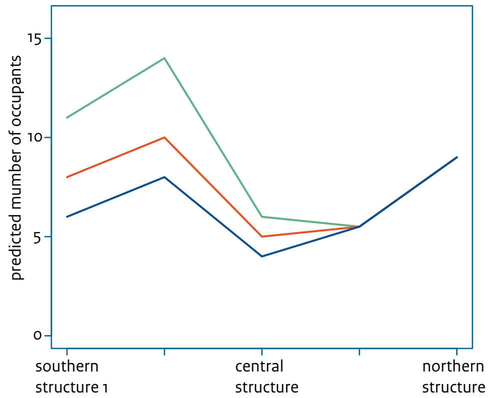



Fig. 10.76 Population estimate based on the area of the interpreted sleeping areas of the structures (Southern and Central Structures are based on the Northern Structures percentage area).

preceding structures if assessed at the lowest threshold, otherwise it is just under the original estimate (intermediate) or nearly 50% lower than the higher estimate.

Assuming the sizes of the structures are proportional to the population size many inferences can be made. This may not be applicable to the society as a whole beyond this settlement; it simply means different numbers of people occupied or were allowed to go to this temporary settlement. Further assessment of more permanent settlements would need to be made before any general comparative trends were extrapolated.

Furthermore, the structural architecture suggests that, rather than a single group using this site, two or three micro-traditions may be present, each with different ideas as to the form of the dwelling structures. These micro-traditions could be either completely separate groups of people or represent a shift in the general tradition of a single group within the wider Single Grave Culture. Indeed, a mixture of these ideas might apply, with the one group building the southern structure and then another group building the central structure. Building fashions may then have changed in this subsequent group, resulting in the northern structures. But any number of interpretations based upon this theme would also be possible.

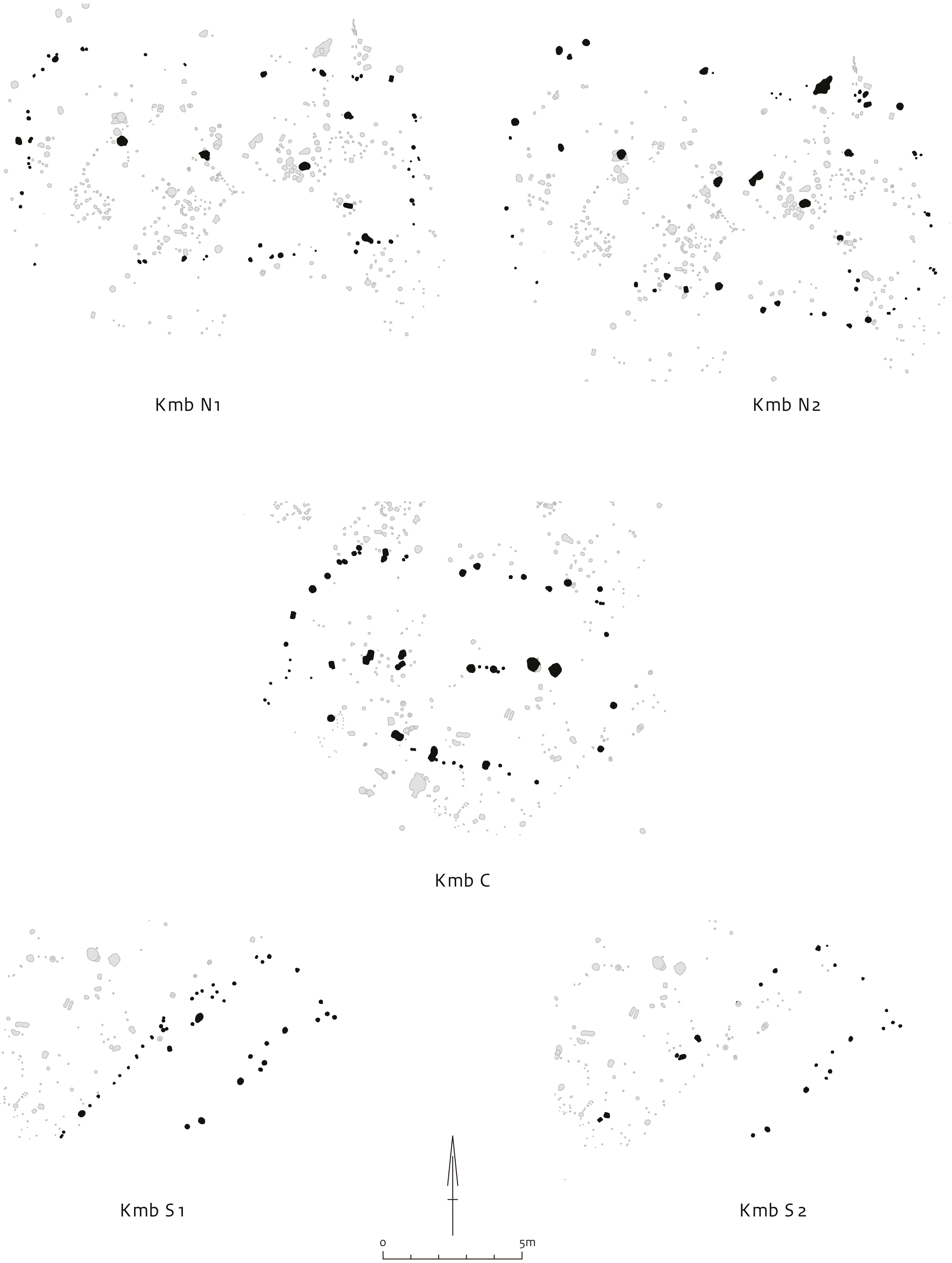



Fig. 10.77 House plans/structures Keinsmerbrug: top left kmb N2 (SGC); top right kmb N1 (SGC); central kmb C (SGC); bottom left kmb S1 (SGC); bottom right kmb S2 (SGC). Presented to a relative orientation and scale.

## 10.9.8 What's in a name?

Structures, constructions, houses, shelters, tents, dwellings, buildings... The list goes on. So which term should be used for these structures? These terms have various cultural meanings associated with them. While Neolithic people may have seen them as houses, the contemporary western world would expect houses to have a solid construction and be durable, but these were not. Tents maybe? Possibly, but this term suggests a canvas-covered temporary structure. Neolithic canvas would be made from animal hides. The structures presented here are thought to have had reed roofs and wattle walls, however.

Shelters perhaps? These structures are large, but shelters are perceived as small. Dwellings? The term dwelling is not commonly used in reference to modern structures. It implies that people were occupying a structure, but does not attribute any modern sociocultural meanings. This term may therefore be the most appropriate for the northern and central structures. However, the southern structures lack information regarding the activities which took place within them, so the term structure is more appropriate here, as it is generic and avoids any attribution of function (Fig. 10.77).

## 10.9.9 Implications

This study raises important issues for Neolithic settlements in this area and beyond. In the immediate area only the settlements at Zeewijk and Mienakker have identified structures. The structure named Zeewijk-Oost is referred to as a ritual house.[240] If the southern structures at Keinsmerbrug are comparable, then are they also ritual? Or does Zeewijk-Oost need to be reconsidered? The author acknowledges that Zeewijk is very different in nature due to its regularity of postholes in terms of both distribution and size.

Beyond the study area, this research presents three unique forms of Neolithic structure. Although the northern structures are similar they do display subtle variations. This therefore reduces them to two new types, the Keinsmerbrug Northern Type and the Keinsmerbrug Central Type. The author presents these types very tentatively and they should not be used as terms, as more structures would be required to create a type series. It could be that more structures of this type exist, but that archaeologists have yet to identify them, since structures of this type have never been identified before.

At Keinsmerbrug the find distributions suggest these structures would have been used in a similar way despite their differing forms, which suggests the style of the structure may be less important than what happens within and around them.

## 10.9.10 Some house comparisons

**Contemporaneous structures**

Only two other structures from this area are known, Zeewijk-Oost and Mienakker. These have been referred to in this report and their plans are shown in figure 10.78.
A structure at Vasse in the municipality of Tubbergen has been compared to Zeewijk and, on this basis, dated to the SGC period.[241] Hogestijn and Drenth identify vast differences between the two structures, but they also question whether the Vasse structure is a house at all. In these authors opinion it is a structure. It measures approx. 30m by 8m, but its form is very different from Zeewijk. If a post in the northeast is excluded and a posthole to the south is included, a structure emerges that bears some similarity to Hesel 1 in figure 10.79, which is from the early or middle Bronze Age. There are particular similarities in terms of the locations of the doors, although some internal features are lacking and it is only 17m long. The author therefore proposes that it is more likely to be attributed to the Hesel B type and is not therefore from the Single Grave period. As a result, it is not useful for any contemporaneous comparison with the Keinsmerbrug structures.

The Single Grave period was preceded by the Funnel Beaker Culture (TRB) and Vlaardingen Culture. A settlement at Slootdorp-Bouwlust revealed a structure from the TRB Culture, rectangular in plan. At Vlaardingen houses 1 and 2 were identified as belonging to the

240 Van Ginkel & Hogestijn 1997, 116.
241 Hogestijn & Drenth 2001, 66.


Fig. 10.78 House plans: top left Vlaardingen house plan 2 levels 1 and 2; top right Vlaardingen house plan 1 after Van Beek bottom left Zeewijk-Oost (SGC); bottom right Mienakker (SGC). After Hogestijn, J.W. & Drenth, E. (2000/2001) Presented to a relative orientation and scale.

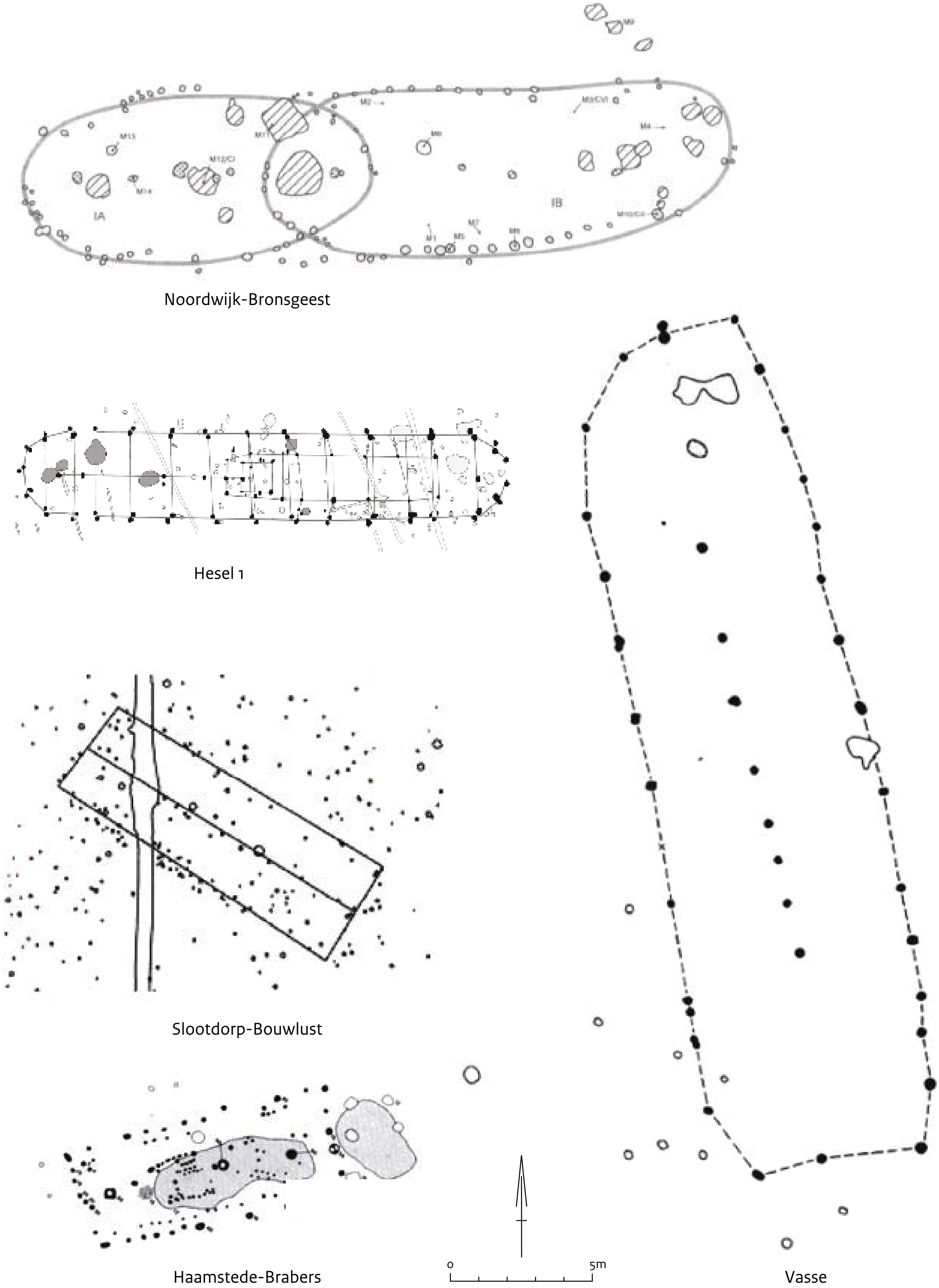



Fig. 10.79 House Plans: top Noordwijk-Bronsgeest (EBA); top left Hesel (EBA); left centre Slootdorp-Bouwlust (TRB); bottom left Haamstede-Brabers (Vlaardingen Culture). After Hogestijn, J.W. & Drenth, E. (2000/2001) and Waterbolk H. T. (2008). Presented to a relative orientation and scale.

Vlaardingen Culture. Haamstede-Brabers also includes a house from this culture. Structures from the Bronze Age, which followed this period, are shown in figure 10.79 (top left, top right and top). The general similarities between structures at Noordwijk-Bronsgeest, Vasse and Hesel should be noted. The structures mentioned are only a selection. Any attempt to identify cultures or micro-traditions through architectural design must be based on many more examples.[242]

## 10.10 Conclusions

### 10.10.1 Spatial analysis

The reader may infer from this report that the Keinsmerbrug methodology is completely appropriate for detailed spatial analysis. Although it presents a highly detailed and thorough investigation, much information and detail could not be discovered. This methodology was developed because the data were not suitable for established techniques. Point pattern methods would have been the most desirable, but the majority of finds were recorded on a metre square scale. This only allows for an analysis beyond the 1m scale, which means lower scale patterns will be missed. Even though the distributions were analysed at a minimum scale of 1m only the 1.75m scale and above (excluding the 2m scale) are thought to be reliable. The reasons for this are explained in appendix 10.1.

Using a 1m square technique of excavation, every find lies within 0.7m of the centre of the square. Other methods may give better results. If the size of the excavation unit were reduced to 0.5m squares, each artefact would be within 0.354m of the centre, doubling the resolution and quadrupling the number of squares. Point collection with the aid of a total station would provide optimal conditions for spatial analysis, especially if Z coordinates were attributed. This would also result in an error, albeit significantly less than the other methods. The error is in fact likely to be less than the total width of the artefact. Perhaps point locations are too accurate as artefacts are volumetric and thus cannot be attributed to a single point. Squares of 20 to 25 cm may therefore be more appropriate.

Beyond the methodological problems of this study (which were due to the excavation technique), the results it yielded exceeded the author's and the rest of the team's expectations. Prior to analysis the site seemed to be a disorderly mix of postholes and pits with some hearths. Structures were believed to be there, but they could not be distinguished. Analysis at a metre scale would not have aided any identification of structures. It is the multi-scalar perspective of the find distributions which helps with the interpretation of the site's features. The analysis alone cannot identify the structures, but it does help the archaeologist to find them.

Scale appears to be the most important issue in this study, not only the scale of analysis but also the scale of data collection. It raises the question: at what scale should archaeologists collect spatial information and at what scale should it be analysed? For now, the latter is of less importance, but the scale of collection is crucial for successful spatial research. Two scales are important at this site: the 1.75m and 2.9m scales. The latter revealed the northern structures and the former identified activity areas, as well as confirming the presence of a wall through density analysis (see Figure 10.68).

These scales were discovered through explorative techniques. There was no prior knowledge of the best scale for analysis. Most analyses were therefore performed at multiple scales. It is not known if these scales will be applicable to other sites, but the author would recommend the use of multiple scales in any intra-site analysis.

As a result of this type of analysis, five formerly unknown structures are proposed, all from separate phases. They are likely to be associated with dwelling rather than any other function, such as ritual. However, this is not to dismiss the possibility that ritual activities took place at the site. Indeed, the building of these structures could in itself be viewed as a ritual process, or at least a community event.

The organisation of the space within the northern dwellings is structured, thus allowing individual activity areas to be identified. These areas would have been used repeatedly for various activities. As discussed, seven activity areas were identified. Only areas 1-5 were within the northern structures. The distribution of flint flakes and waste suggests that flint knapping for flake retouching may have occurred in areas 1-3.

[242] The images in figures 86 and 88 mostly originate from Hogestijn and Drenth's paper (2001). The structure from Hesel is derived from Waterbolk 2009. They have all been aligned on a common axis and scaled to allow for a better visual comparison. The orientation of the structure at Hesel is arbitrary.

These areas have further associations with the hearth and the entrance.

The degree to which find segregation occurs in these areas requires investigation. However an important source of information for comparison of the areas is missing: F. Diederik's trial trench from 1985, which separates the hearth and entrance areas (1 and 3). It is highly possible that these two areas merge, as the original 1986 report refers to the fact that the previous excavation found a large quantity of bird bones.

The reconstructions of the structures presented here are illustrative. They are thought to have been light structures, possibly only intended for use during a single season, although they could have received some running repairs to get them through a second season. The author believes this would be unlikely, however.

The spatial analysis supports the theory of a temporary settlement site with at least five habitation phases. Duck hunting would have been a primary focus for the inhabitants, although other activities also took place.[243] This interpretation applies only to the latter two construction phases of both northern structures. Fish may also have been of more importance in the fourth phase. An area to the south of the site at the boundaries of the first three structures has a notable lack of bird remains, yielding mostly fish and mammal remains. The location of the settlement may not therefore have been driven by a single subsistence strategy. It is expected that all the structures would have contained quantities of artefact material. However, throughout the life of the settlement, the daily routines of the inhabitants would have eroded the remains of the previous visits.

One further element at this site are the cow hoof marks which do not correspond to the final structures. These marks, which cut through their stratigraphy, could have been later than the settlement, having been made by cows seeking higher ground. It is possible that the cowherd was seeking shelter at the recently abandoned site, or just passing by. This requires further investigation.

The population size has been estimated at between four to fourteen individuals. The composition of the group is not known: male, female; young, old; specialised hunters or a mixed skills base. Even though it is a settlement the structures do not appear to have any long-term significance to the inhabitants, although their forms may offer more cultural meaning. Any further conclusions are difficult to draw, even though much more could be said regarding the society that used this site, it would be highly speculative. This site needs to be compared to other contemporaneous examples to confirm whether these interpretations are universal or unique to this site. Only then can further questions be posed and attempts made to answer them.

### 10.10.2 Closing comments

To return to the questions posed at the very beginning of this chapter:

*To what extent can any information be reliably extracted from a dataset gathered using an inconsistent methodological approach and recording techniques which are considered poor compared to current standards?*
The reliability of these results is an interesting problem. At best, finds were collected at a 1m resolution, therefore instantly adding error to any analysis. Without detailed statistical testing, which is beyond the scope of this report, no answer can be offered. It is hoped that an analysis of each grid square relative to each of its neighbours might reduce the error to an acceptable level. But this introduces another problem: what is an acceptable level of error in archaeological intra-site analysis?

*Can assessments of the spatial relationships of finds from a legacy dataset provide any insight into the internal functions of the site?*
This report refutes any criticisms which have been made of computing and statistical analysis in archaeology. As a result five new 'houses' have been added to the archaeological literature. The main concern posed here is scale; the scale at which the data was collected has a significant impact on the scale of analysis.

Even though this site was excavated at a one metre scale, a metre was found to be unreliable as a unit of analysis. Moreover, it was the 3m analysis of the flint which added in the interpretation of the boundaries of the northern structure. The individual activity areas, not

[243] See Zeiler & Brinkhuizen this volume.

apparent at the 3m scale, were observable at the 1.75m scale.

Not only were the internal structures of the site thus distinguishable, but also the individual activity areas. If the site had been excavated in 0.5m squares it is highly likely that either further division of these activity areas would be possible or they would be even clearer. This reinforces the importance of applying a correct scale of analysis to each dataset. As the appropriate scale was unknown, an appropriate range of scales were used.

*In essence: is the original interpretation of a settlement without any clear structural elements still valid?*
As demonstrated this settlement does have clear structures. Data was collected, but only a single dataset – the features – was chosen as the basis for an attempt to try and identify the structures of the site. This traditional method of 'dot to dot' analysis only works with obvious structures.

*Can spatial analysis of find categories improve our understanding of the activities conducted at the site beyond the interpretation of the features?*
In short, yes. Spatial analysis can impart structure to a visually disordered group of features perceived as occurring randomly. Of course, this assumes there is structure to be found.

This report further supports the notion that traditional archaeological practices require continuous development as new methodologies emerge. Accurate recording of artefact locations can be more valuable to the archaeologist than the artefacts themselves specifically in terms of spatial analysis.

# 11 Synthesis - Keinsmerbrug: a kaleidoscope of gathering

*B.I. Smit, S.M. Beckerman, D.C. Brinkhuizen, V. Garcia-Diaz, L. Kubiak-Martens, G.R. Nobles, T. F.M. Oudemans, J.T. Zeiler, O. Brinkkemper, J.P. Kleijne, R.C.G.M. Lauwerier, E.M. Theunissen, A.L. van Gijn & D.C.M. Raemaekers*

## 11.1 Introduction

As stated in chapter 1 the Late Neolithic Single Grave Culture in the Netherlands (SGC; approx. 2800–2400 BC)[244] is generally known from flat graves and barrows. Because of their visibility barrows have long been studied by amateur and professional archaeologists. SGC settlements have only recently become objects of study. Except for the excavations at Zandwerven in 1929, no settlement research was conducted until after 1945. Overviews on the SGC have recently been presented in several publications.[245]

The distribution of known SGC settlements in the Netherlands shows a clear concentration in the northern part of the province of Noord-Holland, known as West Friesland. Sedimentation of clay and development of peat bogs in this area resulted in better preservation of archaeological remains than the SGC sites in other parts of the Netherlands, thus offering multiple research opportunities. In this area both inorganic (flint, stone, pottery) and, more especially, organic archaeological remains have been fairly well preserved. However, we must bear in mind that the known distribution in the province of Noord-Holland might be partly the result of intensive research campaigns in this particular area by the former State Service for Archaeological Investigations (now the Cultural Heritage Agency of the Netherlands). The absence of clusters of settlement sites dating to the SGC in other parts of the Dutch delta could therefore be due to research bias.

### Former interpretations of the Keinsmerbrug site

In the 1990s Keinsmerbrug was described as a small site with no clear structures or evidence of dwellings. It has been interpreted as a seasonal cattle herding camp, a bird hunting camp, a temporal hunting camp, etc. In short: a special activity site.[246] This interpretation will be evaluated on the basis of our research and ideas. First, however, we shall present an overview of the different interpretations people have ascribed to SGC settlement variability and the specific role of Keinsmerbrug in these debates.

Hogestijn has written most extensively on the settlement system and economy of the SGC sites in West Friesland.[247] He distinguishes large and small sites. Small sites are said to measure less than 500 m² and to be located not in the immediate vicinity of open water. It has been suggested that they are temporary camps, which during the summer served as accommodation for small groups of specially selected people who concentrated on a limited number of activities, such as grazing cattle, hunting and fishing. Large settlements are defined as sites that generally measure more than 3,000 m² and are usually located near to open water. These are believed to be residential settlements or base camps. This interpretation is based partly on the ratio between wild and domestic animals in four large and two small settlements, the latter being Mienakker and Keinsmerbrug. Drenth, Brinkkemper and Lauwerier present strong arguments against the foundations on which the dichotomous model is based. The ratio between wild and domestic animals as presented by Hogestijn, in particular, cannot be corroborated by the available published data. Unfortunately, they did not present any alternatives, though did suggest further research.[248] Similar models, consisting of hunting camps and residential settlements, have also been proposed for the Pleistocene parts of the Netherlands.[249] In these models the hunting camps are situated near stream valleys whereas the larger residential settlements are placed on the higher sandy soils where the potential for agriculture might be better than in the delta areas.[250] The research questions below were formulated at the start of the project.

### Research questions

1. What is the spatial extent of settlement areas and how can any intra-site spatial differentiation be characterised?
2. What activities are represented in the artefact assemblages (ceramics, lithics, bone/antler tools, ornaments)?
3. What activities are represented in the characteristics of the archaeozoological and archaeobotanical remains?
4. What is the functional nature of structures and features?
5. What indicators exist for occupation length and seasonality?
6. What evidence exists for group composition?
7. What variability exists in the 'cultural biography' of objects?

244 Lanting & Van der Plicht 2000, 35, 79.
245 Van Heeringen & Theunissen 2001; Drenth 2005, 353-357; Fokkens 2005 a/b; Drenth, Brinkkemper & Lauwerier 2008.
246 Gehasse 1995; Hogestijn 1990; Hogestijn & Van Ginkel 1997.
247 Hogestijn 1992; 1997; 1998; 2001; 2005; Hogestijn *et al.* 1991; Laarman 1990; Lauwerier 1994.
248 Drenth, Lauwerier & Brinkkemper 2008.
249 Gehasse 1995.
250 Gehasse 1995.

8. What ecozones are represented in the archaeozoological and archaeobotanical assemblages?
9. What is the possible origin of inorganic resources?
10. How do the characteristics of the SGC settlements in Noord-Holland compare to SGC/Corded Ware phenomena in the wider geographical setting?

Some of these questions that focus on the site level can now be answered with reference to Keinsmerbrug. Since this is the first monograph to be published the more general questions will be answered after the material from the other sites (Mienakker, Zeewijk) has been analysed.

## 11.2 Chronology

### Relative chronology

During the excavation a cultural layer, several pits, possible hearths, hoof imprints and numerous post- and stakeholes were observed. Stratigraphical observations suggest that the pits are the oldest features at Keinsmerbrug. They show signs of rapid natural backfilling and hardly any finds have been retrieved from them. It is likely that the pits were used as water pits or (unlined) wells. Several pits are covered by the cultural layer, while others cut through this it, providing a relative sequence of events. The cultural layer consists of a homogeneous dark/black, peaty/humic clay approximately 15-20 cm thick, in which burnt bone, ceramics, charcoal, settlement refuse and artefacts have been found. Several phases can be discerned in this layer, based amongst other things on the presence of more or less sterile shell concentrations or shell lenses. The shells are more likely to have been used as construction material to heighten and flatten the living surface of the settlement, than to represent consumption waste.[251] Hearths (ashy clay slabs) have also been identified in the cultural layer. The position of one of the hearths in the cultural layer above one of the pits also proves the sequential nature of the site. Imprints of cattle hoofs have also been found in the cultural layer and underlying natural tidal deposits. These penetrate the cultural layer, suggesting that cattle were kept at the site both before and after the initial phase of formation of the cultural layer. Finally, numerous post- and stakeholes have been found. The cultural layer was at best approx. 20 cm thick. Given the properties of the post- and stakeholes it is likely that the majority of stakes and posts were driven into the ground, without a pre-dug hole. It is likely that several of these poles have cut the cultural layer, though due to the nature of this layer no cutting feature was visible.[252] Based on the sections and the data available a relative chronology can be presented for the phasing of activities at Keinsmerbrug (Table 11.1).

**Table 11.1 Relative chronological phasing of Keinsmerbrug**

| phase | | elements |
|---|---|---|
| 1 | 1 | southern structure 1 |
| | | well pits |
| | 2 | southern structure 2 |
| | | well pits |
| hiatus | hiatus | none identified |
| 2 | 3 | central structure |
| | 4 | northern structure 1 |
| | 5 | northern structure 2 |

During phase 1 the southern structures and some water pits or unlined wells were built and subsequently abandoned. After phase 1 there seems to be a hiatus, as no activity has been recognised. During phase 2 the central structure and the two northern structures were built. Phase 2 represents the phase in which human activity is most clearly visible in the archaeological record.

After phase 2 the site was abandoned and peat developed, thus preserving the Neolithic surface. During the Middle Ages some peat digging took place at and around the former Late Neolithic site.

### Absolute chronology

The phases above represent the different phases which could be discerned at the site on the basis of the stratigraphy. This provides some insight into the differential use of the settlement at Keinsmerbrug. The $^{14}C$ dates obtained all point to activities at the site within the time span of 2580-2450 cal BC.[253] Since the relative phasing

251 Kuijper 2001.
252 The information above is based on the spatial analysis of the features, the analysis of the sections and an unpublished handwritten report by an anonymous member of the State Service for Archaeological Investigations (now the RCE).
253 The samples were taken from the cultural layer; see chapter 3.

was a result of the current research, and no phasing was recognised during the fieldwork, it has not been possible to substantiate this relative chronology with absolute dates. Nor was it possible to place the recent $^{14}C$ dates in a stratigraphical sequence.

## 11.3 Environment

### Ecological zones

For an effective understanding of past behaviour we also need to know about the past landscape and the activities performed by communities at a given location and a given time. The occupation of wetlands is a key aspect of prehistoric occupation in the delta of the western Netherlands. Far from being barely accessible swamps, these wetlands have proven to have been ecological treasure troves and resource-rich environments from the Mesolithic onwards. It is therefore no surprise that these varied landscapes were used by different communities throughout prehistory.[254] The area of Noord-Holland which was the focus of Late Neolithic life was a transition zone between saline and freshwater environments. These different environments included open sea, lagoons, tidal creeks, tidal flats, dunes, salt marshes and even, at the boundary, boulder clay outcrops.

Due to the good preservation of the archaeological remains, the range of different analyses has provided a wealth of information on the former environment. Around 2580-2450 cal BC several people or groups of people used the rich and varied landscape and surroundings of the present-day Keinsmerbrug location. The Late Neolithic site was situated in a tidal landscape on a tidal flat near some tidal creeks (Fig. 11.2). Further to the west a more or less closed beach barrier and dune area was present, with open sea beyond. Between this shoreline and the north and east of the site there was a lagoon/swamp-like landscape. The shell fragments found at Keinsmerbrug are from shells that originated in a brackish lagoon. A salt marsh was present approximately 200 m southwest of the site.[255]

The settlement at Keinsmerbrug was situated in an open landscape. The very low percentages of tree pollen –oak, ash, lime, elm, birch and hazel – suggest that there were no trees near the site, although some may have grown on higher ground further away. The only possible areas where thickets of deciduous trees and shrubs might have grown near the site were the highest spots: drier locations on levees in otherwise relatively wet surroundings. But even these locations would certainly have been inundated by brackish water during spring tides and/or storm surges. The oak, maple, ash and even hazel and birch represented in charcoal assemblages are therefore more likely to have come from stands of deciduous forest growing some distance from the site. One of the possible areas where mixed deciduous forest was present is the Pleistocene boulder clay/sandy soil outcrop near Wieringen, some 20 km to the northeast of Keinsmerbrug. This outcrop must have been a significant elevation in the predominantly flat landscape of the time. Its existence could have been more prominent in Neolithic times, when woodland vegetation developed. Besides the supply of wood that could be gathered here, this outcrop was also a source of flints and hard stone.

Thickets of smaller trees – willow and alder – might however have covered the freshwater backswamps. Interestingly, alder and willow dominated many of the charcoal assemblages, suggesting that both must have been readily available near the site. The salt marsh vegetation near the site seems to have been dominated by coastal grassland – often referred to as brackish pastures – with true grasses such as sea barley, saltmarsh grass and creeping bent. The grasses were accompanied by members of the goosefoot family, including various orache species, annual sea-blite, lesser sea-spurrey and glasswort. The latter species would have dominated the vegetation on mud flats that were exposed to tidal movements. At least four other species – sea aster, saltmarsh rush, wild celery and marsh-mallow – would have grown among the grasses on the higher parts of the salt marsh. The brackish grasslands may have extended to the areas influenced by freshwater. Here, great sedge and various other sedges and rushes would have found their primary habitat. It appears that stands of at least three plants – reed, great sedge and sea club-rush – were present near the site, either in the freshwater marsh or in slightly brackish locations. Besides this variation in vegetation types surrounding

254 Amkreutz in prep.; Louwe Kooijmans 1976, 2003; Louwe Kooijmans & Jongste 2006. Van Ginkel & Hogestijn 1997.

255 Bosman 1986.

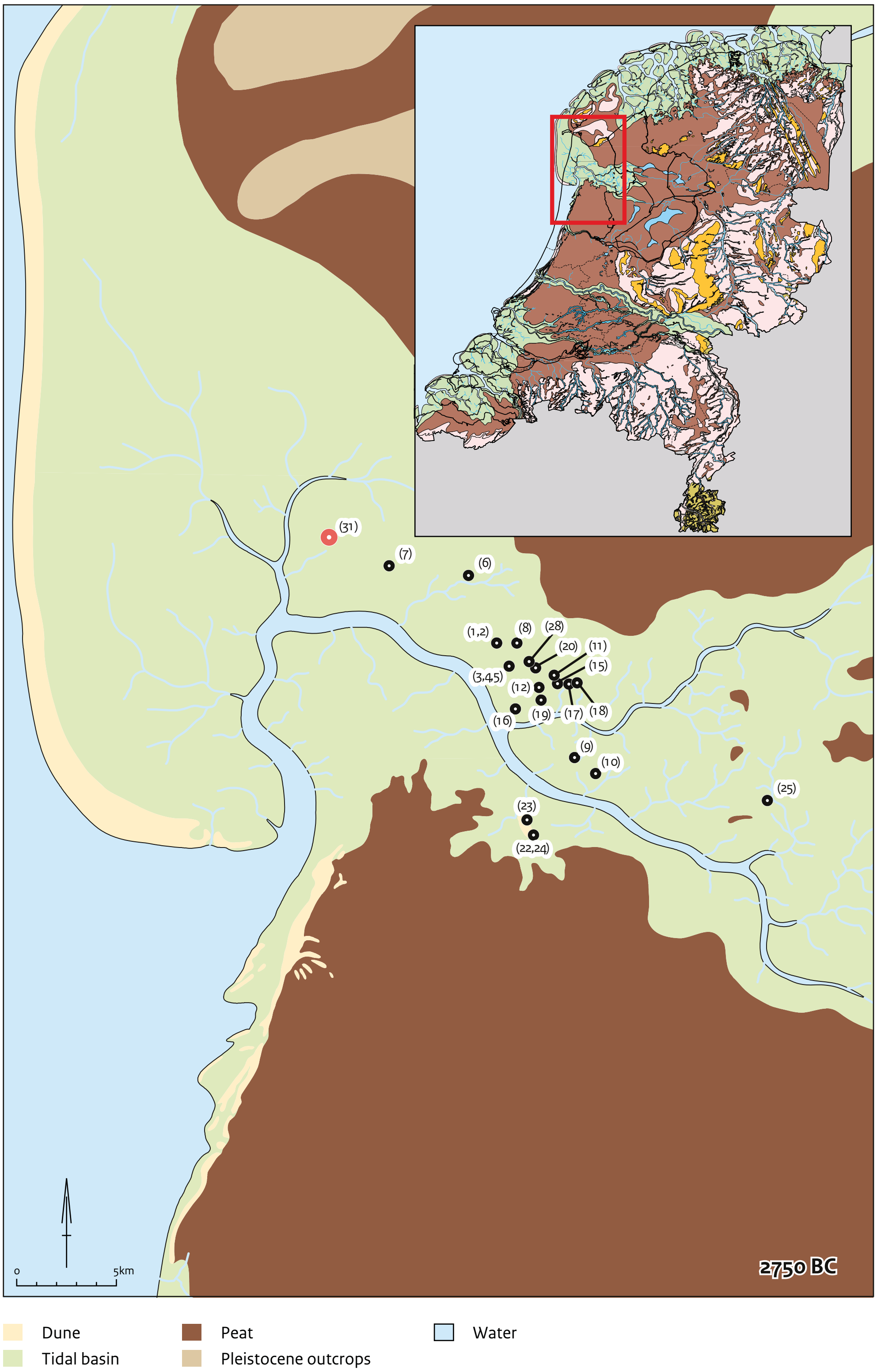



Fig. 11.1 Position of Keinsmerbrug (red dot) in relation to the ecological zones in the former landscape (adapted from Vos & Kiden 2005).

the site, this was also a suitable location for numerous animal species inhabiting and using different parts of this environment. Livestock are likely to have been kept on the marshes near the settlement.

The wetland area of tidal gullies, marshes, sea and tidal ridges was an ideal landscape for various waterfowl. Different species of duck (mallard, teal/garganey, wigeon), greylag goose and brent goose were present at Keinsmerbrug. Besides these, waders such as lapwing, snipe, great snipe, jack snipe and sandpiper also lived near the site. Evidence was found that at least one white-tailed eagle was present. The analysis of fish remains shows a predominance of fish species from a saline and brackish environment. Most remains are from one or more species of right-eyed flatfish. The famous sturgeon, found in numerous Neolithic contexts in the wetlands of the Netherlands, is also present at Keinsmerbrug. The presence of freshwater or very slightly brackish water is indicated by some finds of freshwater fish – perch and tench – and also by remains of frog, toad and grass snake. The nearby sea is represented by bones of common seal and grey seal. Finally, of course, man's best friend is also present: the dog, which is no surprise because its presence in the archaeological record is well known from the Mesolithic onwards.

This all suggests that the people at Keinsmerbrug lived in a mosaic of brackish and freshwater marshes. These general conditions were obviously attractive to the people of the SGC. But other factors would have drawn people there, characteristics that made the site at Keinsmerbrug unique. At least two good reasons can be put forward: the high salt marsh would have provided rich grazing for cattle, while the brackish and freshwater wetlands would have offered excellent places for fowling and fishing.

## 11.4 Exploitation of animal resources

As a result of the good preservation of archaeological remains at Keinsmerbrug we have an opportunity to learn about the exploitation of both animal and plant resources. Based on the archaeozoological evidence it is clear that subsistence was based on a combination of cattle breeding, fishing and fowling.

Breeding cattle was one of the activities in which the communities at Keinsmerbrug engaged. The mammal data also show the minor presence of sheep/goat and pig at the site. The age data from the recovered cattle bones show that mostly adult and subadult animals were slaughtered. The presence of numerous cattle hoof prints discovered at the site also proves the importance of herding cattle there. Besides cattle, some sheep or goats and (young) pigs were also consumed.

Fish from both saline and brackish waters was an important part of the diet. Flatfish, in particular flounder, and sturgeon were caught. Fish were probably caught using semi-permanent fishing gear like fish traps in tidal creeks, used for catching sturgeon. Flatfish could also have been caught with a weir or fence on a sandbank that fell dry at low tide or by means of 'flounder treading', which involved catching fish by standing on them while wading through shallow water.

Besides fishing, the few wild mammals present like wolf, polecat and marten, were probably hunted for their furs.

By far the most astonishing aspect of the archaeozoological analyses of Keinsmerbrug is the huge amount of bird bones discovered. The number of bird bones is so high that their total weight actually exceeds the total weight of mammal bones (generally the heaviest class). This indicates that different kinds of birds, especially ducks (mallard, teal/garganey and wigeon), were caught in huge numbers. Estimates of the total number of birds caught range from 5000 to 10,000. One of the questions this raises is how these huge numbers of animals were caught. The most plausible explanation is that, except for the winter visitor wigeon, the birds were gathered or harvested (if you will) during the moulting period in the nearby lagoon. In the summer, ducks and geese moult and as a result they are unable to fly. They are therefore easy to catch using boats, nets and even one's bare hands. During this moulting period (late summer-early autumn) it is easy to catch large quantities of birds. Birds could also have been caught using nets strategically placed upright on the mudflats in the area.[256] Some of the birds were probably caught to provide a cache for winter elsewhere.

Interestingly, no bone artefacts were found in the bone assemblage at Keinsmerbrug.

[256] Hogestijn & Drenth 2001.

Besides being used in a variety of activities, bone artefacts may also have been regarded as significant and important, and therefore carefully maintained and curated rather than being thrown away.

## 11.5 Exploitation of plant resources

### Cereals

The two food crops most frequently found at Keinsmerbrug are naked barley and emmer wheat. Although both crops were often cultivated in the coastal area, evidence indicates that the crops discovered at Keinsmerbrug were almost certainly not grown in the immediate vicinity of the site, but were transported in. This is suggested by the fact that both cereals were already at least partly processed. No remains of threshing, the early stage of barley processing, were found. This suggests that this free-threshing cereal was brought to the site as cleaned grain. Emmer (a hulled cereal) was brought to the site in semi-cleaned spikelets. The last stage of emmer processing, the de-husking of the grain, did take place at the site, presumably before food preparation. If cereals were carried to the site already partially processed, it is not surprising that so few seeds of potential arable weeds found their way into the archaeobotanical evidence at Keinsmerbrug.

### Wild plant foods

Besides cereals, it appears that seeds of various orache species were gathered for food at Keinsmerbrug. This assertion is based on the large numbers of orache seeds among the charred seeds, and their presence in a lump of processed food discovered at the site. In the lump of food, orache seeds were found together with grains of emmer, suggesting that a kind of mush consisting of emmer grain and orache seeds was made and probably eaten. Apart from the orache seeds, no wild plant foods have been found at Keinsmerbrug. This is truly remarkable since wild plant foods such as crab apple, berries, hazelnuts and acorns are present in plant assemblages from other SGC sites in the area.[257] There are different explanations for their absence from the plant food evidence at Keinsmerbrug. Firstly, these wild plant foods were almost certainly not available near the settlement. But even if they were available, the site may not have been used during the gathering season for these wild foods (late summer and early autumn), or it might not have been used for fruit and nut gathering expeditions (such plant foods could have been gathered during expeditions to the forests near Wieringen). Evidence for the gathering of roots and tubers for food is also lacking at Keinsmerbrug. Although some charred remains of parenchyma (vegetative tissue) were discovered, they were derived from plants that were collected for purposes other than use as food.

## 11.6 Non-food plant use

Besides the use of plants for food, various herbaceous plants, shrubs and trees were used as raw material for several other activities. The presence of ash lenses or hearths and the numerous pieces of burnt or charred material (bones, plants, charcoal, and flints) shows that fires were made at the settlement. The cultural layer of the settlement consists of a dark-coloured layer rich in charcoal and other burnt material.

At any settlement, and hence also at Keinsmerbrug, people would have needed wood for fuel and other purposes – such as artefacts and construction – for which they may have deliberately selected wood of a specific type and species. It appears that the inhabitants of Keinsmerbrug could obtain their alder firewood from near the settlement. Some of the firewood might however have been collected near the site but not necessarily derived from local stands of woody vegetation (for example driftwood collected as fuel). Obtaining good construction wood from near the site might have been more problematic, so a wider area around the site would have had to be explored.

One remarkable feature of the charcoal assemblage from Keinsmerbrug is that most of it derived from trunk wood. This has been clearly observed for oak, ash and maple. It is less obvious in the case of hazel and birch. All the trunk wood may have been used as construction material, for making posts and pegs or house frames for example. It is also interesting to note that most of the willow charcoal clearly derived from branches and twigs. This suggests that

257 Drenth, Brinkkemper & Lauwerier 2008.

willow branches were collected as wattle or for binding and tying, perhaps also for making fishing traps/installations due to their flexibility, and maybe also as firewood. At least three other plant species growing near the site could have been used as raw material: reed, great sedge and sea club-rush, for example as building material (e.g. thatching for roofs) or to furnish the dwellings (e.g. to raise the settlement area, provide insulation from damp subsoil, and to make mats). Eventually these materials (along with the structures) may have been burnt during accidental or deliberate fires. This may explain the scatters of charred reed stems, and also the abundance of seeds of great sedge and sea club-rush. Dry stands of reed, great-sedge, sea club-rush or even sea aster, glasswort and orache may all have been collected as fuel. It would have been poor-quality fuel, but nonetheless a welcome addition to wood which was far from abundant near the site, located as it was in a tidal landscape.

## 11.7 Food processing

The way food was cooked at Keinsmerbrug has been revealed by combined botanical and chemical analysis of organic residues found in association with pottery. Both the chemical and the botanical evidence showed a very uniform residue assemblage. The botanical evidence showed the cooking of emmer as a food in almost all residues. It is difficult to specify whether the cereal grain was ground or pounded prior to cooking, or the whole grain was used. However, it is clear from the microstructure of the residues, that the grain was cooked in liquid. Only one of the residues clearly differs in botanical terms. This residue contained evidence of the processing not of a cereal food, but of a vegetative food. Such foods might have included roots, tubers or green vegetables, or non-vegetative parenchymatous food, such as fleshy fruits or green vegetables. Since no evidence for the gathering of fleshy fruits has been found in the Keinsmerbrug macrofossil assemblage,[258] it can be assumed that this organic residue derives from the processing of vegetative food. In Late Neolithic Keinsmerbrug many plants grew which could have been used as green vegetables (such as orache, wild celery, glasswort and sea aster) and at least one plant that could have been utilised for its edible tubers (namely sea club-rush).

Chemical evidence confirmed that all of the indicative residues were the result of the cooking or heating of a starch-rich food. Both cereals and vegetative foods such as roots or tubers contain large amounts of starch. The chemical evidence also showed these starch-rich foods were mixed with a small amount of animal fat or fish oil. Although the amount of fat varies, it is present in all residues. It is interesting to note that no protein was present in the residues, which means neither animal nor fish meat, nor protein-rich plants such as pulses, were cooked in the vessels.

It looks like the residues are the result of one specific activity: heating or cooking a starch-rich food, most likely emmer grain, mixed with a small amount of fat (animal/fish). This suggests that some other functions otherwise performed in ceramics at Neolithic settlement sites were not performed at the settlement site at Keinsmerbrug (for example cooking of meat or fish), or that these functions were performed without ceramic containers. Meat and fish were probably prepared for consumption using fire (open or otherwise), in the form of smoking, grilling and/or preparation in ashpits. Similar cooking strategies and/or drying on racks were used to conserve the large number of ducks and fish which must have been prepared for storage and transport to other settlements.

## 11.8 Production and use of ceramics

One striking feature of the ceramics from Keinsmerbrug is the variety in thickness, tempering and decoration in the assemblage. Based on these variables, three classes of ceramic ware could be discerned. The first class consists of fine wares that have been tempered with grog, sand, quartz and/or plant material. The second type of ware is coarse-walled and contains grog, sand, red granite and granite temper. The third category is the smallest, in number and this ware is smoothed on the outside, medium thick-walled and frequently tempered with stone grit.

Only nineteen individual vessels, comprising both fine and coarse ware, could be

[258] Kubiak-Martens this volume.

reconstructed on the basis of unique rim fragments. Organic residues were present on both these types of pottery. Chemical and botanical evidence shows that there are no direct functional differences between the wares; both types have at least been used for the production of one type of food. More specifically, ceramic vessels have been used for the cooking and heating of emmer porridge with fat. This interpretation does not exclude other uses, such as storage or containers for a whole range of different products.

Analysis of the decoration shows that the decorated ceramics are likely to belong to the later phases of the SGC (types 1d and 1f and ZZ-beakers [zigzag decoration] are present in the assemblage).[259] We have to bear in mind that the typochronology is largely based on decorated ceramics from grave contexts and its absolute claims are being called into question. We cannot therefore be certain that the subdivision of ceramics from graves is also applicable to settlement contexts. In addition to the typological argument, $^{14}$C dates obtained from Keinsmerbrug also point to the later phases of the SGC (phase 4).[260]

The most intriguing aspect of the ceramics is the large variation. Although the ceramics are low in number the variation in thickness, tempering and decoration is high. This variation could have been caused by chronological or functional factors. However, as shown, both chronology and function can be disregarded. It is therefore more likely that the variation is caused by differences in the origins of the vessels or the origins or preferences of the individual potters. People from different local SGC traditions probably visited this specific location at different times, each bringing their own vessels and using them for the preparation of only one specific type of food.

## 11.9 Production and use of flint, hard stone and amber

The analysis of the flint, hard stone and amber objects from Keinsmerbrug provides important information to help us understand the economic and social role of the site. As with ceramics, studies of SGC settlement flint, hard stone and amber assemblages are not numerous.[261]

First of all, the absence of imported material suggests that the flint, hard stone and amber were probably collected in nearby areas, at the coastal beach barrier or on the glacial till deposits at Wieringen. The flint was carried to the site in small nodules and the knapping process was performed on the site to obtain the tools needed. Given the absence of core preparation during the knapping process and/or the lower level of retouched implements, the technology can be considered 'opportunistic' or 'ad hoc'. In fact, the production of tools focused on flakes; only five retouched implements were found at the site. In addition to this, two strike-a-lights were found. The scant evidence from other SGC settlement sites, such as Mienakker,[262] shows a similar 'ad hoc' attitude towards the production of flint and hard stone implements.

Although only a small number of tools show use wear (3.8%), some conclusions can nevertheless be drawn. Subsistence practices have been rarely been recorded on the basis of the study of flint artefacts from Keinsmerbrug. Even though 64.7% of the tools were used to process animal resources, just one of them was probably used for butchering. Craft activities like plant processing and woodworking have been recorded for one blade, two flakes and one piece of flint waste. Evidence for the working of softwood (e.g. willow) as well as hardwood has been found on flint tools. Activities involving hardwood include scraping and sawing, and one flake shows a polish which is the result of cutting softwood. It is reasonable to assume that wood was used for a number of different purposes, only some of which can be recognised in the archaeological record. Finally, some pieces of shaped charcoal, which could have been part of a bowl-like object, were also found.[263] The working of plants and wood is usually related to tool manufacture, the construction of houses and other structures, and also with daily activities like the production of rope or clothing. The absence of points of arrowheads and sickles, which are related to cereal cultivation, is remarkable. However, this absence is frequently observed at other SGC sites, too.[264] Finally, the presence of two strike-a-lights, besides being handy tools, also could be related the symbolic life of the people of Keinsmerbrug. Following other authors' explanations, these tools can be considered personal items.[265]

259 According to the typochronological type division by Van der Waals & Glasbergen (1955); Drenth 2005.
260 Drenth 2005.
261 Van Gijn 2010, 148; however, see several studies by Peeters 2001a/b.
262 Peeters 2001a.
263 Kooistra 2001, 206.
264 Peeters 2001a; 2001b; Van Iterson Scholten & De Vries-Metz 1981 in Van Gijn 2010.
265 Van Gijn *et al* 2006.

Little information was obtained from the use-wear analysis of the stone tools. Stone tools were probably also related to subsistence activities, but this cannot be substantiated. Only one granite artefact shows clear traces of use, related to pounding and percussion, which suggest its use as a hammer stone. Unfortunately, the worked material could not be identified.

Finally, the amber bead fragment shows wear traces along the rim of the perforation, indicating that it was worn on a string, possibly as a personal decorative ornament. Unfortunately, the small number of amber ornaments makes it impossible to determine whether there were any social differences in terms of personal ornaments.

The role of flint in the hunting activities was probably secondary. It is likely that other tools, like traps or wooden arrowheads, were used for hunting. However, these tools were not discarded or preserved at the site.

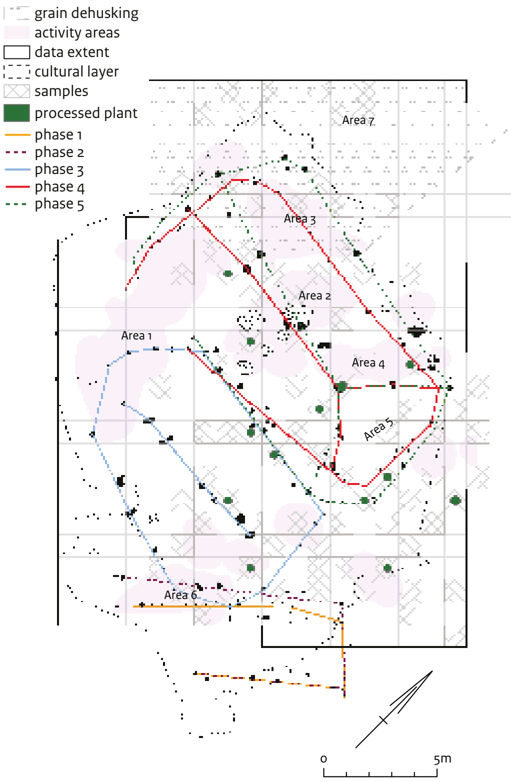



Fig 11.2: Discerned structures, phases and activity areas.

## 11.10 Dwellings and spatial use of the site

The settlement at Keinsmerbrug is approximately 312 m² in size (extent of the cultural layer). The immediate surroundings of the site will of course also have had some function in the use of the settlement.

No patterns or configurations were observed in the stake- and postholes during the excavation of the site. Nor were any house plans reconstructed after the excavation, when the features were analysed, as this did not appear to be possible.[266] Using a set of fresh eyes and applying currently available spatial analysis programmes to a multitude of datasets, five structures or dwellings have now been identified, however. Furthermore, the spatial analysis of all the data shows the presence of at least seven identifiable (large) activity areas (Fig. 11.2).

Three of the five structures have been identified as dwellings (house plans) based on their more or less regular outline and on the fact that particular activities or activity areas could be connected to them. The dwellings have been named ‘northern structure 1’ (Kmb N1), ‘northern structure 2’ (Kmb N2) and ‘central structure’ (Kmb C).

Because the southern structures have only been partially identified and no clear activity areas could be assigned to them, they are regarded as less convincing (partial house plans). The interpretation of these two structures is not therefore associated with any further functional connotation, and they are referred to as ‘southern structure 1’ (Kmb S1) and ‘southern structure 2’ (Kmb S2). The reason for the fact that the southern structures could be only partly identified is related to taphonomic processes. These structures are likely to represent an earlier use of the settlement. Later occupation at the site has obscured older traces.

The dwellings are all two-aisled, similar to known dwellings at other Neolithic settlements. The dwellings and structures at Keinsmerbrug are likely to have been relatively light constructions (based on the diameter of the posts and stakes). Locally gathered wood (trunks and branches) and perhaps also driftwood were probably used for the walls. The walls could have been made of wattle alone. There is no evidence to suggest the presence of daub at the site. The roofs were probably made of reed or other plants (great sedge and sea club-rush).

[266] Woltering *et al.* 1987, 30; Woltering 1987; Hogestijn 1992; Van Heeringen & Theunissen 2001 part II, 299.

The presence of burnt reed fragments in the cultural layer could be indicative of the deliberate burning of reed shoots when the settlement was revisited, to create an open surface. Alternatively, the remains of former dwellings/structures may have been burnt at the beginning or end of a use period to create a clean living area, and to get rid of unpleasant microfauna and fungi. Furthermore, besides practical motives, social or ideological motives like abandonment or settling/resettling rituals might explain the evidence of burning. In the light of these motives it is noteworthy that a large boulder (perhaps a quern stone) was found in one of the pits at the site. The presence of this boulder is remarkable because it must have been brought to the settlement, probably from a glacial outcrop nearby (Wieringen). The presence of this stone could either be due to normal discard or could be indicative of some kind of meaningful deposition.

Five out of the seven identified activity areas (activity area 1 to 5) could be assigned to the two northern dwellings. Activity areas 1 and 3 might have been part of one large activity area which was divided by one of the test trenches from 1985, for which no data are present. However, based on the distribution of specific finds, these activity areas have been interpreted as location where food preparation, processing of animal and botanical resources (cleaning skins, basketry) and flint knapping were carried out. Area 2 has been interpreted as a cooking area, in view of the presence of ceramics and a hearth. Area 3 is a discard area from which predominantly animal remains have been recovered. Area 4 seems to be a discard area and a toss zone for flint waste. Fish and bird remains have also been found there. We propose that activity area 5 was the place where the inhabitants would have slept. Activity area 6 is more ambiguous. It seems to be an (older?) discard area for fish and mammal remains which might be connected to one or both of the southern structures. Finally, area 7 is a grain threshing area in the north of the settlement outside the northern dwellings, which could have been used for de-husking emmer. The separation of area 6 from the other activity areas, its connection with the southern structures and the fact that bird remains are lacking from this area might hint to a shift in economy during the use of the settlement. This may suggest that in an earlier phase of the occupation fishing and herding of mammals were dominant, whereas in a later phase the focus shifted to the hunting of birds.

## 11.11 Temporality/seasonality

The analyses show that Keinsmerbrug was a temporarily occupied settlement, used occasionally or perhaps even only seasonally. The limited range of other activities combined with the characteristics of the material culture (low number of flints and ceramics, variation in the temper of the ceramics, small range of different flint and stone tools) is indicative of such short-term use (most likely multiple). During some of these periods of use the settlement dwellings were erected, using locally available wood, plants and perhaps driftwood or larger trunks from thickets of forest in the surrounding area. Unfortunately, the phasing and use of the settlement can only be assessed in relative terms. Although six absolute dates are available no definitive short-term time ranges can discerned because of a plateau in the calibration curve. At least five phases of use can be discerned if we accept the notion that a dwelling was erected during each use phase. Of course it is also possible that the settlement was used for activities for which no dwellings or structures were needed.

It appears that the site was used outside the gathering season for nuts, fruits and berries, so it was not used during late summer and early autumn, as no remains of nuts, fruits and berries have been found. The absence of edible root and tuber remains is also surprising, considering that various root foods were gathered and consumed by other Neolithic groups along the Dutch coast. Their absence from our current assemblage – with the exception of one organic residue with evidence of vegetative food – suggests that the site was used outside the gathering season for root foods. Although roots and tubers can be collected and consumed throughout most of the year, their highest concentration of stored carbohydrates occurs between autumn and early spring. It is thus tempting to suggest that the absence of root foods at Keinsmerbrug is due to the fact that the site was not used between autumn and early spring either, provided that these resources were well known to the people at Keinsmerbrug.

The archaeozoological evidence also hints at some form of seasonality. The clearest indications of seasonal activities have been found in the bird remains. Estimates of the total number of birds caught range from 5000 to 10,000. The question is how these huge numbers were caught. The most plausible option is that the birds were caught in the nearby lagoon during the moulting period. During this moulting period (late summer) it is easy to catch large quantities of birds. The winter visitor wigeon, however, must have been caught by other means. This species occurs between August and May and could therefore have been caught in spring or early autumn and not specifically in winter. There is some seasonal evidence from the fish remains, with mullet and bass pointing to fishing in summer. The presence of grey seal points in the same direction. Since it leaves the coast in the winter in search of deeper water, it must have been caught somewhere between spring and late autumn. The combined evidence of bird catching and fishing therefore suggests the settlement was used between spring and late autumn.

Based on the combined evidence of all the analyses it is likely that, in terms of seasonality, the main period of use – probably consisting of several episodes of short-term use – occurred from spring to autumn. Use of the settlement during winter is not likely, but cannot be excluded.

## 11.12 There is more to Keinsmerbrug than ducks and cattle

In general terms, Keinsmerbrug is interpreted as a non-residential settlement: a gathering settlement in the broadest sense of the word, for the gathering of people and resources (special activity site). In this respect, even after the new analyses the site 'fits' the model proposed by Hogestijn in the 1990s.[267] The settlement at Keinsmerbrug qualifies as a small site (< 500m$^2$), it does not directly border water (although streams or open water are not far away), it does not seem to be permanently occupied and a limited range of activities were conducted there.

However, it is an intriguing site characterised by numerous specific activities, so simply fitting it to the existing model is simplifying matters too much. Though it is not a settlement site with year-round occupation, nor is it a special activity site used for one specific activity like the herding of cattle or the hunting of ducks. Several different activities were performed at the settlement at Keinsmerbrug which are not necessarily contemporaneous. The limited range of activities plus the characteristics of the material culture (low number of flints and ceramics both in absolute numbers and in types or number of vessels, the small range of different flint and stone tools) suggest short-term or multiple short-term use of the settlement. Furthermore, this is the most northwestern SGC site known in this area and it clearly does not lie in the centre of this distribution. Given this fact, it might be viewed as an exception. At the Keinsmerbrug settlement there is clear evidence of cattle herding, fowling and fishing. This breeding and/or herding of cattle is one of the intriguing aspects of the settlement. Although it is known that marshes are suitable for the keeping of livestock, the combination of activities performed at Keinsmerbrug seems a little peculiar. The number of ducks caught there is so high that at least some of them must have been transported to other localities after being processed and preserved at Keinsmerbrug. At least part of the catch was consumed at the site; the large number of duck bones could well be the result of accumulation over the years.

The specific foods cooked in the ceramic vessels are also remarkable. It seems that mainly one type of food was cooked at Keinsmerbrug: a starch-rich porridge made of emmer grain, orache, water and mixed with some fat which originates from either animal or fish. This contrasts sharply with other studies of residue assemblages from settlement sites dating to the Dutch Neolithic (Hazendonk, P14, Schipluiden and Ypenburg), which show more internal chemical and botanical variation. At Keinsmerbrug there is no indication that cereals were grown locally. Both, barley and emmer were brought to the settlement in (partly) processed form. The residues of this porridge were found on several sherds which in themselves also provide an unusual picture. A large variety in tempers, wares and decoration was found

[267] Hogestijn 1992; 1998; Drenth 2005.

within the small assemblage of ceramics present at Keinsmerbrug. This suggests they had different origins, perhaps potters from different households. Finally, the presence of several dwellings with dimensions which provide room for dozens of people is a new and hitherto unknown aspect.

Given the fact that Keinsmerbrug is the first site which has been comprehensively studied under the Odyssey project we do not yet know whether our findings are generic for the Late Neolithic in Noord-Holland, or whether the settlement at Keinsmerbrug was also special in some way to the Late Neolithic people who created and used it. An answer to this question can be given only once other sites have been studied.

The wetland environment in which the settlement at Keinsmerbrug was established around 2500 BC provided a wealth of different resources for SGC communities. Small groups of this community used the settlement in a variety of ways, probably at different times, guided by a combination of seasonal availability of desired resources and social motives.

Combining the information presented in the preceding chapters, one gets the impression that Keinsmerbrug was a settlement where people (from different households or groups) gathered for special reasons like feasting, and consumption of specific food, besides the hunting of ducks, fishing and/or herding of cattle. It is conceivable that these people gathered on occasion to hunt huge numbers of ducks and fish and simultaneously used this period to share information and eat specific foods.

During their stay the settlement area was structured with dwellings, pits/unlined wells and specific activity areas. The dwellings were made from locally available materials like wood from nearby trees and plants, however the use of driftwood and non-local wood (from areas like Wieringen),can not be excluded. Since this was a non-residential settlement one of course wonders where the contemporaneous seasonal and residential settlements might be. Future analysis of the sites at Mienakker and Zeewijk will hopefully show that these locations are the counterparts of the settlement at Keinsmerbrug.

# Bibliography



In this bibliography reference to all mentioned literature is made. In addition to the standard way of citing, a special hyperlink has been added to some records. This hyperlink is a combination of a resolver (like http://dx.doi.org) and a 'digital object identifier' (DOI), a unique code which forever refers to the original digital document. This identifier is only present when a document is digitally made available through a trusted online repository. This DOI can be used to cite and link to an electronic document, whether it is a dataset in the DANS EASY archiving system, a journal article made available on ScienceDirect (or any other online publisher) or a book section in a university repository. By clicking on the hyperlink, one finds the official location of the digital document on the World Wide Web.


**Adams, J.L.**, 1988: Use-wear analysis on Manos and Hide-processing stones, *Journal of Field Archaeology* 15, 307-315. *http://dx.doi.org/10.1179/009346988791974394*

**Akeret, Ö. & P. Rentzel** 2001: Micromorphology and plant macrofossil analysis of cattle dung from the Neolithic lake shore settlement of Arbon-Bleiche 3, *Geoarchaeology* 16, 687-700. *http://dx.doi.org/10.1002/gea.1016*

**Amkreutz, L.W.S.W.**, in prep: *Persistant Places. Negotiating Neolithisation in the Lower Rhine Area (5500-2500 cal BC)*, Leiden (PhD Thesis Leiden University).

**Amkreutz, L.W.S.W. & R. Corbey** 2008: An eagle-eyed perspective. *Haliaeetus albicilla* in the Mesolithic and Neolithic of the Lower Rhine Area, in: H. Fokkens, B.J. Coles, A.L. van Gijn, J.P. Kleijne, H.H. Ponjee & C.G. Slappendel (eds.), *Between Foraging and Farming: An extended broad spectrum of papers presented to Leendert Louwe Kooijmans*, Leiden (Analecta Praehistorica Leidensia 40), 167-180. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-pej-6ha*

**Anselin, L.**, 1995: Local Indicators of Spatial Association - LISA, *Geographical Analysis* 27, 93-115. *http://dx.doi.org/10.1111/j.1538-4632.1995.tb00338.x*

**Arnoldussen, S.**, 2008: *A Living Landscape. Bronze Age settlement sites in the Dutch river area (c. 2000-800 BC)*, Leiden. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-5k2-1v7*

**Bakels, C.C.**, 1978: *Four Linearbandkeramik Settlements and Their Environment: A Paleoecological Study of Sittard, Stein, Elsloo and Hienheim* Leiden (Analecta Praehistorica Leidensia 11). *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-how-box*

**Bakels, C.C.**, 2000: Pollen diagrams and prehistoric fields: the case of Bronze Age Haarlem, the Netherlands, *Review of Palaeobotany and Palynology* 109, 205-218. *http://dx.doi.org/10.1016/S0034-6667(99)00055-X*

**Bakels, C.C. & J.T. Zeiler** 2005: The fruits of the land. Subsistence in the Neolithic, in: L.P. Louwe Kooijmans, P.W. van den Broeke, H. Fokkens & A.L. van Gijn (eds.), *The Prehistory of the Netherlands*, Amsterdam, 311-335.

**Baxter, M.J., C.C. Beardah & R.V.S. Wright** 1997: Some Archaeological Applications of Kernel Density Estimates, *Journal of Archaeological Science* 24, 347-354. *http://dx.doi.org/10.1006/jasc.1996.0119*

**Baxter, M.J. & H.E.M. Cool** 2010: Detecting modes in low-dimensional archaeological data, *Journal of Archaeological Science* 37, 2379-2385. *http://dx.doi.org/10.1016/j.jas.2010.04.006*

**Bayliss, A., C. Bronk Ramsey, J. Van Der Plicht & A.W.R. Whittle** 2007: Bradshaw and Bayes: Towards a Timetable for the Neolithic, *Cambridge Archaeological Journal* 17 (suppl.), 1-28. *http://dx.doi.org/10.1017/S0959774307000145*

**Bazelmans, J.G.A., M.J. van ver Meulen & H.J.T. Weerts (eds.)**, 2011: *Atlas van Nederland in het Holoceen*, Amsterdam.

**Beerenhout, B.**, 1994: What conclusions can be drawn from mature haddock bones in a neolithic site in the Netherlands?, *Offa* 51, 341-347.

**Beerenhout, B.**, 1996: Vissen bij Wateringen (Zuid-Holland) rond 3700 v. Chr., *Westerheem* 45, 125-131.

**Beug, H.-J.**, 2004: *Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende Gebiete*, München.

**Bienenfeld, P.**, 1988: Stone tool use and the organisation of technology in the Dutch Neolithic, in: S. Beyries (ed.), *Industries Lithiques: Tracéologie et technologie*, Oxford (British Archaeological Reports International Series 411), 219-230.

**Bijlsma, R.G., F. Hustings & C.J. Camphuysen** 2001: *Algemene en schaarse vogels in Nederland*, Haarlem/Utrecht (Avifauna van Nederland 2).

**Bochenski, Z.M.**, 2004: Owls, diurnal raptors and humans: signatures on avian bones, in: T. O'Connor (ed.), *Biosphere to Lithosphere. New studies in vertebrate taphonomy (Proceedings of the 9th Conference of the International Council of Archaeozoology, Durham, August 2002)*, Durham, 31-45.

**Boon, J.J.**, 2006: Analytical report on some archaeological charred residues from Schipluiden, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 353-361. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy*

**Boon, J.J. & T.F.M. Oudemans** 2007: A comparative study of extractable lipids in the sherds and surface residual crusts of ceramic vessels from Neolithic and Roman Iron Age settlements in the Netherlands, in: H. Barnard & J.W. Eerkens (eds.), *Theory and Practice of Archaeological Residue Analysis*, Oxford (British Archaeological Reports International Series 1650), 99-124.

**Bosman, W.**, 1986: *Keinsmerbrug. Beknopt Geologisch Onderzoek* (not published).

**Bove, F.J.**, 1981: Trend surface analysis and the Lowland Classic Maya collapse, *American Antiquity* 46, 93-112. *http://dx.doi.org/10.2307/279989*

**Bovy, K.M.**, 2002: Differential avian skeletal part distribution: explaining the abundance of wings, *Journal of Archaeological Science* 29, 965. *http://dx.doi.org/10.1006/jasc.2001.0795*

**Braadbaart, F.**, 2004: *Carbonization of Peas and Wheat - A Window into the Past*, Leiden (PhD Thesis Leiden University).

**Braadbaart, F., J. Van Der Horst, J.J. Boon & P.F. Van Bergen** 2004: Laboratory simulations of the transformation of emmer wheat as a result of heating, *Journal of Thermal Analysis and Calorimetry* 77, 957-973. *http://dx.doi.org/10.1023/B:JTAN.0000041672.45140.e9*

**Brandt, R.W.**, 1988: Aardewerk uit enkele Bronstijdnederzettingen in West-Friesland, in: J.H.F. Bloemers (ed.), *Archeologie en oecologie van Holland tussen Rijn en Vlie*, Assen (Studies in Prae- en protohistorie 2), 206-276.

**Brinkhuizen, D.C.**, 1989: *Ichthyo-archeologisch onderzoek: methoden en toepassing aan de hand van Romeins vismateriaal uit Velsen (Nederland)*, Groningen (PhD Thesis University of Groningen). *http://irs.ub.rug.nl/ppn/053393791*

**Brinkhuizen, D.C.**, 1992: *Het dieet van de otter (Lutra lutra) in De Deelen en de Oude Venen (Friesland) bepaald door middel van analyse van spraints*, Groningen.

**Brinkhuizen, D.C.**, 2006: Fish, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 449-470. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy*

**Bronk Ramsey, C.**, 2009: Bayesian analysis of radiocarbon dates, in: *Radiocarbon* 51, 337-360.

**Bulten, E.E.B.**, 2001: Het barnsteen van de laat-neolithische nederzetting "Mienakker": Een onderzoek naar de bewerking van barnsteen in een nederzetting van de Enkelgrafcultuur, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 471-483. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Cappers, R.T.J. & D.C.M. Raemaekers** 2008: Cereal Cultivation at Swifterbant? Neolithic Wetland Farming on the North European Plain, *Current Anthropology* 49, 385-402. *http://dx.doi.org/10.1086/588494*

**Carter, G.**, 2009: *Elsloo 32, a Neolithic longhouse made from trees'*, (Theoretical structural archaeology weblog, accessed 20th September 2010 *http://structuralarchaeology.blogspot.com/2009/08/33-elsloo-32-neolithic-longhouse-made.html*).

**Ciminale, M., D. Gallo, R. Lasaponara & N. Masini** 2009: A Multiscale Approach for Reconstructing Archaeological Landscapes: Applications in Northern Apulia (Italy), *Archaeological Prospection* 16, 143-153. *http://dx.doi.org/10.1002/arp.356*

**Clason, A.T.**, 1967: *Animal and man in Holland's past*, Groningen (Palaeohistoria 13).

**Clemente Conte, I.**, 1997: *Los instrumentos líticos de Túnel VII: una aproximación etnoarqueológica*, Madrid (Treballs d´Etnoarqueologia 2).

**Conolly, J. & M.W. Lake** 2006: *Geographical Information Systems in Archaeology*, Cambridge. *http://dx.doi.org/10.2277/0521797446*

**Crema, E.R., A. Bevan & M.W. Lake** 2010: A probabilistic framework for assessing spatio-temporal point patterns in the archaeological record, *Journal of Archaeological Science* 37, 1118-1130. *http://dx.doi.org/10.1016/j.jas.2009.12.012*

**De Mulder, E.F.J. & J.H.A. Bosch** 1982: Holocene stratigraphy, radiocarbon datings and palaeogeography of central and northern North-Holland (The Netherlands), *Mededelingen Rijks Geologische Dienst* 36-1, 111-160.

**De Nie, H.W.**, 1996: *Atlas van de Nederlandse zoetwatervissen*, Doetinchem.

**De Smith, M.J., M.F. Goodchild & P.A. Longley** 2007: *Geospatial Analysis: A comprehensive guide to principles, techniques and software tools*, Leicester.

**De Vries, L.S.**, 1996: *De faunaresten van Zeewijk, een laatneolithische nederzetting in de Groetpolder (N-H)*, Leiden (Master Thesis Leiden University).

**De Vries, L.S.**, 2001: De faunaresten van Zeewijk, een laatneolithische nederzetting in de Groetpolder (N-H), in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 281-332. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Deeben, J.H.C., D.P. Hallewas, P.C. Vos & W.K. van Zijverden** 2005: *Paleogeografie en landschapsgenese*, Amersfoort (De Nationale Onderzoeksagenda Archeologie 8; versie 1.0 *http://www.noaa.nl*).

**Diederik, F.**, 1986: Jaarverslag 1985 van de werkgroep Schagen, *Mededelingenblad van de AWN-afdeling Noord-Holland* 1, 9-10.

**Diot, M.F.**, 1992: Études palynologiques de blés sauvages et domestiques issus de cultures expérimentales, in: P. Anderson (ed.), *Préhistoire de l'agriculture: nouvelles approches expérimentales et ethnographiques*, Paris (Monographie du CRA 6), 107-111.

**Dörfler, W. & J. Müller** 2008: *Umwelt – Wirtschaft – Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens*, Neumünster (Offa 84).

**Drenth, E.**, 2005: Het Laat-Neolithicum in Nederland, in: J.H.C. Deeben, E. Drenth, M.-F. van Oorsouw & L.B.M. Verhart (eds.), *De Steentijd van Nederland*, Zutphen (Archeologie 11/12), 333-365.

**Drenth, E., O. Brinkkemper & R.C.G.M. Lauwerier** 2008: Single Grave Culture Settlements in the Netherlands: the state of affairs anno 2006, in: W. Dörfler & J. Müller (eds.), *Umwelt – Wirtschaft – Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens*, Neumünster (Offa 84), 149-181.

**Drenth, E. & J.W.H. Hogestijn** 1999: De klokbekercultuur in Nederland: De stand van onderzoek anno 1999, *Archeologie* 9, 99-149.

**Drenth, E. & J.W.H. Hogestijn** 2001: The Bell Beaker Culture in the Netherlands: the state of research in 1998, in: F. Nicolis (ed.), *Bell beakers today. Pottery, people, culture, symbols in prehistoric Europe. Proceedings of the International Colloquium Riva del Garda (Trento, Italy), 11-16 May 1998*, Trento, 309-332.

**Drenth, E. & J.N. Lanting** 1992: Die Chronologie die Einzelgrabkultur in den Niederlanden, in: M. Buchvaldek & C. Strahm (eds.), *Die Kontinentaleuropäischen Gruppen der Kultur mit Schnurkeramik, Schnurkeramik Symposium 1990*, Praha (Praehistorica XIX), 103-114.

**Ebbinge, B.**, 2007: *In de greep van Siberische lemmingen*, Zeist.

**Enghoff, I.B.**, 1989: Fishing from the Stone Age Settlement Norsminde, *Journal of Danish Archaeology* 8, 41-50.

**Erdtman, G.**, 1960: The Acetolysis Method, *Svensk Botanisk Tidskrift* 54, 561-564.

**Ericson, P.G.P.**, 1987: Interpretations of archaeological bird remains: a taphonomical approach, *Journal of Archaeological Science* 14, 65-75. *http://dx.doi.org/10.1016/S0305-4403(87)80006-7*

**Floore, P.M.**, 1990: *Golfbandpotten van de Enkelgrafcultuur*, Amsterdam (Master Thesis University of Amsterdam).

**Fokkens, H.**, 1998: *Drowned Landscape. The Occupation of the Western Part of the Frisian-Drenthian Plateau, 4400 BC - AD 500*, Groningen (PhD Thesis Groningen University).

**Fokkens, H.**, 2005a: Late Neolithic, Early and Middle Bronze Age: introduction, in: L.P. Louwe Kooijmans, P.W. van den Broeke, H. Fokkens & A.L. van Gijn (eds.), *The Prehistory of the Netherlands*, Amsterdam, 357-370.

**Fokkens, H.**, 2005b: Longhouses in unsettled settlements. Settlements in Beaker period and Bronze Age, in: L.P. Louwe Kooijmans, P.W. van den Broeke, H. Fokkens & A.L. van Gijn (eds.), *The Prehistory of the Netherlands*, Amsterdam, 407-428.

**Fontijn, D.R.**, 2002: *Sacrificial Landscapes. Cultural biographies of persons, objects and 'natural' places in the Bronze Age of the southern Netherlands, c. 2300-600BC*, Leiden (Analecta Praehistorica Leidensia 33/34). *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-9cs-ipo*

**Fortin, M.-J. & M.R.S. Dale** 2009: *Spatial Analysis: A guide for ecologists*, Cambridge.

**Gehasse, E.F.**, 1995: *Ecologisch-archeologisch onderzoek van het Neolithicum en de Vroege Bronstijd in de Noordoostpolder met de nadruk op P14 gevolgd door een overzicht van de bewoningsgeschiedenis en de bestaanseconomie binnen de Holocene delta*, Amsterdam (PhD Thesis University of Amsterdam).

**Gehasse, E.F.**, 2001: Aartswoud: an environmental approach of a Late Neolithic site, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 161-201. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Getis, A. & K. Ord** 1992: The analysis of spatial association by distance statistics, *Geographical Analysis* 24, 189-206. *http://dx.doi.org/10.1111/j.1538-4632.1992.tb00261.x*

**Groenman-Van Waateringe, W.**, 1986: Grazing possibilities in the Neolithic of the Netherlands based on palynological data, in: K.-E. Behre (ed.), *Anthropogenic indicators in pollen diagrams*, Rotterdam, 187-202.

**Grogan, E.**, 2002: Neolithic Houses in Ireland: a broader perspective, *Antiquity* 76, 517-525.

**Grohmann, C.H.**, 2005: Trend-surface analysis of morphometric parameters: a case study in Southeastern Brazil, *Computers & Geosciences* 31, 1007-1014. *http://dx.doi.org/10.1016/j.cageo.2005.02.011*

**Habermehl, K.-H.**, 1975: *Die Alterbestimmung bei Haus- und Labortieren*, Berlijn/Hamburg.

**Hakbijl, T., J.P. Pals & C.D. Troostheide** 1989: Plant and Insect Remains from the Late Neolithic Well at Kolhorn, *Palaeohistoria* 31, 157-163.

**Hall, V.A.**, 1988: The Role of Harvesting Techniques in the Dispersal of Pollen Grains of Cerealia, *Pollen et Spores* 30, 265-270.

**Hamburg, T. & L.P. Louwe Kooijmans** 2006: Features, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 39-65. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy*

**Harris, E.**, 1997: *Principles of Archaeological Stratigraphy*, London.

**Hillman, G.C.**, 1981: Reconstructing crop husbandry practices from charred remains of crops, in: R.J. Mercer (ed.), *Farming Practice in British Prehistory*, Edinburgh, 123-162.

**Hillman, G.C.**, 1984: Interpretation of archaeological plant remains: the application of ethnographic model from Turkey, in: W. van Zeist & W.A. Casparie (eds.), *Plants and ancient man: studies in palaeoethnobotany: proceedings of the Sixth Symposium of the International Work Group for Palaeoethnobotany, Groningen, 30 May-3 June 1983*, Groningen, 1-41.

**Hodder, I. & C. Orton** 1976: *Spatial analysis in archaeology*, Bath.

**Hogestijn, J.W.H.**, 1990: Enkele aspecten van het nederzettingssysteem van de Enkelgrafcultuur in het westelijke kustgebied van Nederland, in: J.H.C. Deeben & E. Drenth (eds.), *Bijdragen aan het onderzoek naar de Steentijd in Nederland*, Amersfoort (Rapportage Archeologische Monumentenzorg 68), 97-109.

**Hogestijn, J.W.H.**, 1992: Functional differences between some settlements of the Single Grave culture in the northwestern coastal area of the Netherlands, in: M. Buchvaldek & C. Strahm (eds.), *Die Kontinentaleuropäischen Gruppen der Kultur mit Schnurkeramik, Schnurkeramik Symposium 1990*, Praha (Praehistorica XIX), 199-205.

**Hogestijn, J.W.H.**, 1997: Enkele resultaten van het archeologische onderzoek op twee woonplaatsen van de Enkelgrafcultuur bij Winkel in de Groetpolder, in: D.P. Hallewas, G.H. Scheepstra & P.J. Woltering (eds.), *Dynamisch Landschap, archeologie en geologie van het Nederlandse kustgebied*, Assen, 27-45.

**Hogestijn, J.W.H.**, 2001: Enkele aspecten van het nederzettingssysteem van de Enkelgrafcultuur in het westelijk kustgebied van Nederland, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 145-158. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Hogestijn, J.W.H.**, 2005: Shell fishers and cattle herders. Settlements of the Single Grave culture in Westfrisia, in: L.P. Louwe Kooijmans, P.W. van den Broeke, H. Fokkens & A.L. van Gijn (eds.), *The Prehistory of the Netherlands*, Amsterdam, 429-432.

**Hogestijn, J.W.H., B. Beerenhout, E.E.B. Bulten, W.J. Kuijper, G. Lenselink, J.M. Passveer, J.H.M. Peeters, F.W. Schnitger, D.G. Van Smeerdijk & H.T.T.C. Uytterschaut** 1991: De Neolithische bewoning van Noord-Holland, *Jaarverslag van de Rijksdienst voor het Oudheidkundig Bodemonderzoek 1990*, 33-37.

**Hogestijn, J.W.H. & E. Drenth** 2001: In Slootdorp stond een Trechterbeker-huis? Over Midden- en Laat-Neolithische huisplattegronden uit Nederland, *Archeologie* 10, 42-79.

**IJzereef, G.F. & J.F. Van Regteren Altena** 1991: Nederzettingen uit de midden- en late bronstijd bij Andijk en Bovenkarspel, in: N. Roymans & H. Fokkens (eds.), *Nederzettingen uit de Bronstijd en Vroege IJzertijd in de Lage Landen*, Amersfoort (Nederlandse Archeologische Rapporten 13).

**Ingold, T.**, 2000: *The Perception of the Environment. Essays in livelihood, dwelling and skill*, London.

**Jones, G.E.M.**, 1984: Interpretation of archaeological plant remains: Ethnographic models from Greece, in: W. van Zeist & W.A. Casparie (eds.), *Plants and ancient man: studies in palaeoethnobotany: proceedings of the Sixth Symposium of the International Work Group for Palaeoethnobotany, Groningen, 30 May-3 June 1983*, Groningen, 43-61.

**Knörzer, K.-H.**, 1971: Pflanzliche Grossreste aus der rössenerzeitlichen Siedlung bei Langweiler, Kreis Jülich, *Bonner Jahrbücher* 171, 9-33.

**Kok, M.S.M.**, 2002: *Projectgroep Archeologie AHR. Specificaties voor datastructuur en formulieren ten behoeve van Archeologische Monumentenzorg AHR-project*, Delft.

**Kooistra, L.I.**, 2001: Houtskool uit een laat-neolitische site te Zijpe (Noord-Holland), in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 203-212. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Kooistra, L.I.**, 2006: Wood and charcoal, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 363-374. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy*

**Kooistra, M.J., L.I. Kooistra, P. van Rijn & U. Sass-Klaassen** 2006: Woodlands of the past. The excavation of wetland woods at Zwolle-Stadshagen (The Netherlands): Reconstruction of the wetland wood in its environmental context, *Netherlands Journal of Geosciences* 86, 37-60. *http://trove.nla.gov.au/work/24484185*

**Koot, J.M., L. Bruning & R.A. Houkes (eds.)**, 2008: *Ypenburg-Locatie 4. Een nederzetting met grafveld uit het Midden-Neolithicum in het West-Nederlandse kustgebied*, Leiden.

**Kopytoff, I.**, 1986: The cultural biography of things: commodization as process, in: A. Appadurai (ed.), *The Social Life of Things: commodities in a cultural perspective*, Cambridge, 64-94.

**Körber-Grohne, U.**, 1967: *Geobotanische Untersuchungen auf der Feddersen Wierde*, Wiesbaden.

**Körber-Grohne, U.**, 1992: Studies in salt marsh vegetation and their relevance to the reconstruction of prehistoric plant communities, *Review of Palaeobotany and Palynology* 73, 167-180.

**Kruidhof, C.N., Y. Raczynski-Henk, E. Lyklema & L. Koehler** 2011: *Een boomstamkano in Dijkgatsweide; een bijzondere vondst uit het Midden Neolithicum, gemeente Wieringermeer*, Amsterdam (RAAP Rapport 2161).

**Kubiak-Martens, L.**, 1999: The plant food component of the diet at the late Mesolithic (Ertebølle) settlement at Tybrind Vig, Denmark, *Vegetation History and Archaeobotany* 8, 117-127. *http://dx.doi.org/10.1007/BF02042850*

**Kubiak-Martens, L.**, 2002: New evidence for the use of root foods in pre-agrarian subsistence recovered from the late Mesolithic site at Halsskov, Denmark, *Vegetation History and Archaeobotany* 11, 23-31. *http://dx.doi.org/10.1007/s003340200003*

**Kubiak-Martens, L.**, 2006: Roots, tubers and processed plant food in the local diet, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 339-352. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy*

**Kubiak-Martens, L.**, 2008: Wortels, knollen en bereid plantaardig voedsel, in: J.M. Koot, L. Bruning & R.A. Houkes (eds.), *Ypenburg-Locatie 4. Een nederzetting met grafveld uit het Midden-Neolithicum in het West-Nederlandse kustgebied*, Leiden, 325-335.

**Kubiak-Martens, L. & T.F.M. Oudemans** 2007: *Geen voedsel maar teer – Botanisch en chemisch onderzoek aan de inhoud van een vroege-ijzertijdpot uit Wierden, Enter "De Akkers"*, Leiden/Zaandam (Kenaz Rapport 2; BIAXiaal 331).

**Kubiak-Martens, L. & T.F.M. Oudemans** 2008: *Voedsel in inheems-Romeins Egmond - Botanisch en chemisch onderzoek van verkoolde en onverkoolde residuen*, Leiden/Zaandam (Kenaz Rapport 3; BIAXiaal 354).

**Kubiak-Martens, L. & T.F.M. Oudemans** 2009a: *Voedselresiduen in trechterbeker- en bronstijdaardewerk uit Hattemerbroek Bedrijventerrein Zuid (HB068)*, Leiden/Zaandam (Kenaz Rapport 6).

**Kubiak-Martens, L. & T.F.M. Oudemans** 2009b: *Gefermenteerd voedsel? Chemische en botanisch onderzoek van organische residuen op aardewerk uit 1e eeuws Leidsche Rijn (LR60)*, Leiden/Zaandam (Kenaz Rapport 5; BIAXiaal 389).

**Kühn, M. & P. Hadorn** 2004: Pflanzliche Makro- und Mikroresten aus Dung von Wiederkäuern, in: S. Jacomet, U. Leuzinger & J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3. Umwelt und Wirtschaft*, Frauenfeld (Archäologie im Thurgau 12), 327-350.

**Kuhnlein, H.V. & N.J. Turner** 1991: *Traditional plant foods of Canadian indigenous peoples: nutrition, botany and use. In: S.H. Katz (ed.) Food and nutrition in history and anthropology, volume 8, Philadelphia (Gordon and Breach)*, Philadelphia (Food and nutrition in history and anthropology 8).

**Kuijper, W.J.**, 2001: Malacologisch onderzoek naar mariene mollusken uit laat-neolithische vindplaatsen in Noord-Holland, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 333-347. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Kvamme, K.L.**, 1990: Spatial Autocorrelation and the Classic Maya Collapse Revisited: Refined Techniques and new Conclusions, *Journal of Archaeological Science* 17, 197-207. *http://dx.doi.org/10.1016/0305-4403(90)90059-E*

**Laarman, F.**, 1990: Project westelijk kustgebied. Zijpe, *Jaarverslag van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 1989, 101-102.

**Lanting, J.N.**, 1973: Laat Neolithicum en Vroege Bronstijd in Nederland en N.W.-Duitsland: Continue ontwikkelingen, *Palaeohistoria* 15, 215-312.

**Lanting, J.N. & J. Van Der Plicht** 2000: De 14C Chronologie van de Nederlandse Pre- en Protohistorie III: Neolithicum, *Palaeohistoria* 41/42, 1-110.

**Lanting, J.N. & J.D. Van Der Waals** 1976: Beaker culture relations in the Lower Rhine Basin, in: J.N. Lanting & J.D. Van Der Waals (eds.), *Glockenbecher Symposion Oberried 1974*, Bussum/Haarlem, 1-80.

**Larsson, Å.M.**, 2009: *Breaking and Making Bodies and Pots: Material and Ritual Practices in Sweden in the Third Millennium BC*, Uppsala (PhD Thesis Uppsala University).

**Lasaponara, R. & N. Masini** 2010: Facing the archaeological looting in Peru by using very high resolution satellite imagery and local spatial autocorrelation statistics, in: T. Taniar, O. Gervasi, B. Murgante, E. Pardede & B. Apduhan (eds.), *Computational science and its applications – ICCSA 2010*, Berlin, 254-261.

**Lauwerier, R.C.G.M.**, 1994: Nieuwe Niedorp Zeewijk, *Jaarverslag van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 1993, 119-120.

**Lauwerier, R.C.G.M.**, 2001: Archeozoölogie, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 174-219. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Lenselink, G.**, 2001a: Booronderzoek laat-neolithische en vroege Bronstijd-nederzettingen ruilverkavelingsgebied 'De Gouw' (N.-H.) 1989, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 21-96. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Lenselink, G.**, 2001b: Verkenning Trechterbekervindplaats Bouwlust (kavel B36), Wieringermeer: Luchtfoto-interpretatie en booronderzoek, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 97-110. http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg

**Lenselink, G.**, 2001c: Fysisch-geografisch onderzoek in de omgeving van Mienakker, een nederzetting van de Enkelgrafcultuur, Aartswoud (N.-H.), in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 111-144. http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg

**Livingstone, S.D.**, 1989: The taphonomic interpretation of avian skeletal part frequencies, *Journal of Archaeological Science* 16, 537-547. http://dx.doi.org/10.1016/0305-4403(89)90072-1

**Louwe Kooijmans, L.P.**, 1974: *The Rhine/Meuse Delta, four studies on its prehistoric occupation and Holocene geology*, Leiden (Analecta Praehistorica Leidensia 7). http://hdl.handle.net/1887/2787

**Louwe Kooijmans, L.P.**, 1976: Local developments in a borderland; a survey of the Neolithic at the Lower Rhine, *Oudheidkundige Mededelingen van het Rijksmuseum van Oudheden te Leiden* 57, 227-297. http://hdl.handle.net/1887/2790

**Louwe Kooijmans, L.P.**, 2003: The Hardinxveld sites in the Rhine/Meuse delta, the Netherlands, 5500-4500 cal BC, in: L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler & A. Åkerlund (eds.), *Mesolithic on the move: Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm* 2000, 608-624. http://hdl.handle.net/1887/2862

**Louwe Kooijmans, L.P. & P.F.B. Jongste (eds.),** 2006: *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal* BC, Leiden (Analecta Praehistorica Leidensia 37/38). http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy

**Maier, C.**, 1999: Agricultural activities and land use in a Neolithic village around 3900 B.C.: Hornstaad Hörnle I A, Lake Constance, Germany, *Vegetation History and Archaeobotany* 8, 87-94. http://dx.doi.org/10.1007/BF02042846

**Mason, S.L.R. & J.G. Hather** 2000: Parenchymatous plant remains from Staosnaig, in: S. Mithen (ed.), *Hunter-gatherer landscape archaeology. The Southern Hebrides Mesolithic Project* 1988-1998, Cambridge (McDonald Institute Monographs), 415-425.

**Mears, R. & G.C. Hillman** 2007: *Wild food*, Hodder&Stoughton.

**Miller, N.**, 1984: The use of dung as fuel: an ethnographic example and an archaeological application, *Paléorient* 10, 71-79.

**Moore, A.M.T.**, G.C. Hillman & A.J. Legge 2000: *Village on the Euphrates. From Foraging to Farming at Abu Hureyra*, Oxford.

**Moran, P.A.**, 1948: The interpretation of statistical maps, *Journal of the Royal Statistical Society: Series B (Methodological)* 10, 243-251.

**Nijssen, H. & S.J. De Groot** 1987: *De vissen van Nederland*, Utrecht (Natuurhistorische Bibliotheek van de Koninklijke Nederlandse Natuurhistorische Vereniging 43).

**Oudemans, T.F.M.**, 2007: *Teer in Haardkuilen- Moleculaire DTMS karakterisering van extraheerbare organische verbindingen in de vulling van vroeg Holocene haardkuilen in "Knooppunt Hattemerbroek"*, Zaandam (Kenaz Rapport 1).

**Oudemans, T.F.M.**, 2008: *Kookaardewerk uit Peizermaden – Chemisch onderzoek van verkoolde residuen op aardewerk uit de 12e tot 14e eeuw*, Zaandam (Kenaz Rapport 4).

**Oudemans, T.F.M.**, 2009: *Berkenbastteer op Gallo-Romeins aardewerk uit West-België – Chemische karakterisering van organische residuen met behulp van DTMS*, Zaandam (Kenaz Rapport 8).

**Oudemans, T.F.M.**, 2010: *Pitch & Porridge in Slavic Ceramics - chemical characterisation of organic residues found in 9th -12th century ceramics from Slavic sites (Wustrow 10 and Lenzen 1) in the Elbe valley*, Zaandam (Kenaz Rapport 10).

**Pals, J.P.**, 1984: Plant remains from Aartswoud, a Neolithic settlement in the coastal area, in: W. van Zeist & W.A. Casparie (eds.), *Plants and ancient man: studies in palaeoethnobotany: proceedings of the Sixth Symposium of the International Work Group for Palaeoethnobotany, Groningen, 30 May-3 June 1983*, Groningen, 313-321.

**Pastorova, I., R.E. Botto, P.W. Arisz & J.J. Boon** 1994: Cellulose char structure: a combined analytical Py-GC-MS, FTIR and NMR study, *Carbohydrate Research* 27, 27-47.

**Pastorova, I., T.F.M. Oudemans & J.J. Boon** 1993: Experimental polysaccharide chars and their 'fingerprints" in charred archaeological foods, *Journal of Analytical and Applied Pyrolysis* 25, 63-74.

**Peeters, J.H.M.**, 2001a: Lithisch materiaal van Mienakker: Technologische organisatie en typologie, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 515-625. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Peeters, J.H.M.**, 2001b: Het (vuur)steenmateriaal van de laat-neolithische en vroege Brondstijd-nederzettingen van de Gouw (AAO-campagne 1989), in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 485-511. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Piena, H. & E. Drenth** 2001: Doorboorde sieraden van de laat-neolithische site Aartswoud, gem. Opmeer, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 433-469. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Premo, L.S.**, 2004: Local spatial autocorrelation statistics quantufy multi-scale patterns in distributional data: an example from the Maya lowlands, *Journal of Archaeological Science* 31, 855-866. *http://dx.doi.org/10.1016/j.jas.2003.12.002*

**Punt, W.**, 1976: *The Northwest European Pollen Flora I*, Amsterdam.

**Punt, W. & S. Blackmore** 1991: *The Northwest European Pollen Flora VI*, Amsterdam.

**Punt, W., S. Blackmore & G.C.S. Clarke** 1988: *The Northwest European Pollen Flora V*, Amsterdam.

**Punt, W., S. Blackmore & P.P. Hoen** 1995: *The Northwest European Pollen Flora VII*, Amsterdam.

**Punt, W., S. Blackmore & P.P. Hoen** 2003: *The Northwest European Pollen Flora VIII*, Amsterdam.

**Punt, W. & G.C.S. Clarke** 1980: *The Northwest European Pollen Flora II*, Amsterdam.

**Punt, W. & G.C.S. Clarke** 1981: *The Northwest European Pollen Flora III*, Amsterdam.

**Punt, W. & G.C.S. Clarke** 1984: *The Northwest European Pollen Flora IV*, Amsterdam.

**Reimer, P.J., M.G.L. Baillie, E. Bard, A. Bayliss, J.W. Beck, P.G. Blackwell, C. Bronk Ramsey, C.E. Buck, G.S. Burr, R.L. Edwards, M. Friedrich, P.M. Grootes, T.P. Guilderson, I. Hajdas, T.J. Heaton, A.G. Hogg, K.A. Hughen, K.F. Kaiser, B. Kromer, F.G. McCormac, S.W. Manning, R.W. Reimer, D.A. Richards, J.R. Southon, S. Talamo, C.S.M. Turney, J. Van Der Plicht & C.E. Weyhenmeyer** 2009: IntCal09 and Marine09 radiocarbon age calibration curves, 0-50,000 years cal BP, in: *Radiocarbon* 514, 1111-1150.

**Risch, R.**, 2002: *Recursos naturales, medios de producción y explotación social. Un análisis económico de la industria lítica de Fuente Álamo (Almería), 2250-1400 antes de nuestra era*, Madrid (Iberia Archaeologica 3).

**Roessingh, W. & E. Lohof (eds.)**, 2011: *Bronstijdboeren op de kwelders. Archeologisch onderzoek in Enkhuizen - Kadijken*, Amersfoort (ADC Rapport 2200). *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-9jf-vqg*

**Roorda, I.M.**, 2001: Het beker en nederzettingsaardewerk van de Enkelgrafcultuur: wat is het verschil?, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 349-377. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Rots, V.**, 2008: Hafting traces on flint tools, in: L. Longo & N. Skakun (eds.), *"Prehistoric Technology" 40 years later: Functional Studies and the Russian Legacy*, Oxford (British Archaeological Reports: International Series 1783), 75-84.

**Rots, V. & P.M. Vermeersch** 2004: Experimental characterization of hafting traces and their recognition in archaeological assemblages, in: E.A. Walker, F. Wenban-Smith & F. Healy (eds.), *Lithics in Action: Papers from the conference Lithic Studies in the Year 2000*, Oxford (Lithic Studies Society Occasional Papers 8), 156-168.

**Schaminée, J.H.J., E.J. Weeda & V. Westhoff** 1999: *De vegetatie van Nederland Deel 4. Plantengemeenschappen van de kust en van binnenlandse pioniermilieus*, Uppsala/Leiden.

**Semenov, S.A.**, 1981 [1957]: *Tecnología prehistórica: estudio de las herramientas y objetos antiguos a través de las huellas del uso*, Madrid.

**Sergeant, J., P. Crombé & Y. Perdaen** 2006: The 'invisible' hearths: a contribution to the discernment of Mesolithic non-structured surface hearths, *Journal of Archaeological Science* 33, 999-1007. *http://dx.doi.org/10.1016/j.jas.2005.11.011*

**Serjeantson, D.**, 2009: *Birds*, Cambridge (Cambridge Manuals in Archaeology).

**Sier, M.M.**, 2001: Het aardewerk van Zeewijk, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 379-415. *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Spikins, P.**, H. Ayestaran & C. Conneller 1995: 'Meaningful patterns or mere pictures?': The influence of collection strategy on the interpretation of lithic scatters, in: A.J. Schofield (ed.), *Lithics in Context: suggestions for the future direction of lithic studies*, Oxford (Lithics Studies Society Occasional Paper 5), 125-137.

**Stapert, D. & L. Johansen** 1999: Flint and pyrite: making fire in the Stone Age, *Antiquity* 73, 765-777.

**Stilborg, O. & I. Bergenstråhle** 2000: Traditions in Transition. A Comparative Study of the Patterns of Ertebølle Lithic and Pottery Changes in the Late Mesolithic Ceramic Phase at Skateholm I, III and Soldattorpet in Scania, Sweden, *Lund Archaeological Review* 6, 23-41.

**Sutterlin, P.G. & J.P. Ghastings** 1986: Trend-surface analysis revisited – A case history, *Computers & Geosciences* 12, 537-562. *http://dx.doi.org/10.1016/0098-3004(86)90068-3*

**Swenson, N.G. & D.J. Howard** 2005: Clustering of Contact Zones, Hybrid Zones, and Phylogeographic Breaks in North America, *The American Naturalist* 166, 581-591. *http://view.ncbi.nlm.nih.gov/pubmed/16224723*

**Tan, P.-N., C. Potter, M. Steinbach, S. Klooster, V. Kumar & A. Torregrosa** 2001: Finding Spatio-Temporal Patterns in Earth Science Data, in: *Proceedings of KDD Workshop on Temporal Data Mining*, San Francisco, 1-12.

**Therkorn, L.L., E.A. Besselsen, M. Diepeveen-Jansen, S. Gerritsen, J. Kaarsemaker, M.S.M. Kok, L. Kubiak-Martens, J. Slopsma & P.C. Vos** 2009: *Landscapes in the Broekpolder. Excavations around a monument with aspects of the Bronze Age to the Modern (Beverwijk & Heemskerk, North-Holland)*, Amsterdam (Themata 2). *http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-e5x-5ah*

**Tobler, W.R.**, 1970: A computer movie simulating urban growth in the Detroit region, *Economic Geography* 46, 234-240. http://dx.doi.org/10.2307/143141

**Valamoti, S.M.**, D. Samuel, M. Bayram & E. Marinova 2008: Prehistoric cereal foods from Greece and Bulgaria: investigation of starch microstructure in experimental and archaeological charred remains, *Vegetation History and Archaeobotany* 17, 265-276. http://dx.doi.org/10.1007/s00334-008-0190-6

**Van Beek, B.L.**, 1990: *Steentijd te Vlaardingen, Leidschendam en Voorschoten: de vondstverspreiding in laat-neolithische nederzettingen in het Hollandse kustgebied*, Amsterdam (PhD Thesis University of Amsterdam).

**Van Beurden, L.**, 2008: Macroresten, in: J.M. Koot, L. Bruning & R.A. Houkes (eds.), *Ypenburg-Locatie 4. Een nederzetting met grafveld uit het Midden-Neolithicum in het West-Nederlandse kustgebied*, Leiden, 315-324.

**Van de Berg, A.B. & C.A.W. Bosman** 2001: *Zeldzame vogels van Nederland*, Haarlem/Utrecht (Avifauna van Nederland 1).

**Van der Beek, Z. & H. Fokkens** 2001: 24 years after Oberried: the 'Dutch' model reconsidered, in: F. Nicolis (ed.), *Bell beakers today. Pottery, people, culture, symbols in prehistoric Europe. Proceedings of the International Colloquium Riva del Garda (Trento, Italy), 11-16 May 1998*, Trento, 301-308.

**Van der Ploeg, D.T.E.**, 1977: Vogels en wetten, in: D.T.E. Van der Ploeg, W. de Jong, M.J. Swart, J.A. de Vries, J.H.P. Westhof, A.G. Witteveen & B. van der Veen (eds.), *Vogels in Friesland (deel II)*, Leeuwarden, 547-584.

**Van der Veen, M.**, 2007: Formation processes of desiccated and carbonized plant remains-the identification of routine practice, *Journal of Archaeological Science* 34, 968-990. http://dx.doi.org/10.1016/j.jas.2006.09.007

**Van der Waals, J.D. & W. Glasbergen** 1955: Beaker types and their distribution in the Netherlands, *Palaeohistoria* 4, 3-46.

**Van Geel, B.**, 1976: *A Palaeoecological Study of Holocene Peat Bog Sections, based on the Analysis of Pollen, Sporen and Macro- and Microscopic Remains of Fungi, Algae, Cormophytes and Animals*, Amsterdam (PhD Thesis University of Amsterdam).

**Van Gijn, A.L.**, 1989: *The Wear and Tear of Flint: principles of functional analysis applied to Dutch Neolithic assemblages*, Leiden (Analecta Praehistorica Leidensia 22). http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-2f6-gfp

**Van Gijn, A.L.**, 2010: *Flint in Focus. Lithic Biographies in the Neolithic and Bronze Age*, Leiden.

**Van Gijn, A.L. & J.J. Boon** 2006: Birch bark tar, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 261-266. http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy

**Van Gijn, A.L., V. van Betuw, A. Verbaas & K. Wentink** 2006: Flint, procurement and use, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 129-166. http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy

**Van Ginkel, E.J. (ed.)**, 2010: *Programma Odyssee. 32 archeologische projecten behouden thuis. Wetenschappelijke en maatschappelijke meerwaarde van vergeten opgravingen*, Amsterdam.

**Van Ginkel, E.J. & J.W.H. Hogestijn** 1997: *Bekermensen aan zee*, Abcoude/Amersfoort.

**Van Haaster, H.**, 2008: *Palynologisch onderzoek in het tracé van de Hanzelijn (Oude Land)*, Zaandam (BIAXiaal 316).

**Van Haaster, H.**, 2009: Pollen aus Brunnen und Viehtränken, *Archäologie in Deutschland* 2, 34-35.

**Van Heeringen, R.M. & E.M. Theunissen (eds.)**, 2001: *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland (3 delen)*, Amersfoort (Nederlandse Archeologische Rapporten 21).
*http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Van Smeerdijk, D.G.**, 2001: Archeobotanisch onderzoek van de vindplaats Mienakker, in: R.M. van Heeringen & E.M. Theunissen (eds.), *Kwaliteitsbepalend onderzoek ten behoeve van duurzaak behoud van neolithische terreinen in West-Friesland en de Kop van Noord-Holland. Deel 3: Archeologische onderzoeksverslagen*, Amersfoort (Nederlandse Archeologische Rapporten 21), 223-258.
*http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-clt-stg*

**Van Zeist, W.**, 1974: Palaeobotanical studies of settlement sites in the coastal area of the Netherlands, *Palaeohistoria* 16, 223-371.

**Van Zeist, W., T.C. Van Hoorn, S. Bottema & H. Woldring** 1976: An agricultural experiment in the unprotected saltmarsh, *Palaeohistoria* 18, 111-153.

**Van Zijverden, W.K.**, 2011: De ontwikkeling van het landschap, in: W. Roessingh & E. Lohof (eds.), *Bronstijdboeren op de kwelders. Archeologisch onderzoek in Enkhuizen - Kadijken*, Amersfoort (ADC Rapport 2200), 35-50.
*http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-9jf-vqg*

**Verbaas, A. & A.L. van Gijn** 2008a: Use-wear analyses of the flint tools from Geleen-Janskamperveld, in: P. van de Velde (ed.), *Excavations at Geleen-Janskamperveld 1990/1991* Leiden (Analecta Praehistorica Leidensia 39), 174-184.
*http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-we6-7xx*

**Verbaas, A. & A.L. van Gijn** 2008b: Querns and other hard stone tools fron Geleen-Janskamperverld, in: P. van de Velde (ed.), *Excavations at Geleen-Janskamperveld 1990/1991* Leiden (Analecta Praehistorica Leidensia 39), 191-204.
*http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-we6-7xx*

**Von den Driesch, A.**, 1976: *A guide to the measurement of animal bones from archaeological sites*, Cambridge (MA).

**Vos, P.C. & P. Kiden** 2005: De Landschapsvorming tijdens de Steentijd, in: J.H.C. Deeben, E. Drenth, M.-F. Van Oorsouw & L.B.M. Verhart (eds.), *De Steentijd van Nederland*, Zutphen (Archeologie 11/12), 7-37.

**Waijjen van, M. & C. Vermeeren** 2006: Coprolites, macroscopic analysis, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 301-304.
*http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy*

**Wansleeben, M. & L.P. Louwe Kooijmans** 2006: The archaeological remains: a critical spatial approach, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 67-87.
*http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy*

**Waterbolk, H.T.**, 2009: *Getimmerd Verleden*, Groningen.

**Wheeler, A. & A.K.G. Jones** 1989: *Fishes*, Cambridge (Cambridge Manuals in Archaeology).

**Whitley, D.S. & W.A. Clark** 1985: Spatial Autocorrelation Tests and the Classic Maya Collapse: methods and Inferences, *Journal of Archaeological Science* 12, 377-395.
*http://dx.doi.org/10.1016/0305-4403(85)90066-4*

**Williams, J.T.**, 1993: Spatial Autocorrelation and the Classic Maya Collapse: One Technique, One Conclusion, *Journal of Archaeological Science* 20, 705-709.
*http://dx.doi.org/10.1006/jasc.1993.1044*

**Woltering, P.J.** 1987: Zijpe, Keinsmerbrug, *Archeologische kroniek van Holland over 1986, I: Noord-Holland* (Holland 19), 295-297.

**Woltering, P.J., G. van Haaf, J. Buurman & F. Laarman** 1987: Keinsmerbrug, gem. Zijpe, *Jaarverslag van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 1986, 29-30.

**Zeiler, J.T.**, 1988: Zoogdieren, vogels, vissen en amfibieën, in: D.A. Gerrets, E.E.B. Bulten & J.M. Pasveer (eds.), *De laat-neolithische nederzetting 'Zeewijk'. Verslag van een kwartair-geologische boorverkenning in de Groetpolder (Noord-Holland)*, Groningen (Vakgroep F.G.B. rapport nr. 25), 26-28.

**Zeiler, J.T.**, 1997: *Hunting, fowling and stock-breeding at Neolithic sites in the western and central Netherlands*, Groningen (PhD Thesis University of Groningen). http://irs.ub.rug.nl/ppn/161617514

**Zeiler, J.T.**, 2006a: Mammals, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 375-420. http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy

**Zeiler, J.T.**, 2006b: Birds, in: L.P. Louwe Kooijmans & P.F.B. Jongste (eds.), *Schipluiden: A Neolithic Settlement on the Dutch North Sea Coast c. 3500 cal BC*, Leiden (Analecta Praehistorica Leidensia 37/38), 421-422. http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-bi6-nuy

**Zeiler, J.T., D.C. Brinkhuizen & D.L. Bekker** 2007: *Niet bij vee alleen. Archeozoölogisch onderzoek van de Vroege Bronstijdvindplaats Hoep Noord te Schagen*, Schagen (ArchaeoBone rapport nr. 54; Intern rapport in opdracht van Archeologische Werkgroep 'Kop van Noord-Holland'). http://www.persistent-identifier.nl/?identifier=urn:nbn:nl:ui:13-jd9-8iu

**Zeiler, J.T. & A.T. Clason** 1993: Fowling in the Dutch Neolithic at inland and coastal sites, *Archaeofauna* 2, 67-74.

**Zurro, D., R. Risch & I. Clemente Conte** 2005: Analysis of an Archaeological Grinding Tool: What to do with Archaeological Artefacts, in: X. Terradas (ed.), *Lithic Toolkits in Ethnoarchaeological Contexts: actes du XIV congrès UISPP, Université de Liège, Belgique, 2-8 septembre 2001*, Oxford (British Archaeological Reports: International Series 1370), 57-64.

# List of contributors

*(in alphabetical order)*


**S.M. (Sandra) Beckerman, MA**
Groningen Institute of Archaeology
Groningen University
Poststraat 6
9712 ER Groningen
The Netherlands
*s.m.beckerman@rug.nl*

**Dr. D.C. (Dick) Brinkhuizen**
Brinkhuizen Medical Trade (BMT)
Koninginnelaan 18a
9717 BT Groningen
The Netherlands
*bmt.dick@planet.nl*

**Dr. O. (Otto) Brinkkemper**
Cultural Heritage Agency of the Netherlands
P.O. Box 1600
3800 BP Amersfoort
The Netherlands
*o.brinkkemper@cultureelerfgoed.nl*

**V. (Virginia) García Díaz, MA**
Faculty of Archaeology
Leiden University
P.O. Box 9515
2300 RA Leiden
The Netherlands
*v.garcia.diaz@arch.leidenuniv.nl*

**Dr. H. (Henk) van Haaster**
BIAX Consult
Hogendijk 134
1506 AL Zaandam
The Nederlands
*haaster@biax.nl*

**J.P. (Jos) Kleijne, MPhil**
Cultural Heritage Agency of the Netherlands
P.O. Box 1600
3800 BP Amersfoort
The Netherlands
*j.kleijne@cultureelerfgoed.nl*

**Dr. L. (Lucy) Kubiak-Martens**
BIAX Consult
Hogendijk 134
1506 AL Zaandam
The Nederlands
*kubiak@biax.nl*

**Dr. R.C.G.M. (Roel) Lauwerier**
Cultural Heritage Agency of the Netherlands
P.O. Box 1600
3800 BP Amersfoort
The Netherlands
*r.lauwerier@cultureelerfgoed.nl*

**G.R. (Gary) Nobles, MA**
Groningen Institute of Archaeology
Groningen University
Poststraat 6
9712 ER Groningen
The Netherlands
g.r.nobles@rug.nl

**Dr. T. F.M. (Tania) Oudemans**
Kenaz Consult
P.O. Box 842
2300 AV Leiden
The Netherlands
*info@kenaz.nl*

**Dr. J.H.M. (Hans) Peeters**
Groningen Institute of Archaeology
Groningen University
Poststraat 6
9712 ER Groningen
The Netherlands
*j.h.m.peeters@rug.nl*

**Prof.dr. D.C.M. (Daan) Raemaekers**
Groningen Institute of Archaeology
Groningen University
Poststraat 6
9712 ER Groningen
The Netherlands
*d.c.m.raemaekers@rug.nl*

**Dr. B.I. (Bjørn) Smit**
Cultural Heritage Agency of the Netherlands
P.O. Box 1600
3800 BP Amersfoort
The Netherlands
*b.smit@cultureelerfgoed.nl*

**Dr. E.M. (Liesbeth) Theunissen**
Cultural Heritage Agency of the Netherlands
P.O. Box 1600
3800 BP Amersfoort
The Netherlands
*l.theunissen@cultureelerfgoed.nl*

**Prof.dr. A.L. (Annelou) van Gijn**
Faculty of Archaeology
Leiden University
P.O. Box 9515
2300 RA Leiden
The Netherlands
*a.l.van.gijn@arch.leidenuniv.nl*

**Dr. J.T. (Jørn) Zeiler**
ArchaeoBone
Blekenweg 61
9753 JN Haren
The Netherlands
*abone@planet.nl*

# Appendices

# Appendix I: Studied ceramic characteristics

**~1st phase: sherds**
*Type sherd*
1: Rim
2: Neck
3: Shoulder
4: Wall
5: Base
6: Grit
7: indet/younger

**Technological characteristics**
*Tempering material*
Quartz
Granite
Granite, Red
Mica
Grog
Sand
Plant
Shell
Bone
Lime (either shell or bone)
Charcoal
Indet

*Tempering size*
<1: under 1 mm
1-2: 1-2 mm
2-3: 2-3 mm
>3: over 3 mm

*Amount of tempering material*
Very little: 0-5 particles $cm^2$
Little: 5-10 particles $cm^2$
Average: 10-15 particles $cm^2$
Many: over 15 particles $cm^2$

*Thickness*
In mm

*Construction*
*Coil built: Hb-joints*
*Coil built: U-joints*

*Firing method*
Outside-core-Inside
Li: light (fired in an oxygen rich fire)
Da: dark (fired in an oxygen poor fire)

*Surface treatment outside*
Lightly smoothened
Smoothened
Smoothened; with scrape marks
Scrape marks
Polished
Rough
Roughened, marks

*Surface treatment inside*
Lightly smoothened
Smoothened
Smoothened; with scrape marks
Scrape marks
Polished
Rough
Rough: with scrape marks
Roughened, marks
Smitten

**Morphological characteristics**
*Shape of the pot: pot type (partite)*
1partite
2partited
3partited

*Shape of the rim*
Round
Flat
Triangular
Slanting inwards
Slanting outwards

*Shape of the base*
Protruding
Flat
Hollow

**Decoration**
Types according to the Van der Waals and Glasbergen typology
And: technique and motive

**And**
*Weathering*
Secondary burned
Flaked off
Rounded

*Residues*
Yes
No

*Repair holes/perforations*
Type and location

**~2nd phase; pots**

Diameter of the rim, greatest belly circumference and base in cm

# Appendix II: Characteristics of the vessels and decorated wall sherds

## Characteristics of the vessels and decorated wall sherds

| Vessel number | Original vessel nr. | Vessel part | Decoration | Tempering | Thickness | Diameter of the rim | Diameter of the base |
|---|---|---|---|---|---|---|---|
| 1 | 9/18 | rim-shoulder and shoulder-wall | horizontal rows of oblique impressions in alternating direction | grog and sand | 7.5-9 | 24 | x |
| 2 | 2 | rim-shoulder, wall and base | horizontal rows of oblique impressions in alternating direction | grog | 6.5-8.5 | 13 | x |
| 3 | 2 | rim-shoulder | horizontal rows of oblique impressions in alternating direction and fingertip impressions on top of the rim | grog and sand | 6.5-8.5 | 16 | x |
| 4 | extra bag 2 | rim-wall and wall-base | horizontal rows of oval impressions in one direction | grog, plant and sand | 5-7 | 14 | 6 |
| 5 | 10 | rim-shoulder and wall | zigzag | grog and sand | 5.5-7 | x | x |
| 6 | 11 | rim-neck and wall | rope impressions | grog, plant and sand | 5.5 | 10 | x |
| 7 | 25 | rim-shoulder | fingertip impressions | grog and sand | 8-10 | 20 | x |
| 8 | extra bag 3 | rim-neck | fingertip impressions | grog and sand | 8-10 | x | x |
| 9 | 27 | rim-neck | x | sand | 5.5 | 17 | x |
| 10 | 9/18 | rim-neck | x | sand | 7 | x | x |
| 11 | 28 | rim-shoulder | x | quartz and grog | 5 | x | x |
| 12 | 6 | rim-neck and wall | | grog and sand | 6.5-9.5 | 19 | x |
| 13 | 22 | rim-shoulder | x | grog and sand | 8.5 | 27 | x |
| 14 | 15 | rim | x | grog and sand | 8.5 | 19 | x |
| 15 | 1 | rim-neck and base | x | grog and sand | 8-10 | x | 10 |
| 16 | 9/18 | rim-neck | x | grog and sand | 8.5 | x | x |
| 17 | 15 | rim | x | sand | 8 | x | x |
| 18 | 7 | rim-neck | x | grog | 9-10 | 19 | x |
| 19 | 15 | rim | x | granite | 8.5-10.5 | x | x |
| 20 | 16 | wall-base | x | grog and sand | 8 | x | 10 |
| 21 | 20 | wall-base | x | grog | 5-9.5 | x | 8 |
| 22 | 22 | wall and base | perforation | grog and sand | 5-7.5 | x | 7 |
| x | 1 | wall | zigzag | grog and sand | 6.5 | x | x |
| x | 4 | rim (less than 3 gr) | zigzag | x | x | x | x |
| x | 5 | wall | figertip impressions | grog and sand | 6.5 | x | x |
| x | 8 | rim (less than 3 gr) | horizontal rows of oblique impressions in one direction | grog and sand | 5.5 | x | x |
| x | 22 | wall | zigzag | grog and sand | 5.5 | x | x |
| x | 23 | wall (less than 3 gr) | zigzag | x | x | x | x |
| x | 26 | wall | horizontal lines | sand | 5.5 | x | x |

# Appendix III: List of recognized botanical remains

## List of recognized botanical remains

| trench-layer-square | 3-1-99 | 3-1-127 | 3-1-148 | 3-1-180 | 3-1-186 | 3-1-222 | 3-1-230 | 3-1-240 | 3-1-281 |
|---|---|---|---|---|---|---|---|---|---|
| **taxon** | | | | | | | | | |
| **crop plants** | | | | | | | | | |
| Hordeum vulgare | . | . | . | . | . | . | 4 | . | . |
| Hordeum vulgare var. nudum | 5 | 7 | . | 3 | 4 | 1 | . | 1 | . |
| Hordeum vulgare, rachis internode | . | . | . | . | . | . | . | . | . |
| Triticum dicoccon | . | . | . | 1 | . | . | . | . | . |
| Triticum dicoccon, glume base | . | 1 | . | . | . | . | . | . | . |
| Triticum dicoccon, spiklet fork | . | 2 | 1 | . | . | . | . | . | . |
| **weeds** | | | | | | | | | |
| Atriplex patula/prostrata | c.115 | c.230 | c.115 | c.185 | 48 | 27 | 35 | 85 | 25 |
| Atriplex patula/prostrata * | . | . | . | . | . | . | . | . | . |
| Atriplex/Chenopodium | + | ++ | + | + | . | . | . | . | . |
| Brassica rapa * | . | . | . | . | . | . | . | . | . |
| Chenopodium ficifolium * | . | . | . | . | . | . | . | . | . |
| Persicaria lapathifolia | . | . | 1 | 2 | . | . | . | . | . |
| Plantago major * | . | . | . | . | . | . | . | . | . |
| Polygonum aviculare | . | . | 3 | . | . | . | . | . | . |
| Polygonum aviculare * | . | . | . | . | . | . | . | . | . |
| Sonchus asper * | . | . | . | . | . | . | . | . | . |
| Stellaria media * | . | . | . | . | . | . | . | . | . |
| **perennial ruderals** | | | | | | | | | |
| Urtica dioica * | . | . | . | . | . | . | . | . | . |
| **pioneers on damp, nitrate-rich soils** | | | | | | | | | |
| Chenopodium glaucum/rubrum * | . | . | . | . | . | . | . | . | . |
| Myosoton aquaticum * | . | . | . | . | . | . | . | . | . |
| Ranunculus sceleratus * | . | . | . | . | . | . | . | . | . |
| **salt marsh** | | | | | | | | | |
| Agrostis | . | 3 | . | . | . | . | . | . | . |
| Althaea officinalis | . | . | . | . | . | 1 | . | . | . |
| Althaea officinalis * | . | . | . | . | . | . | . | . | . |
| Apium graveolens | . | . | . | . | . | . | . | . | . |
| Apium graveolens * | . | . | . | . | . | . | . | . | . |
| Aster tripolium | . | . | . | . | . | . | . | . | . |
| Aster tripolium * | . | . | . | . | . | . | . | . | . |
| Atriplex littoralis | 28 | 23 | 28 | 45 | 8 | 7 | 6 | 14 | 18 |
| Atriplex littoralis * | . | . | . | . | . | . | . | . | . |
| Bolboschoenus maritimus | 2 | 17 | 1 | 1 | 10 | . | . | 1 | . |
| Bolboschoenus maritimus * | . | . | . | . | . | . | . | . | . |
| Hordeum marinum | 1 | 3 | 2 | 2 | 2 | . | 3 | 3 | . |
| Juncus gerardi * | . | . | . | . | . | . | . | . | . |
| Poa pratensis/trivialis * | . | . | . | . | . | . | . | . | . |

| trench-layer-square | 3-1-289 | 3-1-297 | 4-1-353 | 4-1-360 | 4-1-416 | 4-1-417 | 4-1-427 | 3-2-1001 | 3-2-1003 |
|---|---|---|---|---|---|---|---|---|---|
| **taxon** | | | | | | | | | |
| **crop plants** | | | | | | | | | |
| Hordeum vulgare | . | . | . | . | 3 | . | 1 | . | 2 |
| Hordeum vulgare var. nudum | . | . | . | 1 | . | 4 | 1 | . | . |
| Hordeum vulgare, rachis internode | . | . | . | . | 1 | . | . | . | . |
| Triticum dicoccon | 1 | . | . | . | 1 | . | . | . | . |
| Triticum dicoccon, glume base | . | . | 1 | . | 2 | . | . | . | . |
| Triticum dicoccon, spiklet fork | . | . | 1 | . | 1 | 1 | 1 | . | . |
| **weeds** | | | | | | | | | |
| Atriplex patula/prostrata | c.125 | 41 | c.125 | 25 | c.650 | c.200 | 24 | 16 | 25 |
| Atriplex patula/prostrata * | . | . | . | . | . | . | . | 4 | 4 |
| Atriplex/Chenopodium | ++ | . | . | . | ++ | + | . | . | . |
| Brassica rapa * | . | . | . | . | . | . | . | 2 | 8 |
| Chenopodium ficifolium * | . | . | . | . | . | . | . | 50 | 27 |
| Persicaria lapathifolia | . | . | . | . | 4 | 1 | . | . | . |
| Plantago major * | . | . | . | . | . | . | . | . | 3 |
| Polygonum aviculare | . | . | . | . | . | . | . | 1 | . |
| Polygonum aviculare * | . | . | . | . | . | . | . | . | 2 |
| Sonchus asper * | . | . | . | . | . | . | . | . | 1 |
| Stellaria media * | . | . | . | . | . | . | . | 12 | 38 |
| **perennial ruderals** | | | | | | | | | |
| Urtica dioica * | . | . | . | . | . | . | . | 48 | 27 |
| **pioneers on damp, nitrate-rich soils** | | | | | | | | | |
| Chenopodium glaucum/rubrum * | . | . | . | . | . | . | . | . | 2 |
| Myosoton aquaticum * | . | . | . | . | . | . | . | 25 | 13 |
| Ranunculus sceleratus * | . | . | . | . | . | . | . | 32 | >1000 |
| **salt marsh** | | | | | | | | | |
| Agrostis | 1 | . | . | . | . | . | . | . | . |
| Althaea officinalis | . | . | 1 | . | 1 | 1 | 1 | . | 1 |
| Althaea officinalis * | . | . | . | . | . | . | . | . | 6 |
| Apium graveolens | . | . | 1 | . | . | . | . | 3 | 1 |
| Apium graveolens * | . | . | . | . | . | . | . | 13 | 115 |
| Aster tripolium | . | . | . | . | . | . | . | 1 | . |
| Aster tripolium * | . | . | . | . | . | . | . | . | 2 |
| Atriplex littoralis | 10 | 8 | 42 | 1 | 65 | 25 | 1 | 8 | 6 |
| Atriplex littoralis * | . | . | . | . | . | . | . | 2 | . |
| Bolboschoenus maritimus | . | . | 3 | 1 | 3 | . | . | 1 | . |
| Bolboschoenus maritimus * | . | . | . | . | . | . | . | 4 | 18 |
| Hordeum marinum | 3 | . | 1 | . | 7 | . | . | 1 | 1 |
| Juncus gerardi * | . | . | . | . | . | . | . | 8 | 75 |
| Poa pratensis/trivialis * | . | . | . | . | . | . | . | 8 | 12 |

## List of recognized botanical remains

| trench-layer-square | 3-1-99 | 3-1-127 | 3-1-148 | 3-1-180 | 3-1-186 | 3-1-222 | 3-1-230 | 3-1-240 | 3-1-281 |
|---|---|---|---|---|---|---|---|---|---|
| **salt marsh** | | | | | | | | | |
| Puccinellia distans | . | . | . | . | . | . | . | . | . |
| Salicornia europaea | 1 | 18 | . | . | 1 | . | . | 1 | . |
| Spergularia salina * | . | . | . | . | . | . | . | . | . |
| Suaeda maritima | . | . | . | . | . | . | . | . | . |
| **freshwater marsh** | | | | | | | | | |
| Carex acuta/elata | . | . | . | . | . | . | 1 | . | . |
| Carex riparia * | . | . | . | . | . | . | . | . | . |
| Cladium mariscus | . | 3 | 1 | 1 | 1 | 2 | . | 2 | . |
| Eleocharis palustris/uniglumis | . | . | . | . | . | . | . | . | . |
| Galium palustre | . | . | . | . | . | . | . | . | . |
| Mentha aquatica/arvensis * | . | . | . | . | . | . | . | . | . |
| Phragmites, culm frg | ++ | . | ++ | . | + | + | + | . | + |
| Phragmites, culm frg * | . | . | . | . | . | . | . | . | . |
| Ranunculus lingua | . | . | . | . | . | . | . | . | . |
| **grassland** | | | | | | | | | |
| Carex otrubae * | . | . | . | . | . | . | . | . | . |
| Taraxacum officinale | . | . | . | . | . | . | . | . | . |
| **Various plant remains** | | | | | | | | | |
| Agrostis/Poa | . | . | . | . | 2 | . | . | 1 | . |
| Alopecurus myosuroides/pratensis * | . | . | . | . | . | . | . | . | . |
| Carduus/Cirsium * | . | . | . | . | . | . | . | . | . |
| Carex 3stig. | . | . | . | 1 | . | . | . | . | . |
| Cerealia/Phragmites, culm frg | . | ++ | . | + | . | . | . | . | . |
| cf. Empetrum nigrum | . | . | . | . | . | . | . | 1 | . |
| Chenopodiaceae * | . | . | . | . | . | . | . | . | . |
| Malva * | . | . | . | . | . | . | . | . | . |
| Poa * | . | . | . | . | . | . | . | . | . |
| indet. | . | . | 1 | . | . | . | . | . | . |
| parenchymatous plant tissue | . | 1 frg | . | . | 2 frg | 1 tuber+1frg | . | 6 frg (Atriplex) | 1 frg |
| processed plant food, isolated lumps | 3 frg | 2 frg | . | . | . | . | 4 frg | 3 frg | . |

| trench-layer-square | 3-1-289 | 3-1-297 | 4-1-353 | 4-1-360 | 4-1-416 | 4-1-417 | 4-1-427 | 3-2-1001 | 3-2-1003 |
|---|---|---|---|---|---|---|---|---|---|
| **salt marsh** | | | | | | | | | |
| Puccinellia distans | . | . | . | . | . | . | . | 5 | . |
| Salicornia europaea | . | . | 2 | 2 | 1 | . | . | 1 | . |
| Spergularia salina * | . | . | . | . | . | . | . | . | 1 |
| Suaeda maritima | . | . | . | . | 1 | . | . | 1 | . |
| **freshwater marsh** | | | | | | | | | |
| Carex acuta/elata | . | . | . | . | . | . | . | . | . |
| Carex riparia * | . | . | . | . | . | . | . | . | 2 |
| Cladium mariscus | . | . | 1 | . | 3 | 2 | . | . | . |
| Eleocharis palustris/uniglumis | 1 | . | . | . | . | . | . | . | . |
| Galium palustre | . | . | . | . | . | . | . | . | 2 |
| Mentha aquatica/arvensis * | . | . | . | . | . | . | . | 2 | 1 |
| Phragmites, culm frg | + | (+) | + | + | ++ | ++ | + | + | + |
| Phragmites, culm frg * | . | . | . | . | . | . | . | . | + |
| Ranunculus lingua | . | . | 1 | . | . | . | . | . | . |
| **grassland** | | | | | | | | | |
| Carex otrubae * | . | . | . | . | . | . | . | . | 7 |
| Taraxacum officinale | . | . | . | . | . | . | . | 5 | . |
| **Various plant remains** | | | | | | | | | |
| Agrostis/Poa | . | . | 2 | . | . | . | . | . | . |
| Alopecurus myosuroides/pratensis * | . | . | . | . | . | . | . | 9 | . |
| Carduus/Cirsium * | . | . | . | . | . | . | . | 1 | . |
| Carex 3stig. | . | . | . | . | 1 | . | 1 | . | . |
| Cerealia/Phragmites, culm frg | . | . | . | . | . | . | . | . | . |
| cf. Empetrum nigrum | . | . | . | . | . | . | . | . | . |
| Chenopodiaceae * | . | . | . | . | . | . | . | . | 3 |
| Malva * | . | . | . | . | . | . | . | 1 | 1 |
| Poa * | . | . | . | . | . | . | . | . | + |
| indet. | . | . | . | . | . | . | . | . | . |
| parenchymatous plant tissue | 2 frg | . | 5 frg | 3 frg | + | . | . | . | . |
| processed plant food, isolated lumps | 2 frg | . | . | . | . | 3 frg | . | . | . |

# Appendix IV: Latin, English and Dutch names of recognized botanical remains

### Latin, English and Dutch names of recognized botanical remains

| Scientific names | English names | Dutch names |
|---|---|---|
| Acer | Maple | Esdoorn |
| Agrostis | Bent Grass | Struisgras |
| Alnus | Alder | Els (G) |
| Althaea officinalis | Marsh-mallow | Echte heemst |
| Apium graveolens | Wild Celery | Selderij |
| Aster tripolium | Sea Aster | Zulte |
| Atriplex littoralis | Shore Orache | Strandmelde |
| Atriplex patula/prostrata | Common/Spear-leaved Orache | Uitstaande/Spiesmelde |
| Betula | Birch | Berk (G) |
| Bolboschoenus maritimus | Sea Club-rush | Heen |
| Brassica rapa (campestris) | field mustard | Raapzaad |
| Carduus/Cirsium | Thistle | Distel |
| Carex 3stig. | Sedge | Zegge |
| Carex acuta/elata | Slender Tufted-sedge | Scherpe-/Stijve zegge |
| Carex otrubae | Flase Fox-sedge | Valse voszegge |
| Carex riparia | Greater Pond-sedge | Oeverzegge |
| Cerealia | Cereals | Granen |
| Cerealia/Phragmites | Cereals/Reed | Granen |
| Chenopodiaceae | Fathen Family (chenopods) | Ganzenvoetfamilie |
| Chenopodium ficifolium | Fig-leaved Goosefoot | Stippelganzenvoet |
| Chenopodium glaucum/rubrum | Glaucous/Red Goosefoot | Zeegroene/Rode ganzenvoet |
| Cladium mariscus | Great Sedge | Galigaan |
| Cornus sanguinea | Dogwood | Rode kornoelje |
| Corylus avellana | Hazel | Hazelaar |
| Eleocharis palustris/uniglumis | Spike-rush | Gewone/Slanke waterbies |
| Empetrum nigrum | Crowberry | Kraaihei |
| Fraxinus excelsior | Ash | Es |
| Galium palustre | Common Marsh-bedstraw | Moeraswalstro |
| Hordeum marinum | Sea Barley | Zeegerst |
| Hordeum vulgare | Six-row Barley | Gerst |
| Hordeum vulgare var. nudum | Naked six-row barley | Naakte zesrijige gerst |
| indet. | Not identified | Niet determineerbaar |
| Juncus gerardi | Mud Rush / Salt Marsh Rush | Zilte rus |
| Malva | Mallow | Kaasjeskruid |
| Mentha aquatica/arvensis | Water Mint/Corn Mint | Watermunt/Akkermunt |
| Myosoton aquaticum | Water Chickweed | Watermuur |
| Persicaria lapathifolia | Pale Persicaria | Beklierde duizendknoop |
| Phragmites | Reed | Riet |
| Pinus | Pine | Den |
| Plantago major | Greater Plantain | Grote weegbree |
| Poa | Meadow-grass | Beemdgras |

| Scientific names | English names | Dutch names |
|---|---|---|
| Poa pratensis/trivialis | Smooth/Rough Meadow-grass | Veldbeemdgras/Ruw beemdgras |
| Polygonum aviculare | Knotgrass | Gewoon varkensgras |
| Puccinellia distans | Reflexed Saltmarsh-grass | Stomp en Bleek kweldergras |
| Quercus | Oak | Eik |
| Ranunculus lingua | Greater Spearwort | Grote boterbloem |
| Ranunculus sceleratus | Celery-leaved Crowfoot | Blaartrekkende boterbloem |
| Rhamnus cathartica | Purging Buckthorn | Wegedoorn |
| Salicornia europaea | Glasswort | Kortarige zeekraal |
| Salix | Willow | Wilg |
| Sambucus nigra | Elder | Gewone vlier |
| Sonchus asper | Prickly Sow-thistle | Gekroesde melkdistel |
| Spergularia salina | Lesser Sea-spurrey | Zilte schijnspurrie |
| Stellaria media | Chickweed | Vogelmuur |
| Suaeda maritima | Annual-seablite | Schorrenkruid |
| Taraxacum officinale | Common Dandelion | Gewone paardenbloem |
| Triticum dicoccon | Emmer | Emmer |
| Urtica dioica | Stinging Nettle | Grote brandnetel |

# Appendix V:
# The Working Environment of GIS analysis

Listed below is the computer hardware and software which was utilised within this study, this is not only listed for purposes of repeatability but it also may aid future researchers in the selection of suitable equipment for similar studies.

## Computer hardware

| Specification | Description |
|---|---|
| **Make** | HP |
| **Processor x4** | Intel(R) Core(TM)2 Quad CPU Q9400 @ 2.66GHz |
| **CPU MHz** | 1998.000 |
| **cache size** | 3072 KB |

### Software

An Ubuntu 9.04 Server Edition Operating system was utilised, the current release is freely available from www.ubuntu.com as of 15th January 2010.
Within this architecture the following programs were installed:

- GRASS GIS
- MySQL
- R
- Apache Server
- Php
- PhpMyAdmin

All are freely available for download. GRASS GIS is an open source Geographical Information System see http://grass.itc.it/ for details. MySQL was chosen for the database as the author has had previous experience with it. Furthermore it has a spatial extension which means it can connect to GRASS GIS and vice versa, it is able to be downloaded from www.mysql.com. R is a statistical package which runs using various libraries; the spgrass6 library was used to connect to the GRASS mapsets and the RMySQL library to connect to the database.

Apache server, Php and PhpMyAdmin were installed so the system could be accessed remotely, PhpMyAdmin was used to manage the database as a frontend in preference to the command line interface. Theses are available from: www.apache.org, http://php.net and www.phpmyadmin.net.

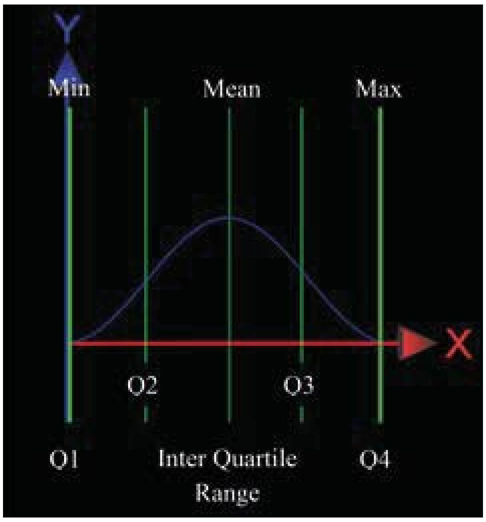
***Important basic statistics***

Various statistical terms are used within this chapter, they are briefly explained here. The **count** referees to the number of squares where remains are present. The **sum** is the quantity of these finds; the **mode** is the most common quantity. The **mean** is also known as the average, whereas the **median** is the middle number if ordered ascending or descending. The **maximum** and **minimum** values relate to the highest and lowest amount found in a square. These former statistics relate to the centrality of the data.

It is possible to measure the mathematical spread of the data, for this we use the following terms. The **range** illustrates the breath of the data values. The **quartiles** are: **Q0**, the minimum, **Q1** is the lower quartile, in a graph is the first 25% or 25th percentile, **Q2** the median or 50th percentile, **Q3** the upper quartile 75% to 100% or 75th percentile and **Q4** which is the maximum. The **inter-quartile range** represents the difference between the upper and lower quartiles (Q3-Q1). The **standard deviation** also denoted S.D. quantifies the variance of the dataset from its mean value, therefore the higher the value the more the data spreads beyond its mean.

Two further statistics are the **skewness** and **kurtosis**; these are measures of shape of the graphed data. For the former if the graph is unimodal or normally distributed around its mean then the value will be 0, if it is skewed to the right it will be positive or negative if skewed to the left. The **kurtosis** is an indicator of the peak of the graph, the higher the value the more pointed the graph will be. A fuller explanation can be found in many statistical books.[268]

These terms can cause confusion therefore




[268] De Smith *et al* 2007, 23-28; Conolly & Lake 2006, 141-143.

it is useful to relate these to the associated bar graph which is located next to each table in the datasheets. A common term which is associated with the graphs are the bin value or bins. This refers to categories of numbers, for instance if the squares contained between 50 and 100 artefacts then the total amount of animal remains will be presented within that bar of the chart.

### *Hypothesis testing*

Hypothesis testing is a method employed in statistics to accept or reject a certain hypothesis. In this case spatial randomness is the working hypothesis, also known as the null hypothesis.

In statistical analysis there are two simple concepts, the type 1 error and the type 2 error. These relate to two hypotheses, the null hypothesis and the alternative hypothesis. The null hypothesis is what would always be expected other wise an alternative hypothesis has to be sought.

In a spatial context the null hypothesis is complete spatial randomness where as the alternative would be clustering. If a significance value of 0.05 is used then there is a 5% chance of error when rejecting the null hypothesis and accepting the need of an alternative hypothesis.

## Basic Statistical Methodology

All the basic statistical characterisation was created from the data output from the GRASS GIS module r.stats and the summary function in R. All of the graphically displayed statistics relate to finds per metre square. The distribution maps, basic statistics and associated graphs are located on their datasheet's (see Appendix VI).

## Advanced Spatial Analysis Methodology

Statistics are full of scientifically meaning full words and terms which can appear alien to the non statistician, a basic concept is Tobler's first law of geography where he states:

> "Everything is related to everything else, but near things are more related than distant things."[269]

So the closer something is to something else the more related they become, this is the core principles of the following analyses. What follows is a well rounded explanation of the analyses employed in this study.

## Global Analyses

Global analysis is a way of analysing the entire site and providing a 'one method fits all' approach, it gives an overview, for instance trend surface analysis in its simplest form produces a linear high to low occurrence relationship.

### *Trend Surfaces*

These can identify the general trend of the data, simple questions like: "are more artefacts located in the north rather than the south?" can be posed. The simple form is defined as a first order trend surface; it is more akin to placing a piece of paper over the data points. As the mathematical algorithm becomes more complex the orders increase, second order, third order and so on. These more complex models bend the surface around the points, the higher the order the more localised the model.

They allow for assessment of the underlying data without prior knowledge of the spatial pattern, they are more often utilised in predictive modelling to predict the presence or absence of archaeological sites. Although they are not with out their difficulties, they approximate the space to a best fit opposed to an accurate representation of the data. Often predicted values will be greater or lower than the observed ones, Fortin and Dale state that it generates an approximate value rather than an exact interpolation.[270]

The surfaces presented later in this chapter range from a first order through to the twelfth order. It illustrates their strengths and weaknesses as the orders or polynomials increase. No statistical significance was applied to this global analysis as it was to aid in the assessment of the underlying data not as a predictor as it is more commonly used.

### *Moran's I*

Proposed in 1948 Moran's I provides a statistic which describes the distribution as dispersed, random or clustered.[271] It is notated as follows:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{j=1}^{n}(y_i - \bar{y})^2},$$

Where $\boldsymbol{w}_{ij}$ (***d***)is the binary weight matrix, 1 or 0 depending if that point (***j***) is within a defined distance (***d***) of the target point (***i***). $\mathbf{x}_i$ and $\mathbf{x}_j$ are the values at the target point (***i***) and its

[269] Tobler 1970, 236.
[270] Fortin & Dale 2009.
[271] Moran, 243-251.

neighbour (***i***). A high ***z*** score suggests clustering; a low ***z*** score suggests dispersion and at or close to zero indicates a random distribution. The ***z*** score can change depending upon which distance (***d***) is adopted.

*Getis and Ord's General G*
This statistic describes the patterning of clustering as defined by Moran's I as high, random or low values

$$G(d) = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(d)x_i x_j}{\sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j}$$

Where $\boldsymbol{w}_{ij}$ is the binary weight matrix (1 or 0) and $\boldsymbol{x}_i$ is the value of the target point (***i***) and $\boldsymbol{x}_j$ is the value of the neighbouring point (***j***) within the set distance (***d***).

These statistics measure the degree of spatial autocorrelation or dependence, it assesses whether different locations are associated. For instance a barrow in a barrow cemetery is more likely to be associated with those around it than others in another cemetery. However they do not take into account spatial-temporal autocorrelation, as demonstrated by Tan et al. with regard to ecological data.[272] This type of analysis is not applicable in this case due to the lack of temporal information.

In summary Moran's I identifies if the distribution is clustered, dispersed or random General G describes the clustering, is it high or low levels of clustering.

**Local Analysis**
As the global analysis showed signs of regional patterning more localised analysis was required to investigate them further. Unfortunately local multi-scalar spatial analysis has had little application to archaeological investigation, although it is becoming a more established technique within remote sensing and archaeological prospection. A recent study used the $G_i$*statistic, amongst others, to enhance aerial photography where crop marks were visible.[273]

These Local Indicators of Spatial Association (LISA) has had little application to archaeological distribution patterns and even less if any to intra site analysis. The most prominent group of studies are in relation to the Maya lowlands and the Classic Maya collapse.[274]. Premo notes that previous predictions of the application of spatial autocorrelation's application to archaeology have yet to be realised.[275] Years later this still appears to be the case.

*Getis and Ord's Gi**
Getis and Ord developed an analysis which can identify areas of local clustering, the so named Getis and Ord's $G_i$* statistic, it is part of the G family of statistics.[276]

$$G_i^*(d) = \frac{\sum_j w_{ij}(d)x_j}{\sum_j x_j}$$

Where ***i*** is the point of analysis and ***j*** are the neighbouring points, $\boldsymbol{w}_{ij}$ is a binary weight, 1 if within the specified distance ***d*** and 0 if beyond this distance, $\boldsymbol{x}_j$ is the sum of all the neighbouring ***j*** values.

It is able to:

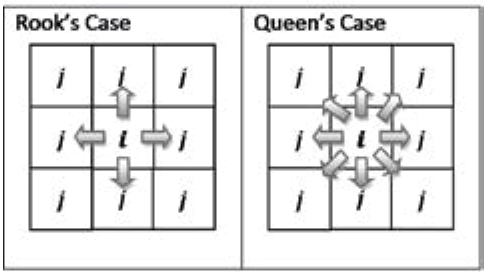
"detect local 'pockets' of [spatial] dependence that may not show up when using global statistics"[277]

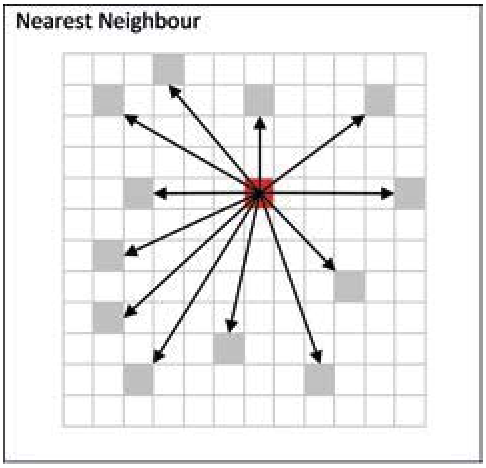
The analysis can be conducted in either Manhattan or Euclidian distance. Manhattan distance is based on a grid and can take the form of either a Rook's Case or a Queen's Case as seen in figure 2. as well as a knight's Case, the latter is not illustrated. A Euclidian distance is 'as the crow flies' point A to point B in a straight line. In the illustrated example a nearest neighbour method takes the nearest 12 cells (***j***) and generates a value for the unknown cell ***i***. In our case the method is slightly different, both ***i*** and (***j***) are known so we can use the nearest neighbours. However the method is simpler in our case, we only need the eight neighbouring cells. $G_i$* uses Euclidian distance, as the data points are at a 1m resolution (the centroid of each cell) a metre distance could be thought as a logical distance. However this would only create a Rook's Case scenario, as the data is spaced at regular intervals (1m) a Queens Case is required. Therefore we need a distance of at least 1.414 as derived from Pythagoras theorem. As illustrated in figure 4 a ***d*** of 1.414 captures every point. To ensure every point was utilised the ***d*** value was set at 1.75 to allow for any unforeseen technical peculiarities. It is a large enough distance to capture the required points but it will not select points from beyond the 3 by 3 neighbourhood.

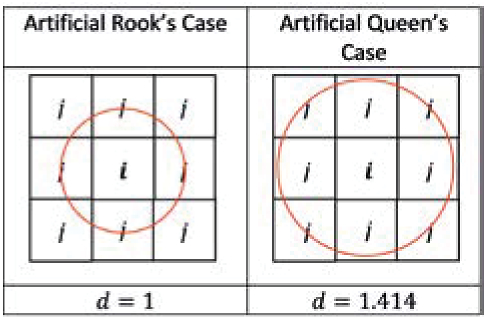
272 Tan *et al* 2001, 1-12.
273 Ciminale et al 2009.
274 Bove 1981; Whitley & Clark 1985; Kvamme 1990; Williams, 1993; Premo 2004.
275 Premo 2004, 855.
276 Getis & Ord 1992.
277 Getis & Ord 1992, 190

This distance is chosen because the underlying data is collected at metre square intervals. However this technique can be used at multiple scales to see the local and not so local clusters. For a 3x3 grid a distance of 1.75m is used, this includes all of the required points. This also is possible for a 5x5 square with a distance of 2.9m. Unfortunately this method does not extend beyond a distance of a 2 cell radius and one is left with a Rook's case scenario. Upon the near completion of this chapter and following the conclusion of the analysis a method for creating a spatial weight matrix with the conceptual spatial relationship of polygon contiguity was discovered. This is where a polygon which shares an edge or a node (boundary or corner) can be neighbours. Further licensing requirements are required in ArcGIS 9.3.1 than were available at the time of analysis. Although this still requires further investigation beyond the limits of this report. It is hoped that a Rook's Case will not alter the end result drastically but it requires further investigation. Analysis was stopped at the 7m radius as it was assumed that this would be sufficient for the local and not so local patterns due to the size of the overall study area. Initially distances of up to 16m were assessed using the animal bone data to validate this choice.

The $\mathbf{G_i}^*$ statistic returns a ***z*** and a ***p*** value; the degree to which the ***z*** value alters from the expected describes the degree of spatial dependence. If the $\mathbf{G_i}^*$ ***z*** score increases significantly beyond the expected then it can be said to be significantly clustered. If the ***z*** score decreases significantly beyond the expected then it can be said to be significantly clustered due to low values, a value at or near zero indicates no clustering. Therefore this statistic identifies areas of presence and absence in regards to the clustering of archaeological material as well as areas of clustering of absence of archaeological material. The ***p*** values indicate the probability value, a high ***z*** value and a low ***p*** value suggests clustering of high vales, a low ***z*** score and low ***p*** value suggests clustering of small values.

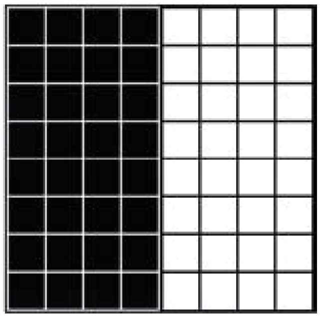


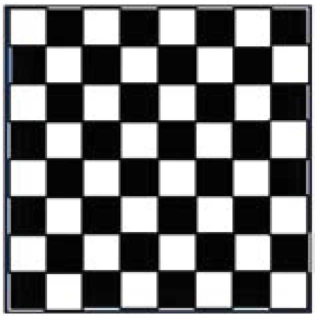



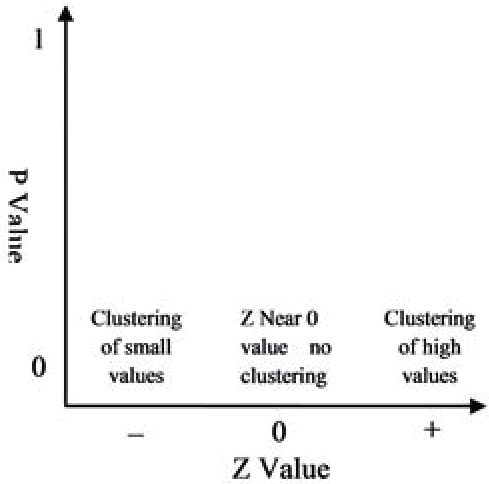




## Mathematical *d* vs utilised *d*

| ***d*** **cells** | **mathematical *d*** | **utilised *d*** |
|---|---|---|
| 1 | 1 | 1 |
| 1* | 1.414 | 1.75 |
| 2 | 2 | 2 |
| 2* | 2.828 | 2.9 |
| 3 | 3 | 3 |
| 4 | 4 | 4 |
| 5 | 5 | 5 |
| 6 | 6 | 6 |
| 7 | 7 | 7 |








*Local Moran's Ii*

Local Moran's I measures the similarity between each target value and its neighbours using the following equation:

$$I_i = (\frac{x_i}{m_2})\sum_j w_{ij} z_j$$

Where $\boldsymbol{z}_i$ and $\boldsymbol{z}_j$ are deviations from the mean of variable ***x***, $\boldsymbol{m}_2$ as defined below, as a second moment, $\boldsymbol{w}_{ij}$ is a binary weight, 1 or 0, as seen in the $\mathbf{G}_i$* statistic.

$$m_2 = \frac{\sum_i Z_i^2}{N}$$

A large positive Local Moran's $I_i$ value occurs when the target value is similar to the adjacent values. A large negative value occurs when the target value ***i*** is dissimilar to the adjacent values and approximately zero when no spatial autocorrelation exists. An idealised result is seen in figures 6 and 7. Were values are similar and large they are in this case black and where they are low and dissimilar they are white, the first figure displays clustering where as the second is dispersion.

As with the $G_i$* statistic the Local Moran's $I_i$ statistic was generated in ArcGIS 9.3.1 again only a Rook's case or Euclidian distance was possible, therefore the same spatial lags (or distances) were used as seen in figure 4 for both consistency and methodology as discussed earlier. Row standardisation was not applied. Although only briefly outlined here the $G_i$* and $I_i$ statistics may seem similar but they are different. $G_i$* is a relative measure of the sum of the target values in the neighbourhood, including the target value itself. $I_i$ measures the degree to which the target value is similar or dissimilar to the targets neighbourhood.

Luc Anselin compares the two techniques and offers a concise comparative description:

"Note that the two statistics measure different concepts of spatial association. For the $G_i$* statistic, a positive value indicates a spatial clustering of high values, and a negative value a spatial clustering of low values, while for $I_i$, a positive value indicates spatial clustering of similar values (either high or low), and negative values a clustering of dissimilar values (for example, a location with high values surrounded by neighbours with low values)"[278]

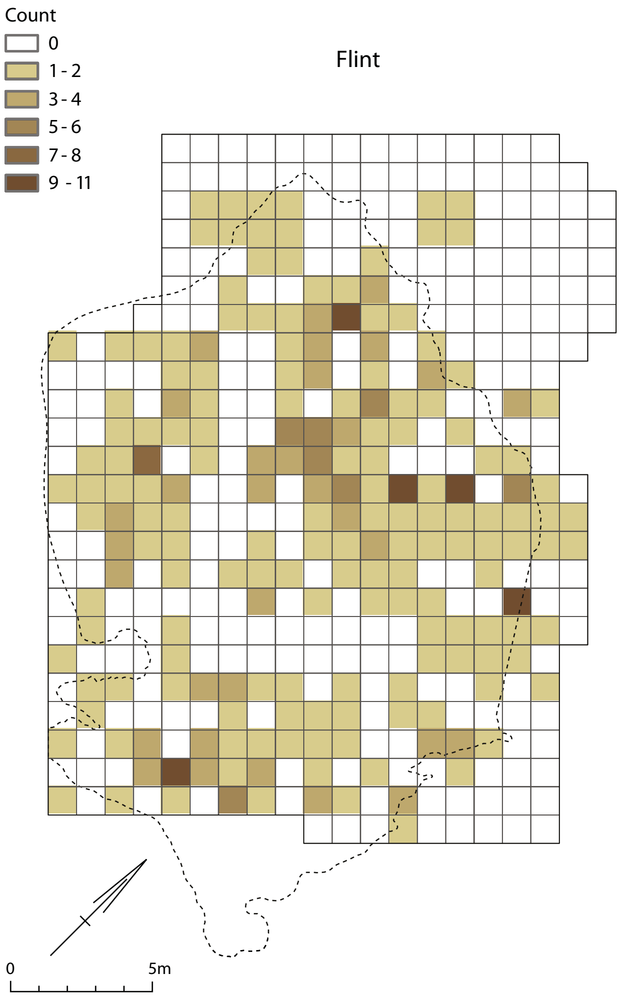
These local statistics have never been applied to intra site analysis even though they help answer many questions which archaeologists regularly ask of their datasets. As seen in the spatial analysis chapter of the Schipluiden site report archaeologists tend to favour visual inspection of results.[279] Therefore the results will be presented visually but with quantification.

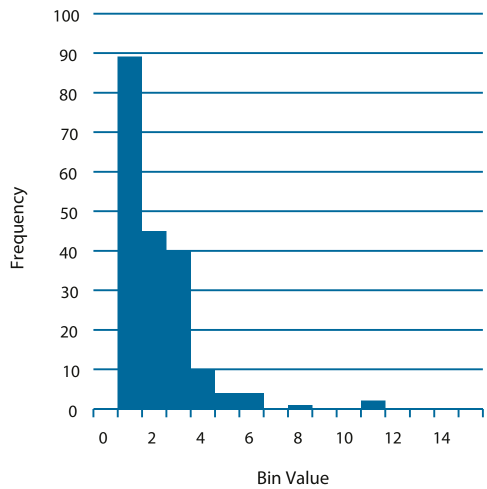
278 Luc Anselin 1995, 102.
279 Wansleeben & Kooijmans 2006.

# Appendix VI: Datasheets

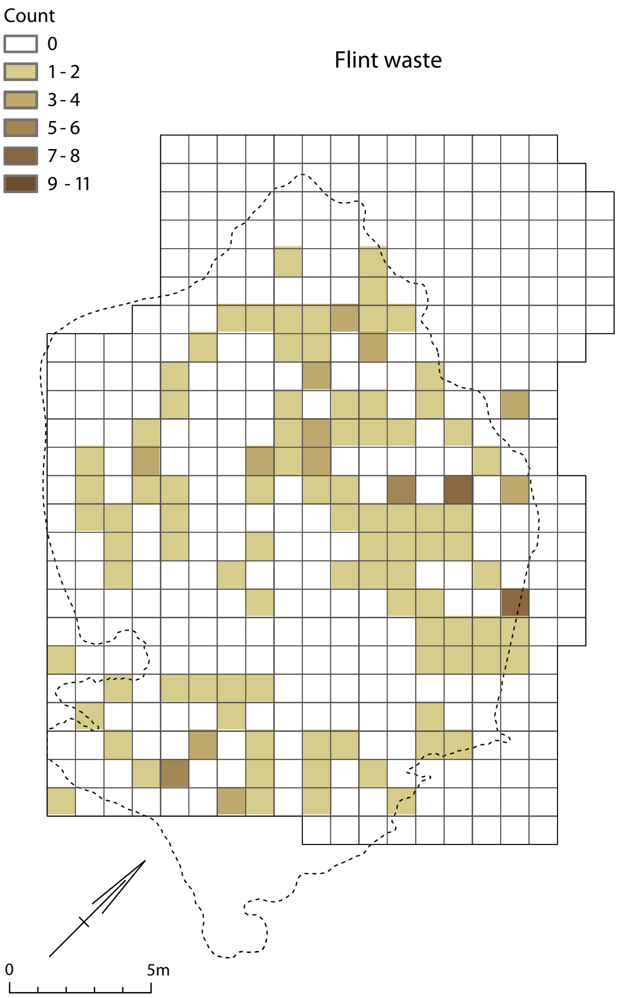
In this appendix thee datasheets of all the archeological remains which have been subject to spatial analysis are presented.

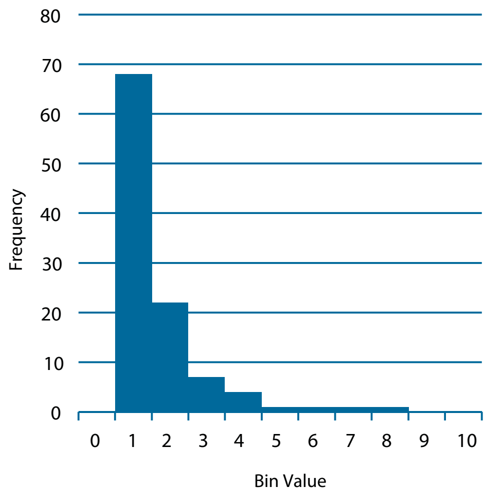
‘Count’ means count of squares
‘Max’ means maximum
‘Min’ means minimum
‘Std’ means standard deviation
‘Inter’ means interquartile range
‘Skew’ means skewness
‘Kurt’ means kurtosis



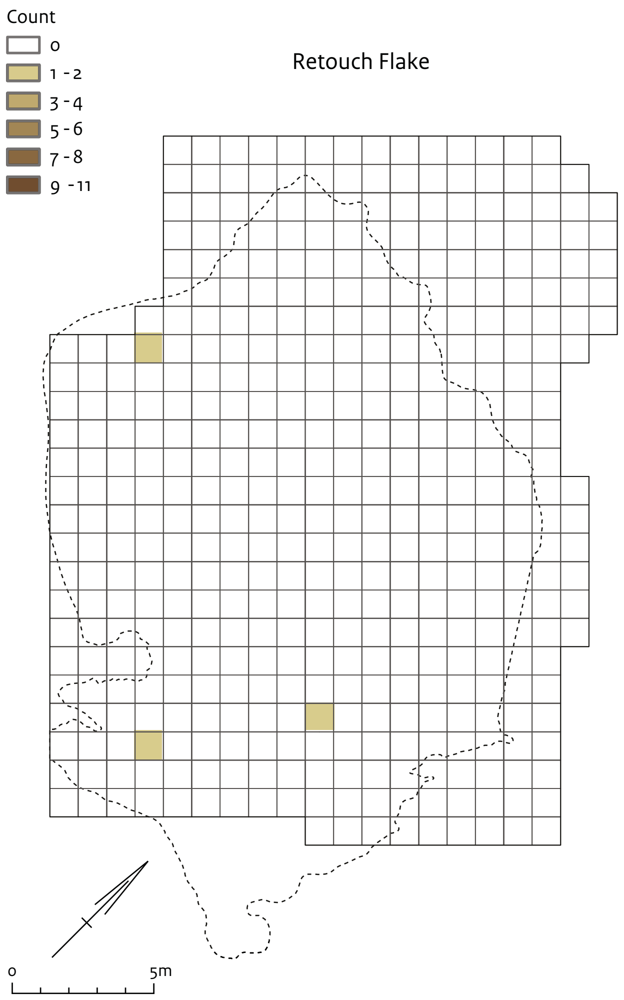



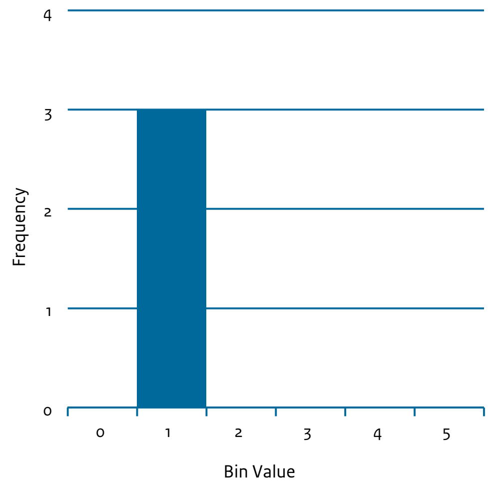

| Statistic | Result |
|---|---|
| Count | 195 |
| Sum | 413 |
| Mode | 1 |
| Mean | 2.12 |
| Median | 2 |
| Min | 1 |
| Max | 11 |
| Range | 10 |
| Std | 1.55 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 2 |
| Q3 | 3 |
| Q4 | 11 |
| Inter | 2 |
| Skew | 2.68 |
| Kurt | 10.99 |



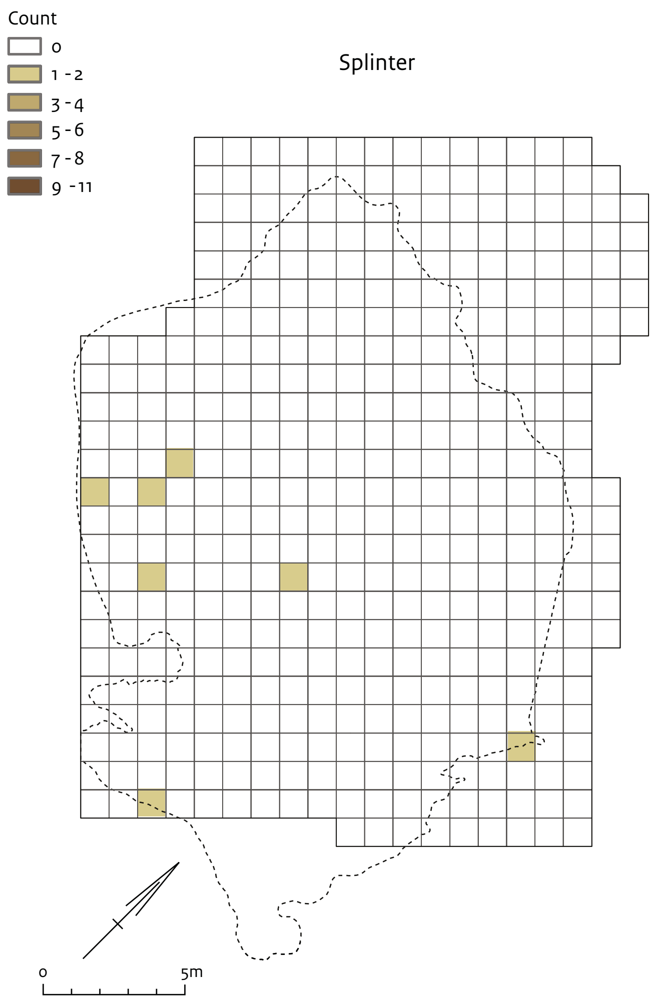



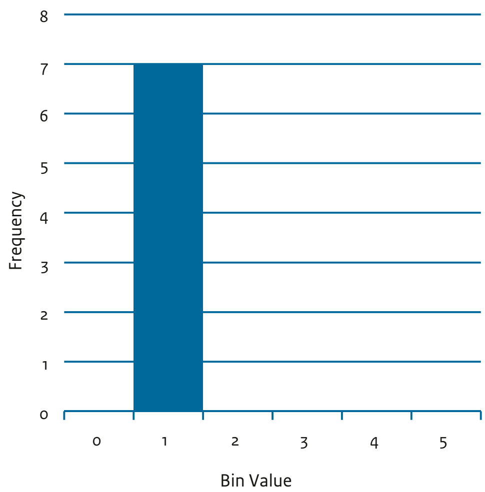

| Statistic | Result |
|---|---|
| Count | 105 |
| Sum | 175 |
| Mode | 1 |
| Mean | 1.67 |
| Median | 1 |
| Min | 1 |
| Max | 8 |
| Range | 7 |
| Std | 1.26 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 1 |
| Q3 | 2 |
| Q4 | 8 |
| Inter | 1 |
| Skew | 2.80 |
| Kurt | 9.20 |



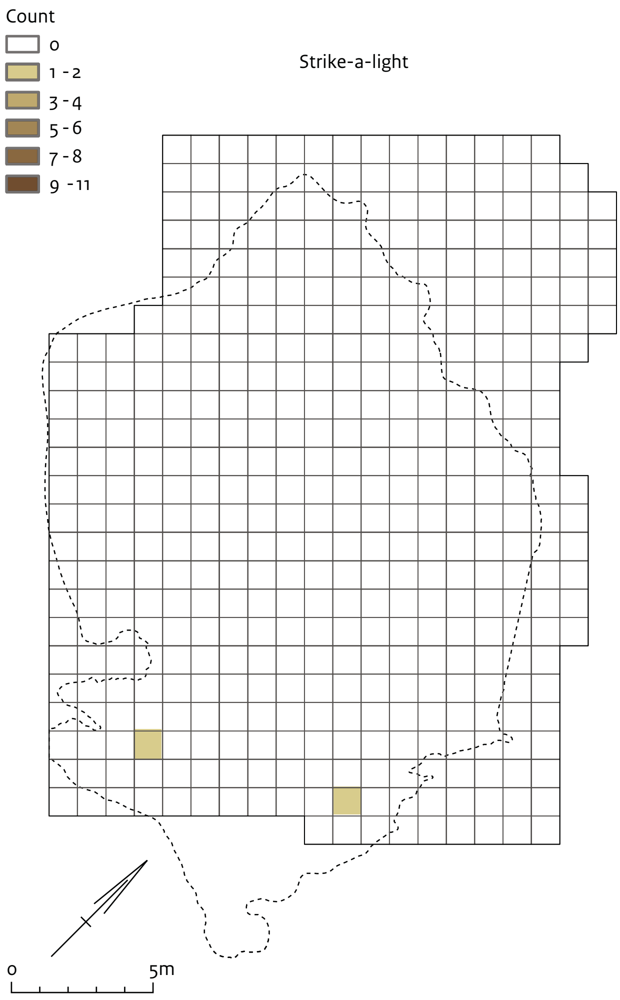



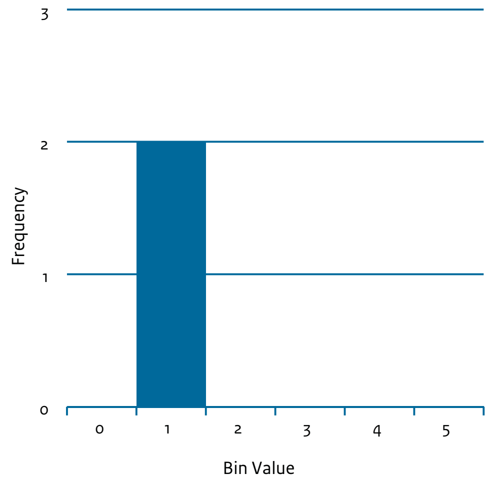

| Statistic | Result |
|---|---|
| Count | 3 |
| Sum | 3 |
| Mode | 1 |
| Mean | 1 |
| Median | 1 |
| Min | 1 |
| Max | 1 |
| Range | 0 |
| Std | 0 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 1 |
| Q3 | 1 |
| Q4 | 1 |
| Inter | 0 |
| Skew | - |
| Kurt | - |



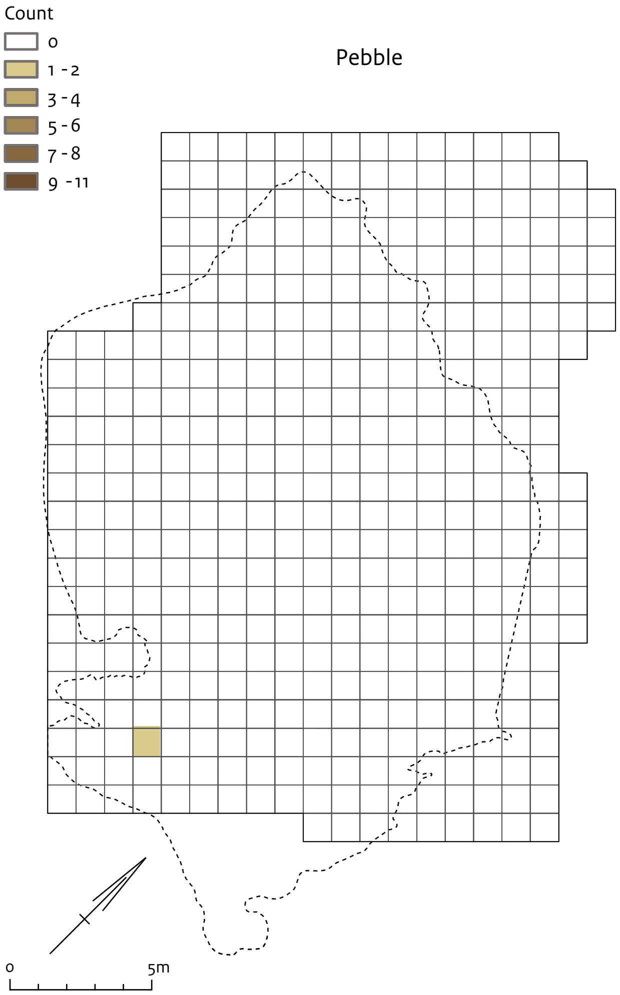



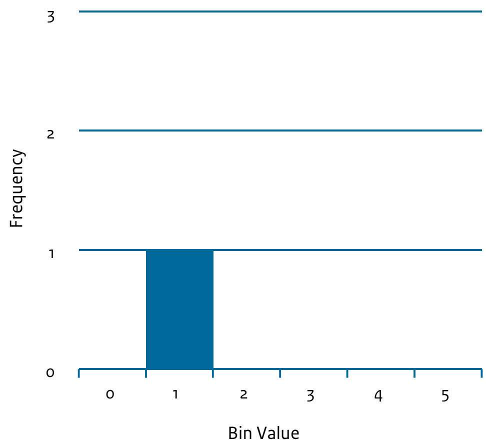

| Statistic | Result |
|---|---|
| Count | 7 |
| Sum | 7 |
| Mode | 1 |
| Mean | 1 |
| Median | 1 |
| Min | 1 |
| Max | 1 |
| Range | 0 |
| Std | 0 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 1 |
| Q3 | 1 |
| Q4 | 1 |
| Inter | 0 |
| Skew | - |
| Kurt | - |



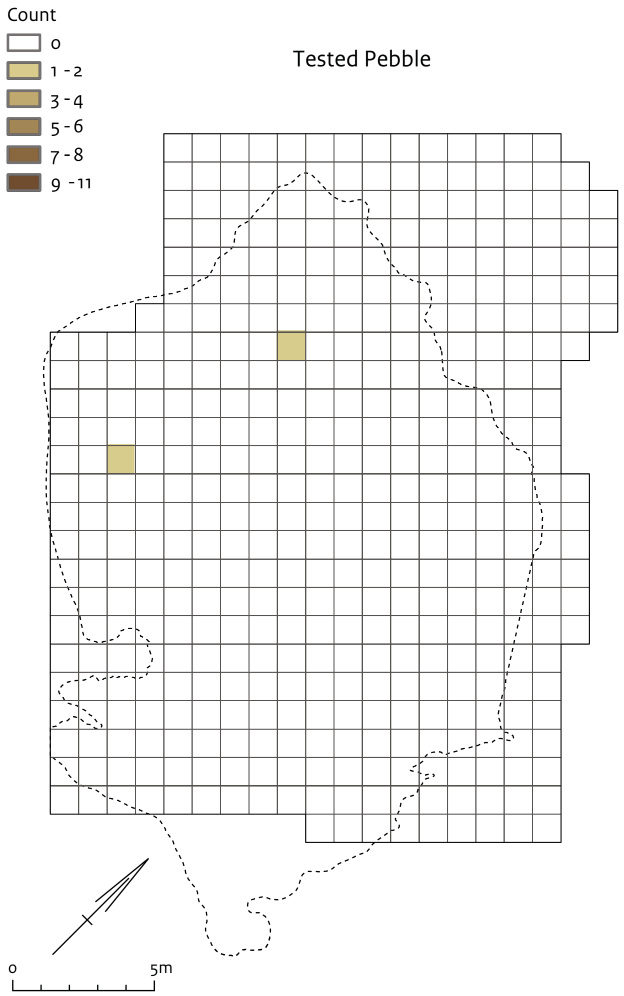



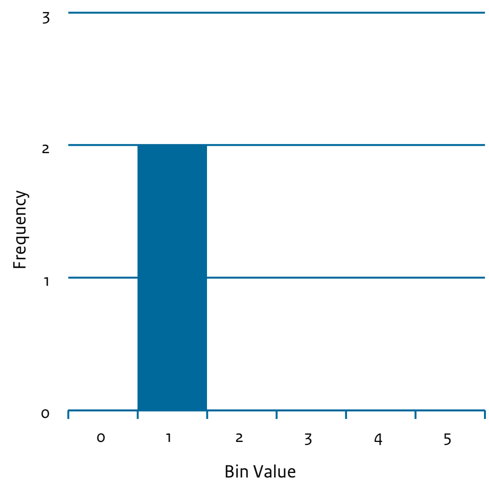

| Statistic | Result |
|---|---|
| Count | 2 |
| Sum | 2 |
| Mode | 1 |
| Mean | 1 |
| Median | 1 |
| Min | 1 |
| Max | 1 |
| Range | 0 |
| Std | 0 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 1 |
| Q3 | 1 |
| Q4 | 1 |
| Inter | 0 |
| Skew | - |
| Kurt | - |



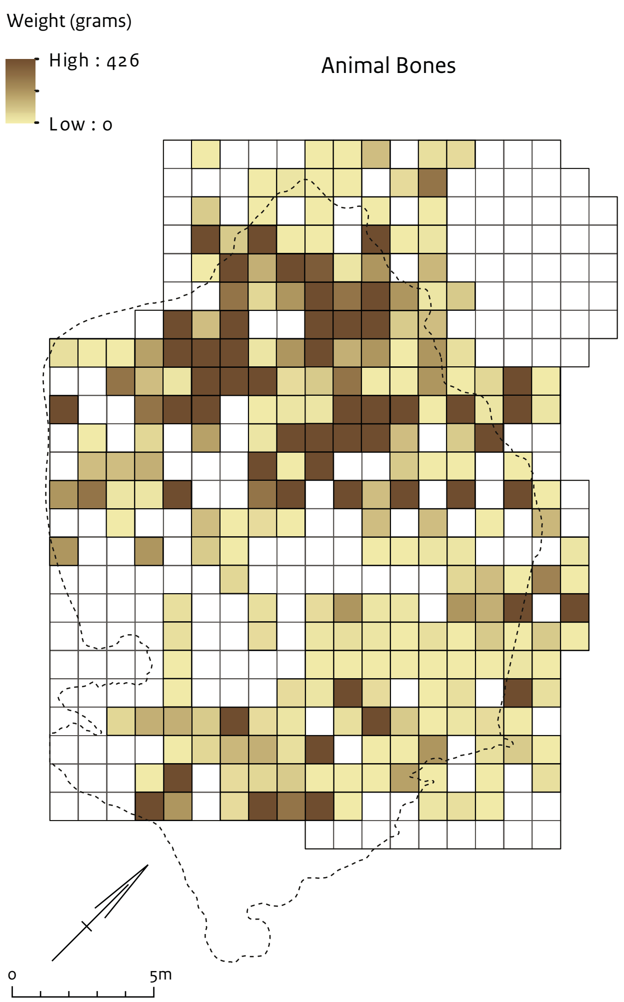



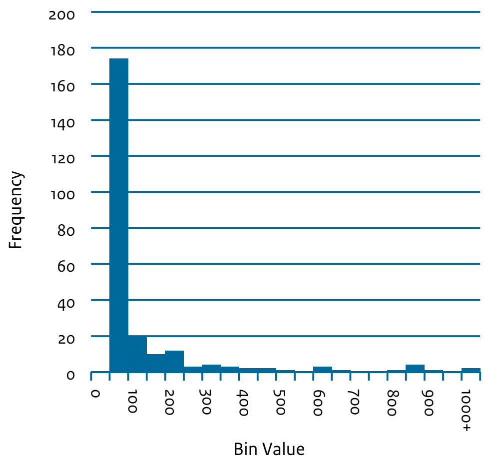

| Statistic | Result |
|---|---|
| Count | 1 |
| Sum | 1 |
| Mode | - |
| Mean | 1 |
| Median | 1 |
| Min | 1 |
| Max | 1 |
| Range | 0 |
| Standard Deviation | - |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 1 |
| Q3 | 1 |
| Q4 | 1 |
| Interquartile Range | 0 |
| Skewnes | - |
| Kurt | - |



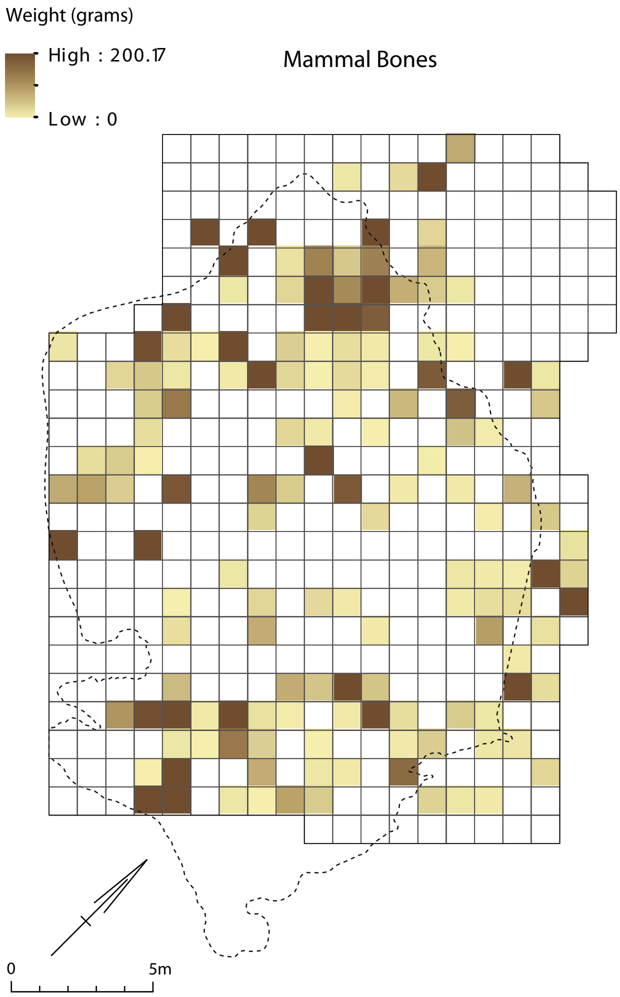



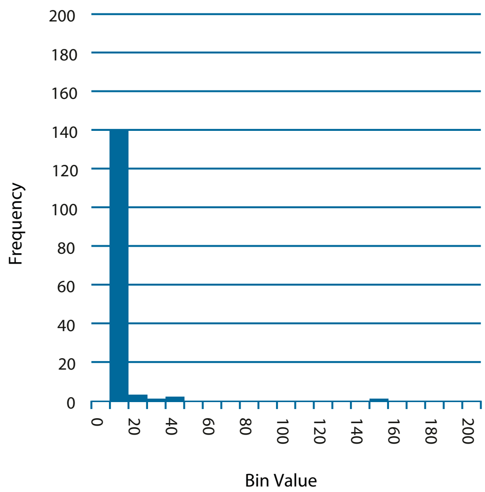

| Statistic | Result |
|---|---|
| Count | 2 |
| Sum | 2 |
| Mode | 1 |
| Mean | 1 |
| Median | 1 |
| Min | 1 |
| Max | 1 |
| Range | 0 |
| Std | 0 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 1 |
| Q3 | 1 |
| Q4 | 1 |
| Inter | 0 |
| Skew | - |
| Kurt | - |



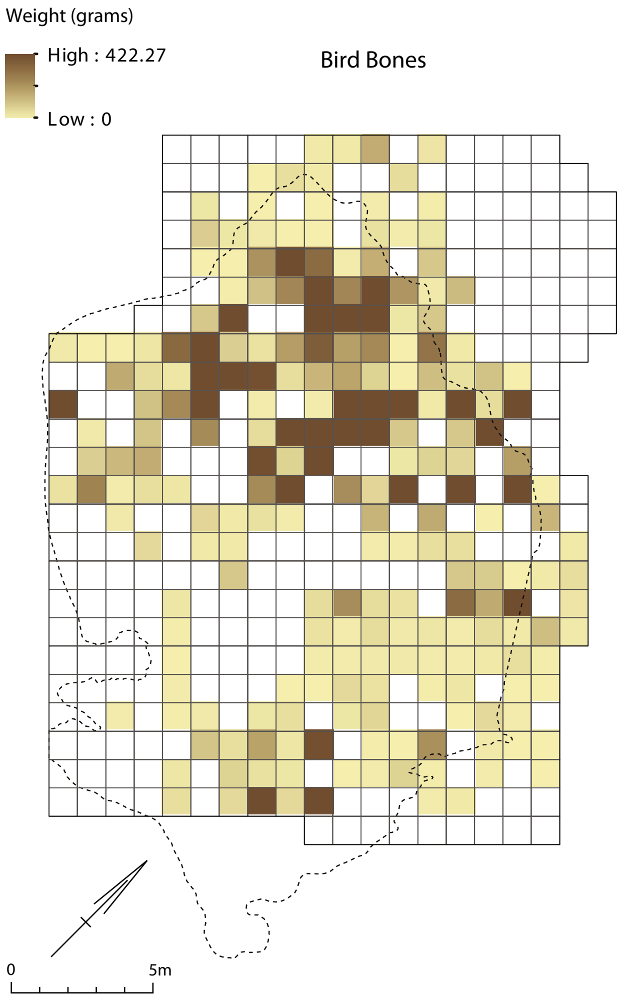



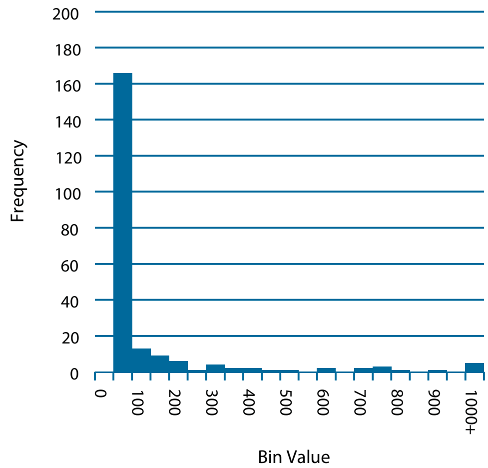

| Statistic | Result |
|---|---|
| count | 243 |
| sum | 29820 |
| mode | 1 |
| mean | 91.78 |
| median | 15 |
| max | 1977 |
| min | 1 |
| range | 1976 |
| std | 214.91 |
| quartiles | |
| | 1 |
| | 4 |
| | 15 |
| | 61 |
| | 1977 |
| inter | 57 |
| skew | 4.66 |
| kurt | 29.07 |



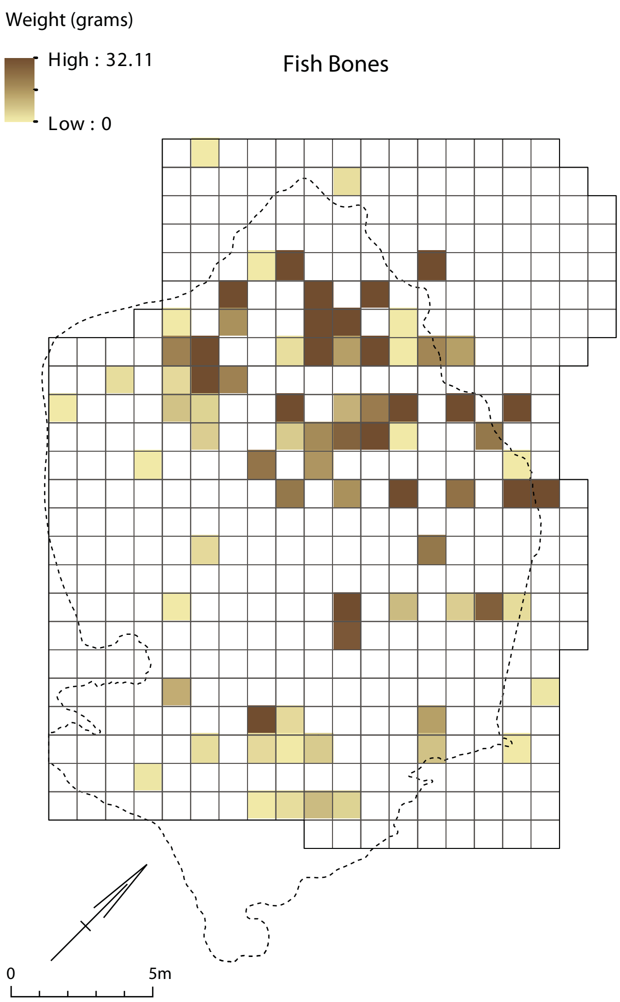



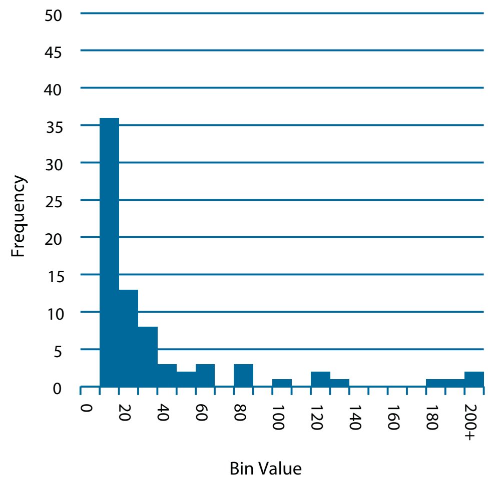

| Statistic | Result |
|---|---|
| Count | 146 |
| Sum | 524 |
| Mode | 1 |
| Mean | 4.44 |
| Median | 2 |
| Max | 146 |
| Min | 1 |
| Range | 145 |
| Std | 12.80 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 2 |
| Q3 | 4 |
| Q4 | 146 |
| Inter | 3 |
| Skew | 9.63 |
| Kurt | 104.40 |



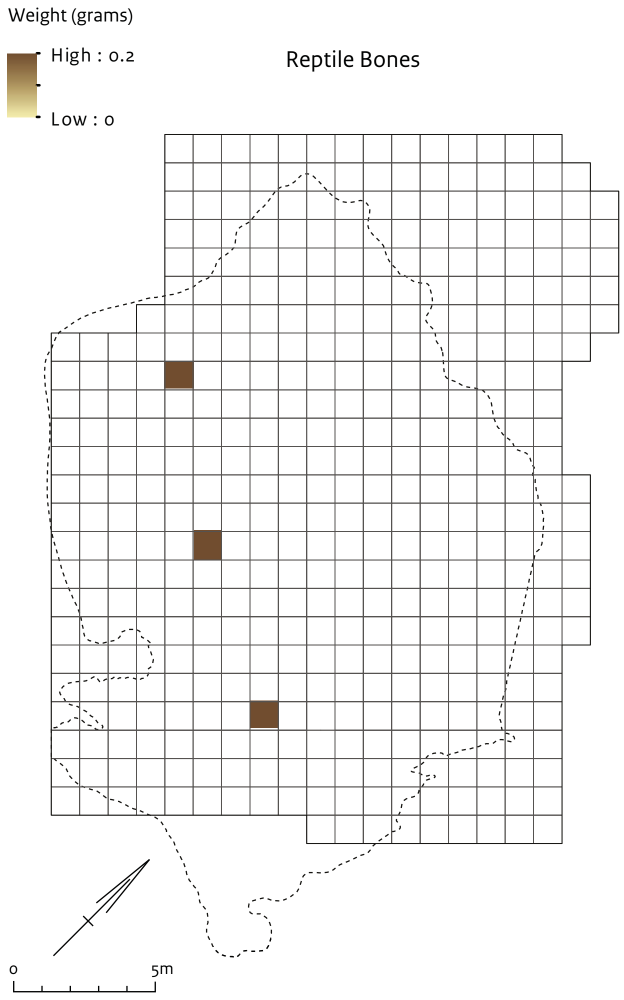



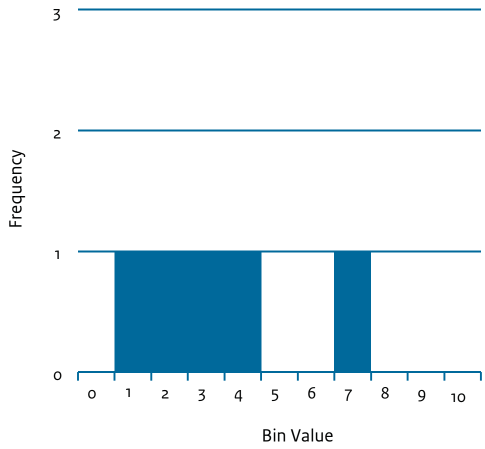

| Statistic | Result |
|---|---|
| Count | 218 |
| Sum | 25302 |
| Mode | 1 |
| Mean | 98.74 |
| Median | 12 |
| Max | 1952 |
| Min | 1 |
| Range | 1951 |
| Std | 247.83 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 4 |
| Q2 | 12 |
| Q3 | 45 |
| Q4 | 1952 |
| Inter | 41 |
| Skew | 4.15 |
| Kurt | 20.63 |



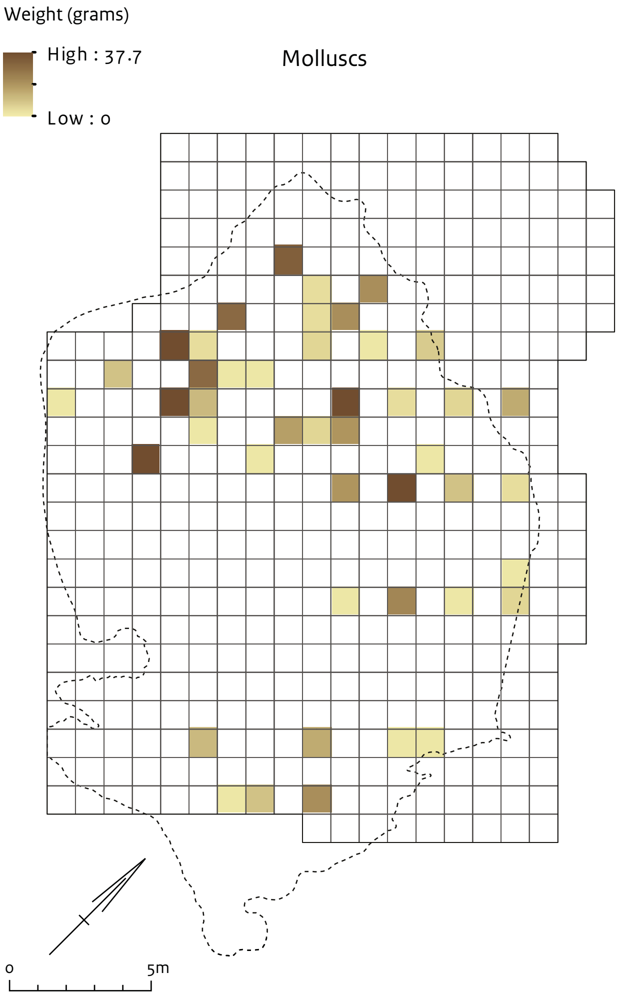



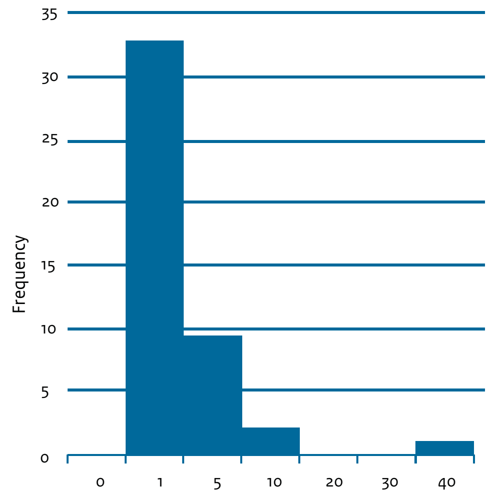

| Statistic | Result |
|---|---|
| Count | 75 |
| Sum | 2690 |
| Mode | 1 |
| Mean | 33.30 |
| Median | 13 |
| Max | 375 |
| Min | 1 |
| Range | 374 |
| Std | 59.90 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 3 |
| Q2 | 13 |
| Q3 | 30 |
| Q4 | 375 |
| Inter | 27 |
| Skew | 3.55 |
| Kurt | 15.33 |




| Statistic | Result |
|---|---|
| Count | 3 |
| Sum | 3 |
| Mode | 1 |
| Mean | 1.5 |
| Median | 1 |
| Max | 3 |
| Min | 1 |
| Range | 2 |
| Std | 1 |
| Quartiles | |
| Q0 | 1 |
| Q1 | 1 |
| Q2 | 1 |
| Q3 | 1.5 |
| Q4 | 3 |
| Inter | 0.5 |
| Skew | 2 |
| Kurt | 4 |




| Statistic | Result |
|---|---|
| Count | 45 |
| Sum | 78.4 |
| Mode | 0.1 |
| Mean | 1.74 |
| Median | 0.4 |
| Min | 0.1 |
| Max | 37.7 |
| Range | 37.6 |
| Std | 5.68 |
| Quartiles | |
| Q0 | 0.1 |
| Q1 | 0.1 |
| Q2 | 0.35 |
| Q3 | 1.05 |
| Q4 | 37.7 |
| Inter | 0.95 |
| Skew | 6.05 |
| Kurt | 38.55 |

The analysis of the Keinsmerbrug site, excavated in 1986, was the first step in our research within the framework of the Odyssey project 'Unlocking Noord-Holland's Late Neolithic Treasure Chest: Single Grave Culture behavioural variability in a tidal environment'. The limited scale of the excavation made Keinsmerbrug an excellent choice, serving as a test case for the approach within the project Single Grave Project. In order to unlock and integrate cultural/ecological information and research data, a group of specialists worked together. In this volume the new results and interpretations are presented. The analyses show that Keinsmerbrug was a temporarily occupied settlement, used occasionally or perhaps even only seasonally within the time span of 2580-2450 cal BC. The main period of use – probably consisting of several episodes of short-term use – occurred from spring to autumn. The site of Keinsmerbrug is interpreted as a non-residential settlement: a gathering settlement in the broadest sense of the word, for the gathering of people and resources (special activity site).

This scientific report is intended for archaeologists, as well as for other professionals and amateur enthusiasts involved in archaeology.

The Cultural Heritage Agency provides knowledge and advice to give the future a past.