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A Mosaic of Habitation at Zeewijk (the Netherlands)

Late Neolithic Behavioural Variability in a Dynamic Landscape

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E.M. Theunissen, O. Brinkkemper, R.C.G.M. Lauwerier,
B.I. Smit & I.M.M. van der Jagt (eds)

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Preface

In 2008, Drenth *et al.* published a paper on Single Grave Culture settlements in the Netherlands. In their conclusions, they drew attention to the numerous sites that had not yet been fully analysed and published, pointing out that 'these sites will generate new and important information about a fascinating era from our prehistory without anyone needing to pick up a spade'.[1] Now, six years later, our project 'Unlocking Noord-Holland's Late Neolithic treasure chest: Single Grave Culture behavioural variability in a tidal environment' has filled an important gap in our knowledge, with the analysis and publication of three sites: Keinsmerbrug, Mienakker and Zeewijk. These results have been achieved thanks to the Odyssey programme funded by the Netherlands Organisation for Scientific Research and the Ministry of Education, Culture and Science,

The publication before you focuses on the Zeewijk site, excavated in three campaigns in 1992, 1993 and 1994. Only 15-20% of this very large site was uncovered, but it nevertheless yielded many finds and numerous features (postholes, cow hoofprints and ard marks, occurring over a large area of about 1 ha). Zeewijk became renowned for the discovery of a large enigmatic structure with wooden stumps that were extremely well preserved. The publication of this ceremonial structure twenty years ago made Zeewijk famous among archaeologists abroad.

Unlocking Zeewijk was quite a different matter from re-examining the fairly small sites at Keinsmerbrug and Mienakker. The large size and huge quantity of finds, the fact that the area was only partially excavated and the potential for sample selection within the project made for very different conditions, but the new results and interpretations make Zeewijk just as fascinating.

The five years spent tackling the backlog in the analysis and publication of three important sites presented us with a serious challenge. However, this was above all a very pleasant journey, working closely together in a team with all kinds of specialists from different institutions and companies to reveal as much as possible about the Late Neolithic communities in the northwestern Netherlands. The final result of this close collaboration is an intriguing new story of Late Neolithic life at Zeewijk, which in many ways differs from Keinsmerbrug and Mienakker.

This unlocked trio shows that a lot can indeed be done without picking up a spade, but there are still numerous aspects to be explored. In a way, it is a great comfort that the treasure chest still holds so much to be discovered.

Thanks to all who took part in this project for their efforts and cooperation, and we hope our readers enjoy perusing this book on Zeewijk.

The editors

1 Drenth, Brinkkemper & Lauwerier 2008, 175.

Content

Summary

A mosaic of habitation at Zeewijk

The third and final excavation analysed in further detail as part of the Odyssey ‘Unlocking Noord-Holland's Late Neolithic Treasure Chest’ project was that performed at the Zeewijk site in 1992, 1993 and 1994. Zeewijk, named after a farm established by the first colonists of the Groetpolder, was regarded as a very promising site, but also a challenging one, considering the huge backlog. The large size and very high quantity of finds, the fact that the area was only partially excavated and the potential for sample selection within the project meant that the narrative capacity of Zeewijk was of a different order.

At Zeewijk, two large areas of cultural layer were distinguished in the 1980s, referred to as Zeewijk-West and Zeewijk-West. Both proved to be located on the sandy levees along a filled creek gully. About 15-20% was excavated, distributed among East and West and over three campaigns. In 1992, a large feature with a wooden post was found at Zeewijk-East and in 1993 it became clear that it belonged to remarkable large structure measuring 22 by 7 m. At Zeewijk-West, the number of features is very high, especially on the highest parts of the levee. In this area five possible house plans were recognised. These buildings vary from approx. 6 to 14 m in length and are approx. 3.5 to 4.5 m wide. Based on the preliminary results from the analyses of the 1992 campaign and interpretation of the large structure, the Zeewijk site was interpreted at the time as a large, more permanent residential settlement.

All kinds of specialists worked closely together to reveal all the cultural/ecological details and other research data, and to thoroughly integrate all the information, focusing on the same research questions as those addressed in the analysis of Keinsmerbrug and Mienakker. The project team consisted of 16 people working at different organisations (commercial agencies, universities and the Cultural Heritage Agency), each of whom contributed their own particular expertise.

Due to the sampling strategy during the excavation campaigns, the selection during our project and some missing find categories, the spatial analysis of the find distributions and posthole clusters was very limited. No clear structures were identified. The numerous postholes, cow hoofprints and ard marks (occurring over a large area measuring about 1 ha) suggest a large settlement area with farmland. All human activities seemed to be arranged in a mosaic pattern: habitation, ploughing, growing crops on small arable fields and raising cattle all occurred simultaneously, successively (all year round) and shifting spatially. Differences in the ceramic assemblage point to different episodes of occupation. Based on typochronological arguments, Zeewijk-East and the northern part of Zeewijk-West can be seen as the earliest phase, perhaps contemporaneous, while the southern part of Zeewijk-West is the latest. In this sequence, the construction of the large structure of Zeewijk-East, cutting through the numerous ard marks and the tearing down of this building and reuse of the wood from the wall posts could have been the final act on the eastern side of the gully. Habitation in the southern part of Zeewijk-West continued, while Zeewijk-East was used for activities other than habitation, or may have been abandoned. The central posts of the large structure remained visible for some time after.

The settlers of Zeewijk chose as their settlement site two sandy ridges separated by an active gully in a varied, fairly open

environment. The levees were covered with plants, shrubs and trees such as willow, alder, ash, bird cherry and field maple. The low-lying parts of these saline and brackish wetlands are more open, with a great diversity of grasses and herbaceous plants, making ideal pasture for cattle. Although this landscape is dominated by marine influences, there are also places at or near the settlement were fresh water accumulates and where beavers lived.

The people of Zeewijk were experienced in different fishing techniques that enabled them to exploit the abundant waters of the tidal creeks. They were able to catch large and small fish, probably with traps, weirs or fences. The large numbers of ducks and geese were probably caught in the moulting period. Beaver were also hunted, as well as other fur animals like stoat, brown bear and wildcat, although these hides could have been passed on as exchanged goods. The hunting of wild boar played a minor but not insignificant role. Cattle were by far the most important food source in terms of meat supply. The abundance of cow hoofprints shows the importance of keeping cattle close by. Though sheep/goats, pigs and dog did forage around the settlement, they were not eaten as frequently. The inhabitants also occasionally harvested food at low tide from the extensive mussel banks in tidal gullies and on sandbanks.

Naked barley and emmer wheat were both grown, as was flax, for its oil-bearing seeds and for its fibres. The farmers brought complete ears of barley and wheat to the settlement, possibly with the stalks still attached. Cultivation was probably small-scale and intensive. The small fields were located on the levees, close to the houses. Cereals were ground, pounded and processed into two types of porridge-like food, one made of coarsely crushed cereals, while the other was a compact, mushy food of finely ground grain. The consumption of acorns was also an important food source. Thin-walled beakers were used to cook the cereals and/or acorns into thick porridge or soup. Charred residue on a ceramic plate fragment indicates that it was used as a griddle. Zeewijk is the first Dutch prehistoric site where use of ceramic plates for baking has been demonstrated.

Stone, flint and amber were collected on the nearby beach or on the higher boulder clay outcrop at Wieringen, where the raw material lay on the surface. Jet could also be found on the nearby beach, but it may also have been obtained by exchange. The southern flint was evidently obtained via long-distance networks. The inhabitants used the flint to make all kinds of tools, including borers and scrapers, which they used for working wood, cleaning skins, scraping fish scales, cutting fish skins/cattle hides and making amber beads. Evidence of craftsmanship is more apparent than at Mienakker. The production of amber ornaments, and maybe of bone beads and 'ripples', spinning and weaving were all activities performed at the site.

Zeewijk is regarded as a large domestic settlement, occupied all year round. We would characterise Zeewijk as a mosaic-like palimpsest, reflecting recurrent habitation alternating with agrarian activities. The local crafts, the large variety in ceramics and the construction and use of the large ceremonial building in East suggests that different groups of Corded Ware households lived at Zeewijk. In our view, this was a community of several families related by kinship both genetic and affinal. How many domestic social units lived there simultaneously or in successive generations is unclear, but the settlers of Zeewijk indisputably knew how to live in this environment.

Samenvatting

Zeewijk, een mozaïek van bewoning

De derde en laatste opgraving die in het kader van het Odyssee-project 'Het openen van de laat-neolithische schatkist van Noord-Holland' is uitgewerkt, is de vindplaats Zeewijk, vernoemd naar de nabijgelegen boerderij van de eerste bewoners van de Groetpolder. Op deze locatie vonden drie opgravingscampagnes plaats, in 1992, 1993 en 1994. Zeewijk werd door het projectteam gezien als een bijzondere vindplaats; groot en vondstrijk, maar ook als een uitdaging vanwege de grote achterstand in uitwerking. Bovendien was de vindplaats slechts gedeeltelijk onderzocht (15-20%). Dit in combinatie met de steekproefselecties binnen het project maakt dat het verhalend vermogen van Zeewijk een andere is dan die van Keinsmerbrug of Mienakker. Het verhaal over Zeewijk is dan ook een voorzichtige vertelling, met meer slagen om de arm.

Booronderzoek in de jaren tachtig wees uit dat de vindplaats Zeewijk bestond uit twee gebieden waar een cultuurlaag aanwezig was. Deze locaties zijn Zeewijk-West en Zeewijk-Oost genoemd. Beide bleken gesitueerd op de oeverwallen van een kreekrug, ter weerszijden van een opgevulde restgeul. Tijdens de opgravingscampagne van 1992 ontdekten de opgravers een houten bekapte staander in Zeewijk-Oost. De campagne van 1993 wees uit dat deze onderdeel uitmaakte van een opmerkelijk grote structuur, met een lengte van 22 en een breedte van 7 meter. In Zeewijk-West was het aantal paalsporen hoger, vooral op de hoogste delen van de oeverwal. Daarin werden vijf mogelijke (huis-)plattegronden herkend, met een lengte van ca. 6 tot 14 meter en een breedte van ca. 3,5 tot 4,5 meter. Op basis van deze resultaten werd Zeewijk destijds bestempeld als een grote, residentiële nederzetting.

Om alle culturele en ecologische onderzoeksdata zorgvuldig te ontsluiten en goed met elkaar te integreren, werkten allerlei specialisten weer nauw samen, vanuit dezelfde onderzoeksvragen als bij het onderzoek van Keinsmerbrug en Mienakker. Het projectteam bestond uit 17 personen met elk hun eigen expertise, werkend vanuit verschillende instanties (bedrijven, universiteiten en de Rijksdienst voor het Cultureel Erfgoed).

Vanwege de selecties die gemaakt zijn, eerst in het veld en daarna bij de uitwerking, en het ontbreken van bepaalde vondstcategorieën, waren de mogelijkheden voor de ruimtelijke analyse van de vondsten en paalspoorclusters beperkt en konden geen nieuwe structuren worden herkend. De vele paalsporen, runderhoefindrukken en ploegkrassen (in een gebied van minimaal 1 ha) wijzen op een groot nederzettingsterrein met akkerland. De door de mens uitgevoerde activiteiten zijn op een mozaïekachtige wijze ruimtelijk verdeeld en gestapeld; wonen, ploegen, gewassen telen op kleine moestuinachtige akkers, veehouden, alles gebeurde tegelijkertijd, opeenvolgend (het gehele jaar rond) en wisselend van locatie.

Verschillen in het aardewerkassemblage wijzen op verschillende gebruiksfasen. Op basis van typochronologische argumenten worden Zeewijk-Oost en het noorden van Zeewijk-West als de oudste fasen beschouwd. De grote houten structuur van Zeewijk-Oost oversnijdt de vele ploegkrassen op die locatie en vormt de laatste fase van het gebruik van de oostelijke zone. Het ontmantelen van deze structuur en het hergebruik van de hout van de wandpalen markeren de laatste handeling. De houten staanders in de centrale as van de grotendeels afgebroken grote structuur bleven in ieder geval lange tijd zichtbaar. Het zuidelijke deel van Zeewijk-West is de jongste bewoningsfase. De bewoning duurde daar voort terwijl aan de oostelijke zijde van de geul het gebied voor andere activiteiten werd gebruikt of was verlaten.

De eerste bewoners van Zeewijk kozen als vestigingsplek twee wat hogere, zandige kwelderruggen uit, die van elkaar gescheiden werden door een actieve geul. De omgeving was vrij open, maar de ruggen waren begroeid met planten, struiken en bomen als de wilg, els, es, vogelkers en Spaanse aak. De laaggelegen delen van de zoute tot brakke wetlands waren meer open. Daar groeide een grote verscheidenheid

aan grassen en kruidachtige planten, dit waren ideale graaslanden voor vee.
Ofschoon dit landschap werd gedomineerd door mariene invloeden, waren er ook plekken in de directe omgeving van de nederzetting waar zoet water aanwezig was en waar bevers en zoetwatervissen voorkwamen. De bewoners hanteerden verschillende vistechnieken om zo de waterrijke omgeving te exploiteren. Ze wisten, gebruikmakend van bijvoorbeeld vallen, fuiken en visweren, zowel grote als kleine vissen te vangen. Ook de grote, uitgestrekte mosselbanken in de getijdengeulen en op de zandplaten werden bij eb af en toe bezocht. De grote hoeveelheden eenden en ganzen zijn vermoedelijk in de ruiperiode gevangen, in juli of augustus. Daarnaast werd gejaagd op bevers, en mogelijk ook op andere dieren met een harige vacht, zoals hermelijn, bruine beer en wilde kat. Het wilde zwijn duikt ook op in het dierlijk botassemblage van Zeewijk. De jacht op dit dier was niet intensief, maar is wel duidelijk aantoonbaar. Hoewel er gejaagd werd, waren runderen de voornaamste voedselbron in termen van vleesvoorziening. De grote hoeveelheid hoefafdrukken van runderen geeft het belang aan van de veehouderij dicht bij huis. Schapen/geiten, varkens en honden werden ook gehouden op de nederzetting, maar werden minder vaak gegeten.
Op de akkers stond naakte gerst en emmertarwe, evenals vlas, voor oliehoudende zaden en voor de vezels. De boeren brachten de complete aren, misschien wel met stengel en al, naar de nederzetting. De verbouw van deze gewassen werd waarschijnlijk uitgevoerd op kleinschalige, intensieve wijze. De akkers waren gelegen op de oeverwallen, dicht bij de huizen. De granen werden verpulverd en gemalen en verwerkt tot in ieder geval twee verschillende papachtige maaltijden: een pap van grof gemalen granen en een andere compacte variant van fijngemalen meel. Ook eikels vormden een belangrijke plantaardige voedselbron. Voor het bereiden van de granen en/of eikels tot een dikke pap of soep, gebruikte men ook dunwandige bekers. De analyse van aankoeksels op een aardewerken plaatfragment geeft aan dat men ook bakplaten gebruikte om voedsel te bereiden. Zeewijk is daarmee de eerste prehistorische vindplaats uit Nederland waar het gebruik van bakplaten is aangetoond.
Zeewijk laat duidelijke aanwijzingen voor ambachtelijke activiteiten zien. De productie van barnstenen sieraden, vuurstenen artefacten, en misschien ook het maken van benen kralen en bobbelkammen, het spinnen en weven, dit alles werd ter plaatse uitgevoerd. De meeste materialen kwamen uit de directe omgeving. Barnsteen werd op het strand verzameld, net als het git, hoewel deze laatste ook via uitwisseling kan zijn verkregen. De keileembult van Wieringen was de meest nabije bron voor steen en vuursteen. Een klein deel van het op Zeewijk aangetroffen vuursteen is van zuidelijke herkomst. De artefacten gemaakt van dit type vuursteen zijn via langeafstandsnetwerken in Zeewijkse handen gekomen. Van het lokaal gevonden vuursteen maakten de bewoners allerlei werktuigen, zoals boortjes en schrapers. Die werden volop gebruikt voor hout- en huidbewerking, voor het verwijderen van de schubben en het snijden van vis en het maken van barnstenen kralen.
Samenvattend kunnen we concluderen dat Zeewijk geïnterpreteerd kan worden als een uitgestrekte nederzettingslocatie waar het gehele jaar rond is gewoond. De vindplaats kan gekenschetst worden als een mozaïek en palimpsest; de neerslag van herhaalde bewoning, afgewisseld met agrarische activiteiten. De lokale handwerkactiviteiten, de grote variatie in aardewerk en de bouw en het gebruik van de grote ceremoniële structuur in Zeewijk-Oost wijzen erop dat verschillende groepen van de Enkelgrafcultuur hun bestaan hadden in Zeewijk. Het gaat om een gemeenschap van verschillende families, verbonden door verwantschap, zowel genetisch als door ‘huwelijk’. Hoeveel ‘huishoudens’ er tegelijkertijd woonden of wat de duur is van deze bewoning (uitgedrukt in generaties), is onbeantwoord, maar dat ze hun levenswijze tot in de puntjes beheersten, is overduidelijk.

1 Introduction

E.M. Theunissen

1.1 The Odyssey project

This last monograph on the Zeewijk site is the third publication to emerge from the Odyssey project, known for short as the 'Single Grave Project'. The project was initiated by the Cultural Heritage Agency and was awarded 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.[2] The general aim of the Odyssey programme is the scientific disclosure of internationally important archaeological field research carried out in the Netherlands between 1900 and 2000 that was not further investigated or published at the time. 32 projects are being carried out from 2009 to 2013: four long-term investigations (lasting four years) and 28 short-term studies (lasting one year). The outcome of these projects will help provide new narratives about the past for local residents and help define research questions for the future. A start has been made in the Odyssey programme on tackling a serious backlog. Unfinished work is being completed and published: large numbers of archaeological finds, drawings and pictures that have often lain in boxes and repositories for years are now being interpreted to reveal human behaviour in the past. This is leading to new scientific insights in archaeology.

Thanks to the Odyssey grant and subsidiary grants from the universities of Leiden and Groningen, plus the involvement of various specialists from commercial companies and the Cultural Heritage Agency (RCE), a multi disciplinary project on the Late Neolithic Single Grave Culture (SGC; approx. 2800-2400 BC) of Noord-Holland saw its official launch in September 2009. The Odyssey project 'Unlocking Noord-Holland's Late Neolithic Treasure Chest: Single Grave Culture behavioural variability in a tidal environment' started with the analysis of the Keinsmerbrug site, excavated in 1986. This small site was interpreted as a non-residential settlement, a gathering settlement in the broadest sense of the word. The results were published in the first monograph *A Kaleidoscope of Gathering at Keinsmerbrug (the Netherlands)*.[3] The second monograph deals with the Mienakker site, excavated in 1990, also a fairly small site.[4] The study showed that the first phase of occupation was intense, with the site inhabited year-round, and associated with a house. The second phase is related to a burial of an adult male and the construction of a mortuary structure. These results and interpretations are presented in the publication *A Matter of Life and Death at Mienakker (the Netherlands)*. This monograph about the Zeewijk site will bring the series of publications from the Cultural Heritage Agency to an end, and serve as one of the building blocks in future discussions about Late Neolithic life.

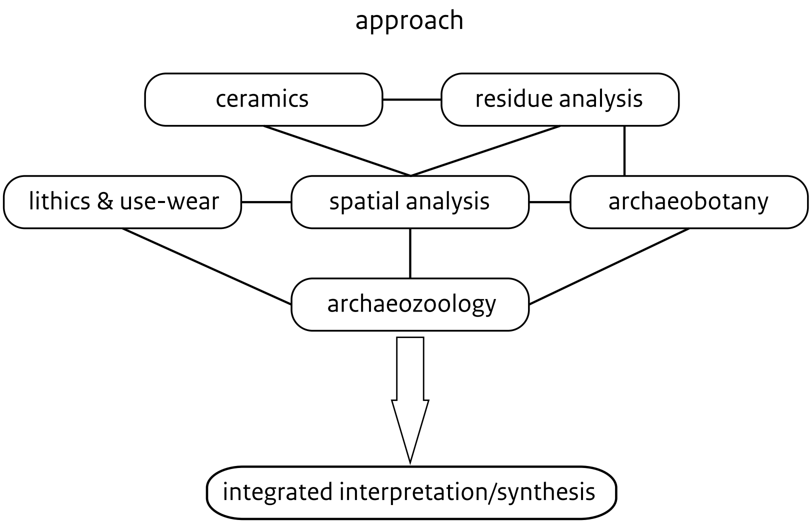


Figure 1.1 Diagram showing relationships between the main research topics.

The 'Single Grave Project' is a combined effort by specialists in different fields of archaeological research. Performing individual analysis, each specialist unlocks the cultural and ecological data and interprets the new information. At expert meetings, when all the team members come together as a research group, the various results and conclusions are discussed and integrated at site level (Fig. 1.1).

Following the same approach as that taken at the Keinsmerbrug and Mienakker sites, the project team are tackling different subjects and working in various institutional settings (commercial agencies and universities), with organisational and scientific backup from senior researchers at the Cultural Heritage Agency (RCE). The archaeobotanical remains are being studied by L. Kubiak-Martens (BIAX Consult),

2 Van Ginkel 2010.
3 Smit *et al.* 2012a.
4 Kleijne *et al.* 2013.

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). Archaeozoological material is being studied by J.T. Zeiler (ArchaeoBone), in the case of material from mammals and birds, while 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. García-Díaz. She is a PhD student at Leiden University supervised by A.L. van Gijn, who also examined the amber. M. van der Hoven studied the charcoal fragments as part of an internship at the Agency. She was coached by O. Brinkkemper (RCE). E.M. Theunissen (RCE) is acting as liaison and focusing on disseminating new knowledge to the general public, in collaboration with R. van Eerden (Noord-Holland provincial authority).

1.2 Research approach

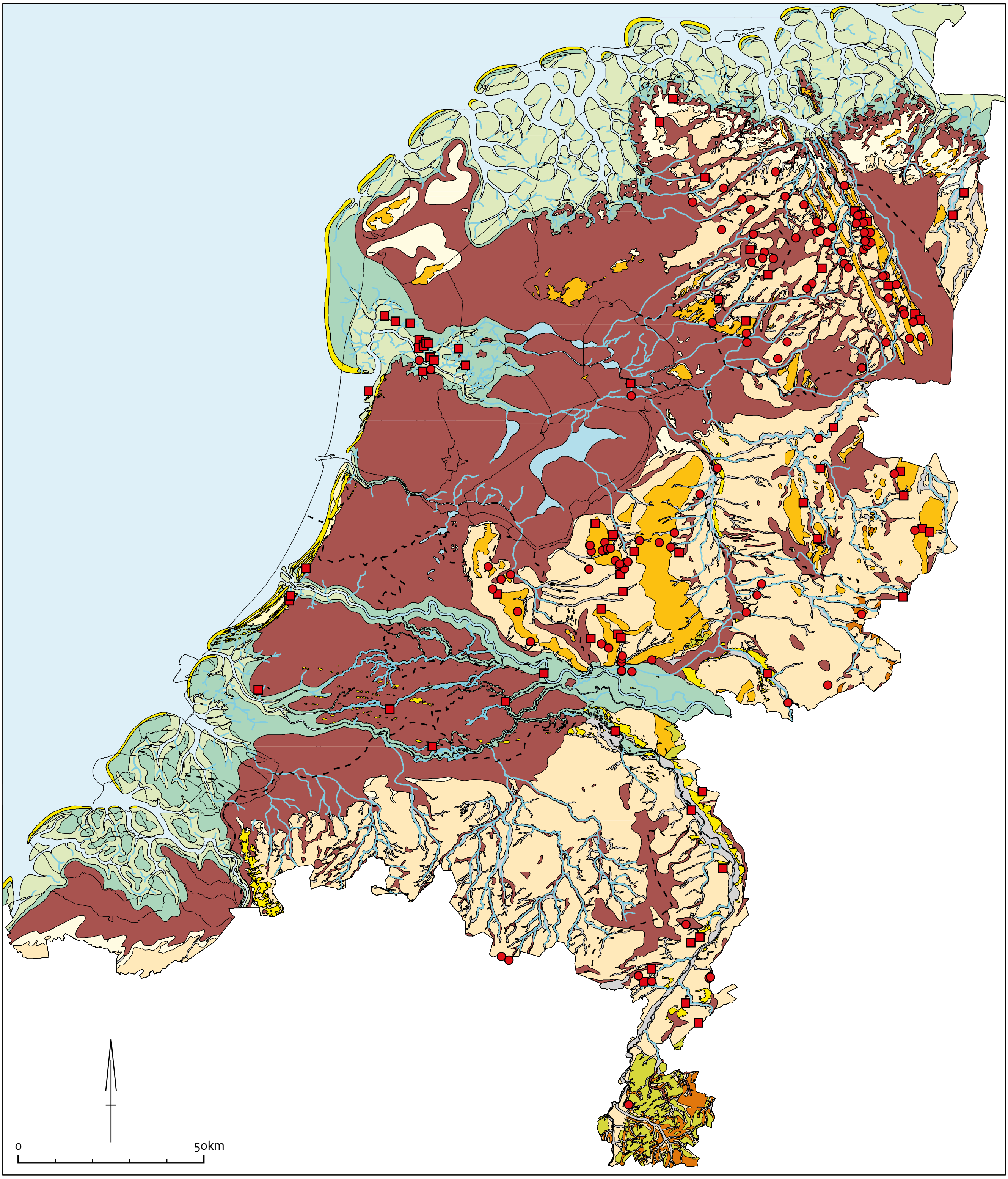
West-Friesland, and the 'De Gouw' district in the province of Noord-Holland in particular, are home to an impressive number of well-preserved sites that can be attributed to the Late Neolithic Single Grave Culture (Fig. 1.2).[5]

In the second half of the 20th century, coring campaigns were conducted and test trenches dug at most of these sites. Some of the sites underwent large-scale excavation. These excavations demonstrated the excellent preservation of organic remains (including human burials), inorganic materials and settlement features. The quality of the find material, 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.[6] In the Dutch context, the quality of these sites far exceeds that of the SGC sites in the surrounding sandy Pleistocene areas, where settlement sites are barely recognisable and the SGC is mainly known from burials (Fig. 1.3).[7] In cases where SGC remains are recognised on sandy soils, these tend to be sites where long-term reuse of locales (palimpsests) has resulted in loss of chronological and spatial resolution. 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 by various institutions. Some analyses were 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 technological developments. In consequence, 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.[8] 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

Figure 1.2 Location of the research area (red square).

5 Van Heeringen & Theunissen 2001a; Drenth, Brinkkemper & Lauwerier 2008.
6 Furholt 2003.
7 Fokkens 2005; Hogestijn 2005; Drenth, Brinkkemper & Lauwerier 2008.
8 Drenth & Hogestijn 2001; Van der Beek & Fokkens 2001; Bakels & Zeiler 2005; Hogestijn 2005.



Beach barriers and dunes
Tidal flats, rivervalleys and floodplains
Peat
Water
Rivervalleys and brookvalleys
Coversand
Ice-pushed ridges
Riverdunes
Loess
Settlements
Burials

Figure 1.3 General overview of SGC settlements and burials in the Netherlands (adapted from Drenth, Brinkkemper & Lauwerier 2008) plotted on a palaeogeographical reconstruction of the Netherlands around 2750 BC adapted from Vos & De Vries 2013.

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 and 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 above all contribute input on several aspects of site variability and group composition, as well as focusing on the identification of the cultural biographies of objects.[9] (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 and 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 do indicators tell us about the duration and seasonality of occupation?
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 Zeewijk

Our ability to address the questions above 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.[10] Of these, 17 sites are considered particularly valuable, and eight sites have a uniquely high potential information value. These eight sites were nominated as sources with higher priority for analysis of excavated remains and publication of results.[11] Among these eight are the sites at Zeewijk, Aartswoud, Kolhorn, Mienakker and Keinsmerbrug, which have been subjected to 'complete' excavation or large-scale test trench investigations. An exception is the famous site of Aartswoud where only a limited area of 341 m² was excavated, resulting in an overwhelming number of finds, totalling over 200,000.[12] The data are very diverse, in terms of both their quantity and their quality. The lack of consistency in the data presents the greatest challenge. Different find categories have been studied at several sites, which makes inter-site comparison impossible. In other cases, analyses have been performed but no final report has been published.

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 three 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 and type variability. The sites at Zeewijk, Kolhorn, Mienakker and Keinsmerbrug fit these criteria best. Regarding the first two, the Kolhorn site had our preference because more find material and cultural and ecological information was already unlocked after excavation, in comparison with the Zeewijk site. All other sites listed in the 2001 inventory have been subjected to only small-scale test trench 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

9 Kopytoff 1986; Fontijn 2003.
10 Van Heeringen & Theunissen 2001a.
11 Van Heeringen & Theunissen 2001a, 227-228.
12 Van Heeringen & Theunissen 2001b, 99-136; Soonius 2012.

however be used as general reference material. Furthermore, the Kolhorn site has to be approached in a more general way. Although several serious attempts have been made, as yet it has proved impossible to relate the find numbers to specific contexts. This problem is the consequence of a new find number system applied some years after excavation during the first analysis of data. No documentation for this new find number system or concordance with the initial find numbers could be found. Due to this lack of context information, the Kolhorn site was abandoned during the course of the project and replaced by Zeewijk, a similar large settlement site.

After the analysis and publication of the fairly small sites at Keinsmerbrug and Mienakker, we now turn our attention to the much larger site of Zeewijk. During our research project, we gained more and more insight into the quality of the data and the potential for answering the research questions at site level, as well as the more general questions on landscape and human behaviour. The site at Keinsmerbrug, which was a test case during our project, became an important point of reference in the analysis of Mienakker. Now, with the analysis of Zeewijk, new information about late Neolithic life has been added, as we gained more knowledge during the process of the project.

1.4 The Zeewijk site: an introduction

Discovery

The Zeewijk site was discovered in 1983 by K. de Lange, the landowner. When filling up a ditch with soil from the surroundings, he discovered blackish earth at the surface containing pottery decorated with cord impressions, flint artefacts and bone material.[13] He showed these finds to his son-in-law M. Jimmink, a shovel machinist who at the time was working on the excavation of the Late Neolithic site of Kolhorn approx. five kilometres away. Jimmink informed the leader of the excavation, J.D. van de Waals, who was associated with the *Biologisch-Archaeologisch Instituut* at the University of Groningen. Jimmink showed him the material, found by his father-in-law. There was no doubt – the ceramics suggested habitation in the Late Neolithic. Van der Waals, accompanied by two students, paid a visit to the spot, on 2 August 1983. And so the second Protruding Foot Beaker site in the Waard- and Groetpolder was identified.

Historic land use and explanation of the site name Zeewijk

The site is situated in the southeastern part of the Groetpolder (Fig. 1.4), a vast area of reclaimed land, approx. 5.5 kilometres by approx. 2 kilometres, created in 1844-1847. This polder, and the Waardpolder, are regarded as a precursor of the reclamation works that created the Zuyder Zee polders. Old West-Frisian land lies to the west. Until 1843 this was a sea coast protected by a 13th-century dike, the *Westfriese Omringdijk*, a 126 kilometre man-made structure enclosing the West Friesland region. To the east lies the Wieringermeer polder, where reclamation work started in 1927, the new land being brought under cultivation in 1934.

One key feature of the Groetpolder is its geometrical form, its most striking element being the *Groetpolderweg*, the former reclamation axis (Fig. 1.5). On both sides of this axis the land was parcelled out in 67 lots of 20 hectares each.[14] The size of most parcels was 800 by 250 metres, divided by ditches into four plots of five hectares. Due to the high salinity of the soil, madder (*Rubia tinctorum*) was one of the few crops that could be cultivated successfully during the early years.[15] Later on, less labour-intensive crops like caraway (*Carum carvi*) flourished. The progressive farmers of the Waard- en Groetpolder were receptive to agrarian improvements; they were among the first to switch to mechanised agriculture, using a sowing machine to drill seeds as early as 1867.[16]

Some names of the farms of the first colonists, such as 'Zeeoogst' (sea harvest), 'Flevo' (Flevomeer, *Flevo Lacus* being the Roman name for what would later become the Zuyder Zee) and 'Zeewijk' (sea quarter) refer to the former sea. Nowadays, the landscape is dominated by a row of wind turbines placed parallel to the Groetpolderweg. Between this road and the wind turbine lies the farm Zeewijk, and the parcels where the excavations took place.

13 Van Heeringen & Theunissen 2001b, 66; Bulten 2001b, 3.
14 Waiboer, Wiedijk & Oudt 1945.
15 Smit 1994, 38-44.
16 Smit 1994, 74-75.

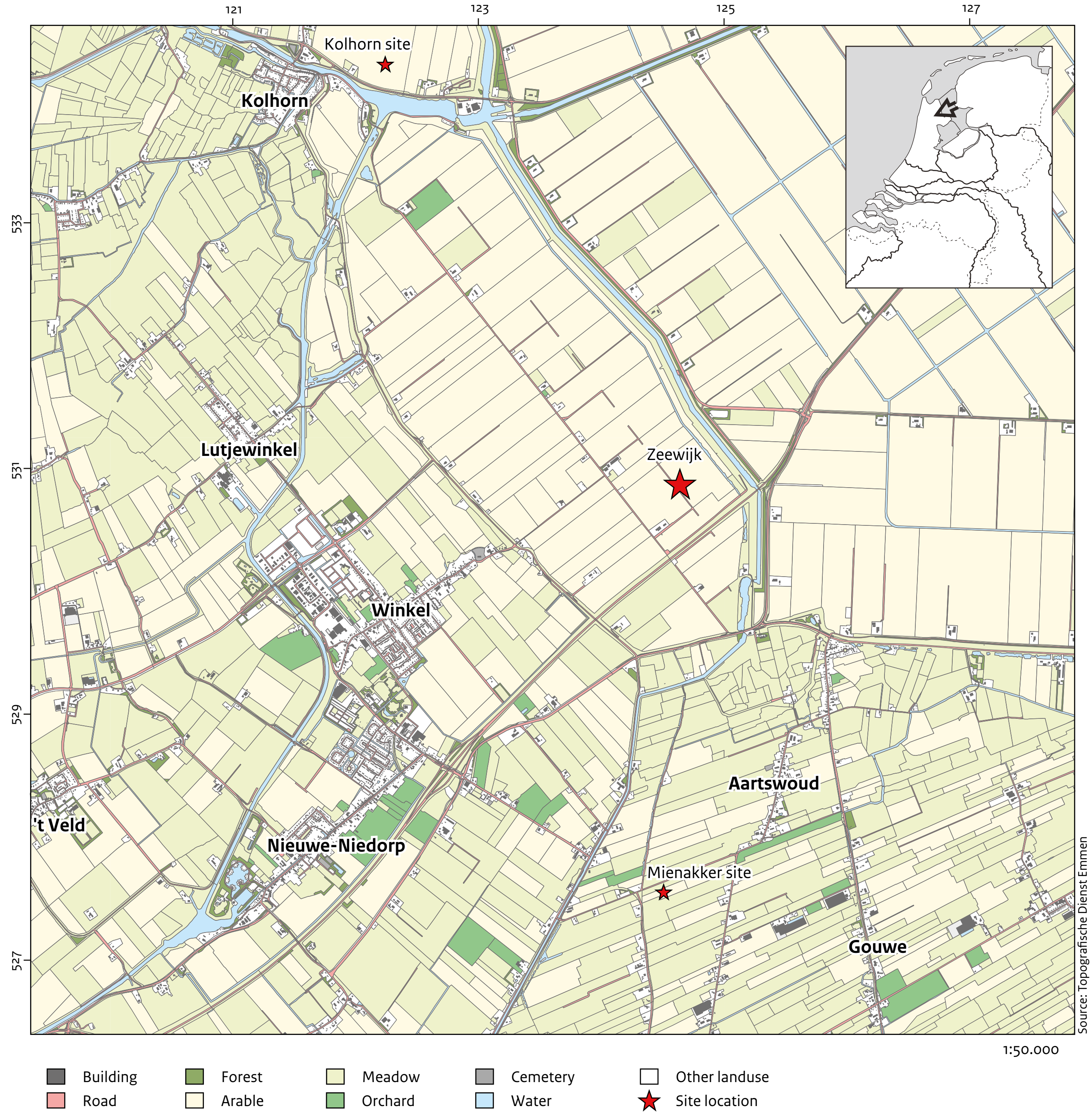


Figure 1.4 Location of the Zeewijk site, situated in the southeastern part of the Groetpolder, and the Kolhorn site in the Waardpolder. More to the south, the Mienakker site is situated.

Test pit and coring campaigns by the *Biologisch-Archaeologisch Instituut*

A year after the discovery, in 1984, a test pit of three by three metres was dug by A. Wit, an amateur archaeologist. He collected a large quantity of finds from the approx. 50 cm-thick dark layer, the ploughsoil in which the cultural layer had to a large extent been incorporated.[17] Over 200 pottery sherds, more than 100 flint artefacts, a large polishing stone and grinding stone fragments, almost 100 pieces of animal bones, three bone implements, an awl and two beads were recognised, plus a lump of loam with an embedded flint flake.

17 Van Heeringen & Theunissen 2001b, 67. The exact location of this test pit has never been recovered, neither during the excavations, nor during the inventory in 1999/2000.

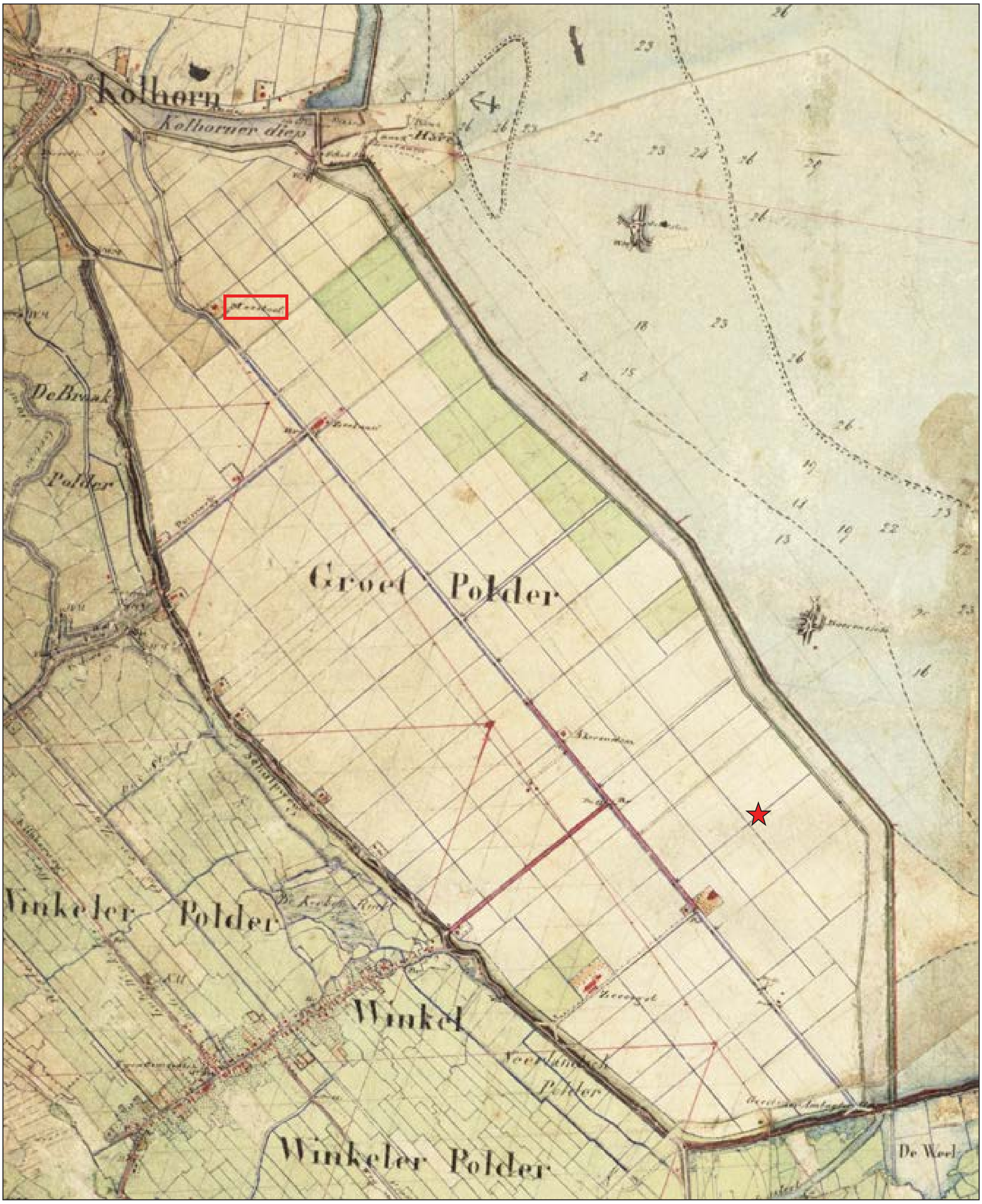


Figure 1.5 A historic overview of the polder in 1850 (Topographical Military Map). Madder (*Rubia tinctorum*) was an important crop in these early years. As well as a few farms occupied by the first colonists, a 'madder stove' ('meestoof' in the red square) was built for the drying and crushing of madder.

In 1986, the first coring campaign took place, followed by a second one in 1987. Both campaigns were carried out by the *Biologisch-Archaeologisch Instituut* at the University of Groningen. The aim was twofold: first, to get a good insight in the nature and genesis of the landscape and second, to reveal the spatial and vertical dimensions of the cultural layer and the setting of the archaeological remains in the local environment. A total of 296 corings were drilled at a distance of 1, 5 and 10 metres and a depth of 2.5 to 3.5 metres below surface. A test pit measuring two by one metres was also dug and three ^{14}C samples were taken from the cultural and peat layer. About 160 litres of soil from this test pit were sieved.

This research revealed the extent of the cultural layer. The spatial dimensions appeared quite large, and two areas could be distinguished. In the north, an archaeological area of approx. 2640 m² was recognised, referred to as Zeewijk-West, and to the south a somewhat larger area of 3100 m², called Zeewijk-East.[18] These two areas of the cultural layer proved to be located on the sandy levees on both sides of a filled creek gully. The slopes of the levees appeared to be fairly high and steep.

Research by the *Rijksdienst voor het Oudheidkundig Bodemonderzoek*

In 1992, the research at Zeewijk was taken over by the forerunner of the Cultural Heritage Agency, the *Rijksdienst voor het Oudheidkundig Bodemonderzoek* (ROB). The work was led by W.J. Hogestijn and E.E.B. Bulten. The State Service had already launched a research programme on Late Neolithic occupation in Noord-Holland in 1986. The excavations of sites at Keinsmerbrug (in 1986) and Mienakker (in 1990) were carried out in this framework. Both appeared at the time to be small sites where special activities were performed by the Neolithic inhabitants. Now, with Zeewijk within reach, the researchers of the ROB directed their interest at a large settlement site to test the hypothesis. Were large sites like Kolhorn residential sites occupied all year round?

The ROB campaign started with a large-scaled boring survey. The 270 borings made it clear that more of the cultural layer had been ploughed up into the topsoil since 1986 and 1987. The campaign also revealed that the area of Zeewijk-East was much larger in extent, comprising over 2000 m² extra to the south. There is no cultural layer in this part, but the vegetation layer (*laklaag*) seems to contain archaeological finds.

The constant erosion of the cultural layer by agricultural activities led to the decision to excavate the Zeewijk site. The idea was not to fully excavate both areas. Taking time and cost into account, a sample of approx. 20-25% distributed over the site was considered realistic. The excavation was divided into three campaigns.

On 13 April 1992, the first excavation campaign started with the laying out of a grid of two by two metre squares over Zeewijk-West and Zeewijk-East. The squares were distributed in an arbitrary way, with the first square (square 1) in the southwestern corner, at coordinate 100,400. Besides these squares, three large trenches were dug and two long evaluation trenches cutting through both Zeewijk-West and Zeewijk-East, in order to obtain a good insight and to assess the relationship between the two sides of the gully that separates West and East. In one of the trenches in Zeewijk-East a large feature with a wooden post was found. In order to determine the larger context, the trench was extended and more large features were found. It became clear that the remains of an uncommon structure were being revealed outside the spatial distribution of the cultural layer.

In 1993, the campaign focused on the full exposure of the large structure of Zeewijk-East. An excavation pit was also dug in Zeewijk-West.

During the last campaign, in 1994, attention was directed at those parts of the site most threatened by the continuous ploughing, such as the top of the sandy levee on the western side, where the cultural layer was very thin and almost completely eroded. Long trenches the width of a shovel were also dug to see to what extent features were present in areas outside the cultural layer.

Like the excavation at Mienakker, the campaigns at Zeewijk were highly labour intensive. A lot of the work was done by hand. Each two-metre square in the 1992 grid was divided into four one-metre squares. The cultural layer in these squares was excavated in spits of 3 cm.[19] These soil samples were wet-sieved at the site using a sieve with a mesh size of 4 mm (Fig. 1.6a).

[18] Bulten 2001b, 3.
[19] Bulten 2001b, 4.

a

b

Figure 1.6a,b Some impressions of the excavation at Zeewijk.

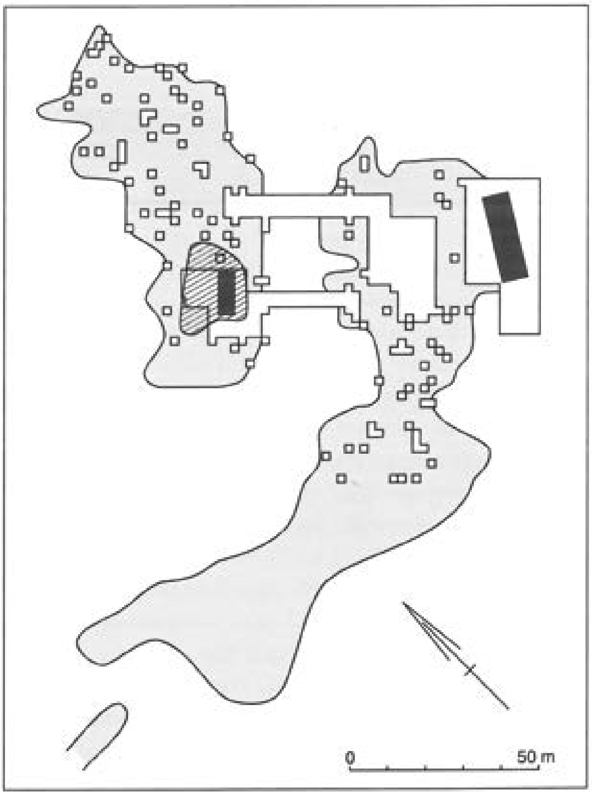


Figure 1.7 Overview of Zeewijk as published in 1997, showing the 1992 and 1993 excavation squares, the distribution of the cultural layer (shaded) and the location of the house plans at Zeewijk-West and the large structure of Zeewijk-East. The hatched part indicates the area where no shell fragments were found during the boring campaigns (from Hogestijn 1997, 31, afb. 2).

The fieldwork during those three years was performed by dozens of volunteers, including many students from the Netherlands and abroad (Fig. 1.6b). They were accommodated in a former home for the elderly, 'De Vijverhof', which the municipality of Niedorp placed at the disposal of the excavators free of charge. An average of 20 to 30 people lived there, with a peak of over 50 from 13 different countries in August 1992. This way of living during the long period of excavation, for 57 weeks over three years, made this a memorable and intense experience, which has become firmly lodged in the memory of many archaeologists.

After the excavation

In 1994, during the last campaign at Zeewijk, the excavators were already aware of another large excavation that was looming: the A27-Hoge Vaart project that started in September 1994.[20] A large proportion of the Zeewijk excavation team were transferred to Zeewolde, in the province of Flevoland.

Meanwhile, the analysis of some find categories excavated in 1992 had started.[21] The ceramics were studied by Sier and the remains of fish, birds and mammals from Zeewijk-West were studied by De Vries. The results were published in 1992 as two student dissertations from Leiden University.[22] Apart from these two student publications, hardly any of the find categories were studied. In 1997, a first brief outline of Zeewijk based on the preliminary results from analyses of the 1992 campaign was published by the excavator Hogestijn.[23] This article focused particularly on the description and interpretation of the remarkable large structure in Zeewijk-East and to the comparison of Zeewijk-West and Zeewijk-East. Differences between the two were highlighted and explained by Hogestijn (Fig. 1.7). For instance, at Zeewijk-West only a few ard marks were noticed, whereas in Zeewijk-East an area of at least one hectare with ard marks was excavated. The pottery sherds from East seem to be considerably smaller than those from West, which was caused by more intense ploughing activities.

Hogestijn pointed out that the variation in stone and flint tools was larger compared to smaller sites like Keinsmerbrug and Mienakker. The faunal remains were also different. One remarkable feature was the abundance of young cattle (up to two years of age) and the ratio of domestic (60-80%) to wild animals (20-40%). A lot of awls, needles, whistles, and bone 'ripples' (*bobbelkammen*) were recognised among the bone implements. It was suggested that these *bobbelkammen* were used to process flax, perhaps in the removal of the seed boxes. Food crusts present on all types of pottery, both thick- and thin-walled, decorated and undecorated pots, indicate that there was no distinction in the pottery used for food preparation.

Hogestijn notes that at Zeewijk-West the number of features is very high, especially on the highest parts of the levee. In this area five possible house plans were recognised. These buildings are in line with the axis of the levee and are from 6 to approx. 14 m in length and approx. 3.5 to 4.5 m wide. This careful identification of five house plans in Zeewijk-

20 Hogestijn & Peeters 2001.
21 Bulten 2001b, 9.
22 Within the framework of the inventory project in 2001 both MA theses (regarded as internal reports) were published, Sier 2001, De Vries 2001.
23 Hogestijn 1997.

West contrasts with the very clear large two-aisled building of Zeewijk-East. In five of the postholes in the central axis of this large 22 m by 7 structure the lower part of some large wooden posts was still preserved. Cut marks made by a stone axe were clearly visible on the surface of these oak posts. The cross-sections of the post holes indicate that the wood was driven into the soil, not dug. No wood was found in the wall post features, and the laminated fillings indicate that the wood was removed after some time. This suggests that the building was pulled down. The absence of a culture layer, domestic refuse and higher phosphate concentrations inside the ground plan suggest that this structure was not used for habitation. The excavators argue that it probably had a ritual or ceremonial function, perhaps being used as a 'community centre'.

In short, Zeewijk was regarded as a very promising site for analysis in the Odyssey project, but also seen as a tough nut to crack considering the amount of work. In comparison with Keinsmerbrug and Mienakker Zeewijk had a severe backlog.[24] Most of the data retrieval had to be performed by the SGC-Odyssey team.

An integrated approach could bring new results and new insights into Neolithic life in Noord-Holland. Compared with the Keinsmerbrug and Mienakker site, Zeewijk is very different in several respects. The large size and very high quantity of finds, and the fact that the area was only partially excavated, results in a different degree of expressive power. The narrative capacity of Zeewijk is of a different order, and raises more questions because the 75-80% that was not excavated and is still *in situ* holds unknown information.

1.5 Sampling strategy applied to the Zeewijk data

In the course of our project, in the summer of 2011 discussed thoroughly the sampling strategy for the Zeewijk data. All the features recorded during the excavations – postholes, pits, cow hoof marks, ard marks and human footprints – were digitised, but the three campaigns yielded far more finds than could be studied, so we had to make a selection. But how? And on what conditions? One of our main goals was to determine whether there was a difference (in character, time, use, function, etc.) between Zeewijk-West and Zeewijk-East. So we had to sample both areas. On the other hand, some specialists had limited time. Various sampling strategies were suggested: a straightforward selection of find boxes, a random spatial sample or a regular spatial sample (see Chapter 11).
It was decided that:
1. we would take the 1992 campaign as a starting point, the random squares over both sites;
2. two similar areas would be selected: one around the large structure of Zeewijk-East and an area of similar size at Zeewijk-West. Both are areas of interest which yielded suspected or actual structures (Fig. 1.8).
3. a third of the available time would be spent on Zeewijk-East and two-thirds on Zeewijk-West.

With these starting points in mind, the specialists set about analysing the different find categories. During the process, depending on the approach chosen, the availability of the material, the potential of the samples and the available time, selections were enlarged and/or somewhat altered.

The analysis of the ceramics (Chapter 4) initially started with the two selected analytical areas, and after that it was decided to enlarge the Zeewijk-West area (Fig. 1.9) and add a random pick from the boxes stored at the provincial repository in Wormer. As the presence of the food crusts is inextricably related to the pots, the study of the organic residues (Chapter 8) followed the ceramics selection.

The approach to the flint, stone and bone implements (Chapter 5) was slightly different. The first step was to enter all the available implements from Zeewijk into a database. Then it became apparent that the flint material from the 1992 campaign was missing, and also some from the 1993 and 1994 trenches. It was not possible to retain the two selected study areas, except for the stone artefacts in the Zeewijk-West area. For the spatial analysis of the flint it was decided to select a new area in Zeewijk-West, south of the initial one (Fig. 1.10). Due to this approach the results from the study of flint and stone are described at a more general level, in terms of the Zeewijk site, with no distinction between West or East.

[24] Currently, in summer 2014, about 90 boxes filled with soil samples from Zeewijk are still waiting to be sieved.

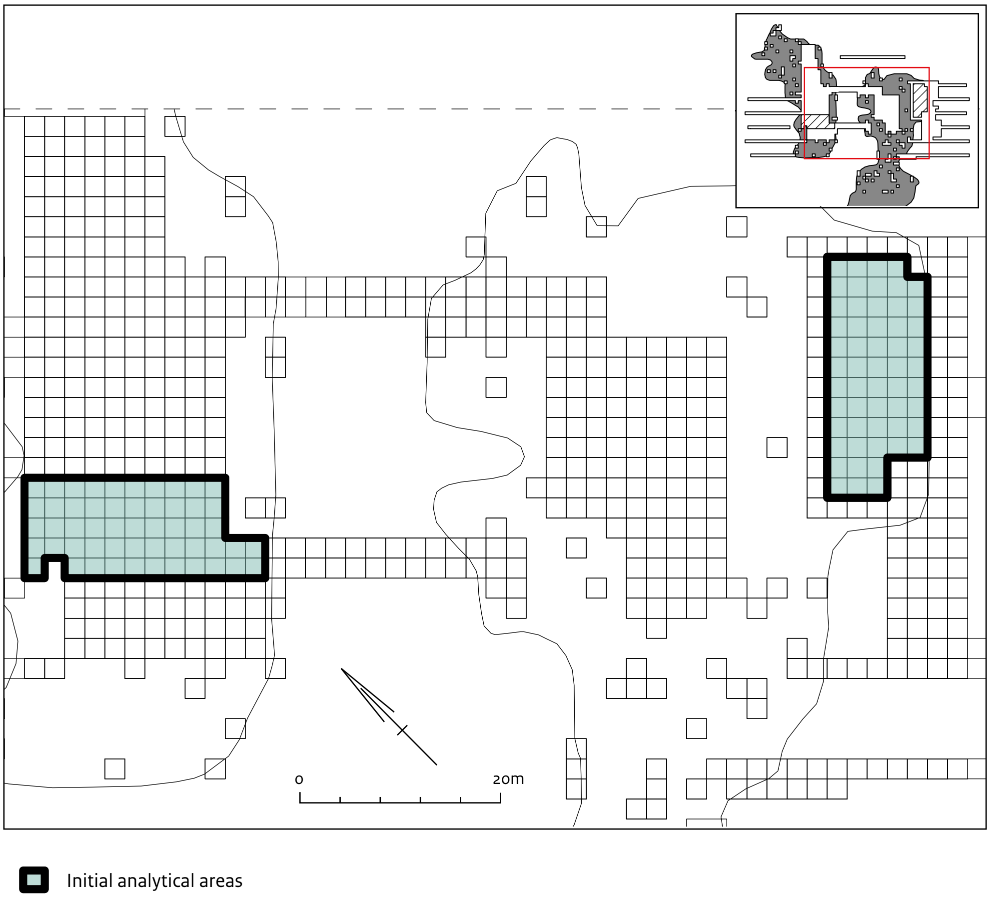


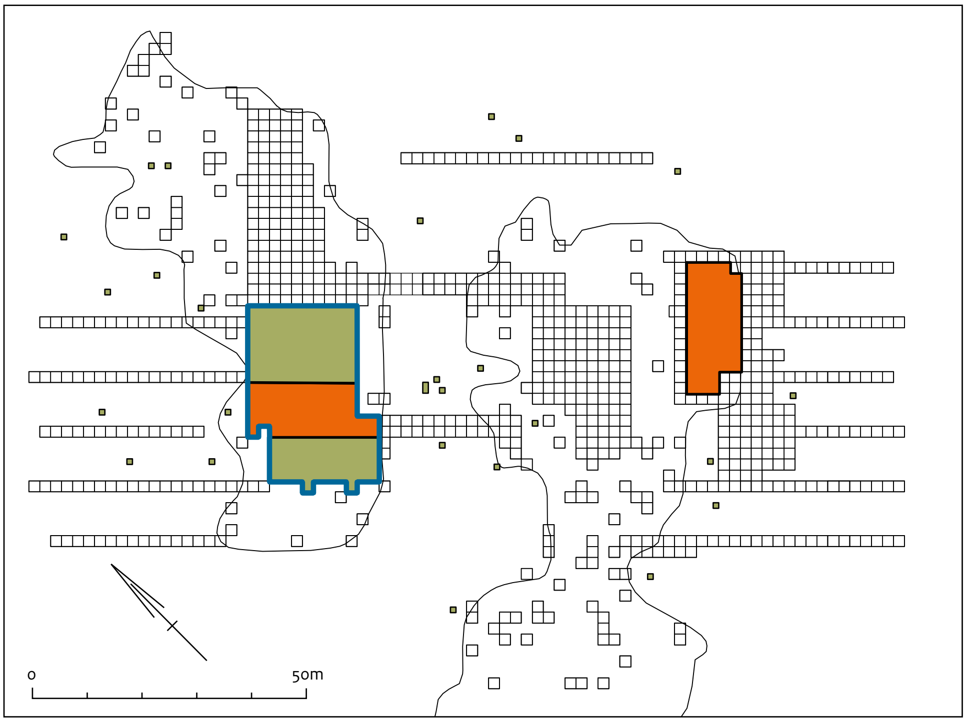
Figure 1.8 The location of the two initial analytical areas of Zeewijk-West and Zeewijk-East

The sample area chosen for amber in Zeewijk-West was also enlarged (Fig. 1.11), but as no amber from the East was present or available, the amber study is restricted to Zeewijk-West.

The study of the botanical macro-remains (Chapter 7) consists of the analysis of 70 soil samples, with a ratio 2:1 from Zeewijk-West (n=46) and Zeewijk-East (n=24). After sieving and assessment, the Zeewijk-West samples revealed far more plant remains than the Zeewijk-East samples. Subsequently, 19 samples from West and two from East were selected for further analysis. In addition to the soil samples several hundred dried residues stored at Wormer were assessed and over 50 were selected for further analysis, randomly scattered over Zeewijk-West and Zeewijk-East (Fig. 1.12). Like the flint and stone the results from the macro-remains analysis are discussed at a larger site level, in terms of 'Zeewijk'. The same applies to the charcoal and wood (Chapter 9).

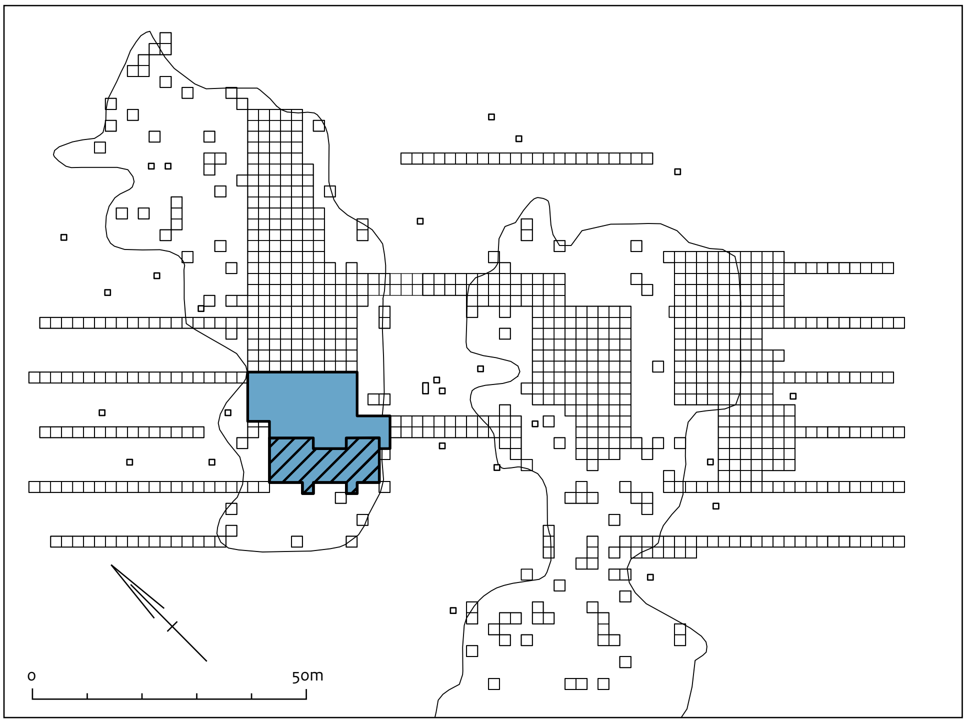
The sample of faunal remains studied (Chapter 10), on the other hand, is more or less restricted to the two sample areas, Zeewijk-West and Zeewijk-East (Fig. 1.13). A small proportion of the material from Zeewijk-West (from the 1992 campaign) was already analysed by De Vries.[25] The selection was enlarged in this Odyssey project to include the study area of Zeewijk-East.

[25] De Vries 1996, 2001.



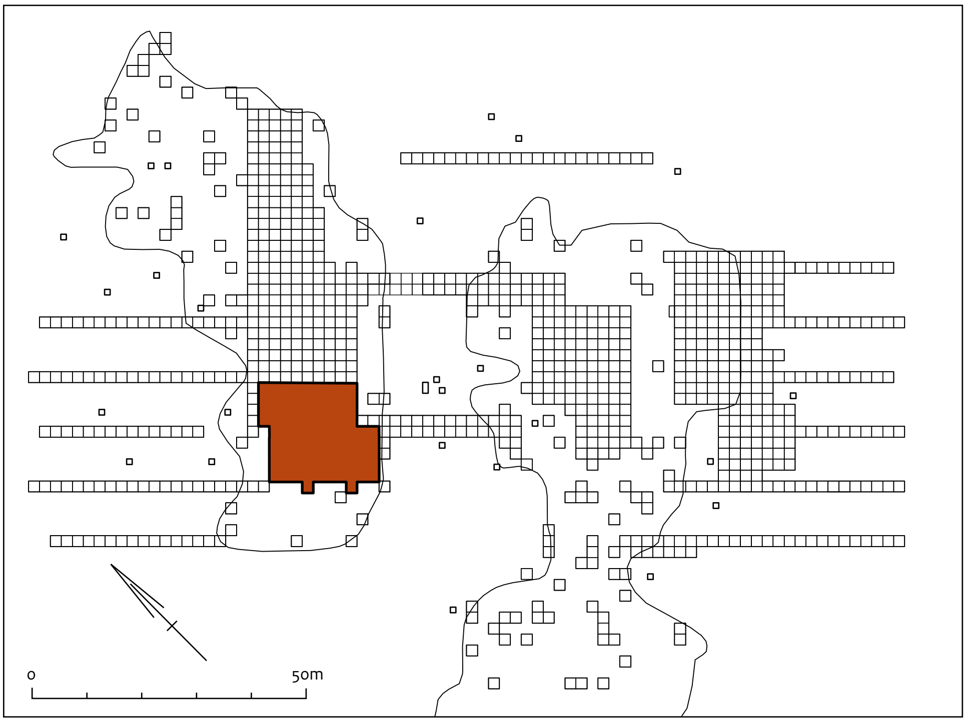
Initial phase   Enlarged in second phase   Area spatial analysis

Figure 1.9 Overview of the selected areas for the analysis of the ceramics.



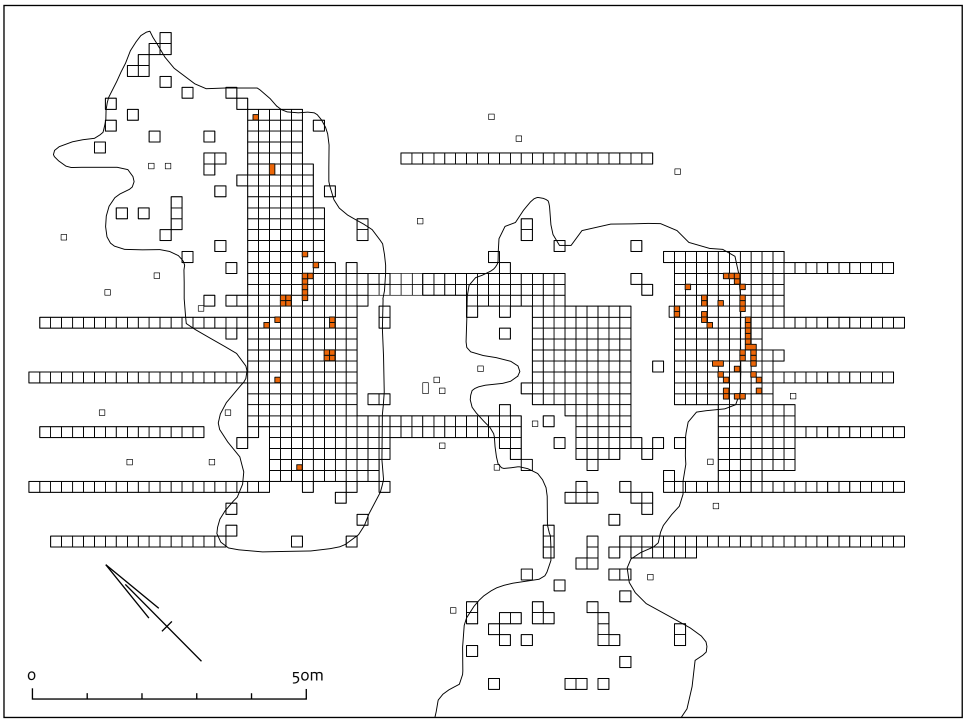
Spatial analysis flint   Spatial analysis stone

Figure 1.10 Overview of the selected areas for the analysis of flint and stone.



Sample area amber

Figure 1.11 Overview of the selected areas for the analysis of amber.



Sample macro-remains

Figure 1.12 Overview of the selected squares for the analysis of the botanical samples.

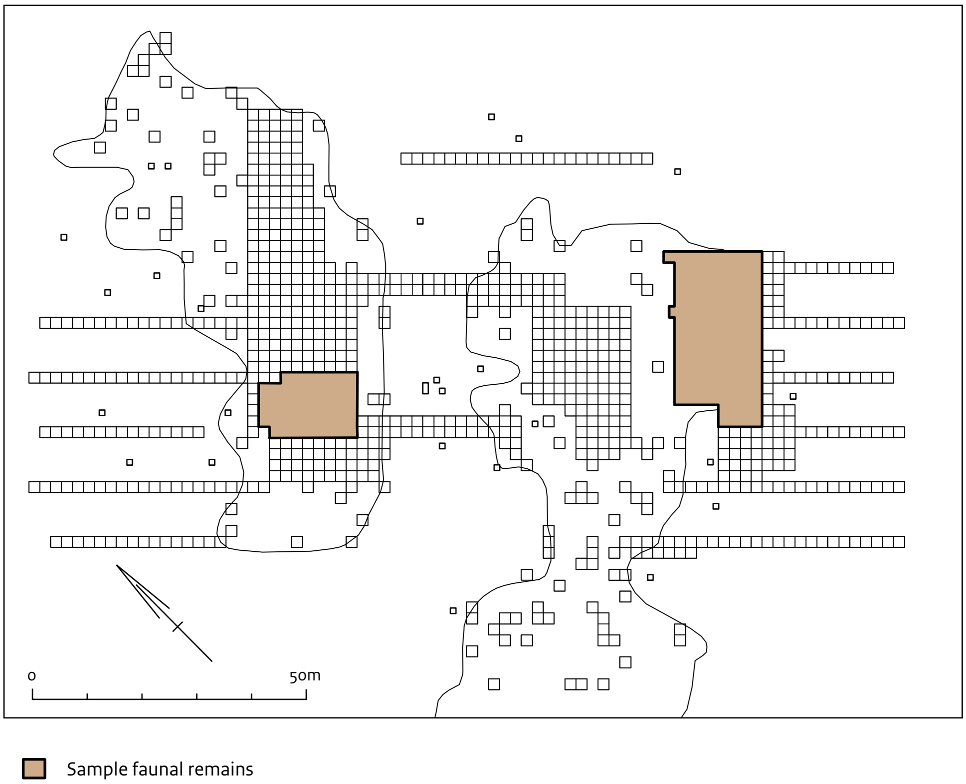


Figure 1.13 Overview of the selected areas for the analysis of the faunal remains.

1.6 Missing data

During the process of digitising excavations plans and sections and integrating the data some challenges were encountered which hampered the interpretation of the site. Not only did some find material appear to be missing, like the flint material from the 1992 campaign, but the documentation also seems to be incomplete. Part of the southern area of Zeewijk-West shows no features, which is a result of either a missing archive drawing, or failure to record finds, rather than the absence of features. Many drawings of the cross-sections of the postholes (*coupetekeningen*), associated photographs and written information about the postholes could not be traced in the archives. The long profile sections are also lacking information. The individual layers are mostly record and named, but they have not been interpreted by an archaeologist or a physical geographer to identify habitation or natural events. Further evaluation or reinterpretation of these features or sections is not therefore possible. In general, much of the feature number information, such as the feature lists, could not be retrieved. Furthermore, some of the field logbooks (*dagrapporten*) appear to be missing, for instance those from the 1994 campaign.

In addition to the absence of finds and documentation the complexity of the site grid was also a great challenge, back in the 1990s and also during the Odyssey project. In 1993, the pattern was altered. The discovery of the large structure the year before forced the excavators to expand the site grid to the east. Unused square numbers from the west were used in the east, resulting in an irrational system. Due to the restrictive nature of the initial grid, in 1994 a new grid numbering method was developed. These alterations can easily lead to confusing situations. Frequent changes of students and communication in English by non-native speakers can lead to a reporting system in which mistakes are easily made. For instance, incorrectly written find and/or square numbers lead to strange find distributions. In this publication some of the distribution maps of find categories, such as ceramics and flint, show finds outside the excavated area. In these cases it seems an incorrect square or find number was used. This is the result of mistakes made in the 1990s.

1.7 Structure of the monograph

Since the approach to the analysis of the Zeewijk site was similar to that at Mienakker and Keinsmerbrug, the structure of the monograph is more or less the same. It was decided to divide the monograph into twelve chapters and an epilogue. The first two chapters introduce the site and its environmental setting. The features are presented in Chapter 3. Chapters 4, 5 and 6 deal with four material categories: the ceramics and the flint, amber and stone artefacts. The results of the botanical analysis are presented in Chapter 7, and the organic residues are discussed in Chapter 8. Charcoal and wood are highlighted in Chapter 9. The faunal remains – mammals, birds and fish – are discussed in Chapter 10. The spatial information will be presented and evaluated in Chapter 11. Chapters 3-11 thus present the reports of the specialist analyses, each based on specific research questions. Chapter 12 brings together the conclusions from the different studies, discussing and synthesising the archaeological data from the site at Zeewijk. This chapter is based on the input from the specialists and presents a joint interpretation of the site by the project team. In the epilogue, we look back at the project as a whole, evaluating the results from the three sites studied, the process and the expectations we had at the start in 2009.

1.8 Administrative information

Province	Noord-Holland
Municipality	Hollands Kroon
Location	Winkel
Toponym	Zeewijk
Centre Coordinate (Dutch coordinate system)	124.65/530.83
Land use	farmland
Year of discovery	1983
Excavation	- 13 April to 3 October 1992 (25 weeks) - 13 April to 10 September 1993 (22 weeks) - 28 April to July 1994 (approx. 10 weeks)

1.9 Acknowledgements

Various people contributed in several ways to the research and the production of this monograph. Their advice, help and constructive criticism were greatly appreciated by the authors. Thanks to: Everhard Bulten, Theo Geurtsen, Marjolein Haars, Willem Jan Hogestijn, Bertil van Os, Jarno Pors, Jean Roefstra, and Martin Veen.

We also would like to thank all those unnamed people who took part in the excavation of Zeewijk more than 20 years ago. Dozens of volunteers were involved, including many students from the Netherlands and abroad. They cherish the memory of Zeewijk. The former excavators would like to commemorate Jeremy Large. He took great care in recording the features of the large structure of Zeewijk-East. Unfortunately, he suffered a fatal accident while hiking in the Atlas Mountains in Morrocco.

2 Landscape, the formation of the site and ¹⁴C chronology

B.I. Smit

2.1 The landscape context

Nowadays situated in a relatively young landscape, predominantly reflecting the layout of historical reclamations of part of the former 'Oude Zuyderzee',[26] the Late Neolithic site at Zeewijk is reminiscent of a completely different and more dynamic environment. Like the more or less contemporaneous sites at Keinsmerbrug and Mienakker, the Zeewijk site originated in a dynamic tidal landscape (Fig. 2.1).[27] Figure 2.1 shows that different ecological zones were present in the environment surrounding Zeewijk near and at some distance from the site. Pleistocene outcrops were present approximately 10 kilometres north of Zeewijk, the sea about 20 kilometres to the west, and there was a large tidal creek close by.

The morphology of the submerged Pleistocene surface influenced the subsequent Holocene geological development in this part of Noord-Holland. The Late Neolithic sites of Noord-Holland lie in a former tidal basin, the Bergen tidal basin. [28] This basin is situated on top of an old (Pleistocene) valley of the river Rhine which, in contrast to the western course of the present Rhine, had a northwest orientation. This Pleistocene branch of the Rhine was abandoned around 40,000 BP. [29] In this abandoned river valley the predecessors of the present Vecht river flowed westward during the late Pleistocene.[30]

In the first half of the Holocene there was rapid sea-level rise in the North Sea basin, causing large parts of the western Netherlands to be inundated and tidal basins to form along the coast. Both the Bergen tidal basin and the other tidal basins were formed as a result of this sea-level rise. In the course of the Holocene the rate of sea-level rise dropped. However, the subsoil of the Netherlands continues to subside as a result of glacio-isostatic processes and its structural geology, and relative sea-level rise has

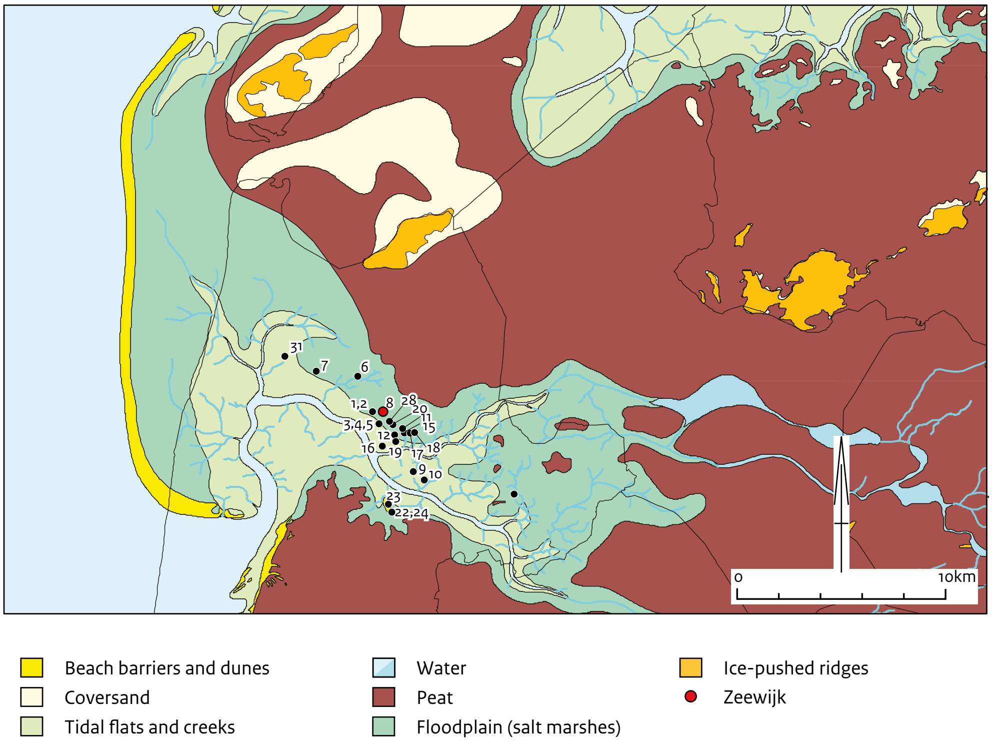


Figure 2.1 Zeewijk (red dot) and other Late Neolithic sites in West-Friesland plotted on a palaeogeographical map of around 2750 BC (after Vos & De Vries 2013): 1, 2: De Vrijheid 1 and 2; 3, 4, 5: Flevo 1,2a and 2b; 6: Kolhorn; 7: Poolland; 8: Zeewijk; 9: De Veken; 10:Meester Juffer; 11: Aartswoud; 12: 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 (numbering after Van Heeringen & Theunissen 2001).

26 Theunissen, this volume.
27 For an extensive description of and further references to the wider geological development of this area see: Kleijne & Weerts 2013; Smit 2012.
28 Also known as the North Holland basin, see Smit 2012.
29 Busschers *et al.* 2007.
30 Kleijne & Weerts 2013; Smit 2012; Vos & Kiden 2005.

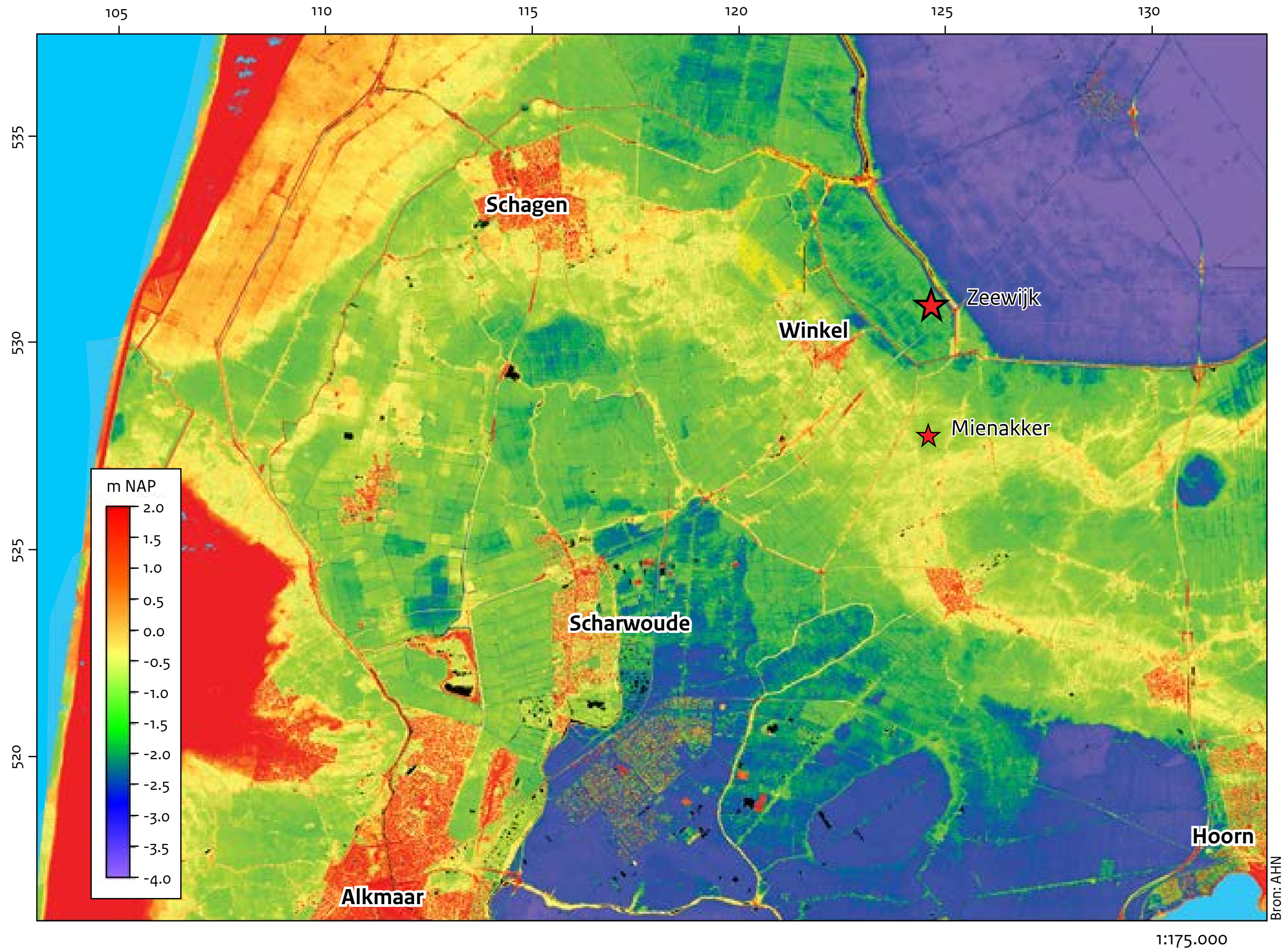


Figure 2.2a. Digital elevation model of the present surface of the West-Frisian area showing the prehistoric creeks: yellow/orange; and marsh deposits: green/blue (source: www.ahn.nl).

therefore also continued.[31]

In the former Bergen tidal basin a large salt marsh transected by tidal creeks came into existence around 3200 BC. One main tidal channel originated from an opening in the coastal dunes and beaches. This channel had a northeastern orientation towards the current town of Wognum and further to Hoogwoud. The landscape was intersected by smaller creeks originating from this main channel.

The levees besides the numerous creeks in this salt marsh were the main locations for prehistoric occupation. In the current agricultural landscape the former creeks are visible due to small differences in height at the surface. In fact this landscape displays the inverted relief of the former landscape. As a result of compaction the main sand body and levees of the former creeks and gullies now exist as higher ridges in the landscape a few dozen centimetres above the marsh deposits. As a result these former creeks can be revealed by LIDAR measurements. In the Netherlands LIDAR measurements of the entire land surface are available.[32] When these measurements are modelled the patterns and forms of past landscapes can be revealed. It is important to realise that the resulting patterns show a myriad of creeks which are in fact a remnant of a dynamic landscape in which numerous creeks developed and eroded over time. The resulting picture is therefore more an approximation of how the former landscape might have looked like than a past reality (Fig. 2.2a and b).

The environment can be characterised as a tidal basin with large tidal creeks bordered by

[31] Weerts 2013.
[32] www.ahn.nl

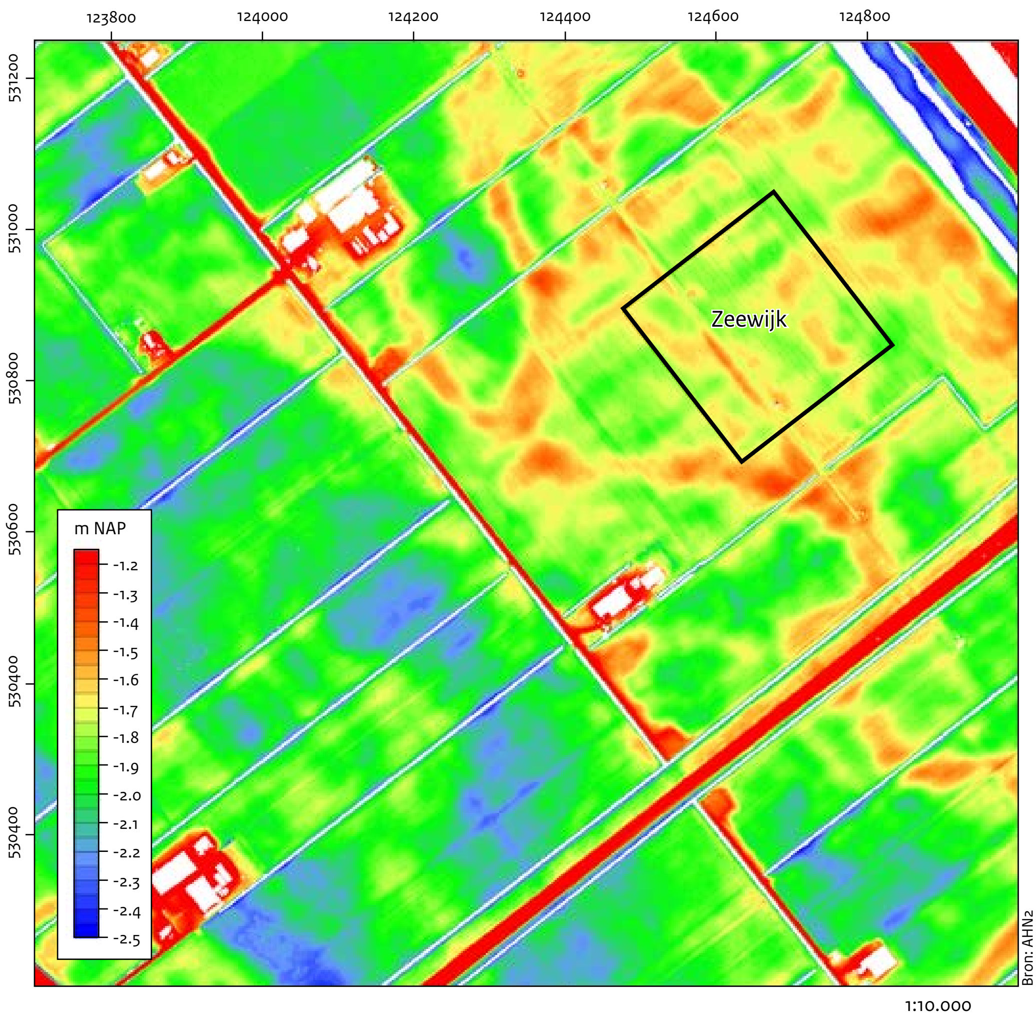


Figure 2.2b. Part of the Groetpolder where the Zeewijk site is situated.

high levees accompanied by marine crevasse splays and open water.[33] As was shown by the analyses of both Keinsmerbrug and Mienakker the presence of different gradient zones between the landscape elements (like tidal creeks, high and low levees, beach barriers, dunes, salt marsh etc.) and their consecutive ecological signatures (flora and fauna) seem to have been one of the main reasons to inhabit this resource-rich landscape.[34]

2.2 The site

The site of Zeewijk was situated in this tidal landscape, as was shown by borehole surveys[35] conducted in 1986-1987 by the *Biologisch-Archaeologisch Instituut* of Groningen University[36] and in 1992 by the *Rijksdienst voor het Oudheidkundig Bodemonderzoek* (State Service for Archaeological Investigations, ROB).[37] The site of Zeewijk was founded on the levees next to a gully. This residual gully is a remnant of a larger older creek. This former creek silted up almost entirely around 2400-2200 BC, leaving a more sandy creek ridge in the tidal landscape. The small residual gully at Zeewijk was located in the centre of this sand body, and the settlement was situated on the levees along this gully.[38] As a result of the presence of this older creek ridge in the subsurface and the subsequent development of levees there was a natural elevation in the landscape next to active watercourses in the surroundings (Fig. 2.3).

As shown by the studies at Mienakker and

33 Van Zijverden 2013, 164.
34 Hogestijn 1997, 1998; Smit *et al.* 2012b; Kleijne *et al.* 2013.
35 Gerrets, Bulten & Pasveer 1988.
36 Now Groningen Institute of Archaeology at the University of Groningen.
37 Now Cultural Heritage Agency of the Netherlands.
38 Hogestijn 1997; 1998.

Keinsmerbrug the higher creek ridges were especially favoured by Late Neolithic people. The clearest evidence of the use of these locations is the presence of a dark (black) cultural layer containing settlement debris (flint, ceramics, burned bone), ash, charcoal and charred reed fragments as well as numerous shells. Initially the settlement at Zeewijk was recognised on the basis of the extent of this dark layer which was transected more or less through the centre by the above-mentioned gully. This gully divided the settlement into two clusters with a cultural layer: Zeewijk-West and Zeewijk-East.

Based on the information from the corings and also from Figure 2.3 it can be deduced that parts of the cultural layers extend into the residual gully. This means that cultural debris and waste were dumped or (re)deposited in this gully and at its border. The layered fill of this gully is another factor suggesting that the residual gully contained water during some periods when the site was occupied. When Zeewijk was excavated it was discovered that areas devoid of this cultural layer showed the presence of archaeological remains like postholes, pits, hoof imprints and artefacts.

2.3 The formation of the site

The presence of a dark cultural layer containing ceramics, lithics, bone (some of it burnt), charred plant remains, ashes and charcoal is one of the characteristics which makes it possible to detect such sites by means of a borehole survey. However, after our investigations of Keinsmerbrug, Mienakker and Zeewijk, we are forced to conclude that this cultural layer is only one of the components of these sites. Archaeological remains and features have been discovered in parts of the sites where this layer is absent. For a good understanding of the site formation processes, it is vital that this layer be thoroughly studied. Due to the fact that we were dealing with an excavation from the archive, the first step was to establish which data were available to help us understand the formation of this layer, and subsequently the entire site.[39] The data sources available are photographs of sections and of excavation surfaces, and field drawings. Based on these sources several processes can be described which had an

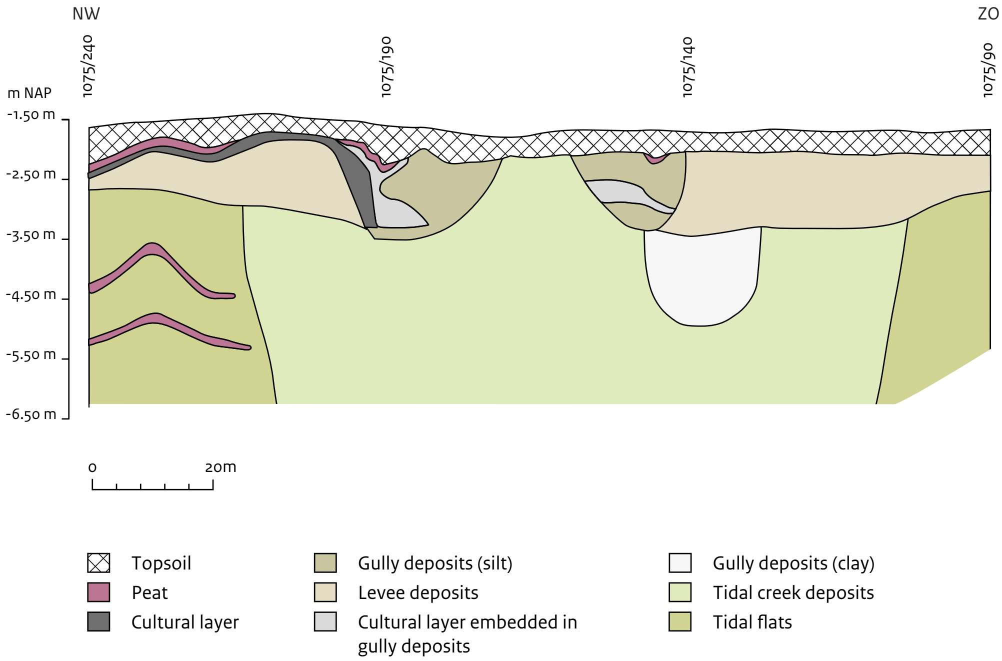


Figure 2.3: Schematic geological section of the Zeewijk site (adapted from Van Heeringen & Theunissen 2001b, Afb. 3, 68).

[39] Nobles, this volume Chapter 3.

Figure 2.5 Example of lateral extension of the cultural layer.

Figure 2.4 Photograph of the cultural layer showing interwoven layers of shells, cultural material and charred reed fragments.

influence on the formation of this layer. Furthermore reference can be made to sites with similar layers on which micromorphological studies have been published.[40] Unfortunately no thin section analyses are available from Zeewijk.

Several processes can be discerned on the basis of the photographs and data available. The cultural layer is composed of interwoven layers of cultural debris (ceramics, lithics, bone and burnt bone, charcoal), shell layers of varying thickness and density, hearths, and black layers consisting of charcoal and charred organic matter (predominantly reed fragments) (Fig. 2.4). This combination of characteristic is highly suggestive of the dumping of cultural debris, waste and large amounts of shells and the (deliberate?) burning of organic material (reed and shrubs).[41] When the arguments presented above are combined it seems that a more or less classic midden formed containing an accumulation of settlement debris and charred organic material.[42]

Some photographs of excavated sections clearly show lateral extension of this cultural layer (Fig. 2.5). This means that the cultural layer (as documented during the excavation) is the result of numerous deposition events which led to the development of a vast midden.

40 Huisman, Jongmans & Raemaekers 2009; Huisman & Raemaekers 2014.
41 Kubiak-Martens, this volume.
42 Hogestijn 1997, 31; Huisman, Jongmans & Raemaekers 2009; Huisman & Raemaekers in 2014.

a

b

Figure 2.6a,b Thin layers of natural clay intersecting the cultural layer.

a

b

Figure 2.7a,b Examples of the 'contact layer' underneath the dark-coloured cultural layer; note also the irregular base of this layer and the lighter-coloured lumps incorporated at the bottom.

In some parts of the midden deposits clear bands or patches of natural clay are present which show that episodes of sedimentation or moments of clay deposition occurred during the formation of the midden (Fig. 2.6a, b). This means that during periods of high water levels, or maybe even due to heavy rain, parts of the site locally flooded and fresh clays were deposited. Photographs and field drawings suggest that these layers of natural clay were

Figure 2.8 The base of the cultural/contact layer with evidence of trampling and/or working of the subsoil as shown in some excavation photographs.

deposited in a low-energy environment. During these wet episodes parts of the cultural layer were eroded and redeposited creating interwoven layers of natural clay and thin layers of cultural material.[43] It has to be noted that these layers and patches of clay are present in some parts of the site and are not evenly distributed, there are no indications that the complete site was flooded entirely during its use in the Late Neolithic. Hogestijn also mentions the presence of some thin layers of peat which intersect the cultural layer in the southern part of Zeewijk-West. The presence of these layers shows that during the habitation of the site peat developed in lower areas, probably as a result of a rising water table.[44]

Underneath the dark cultural layers, a layer of light- to dark-brown/grey clay about 10-15 cm thick is visible (Fig. 2.7a,b). Based on the photographs and drawings of sections it is likely that this layer originally was a vegetation horizon, which shows some anthropogenic influences (see below), on which the Late Neolithic people of Zeewijk founded their settlement. These vegetation horizons develop when a surface is not covered by new sediment, so lies dry for a given period of time and soil formation processes come into effect.[45] Besides the presence of organic matter and other organic elements (as a result of soil formation), these types of horizon also contain microscopic particles of burnt organic matter.[46] During the excavation this layer has been described as 'contact layer'.

Research showed that this 'contact layer' laterally transcends into a vegetation horizon which in lower parts of the site as a whole transcends into a thin peat layer.[47] Based on this observation, the photographs and the field drawings, we can conclude that this 'contact layer' represents the original surface on which the habitants of Zeewijk formed their settlement. Sometimes lumps of material from the cultural layer can clearly be seen in this contact layer, and lumps of lighter-coloured natural clay are also visible (Fig. 2.7a,b). The presence of these natural lumps of clay suggest some form of working of this surface. It is likely that parts of the cultural layer were pressed into this layer as a result of trampling by man and animals.[48] These lumps and evidence of the mixing of the cultural/contact layer due to trampling or working of the soil can be seen in photographs taken during the excavation (Fig. 2.8).

In conclusion, the original natural surface (vegetation horizon) seems to have been worked. Cultural waste was deposited on this surface resulting in the accumulation of a midden (cultural layer), and during the occupation some of these midden deposits were trampled and eroded by man and natural processes.

43 See also Hogestijn 1997, 31.
44 Hogestijn 1997, 31.
45 Steenbeek 1993.
46 Exaltus & Kortekaas 2008.
47 Bulten 2001b.
48 Nobles, this volume Chapter 3.

Table 2.1 ^{14}C dates from Zeewijk.

No.	Site reference	Reference number	Material/site context	^{14}C (years BP)	σ (years)	‰	δ ^{13} C	References
1	Zeewijk West I (find no. 14333-3)	GrA-112	charred reed	4030	30	-	-23.360	Hogestijn 1997, 29; Van Heeringen & Theunissen 2001, part 2, 67; Lanting & Van der Plicht 2000, 79.
2	Zeewijk West II (find no. 14333-7-25)	GrA-113	charred reed	4150	30	60.1	-24.970	Hogestijn 1997, 29; Van Heeringen & Theunissen 2001, part 2, 67; Lanting & Van der Plicht 2000, 79.
3	Zeewijk West III (find no. 23982-10-41)	GrA-114	charred twigs	4140	40	61.1	-24.490	Hogestijn 1997, 29; Van Heeringen & Theunissen 2001, part 2, 67; Lanting & Van der Plicht 2000, 79.
5	Zeewijk East I	GrN- 18488	oak post (outer rings)	3910	50	62.4	-27.090	Hogestijn 1997, 29; Van Heeringen & Theunissen 2001, part 2, 67; Lanting & Van der Plicht 2000, 79.
6	Test pit 1984	GrN-15565	bone fragment from cultural layer	3925	40	50.5	-20.850	Van Heeringen & Theunissen 2001, part 2, 67;
7	Coring 1085/230	GrN-15067	peat layer (intermediate)	4360	110	-	-25.370	Gerrets, Bulten & Pasveer1988, 15.
8	Coring 1085/230	GrN-15068	peat layer (lowest)	4650	80	-	-27.090	Gerrets, Bulten & Pasveer1988, 15.
9	Coring 1075/193	GrN-15069	base of cultural layer	3800	70	56.6	-20.850	Van Heeringen & Theunissen 2001, part 2, 67;
10	Zeewijk West (south part)	GrA-56014	charred residue of vessel 13	4100	40	57.8	-26.040	this volume
11	Zeewijk West (south part)	GrA-56013	charred residue of vessel 30	4030	40	55.8	-26.150	this volume

2.4 ^{14}C chronology

A number of ^{14}C dates are available for Zeewijk (Table 2.1). The samples originate from different parts of the site and different materials have been dated. The exact location (West or East) of the test pit dug in 1984, from which a bone fragment has been dated, is not known (GrN-15565). Most samples, and thus dates, with known locations come from Zeewijk-West. Only one date is from Zeewijk-East, the sample for this date having been taken from the outer rings of one of the posts of the large structure excavated at Zeewijk.

During the coring campaign in the 1980s, material from the lowest part of the cultural layer bordering the gully was dated. Because of this location and the outcome of GrN-15565 (a bone fragment from the cultural layer which has an earlier date) it seems the sample GrN-15069 may be contaminated due to infiltration of more recent material. However, when all the currently available dates from Zeewijk are presented, there is no reason to conclude that the outcome for GrN-15069 is too recent,[49] as it falls neatly within the range of the other dates (Table 2.1 & Fig. 2.9). Furthermore, as was explained above the location of the 1984 test pit is unknown, making it impossible to link the cultural layer found in that pit to observations made during

49 Contra Gerrets, Bulten & Pasveer 1988.

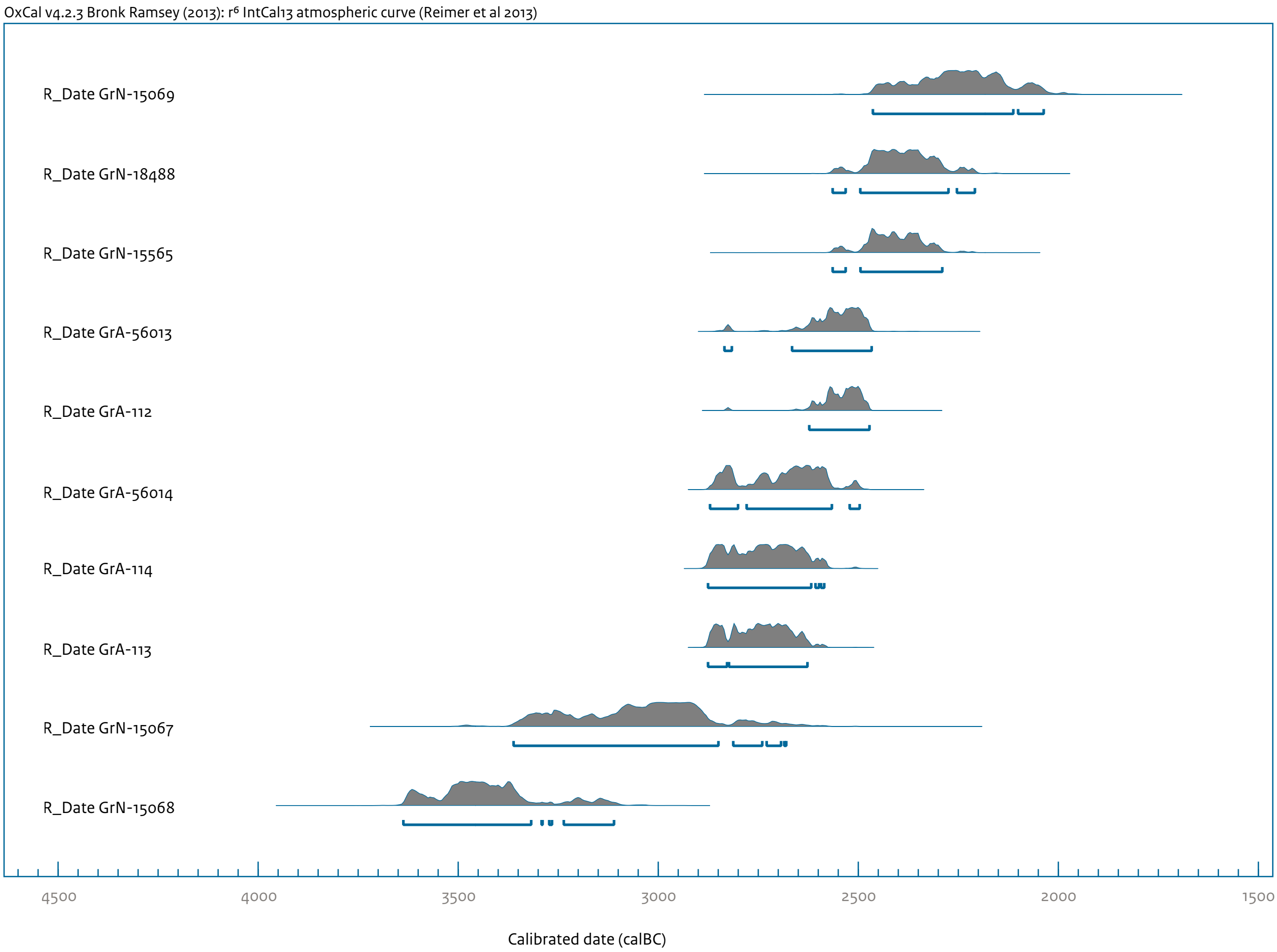


Figure 2.9 Multiplot of ^{14}C dates from Zeewijk.

the borehole survey. As stated above, parts of the cultural layer have ended up in the gully, which could explain the presence of somewhat younger cultural debris in the lower parts of the (eroded?) cultural layer at the location where the sample was taken.

Figure 2.9 shows all the calibrated ^{14}C results in chronological order.[50] As mentioned in our previous publications, Single Grave or Corded Ware chronology is seriously hampered by the presence of several plateaus in the calibration curve.[51] Based on Figure 2.9 and the location and stratigraphical position of the different samples, a rough chronological framework can be set out.

A chronological division into three groups is suggested. These groups correspond closely with the division proposed by Furholt (Fig. 2.10).[52] Because the calibration curve for this period shows several plateaus, this is no surprise. A calibrated date is more likely to lie on one of these plateaus than to correspond to a steep part of the curve. The oldest dates from Zeewijk range from approximately 3650-3000 cal. BC and are from geological deposits formed before habitation started. The first available dates on cultural material range from approximately 2900 to 2600 cal. BC, which corresponds to Furholt phase D. These dates show that there was activity at Zeewijk-West during this period (no data are available for Zeewijk-East). Then there is a series of dates with results between approximately 2600 and 2450 cal. BC (Furholt phase E) which overlap both the older and younger series of dates. Because these dates come from cultural material from Zeewijk-West, they suggest occupation and activity phases of Zeewijk-West. Finally,

50 OxCal v4.2.3; Bronk Ramsey 2009; Reimer *et al.* 2013.
51 Beckerman 2011/2012; Furholt 2003.
52 Furholt 2003.

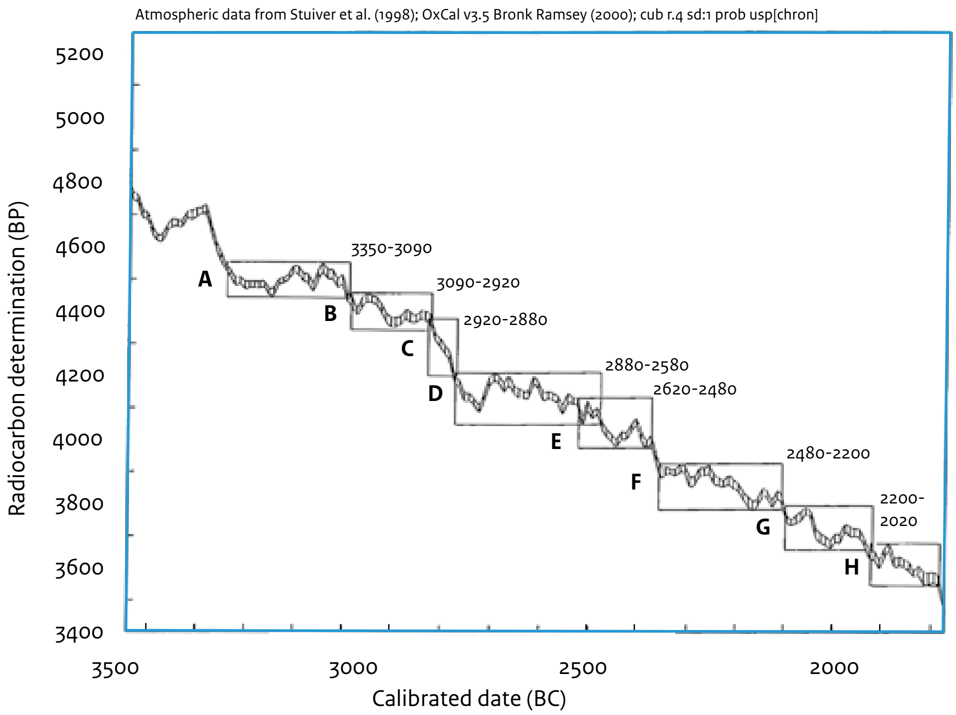


Figure 2.10 Furholt's graph of the calibration curve and phasing for the Single Grave Culture (after Furholt 2003, Fig 1, 15).

there was human activity between approximately 2450 and 2100 cal BC (Furholt phase F), which has been attributed to use of both Zeewijk-West and Zeewijk-East. The occupation at Zeewijk falls within Furholt phase D-F, like the occupation and activities at Mienakker and Keinsmerbrug.[53]

[53] Beckerman, this volume; Kleijne & Weerts 2013.

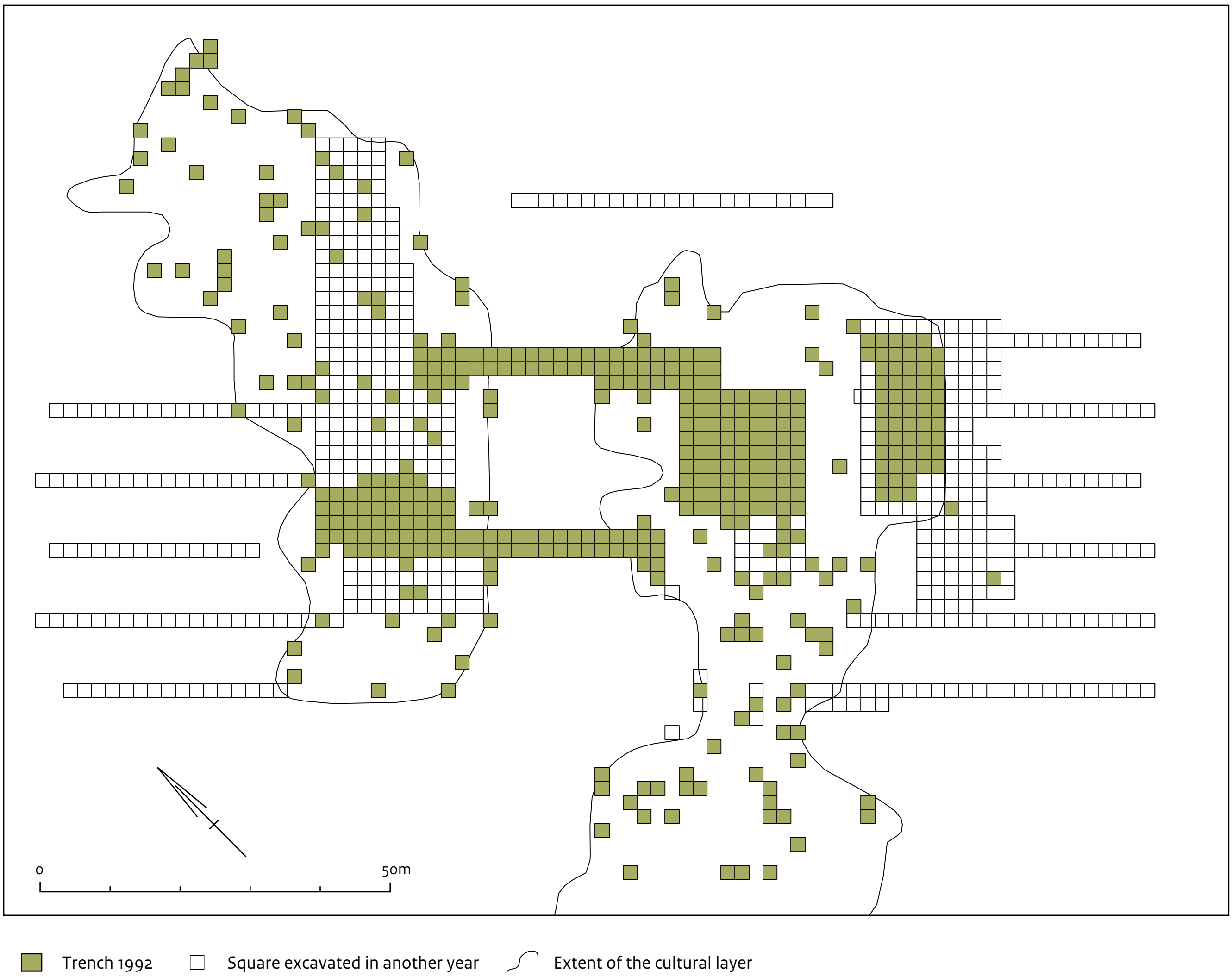


Figure 3.1 Extent of the excavated part in 1992 in relation to the cultural layer.

3 Features

G.R. Nobles

3.1 Introduction

The site was discovered in 1983 during ground works by K. de Lange, the landowner, which revealed the remains of a cultural layer. Unfortunately the work destroyed much of the cultural layer in the central area of the eastern part of the site. A borehole campaign revealed the extent of the cultural layer, and two areas were distinguished.[54] The smaller area, 2927 m², is located to the north, but due to the site's grid orientation and subsequent references, it is referred to as the western area. The area to the south is referred to as the eastern area and covers 5339 m². These two areas are separated by a gully and were named Zeewijk-West and Zeewijk-East during the excavation. Although they are defined as two divisions this does not necessarily mean that they correspond to two phases or two separate locales of habitation. The excavation was undertaken under the auspices of the *Rijksdienst voor het Oudheidkundig Bodemonderzoek* (State Service for Archaeological Investigations, ROB)[55], by volunteers under the supervision of W.J. Hogestijn and E.E.B. Bulten. The excavation was conducted due to the increasing threat of erosion of the site,[56] whilst also allowing an opportunity to validate a hypothesis presented by Hogestijn[57] following the excavations of the settlement sites of Keinsmerbrug, Mienakker and Kolhorn.

3.2 Excavation summary

3.2.1 The 1992 excavation

Following the 1986-1987 borehole campaign[58] large-scale excavations took place from 1992 to 1994.[59] Extra corings were taken prior to the excavation as the visible cultural layer had been masked by the ploughsoil. This aided the detection of the cultural layer, which acted as a proxy for the extent of the settlement. The first campaign started with the laying out of a grid of two by two metre squares over Zeewijk-West and Zeewijk-East. The squares were distributed in an arbitrary way, with the first square in the southwestern corner, at coordinate 100,400. Each two-metre square in the 1992 grid was divided into four one-metre squares. The cultural layer in these squares was excavated in spits of 3 cm.[60] These soil samples were wet-sieved at the site using a sieve with a mesh size of 4 mm.

Also three large trenches were dug and two long evaluation trenches cutting through both Zeewijk-West and Zeewijk-East, in order to obtain a good insight and to assess the relationship between the two sides of the gully that separates West and East (Fig. 3.1). In Zeewijk-East the test pits revealed a wooden post (1.3 m long and 0.3 m wide), initially thought to be modern in consideration of its good preservation. Later it became apparent that it formed a part of a large Neolithic structure.

3.2.2 The 1993 excavation

The 1992 area was extended beyond the test pits in the following year to define the remainder of the structure. In the central eastern area more squares were excavated to the south of the 1992 area, as well as to the south of the western excavation (Fig. 3.2). Part of the structure extended beyond the original excavation grid, indicating that the delimitation of a settlement on the basis of the cultural layer alone is insufficient.[61]

3.2.3 The 1994 excavation

This was to be the final year of excavation. Efforts were concentrated in the west, joining the southern area with the northern section across the gully and extending further northwards. The area excavated in the south in 1993 was extended westwards by six metres. At the time these zones were identified as those most threatened by ploughing. Evaluation trenches were excavated which reached beyond the cultural layers to try to define the extent of the settlement. These were long trenches with an approximate width of 1.5 m, defined by the bucket of the mechanical excavator. Finds from these long trenches were prefixed by the number 94 in the documentation (Fig. 3.3).

54 Van Heeringen & Theunissen 2001a,b.
55 Now *Rijksdienst voor het Cultureel Erfgoed* (Cultural Heritage Agency of the Netherlands, RCE).
56 Van Heeringen & Theunissen 2001b, 71.
57 Hogestijn 1992.
58 Gerrets, Bulten & Pasveer 1988.
59 Van Heeringen & Theunissen 2001b; Bulten 2001b.
60 Bulten 2001b, 4.
61 Bulten 2001b, 5.

Figure 3.2 Extent of the excavated part in 1993 in relation to the campaign of 1992 and the cultural layer.

Figure 3.3 Extent of the excavated part in 1994 in relation to the campaign of 1992 and 1993 and the cultural layer.

3.3 Features

Various features were discovered during the excavation (Figs. 3.4, 3.5, 3.6 and the inset of the overview of all features). Their interpretation is primarily based upon the field documentation, so on the excavators' interpretation. In the absence of many of the sections of the features and associated photographs, reinterpretations are not possible. The archaeological features include postholes, pits, cow hoof marks, ard marks and human footprints.

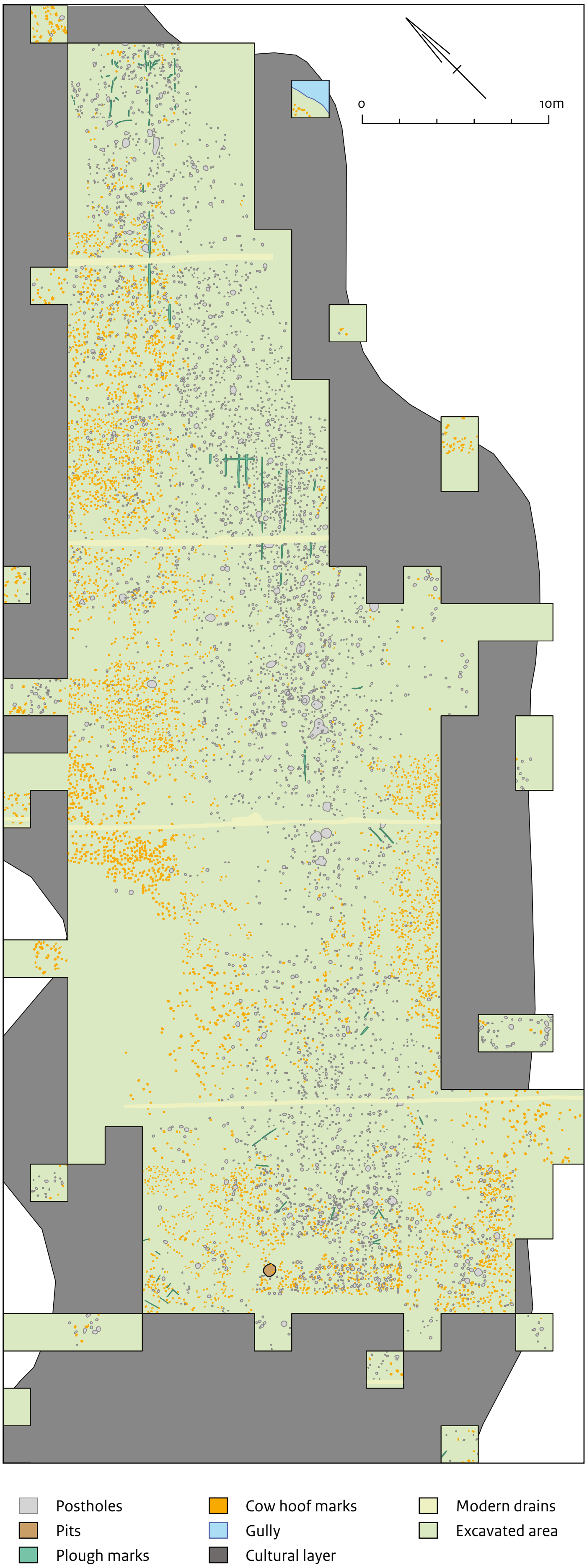


Figure 3.4 Overview of Zeewijk-West, showing all features.

Figure 3.5 Overview of Zeewijk-East (central), showing all features.

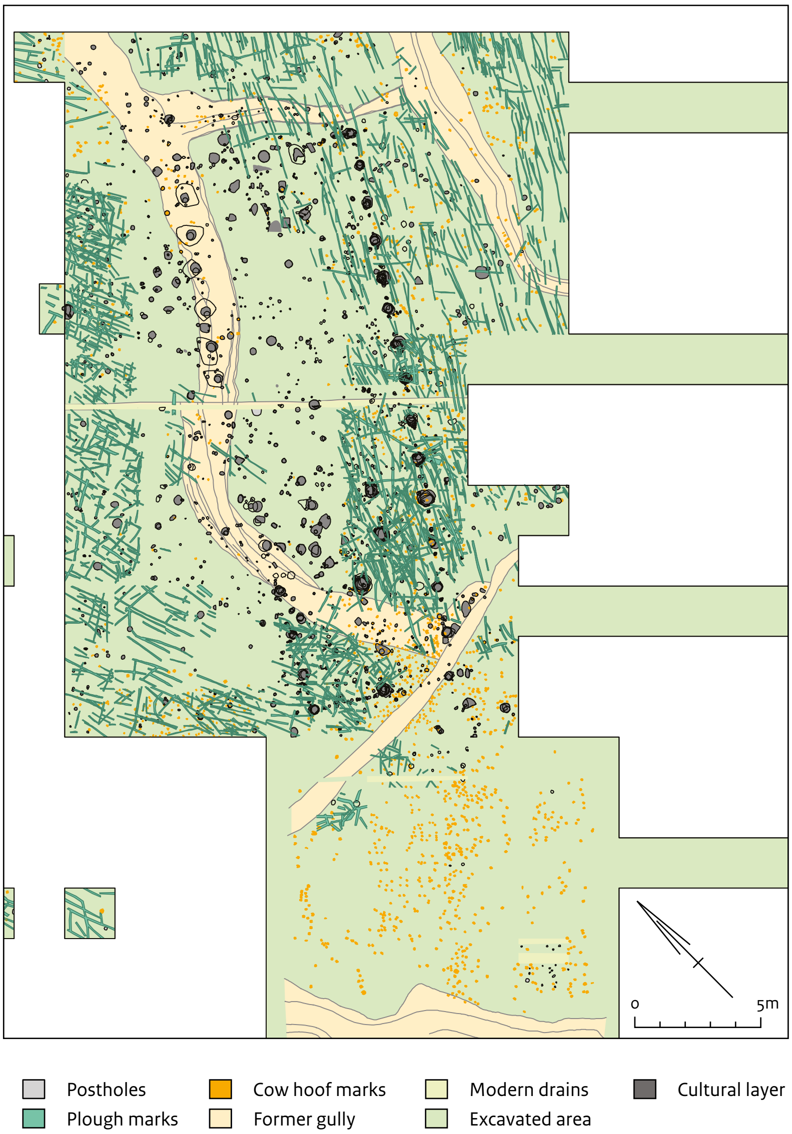


Figure 3.6 Overview of Zeewijk-East (east), showing all features.

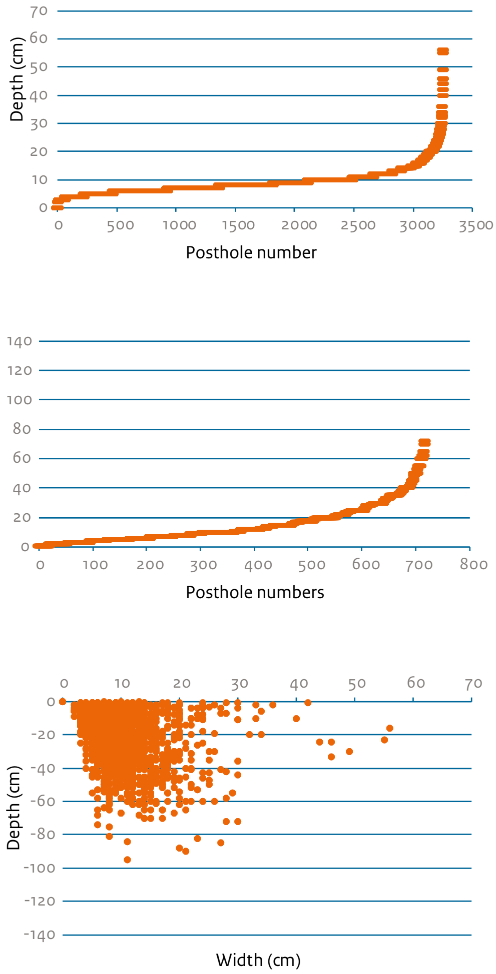
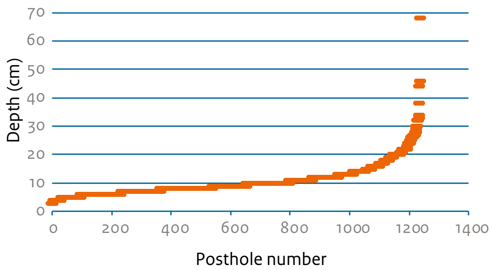


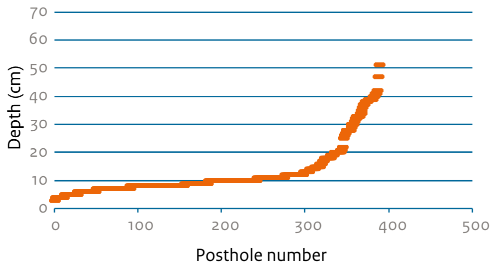
Figure 3.7a Widths and depths of the postholes of Zeewijk-West.

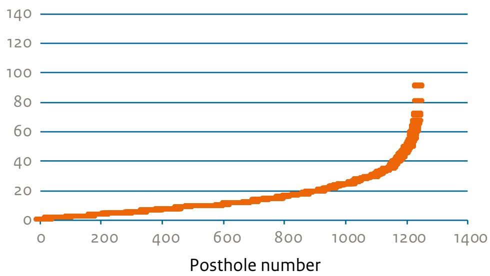
3.3.1 Postholes

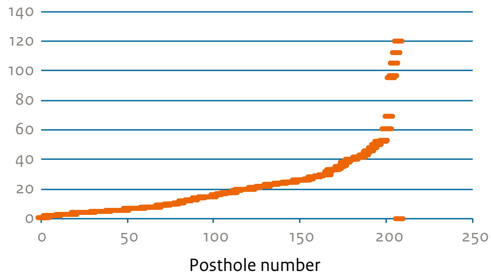
The postholes total 7813 in number. The quantities from each of the subdivisions are included in Table 3.1.

Depth information was available for many but not all of the postholes. The percentages of postholes with this information are shown in Table 3.1. The majority of postholes have a width of less than 30 cm. In Zeewijk-West 14 postholes which are located further north beyond the extent of the defined study area do not appear to correspond to any clear structures. In Zeewijk-East (central) 11 postholes are above this threshold and do not indicate structures. In









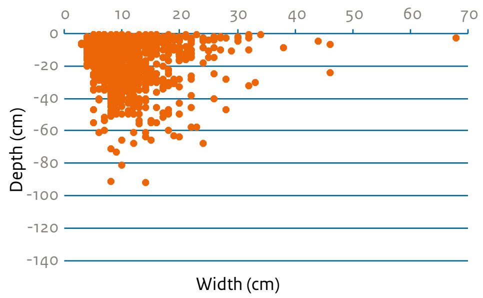


Figure 3.7b Widths and depths of the postholes of Zeewijk-East (central).

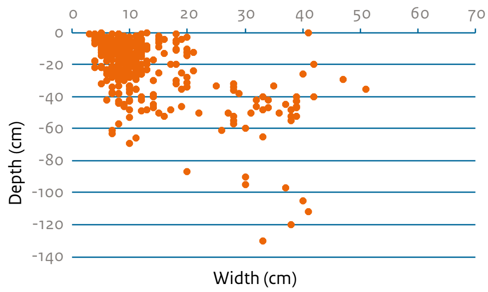


Figure 3.7c Widths and depths of the postholes of Zeewijk-East (east).

Zeewijk-East (east) there are a greater number of postholes above this threshold (n=31), all are related to the previously identified large eastern structure. These postholes can be identified on the associated width graph in Figure 3.7a-c.

The depths of the postholes were examined in Zeewijk-West (Fig. 3.7a). As there is no clear division in the depth data the depths of the postholes were examined at 10 cm intervals, i.e. width greater than 10 cm; width greater than 20 cm; width greater than 30 cm etc. None of these intervals aided in the identification of a structure or structural elements. The same method was applied to the Zeewijk-East (central) area, with the same result (Fig. 3.7b).

In Zeewijk-East (east) the posthole depths are mostly less than 70 cm (Fig. 3.7c). Only seven are deeper than 70 cm (n=25) and relate to the large eastern structure (Fig. 3.8). This questions the usefulness of posthole depths for the identification of structures at these sites. However, when combined with the width data

Table 3.1 Overview of the posthole information from the three areas.

Location	Total number of postholes	Postholes with depth	
		n	% of total
Zeewijk-West	4494	3257	72.5
Zeewijk-East (central)	1327	1239	93.4
Zeewijk-East (east)	1264	388	30.7

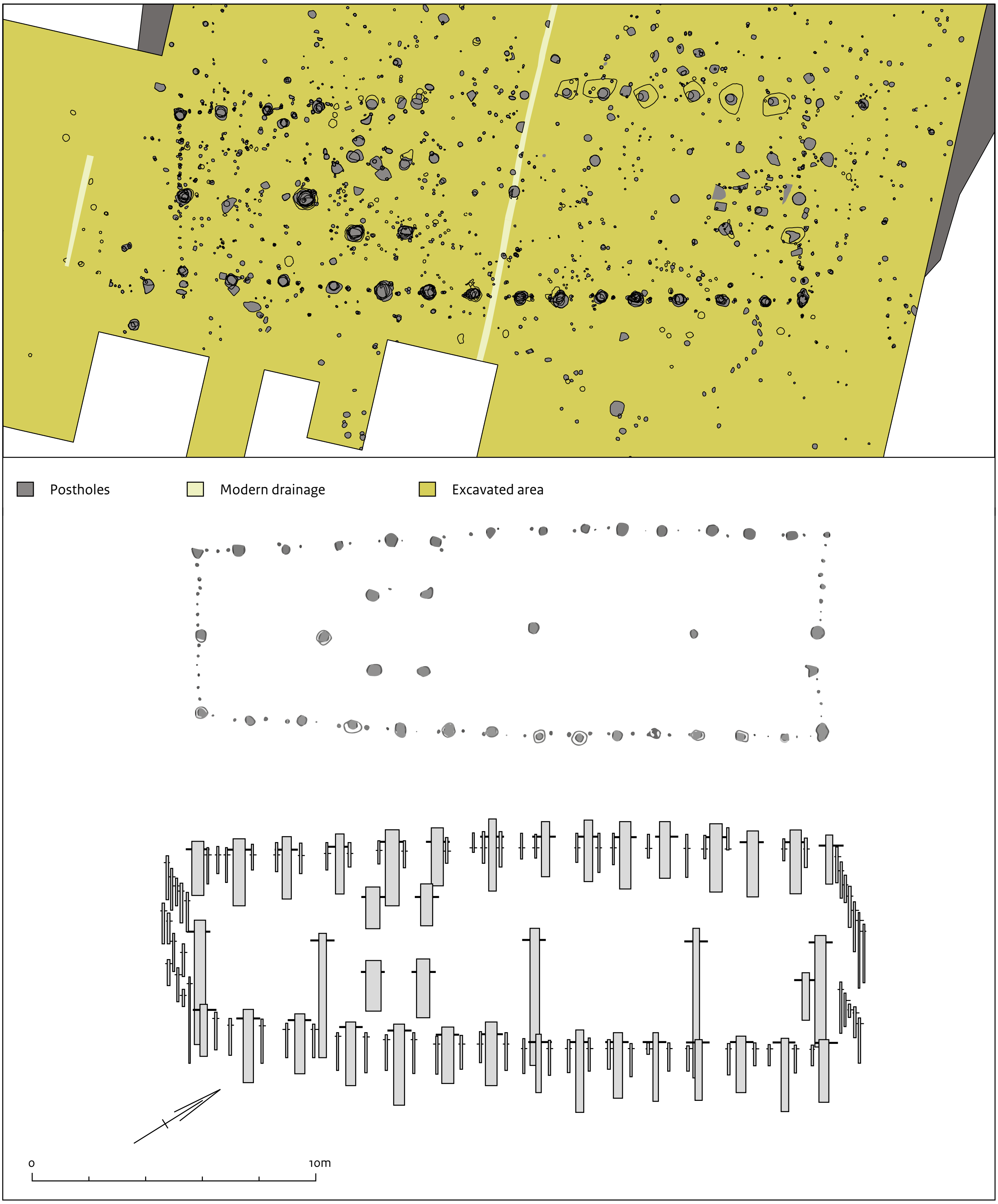


Figure 3.8 The large structure of Zeewijk-East. Above overview of the excavated area of the large structure (in 1993). Below the plan and posthole depts of the large structure as published in 1997 (adapted from Hogestijn 1997, Afb. 7, 36).

Figure 3.9 The base of one of the surviving posts with cut marks clearly visible (a. the base of the post still in situ, b. in removed position).

on a graph the large eastern structure stands out as a second grouping beyond the general pattern. No similar pattern is apparent in the other two areas, Zeewijk-West and Zeewijk-East (central).

The stumps of five posts from the central post line of the large structure were extremely well preserved. The excavators remarked that the chop marks on the bases of these posts could have been made yesterday (Fig. 3.9).

Figure 3.10 shows the outline and sections of excavated postholes of large structure of Zeewijk-East.

The posts were made from oak and were at a depth of up to 1.15 m and a width of up to 40 cm. Bulten[62] estimates the structure to have been 7 m high, whereas Hogestijn[63] suggests 5 m. It is not clear how these estimates were derived. There was an arrangement of another four posts within the structure. The fill of these postholes was similar to that of the exterior postholes, and an association was therefore determined.

With the survival of the central post line, it is curious that the external post lines are not also preserved. The excavators infer the remainder of the structure to have been deliberately demolished.[64] Two, but sometimes three, thinner posts generally stood between the larger exterior posts. Bulten indicates that these could have aided in the construction of wattle fences which were later covered with daub.[65] No actual evidence of wattle or daub survives.

[62] Bulten 2001b.
[63] Hogestijn 1997.
[64] Hogestijn 1997, 38.
[65] Bulten 2001b.

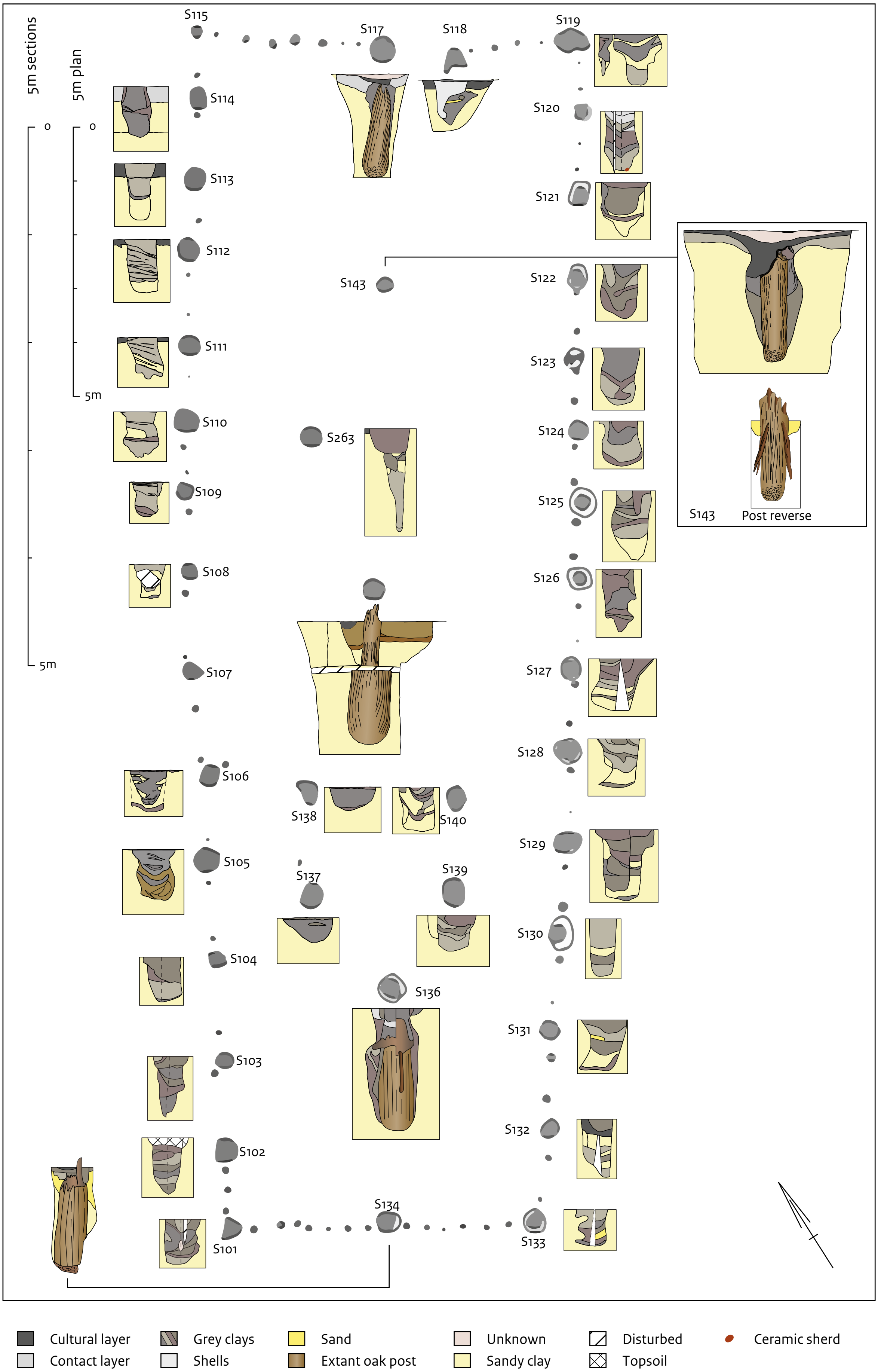


Figure 3.10 Documented section of the large structure of Zeewijk-East, base plan after Hogestijn 1997, post numbers from the archive.

3.3.2 Pits

Despite the large numbers of postholes only four pits were discovered, three in the east (central) and one in the west.[66]

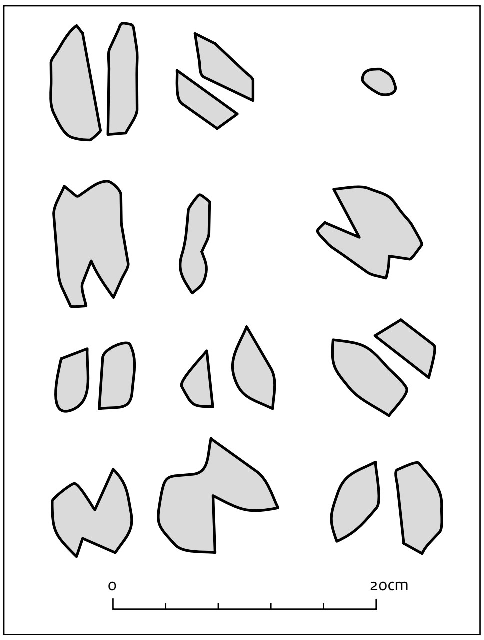


Figure 3.11 Various representations of cow hoof marks.

3.3.3 Cow hoof marks

There are 13650 features interpreted as cow hoof marks. However, on the excavation plans a hoof mark can broadly consist of one or two components, as illustrated in Figure 3.11 en 3.12.

The actual quantity of individual hoof impressions will therefore be upwards of 6825. They appear in all of the excavated areas and within many of the test pits.

Figure 3.12 Cow hoof marks in the excavated square.

[66] The archive contains no further information relating to the pits.

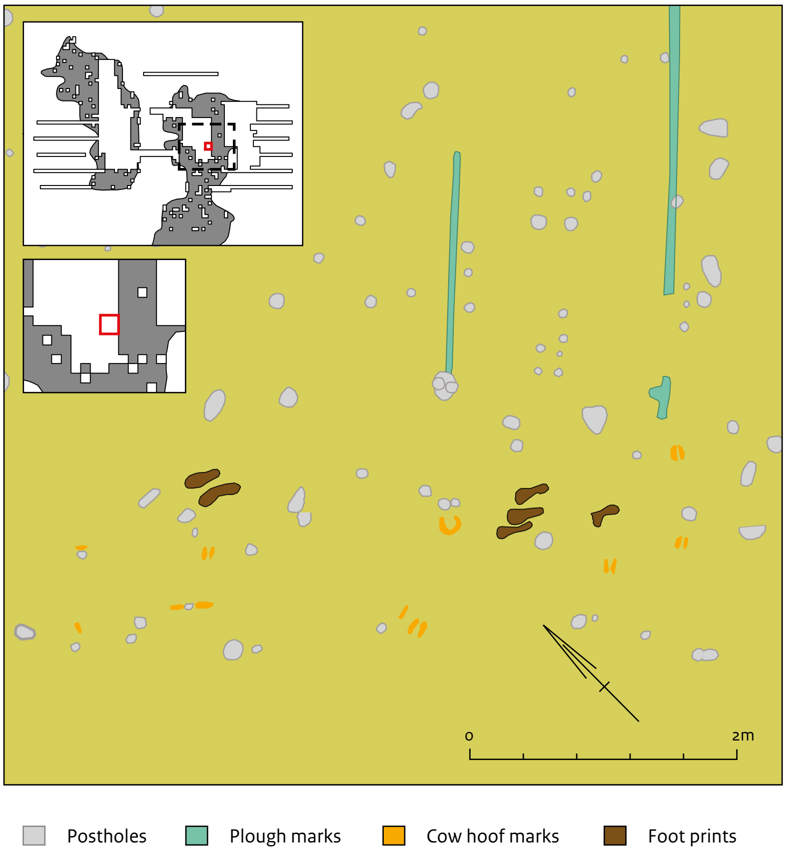


Figure 3.13 The human footprints in the central (east) area.

3.3.4 Ard marks

There are numerous ard marks in all areas of the site. These were not recorded in section but their configuration in a criss-cross pattern supports this interpretation. Ard marks have not been quantified but there are some very dense areas, specifically in the eastern region. Test pits further reveal that ard marks are present in Zeewijk-East and Zeewijk-West, as well as in sparsely investigated areas.

In Zeewijk-East (east) ard marks were documented during the 1993 excavation campaign, but only a few during the 1992 excavation campaign. Further south within this area ard marks were documented in the 1992 test pits but not during the 1993 excavation campaign. This is probably a result of the excavation and documentation methodology rather than the absence of these features. Test pits beyond this trench also indicate areas with high densities of ard marks, further suggesting the continuation of these features. As the excavation methodology appears to reflect the presence or absence of these features it is likely that the entire site would yield some evidence of ploughing.

3.3.5 Human footprints

A possible human footprint has been found in one of the test pits in the western area, and seven more have been identified in the central area within close proximity to each other. These footprints are between 21 and 33 cm long. Most are between 26 and 28 cm long, equivalent to present-day shoe sizes 9-11 (UK) or 42-45 (EU) (Fig. 3.13).

3.4 Phasing

3.4.1 Zeewijk-West

The sections beyond the sample area in the west, particularly those in the 1994 evaluation trenches, demonstrate a fairly quick tapering off of the cultural layer. This broadly coincides with the cultural layer as predicted by the borehole survey.

Within the sample area there is one profile (Fig. 3.14) which extends along the full width of the trenches. It is north facing and begins south of squares 1302-1311 (2 by 2 m squares, these are documented as squares 1238-1247 from the southern unexcavated squares). These mark the southernmost extent of the western trench.

The profile displays some clear build-up of material, the natural sandy clay forming part of the depression, and undulating within this depression. Above this are two ‘contact layer’s, presumably caused by a mixing of the natural layer and the land surface of the time.[67] This could easily have been caused by the movement of cows, especially since their hoof marks dominate this area.

The cultural layers at this site are associated with habitation phases. The initial deposits appear to be divided by two bands of shell located more

[67] Smit, this volume.

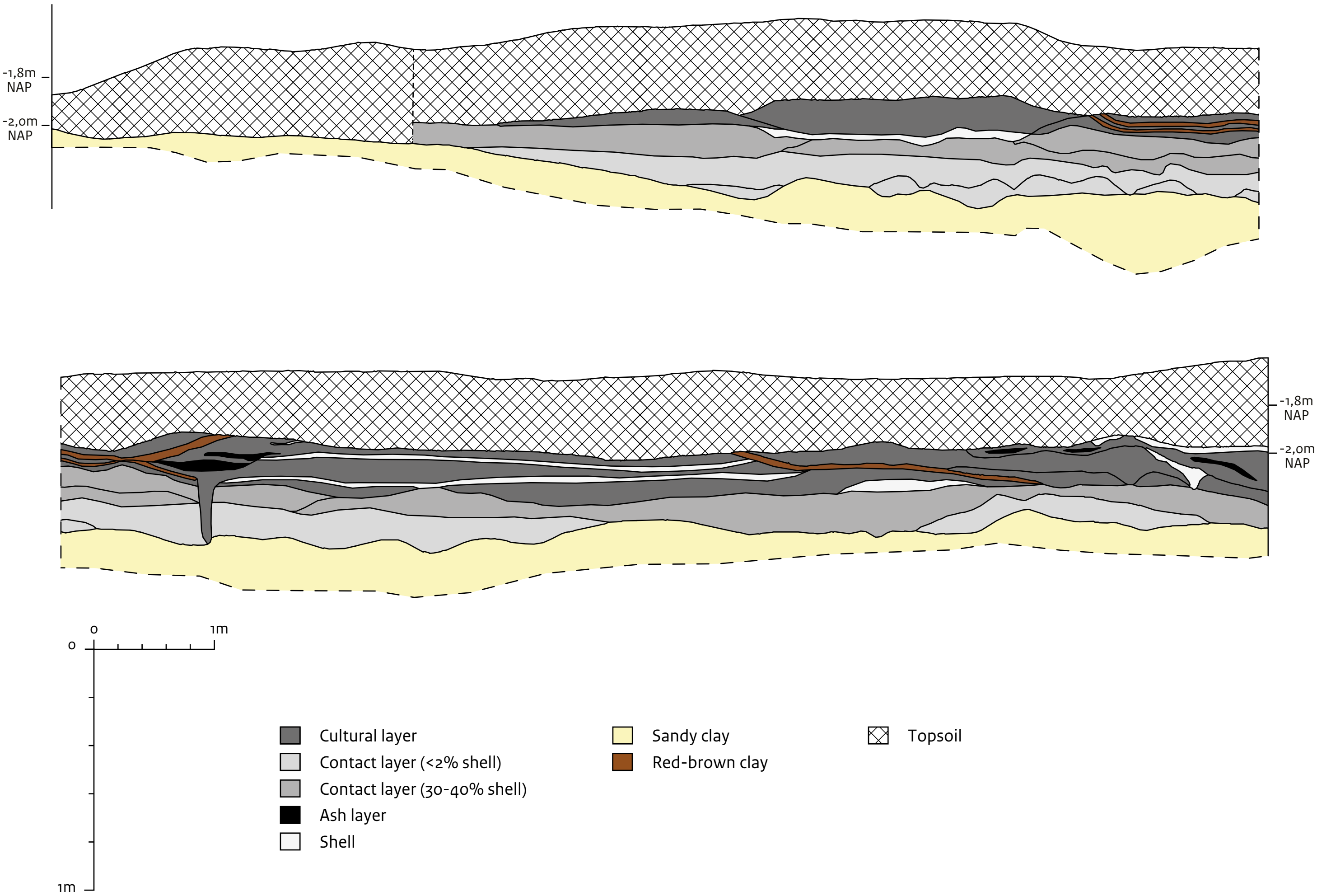


Figure 3.14 The southern profile from the south of Zeewijk-West.

centrally in the profile. On either side of this is a reddish-brown clay layer. Since this rises and stops at the topsoil it is likely that this layer potentially marks a flooding event.[68] The fact that this layer meets the topsoil indicates the site has been truncated, probably as a consequence of modern ploughing. Further cultural or habitation layers continue to build up spreading further to the east and west.

In the north of this area, within the northern posthole concentration, beyond the defined sample area, there is another recorded profile (Fig. 3.15).

In this profile the 'contact layer' is much thinner; cow hoof marks are few in this area, in contrast with the more southern profile (Fig. 3.14).

Habitation phases are defined by the multiple cultural layers. These two profiles indicate multiple habitations in the southern area.

[68] Smit, this volume; Hogestijn 1997.

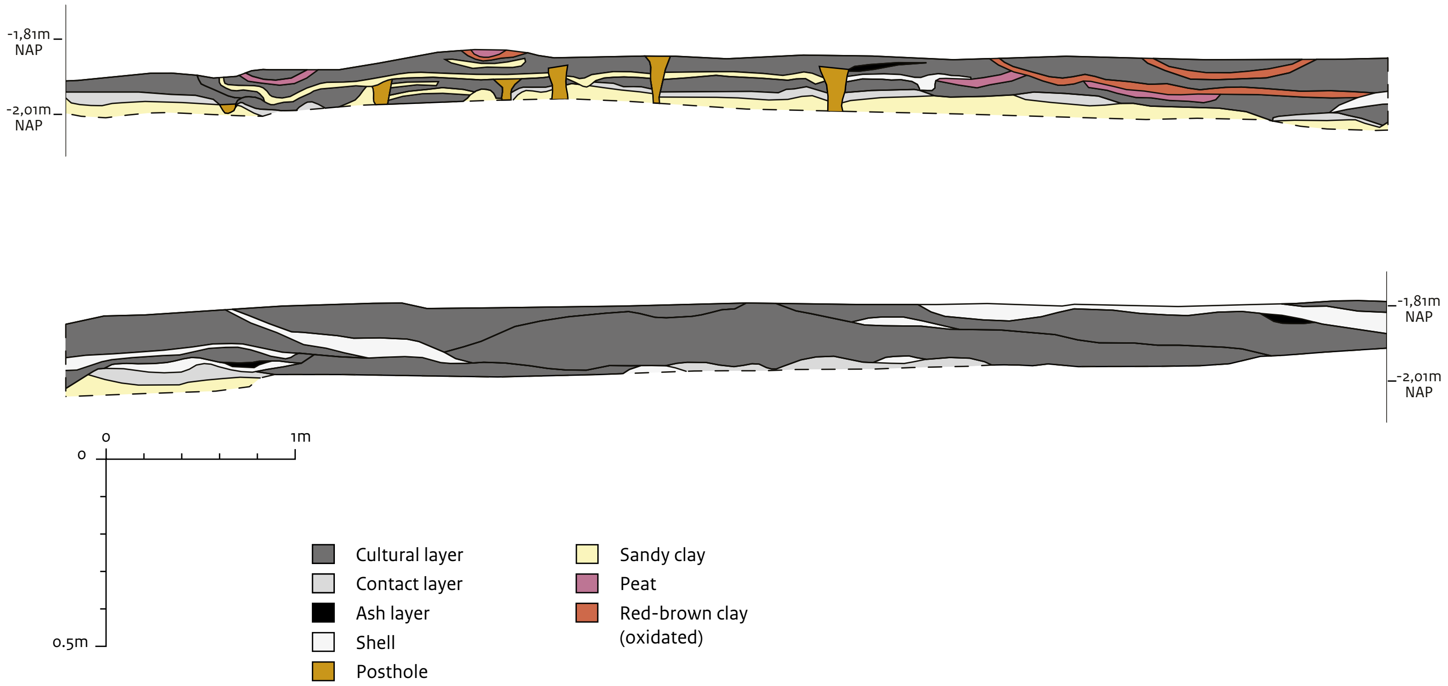


Figure 3.15 The northern profile across Zeewijk-West beyond the study area.

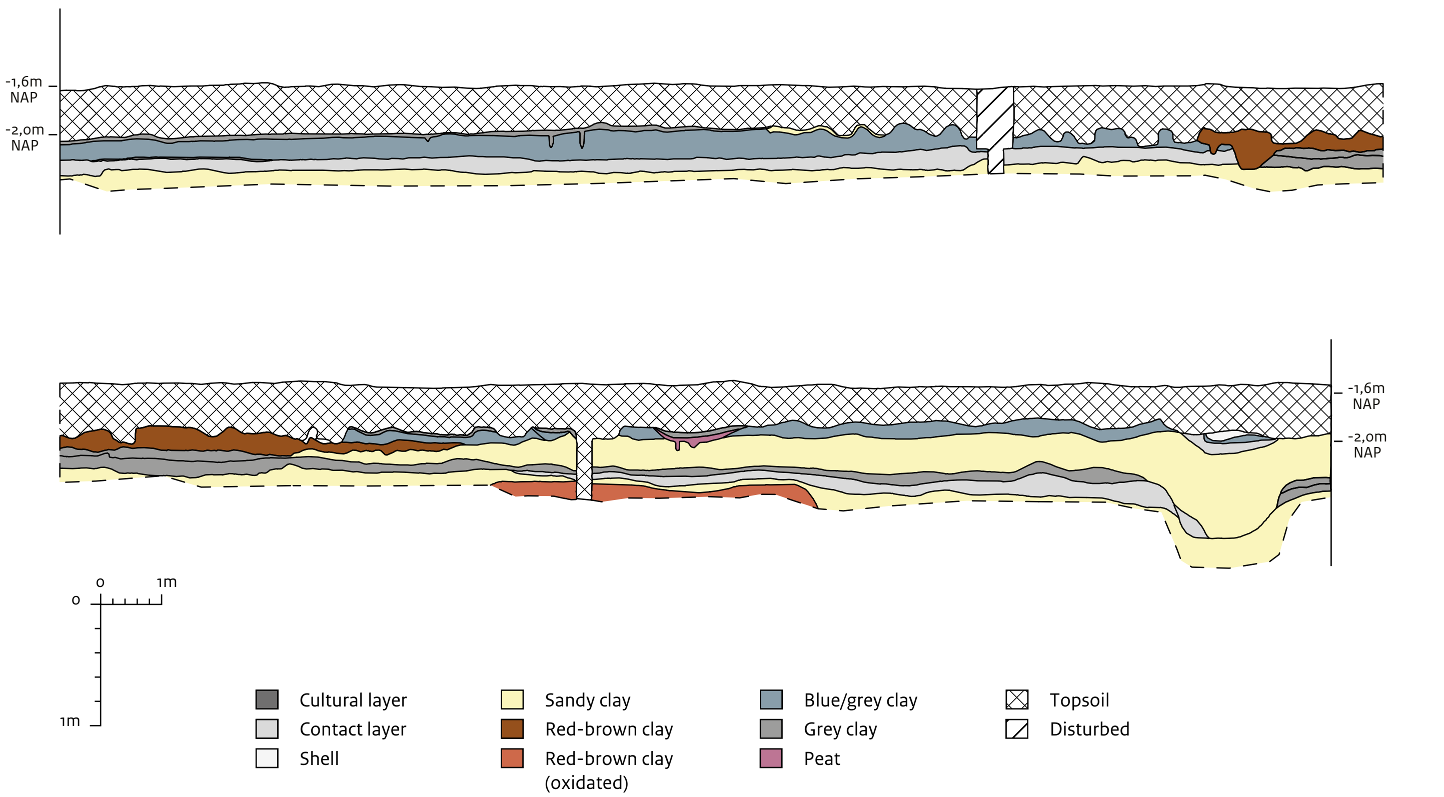


Figure 3.16 Zeewijk-East, the northern profile.

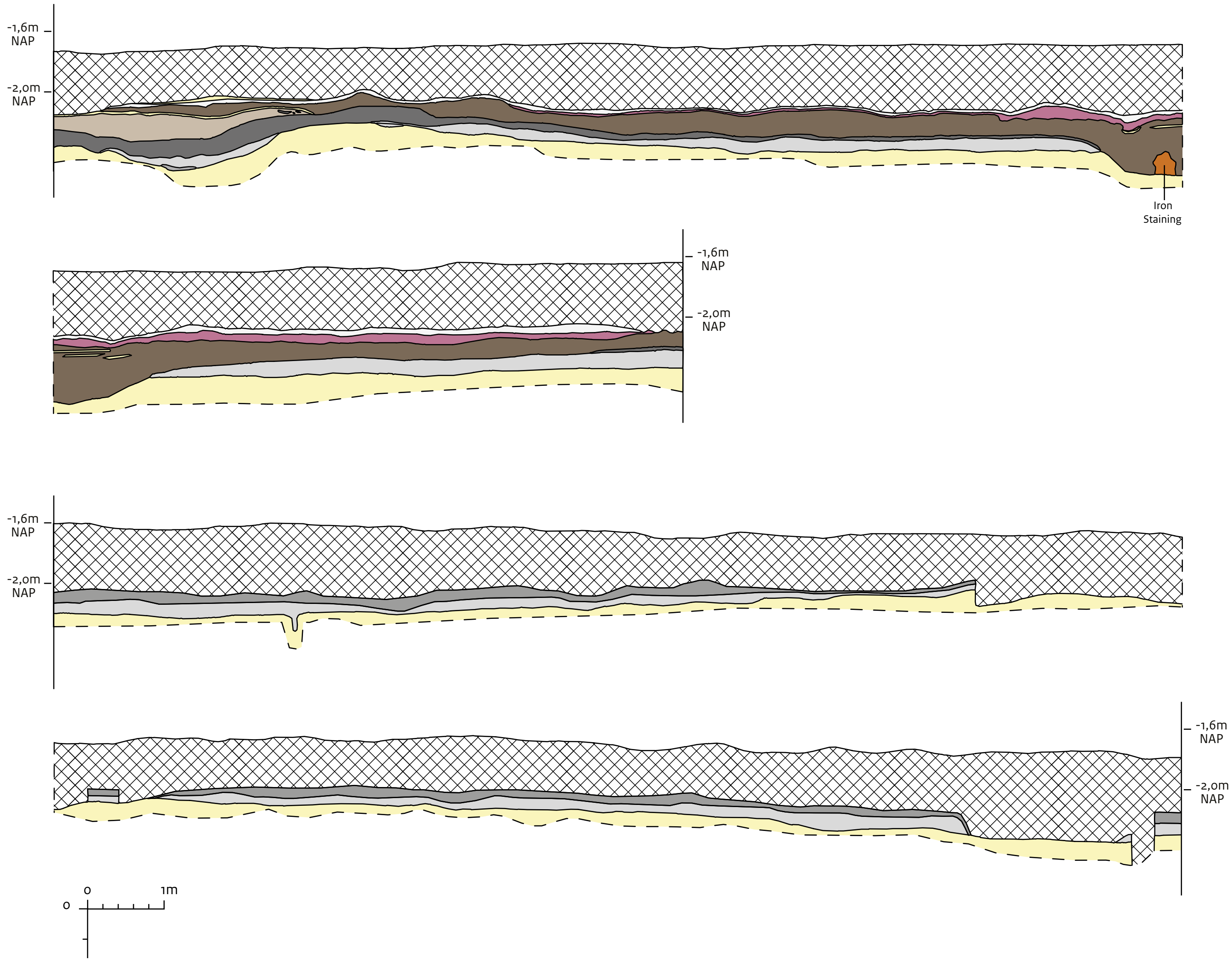


Figure 3.17 Zeewijk-East; top: the northern profile; bottom: the western profile.

3.4.2 Zeewijk-East

Three profiles are available for the easternmost trench which contains the large eastern structure. Unfortunately, none of the profiles cuts through the structure. The easternmost section (Fig. 3.16) has a thick transition from the natural sandy clay upon which, isolated in the north, is a very thin part of the cultural layer. This again coincides with the predicted edge of the cultural layer as defined in the borehole survey.

The northern profile (Fig. 3.17, above) contains much more of a cultural layer, once again above a ‘contact layer’. Above this single layer is the reddish brown clay with some sandy bands. Upon this there was peat development followed by shell deposits. The western profile (Fig. 3.17, below) also indicates the same single cultural layer with a lower ‘contact layer’ and an indication of the reddish brown clay above.

3.4.3 Phasing summary

Based upon these profiles a general pattern of multiple habitation phases can be seen. However, it is not possible to create an overall phasing which describes the associations between the east and the west.

4 Ceramics

S.M Beckerman

4.1 Introduction

The present study provides an opportunity to study a larger selection of the Zeewijk ceramics and compare the results to the recently studied Single Grave Culture (SGC) settlement sites in Noord-Holland known as Keinsmerbrug and Mienakker. Information on the ceramics present at the settlement site in Zeewijk is already available. Sier presented a useful overview of the characteristics of a selection of the ceramics.[69] Hogestijn and Drenth, and Hogestijn presented some hypotheses about the use, role and chronology of the ceramics.[70] However the conclusions are preliminary and various questions have not been addressed or answered. These include the use and role of the settlement and its ceramics. Another question concerns the causes of the differences in the ceramic assemblages present in different areas of the Zeewijk settlement.

The results of the new analysis will be presented in this chapter. First, the research context of the SGC ceramics is presented in Section 5.2. In Section 5.3 the methods and results from the previous analyses are presented and discussed. Section 5.4 deals with the methodology presently used to study these ceramics. A description of the Zeewijk ceramics and ceramic artefacts will be presented in Section 5.5. Their technological and morphological characteristics and decoration will be outlined. The function and use of these vessels will also be analysed. In Section 5.6 the characteristics of the ceramics from three different areas within the Zeewijk settlement – Zeewijk-East and the north and south part of Zeewijk-West –will be compared and discussed. The conclusions of earlier studies will be tested in Section 5.7. In Section 5.8 the Zeewijk ceramics will be compared to the ceramics from Mienakker and Keinsmerbrug. The final conclusions will be presented in Section 5.9.

4.2 SGC Ceramics

Ceramics from SGC funerary contexts have been studied extensively. The first typological and chronological division of the beaker wares was presented in 1955 by Van der Waals and Glasbergen.[71] They divided the SGC beakers on the basis of morphology and decoration into six Protruding Foot (PF)-types (1a-f), and the All Over Ornamented (AOO)-beakers into three types (2IIa-c).[72] In later versions of the model, AOO types 2IId-f where added.[73] Lanting, Lanting and Van der Waals, and Drenth and Lanting made some subsequent adjustments to this typochronological division.[74] The key proposition of this 'unilinear model' is that the development of the beaker ceramics was continuous. In 1999 Drenth and Hogestijn proposed a different developmental trajectory.[75] Their model proposes a two-track development; from the late SGC until the Early Bronze Age there are both half-decorated and completely decorated beakers in both periods, and it is argued that the two types developed independently of each other. An in-depth discussion of the two models and the validity of the arguments on which the models are founded has been published elsewhere.[76]

Both models are based mainly on beakers. Other vessel types have also been distinguished for the SGC, however: plates, bowls and small vessels (*Dosen*), amphora, handled beakers, shortwave moulded vessel types (*golfbandpotten*), fingertip vessels (*vingertoppotten*) and beaker pots (*bekerpotten*).[77] On shortwave moulded pots plastic cordons have been added to the vessel walls and on amphora handles have been added.

Decoration was applied to SGC pottery using three techniques: spatula impression, cord impressions and fingertip or nail impressions. The motifs consist of lines, rows of oblique impressions in one or two directions, zigzags, crosses, cord imprints and fingertip and nail imprints.[78] Several combinations of motifs are possible, including herringbone patterns bordered by grooved lines (type 1b), herringbone with grooved lines between the rows (type 1c), rows of oblique impressions and lines (type 1e), herringbone with cord lines between the rows (with plain spatula type 2IId or with a dentate spatula type 2IIa) and cord with fingertip or nail impressions on top of the rim (type 1a or 2IIb).

Lanting and Van der Waals state that the decorations on PF beakers developed over time from solely consisting of parallel lines of cord impressions, to grooved lines and lines made with a plain spatula. Furthermore the oldest

69 Sier 2001.
70 Hogestijn 1997; Drenth & Hogestijn 2006.
71 Van der Waals & Glasbergen 1955.
72 Van der Waals & Glasbergen 1955.
73 Type 2IId: Hulst, Lanting & Van der Waals 1973, 98; Type 2IIe and f: Sier 1999, 397.
74 Lanting 1973; Lanting & Van der Waals 1976; Drenth & Lanting 1991.
75 Drenth & Hogestijn 1999.
76 Beckerman 2011/12.
77 For examples of the different vessel types see: plates, bowls and cans in Drenth & Lanting 1991; handled beakers and an amphora in Van der Waals 1964; shortwave moulded and fingertip vessels in Floore 1991; beaker pots in Ten Anscher 2012.
78 Van der Waals & Glasbergen 1955.

decoration with both cord and grooved lines consists of horizontal lines. The motifs first transform into a herringbone design and later into horizontal rows of diagonal impressions in one direction.[79] The AOO beakers differ in two respects from the other types: (1) the whole outer surface of the AOO beaker is decorated and (2) grooved lines are absent from AOO beakers.[80]

4.3 Previous research on Zeewijk

Previous research by Sier

Sier studied a selection of 15460.2 g from Zeewijk-West and 4549.1 g from Zeewijk-East.[81] Her publication is the most extensive report on the ceramics from any of the SGC settlement sites.[82] Importantly, Sier was one of the first authors to publish a paper on the SGC settlement ceramics which addressed not only the morphological characteristics and decoration of complete beakers, but also the technological characteristics and the morphological characteristics and decoration at sherd level.[83] In order to study the decoration of the settlement ceramics, Sier developed a new method which has advantages over the 'traditional' type division, whose suitability is limited to complete vessels. She distinguishes five techniques used for rim decoration and six techniques for wall decoration, plus a seventh option for undecorated zones. These different groups are further subdivided on the basis of the pattern applied. For example, there are twelve different patterns for cord decoration and nineteen for spatula decoration. However, Sier also uses the traditional type division and even adds a AOO-type, 2IIf, which is decorated with grooved lines and imprints made with a plain spatula.

The method Sier developed to describe different decoration patterns is not used in the present study, however.[84] Notwithstanding the fact that it offers a framework for studying decoration at sherd level, it is also too detailed and subjective. Different scholars will probably describe the same sherd differently, since the division is detailed but is not described in detail. Furthermore, it does not facilitate distinction between PF and AOO beakers since the length of decoration is not taken into account. Sier used the method only to describe the variability, not to explain it. Sier herself consequently uses the traditional beaker types when comparing Zeewijk with other sites.[85]

Sier characterises the Zeewijk ceramics as being grog-, stone- and or sand-tempered. Thin-walled ware (less than 7 mm) is usually sand tempered whereas thick-walled ware (over 7 mm) is frequently stone grit-tempered.[86] There are several differences between the ceramics from Zeewijk-West and Zeewijk-East. For example, AOO types 2IId, 2IIe and 2IIf are found only in Zeewijk-West.[87] Fingertip-impressed vessels are also only found in Zeewijk-West and cord and groove lines occur more frequently in this area. Stone grit tempering and thick-walled ceramics are more common in Zeewijk-East,.[88] Both Zeewijk-West and Zeewijk-East have been dated to the late phase of the SGC on the basis of the presence of PF and AOO beaker types, but Sier believes that Zeewijk-West was probably inhabited longer or later.[89] She lists three options to interpret the differences in the ceramics: (1) the sites were inhabited at the same time by different groups, (2) the sites were not inhabited simultaneously and (3) the sites were inhabited at the same time by the same group yet the two areas had different functions.[90] Sier argues in favour of option (3) and she sees the presence of thick-walled ware in Zeewijk-East as evidence of a storage function for this area. The presence of more thin-walled beakers in Zeewijk-West may indicate food consumption in this area, according to Sier.[91]

Previous research by Hogestijn

Hogestijn interprets the Zeewijk site as a large residential settlement.[92] The ceramics of such large sites are thought to comprise a diversity of vessel types, with large cooking pots and storage vessels, whereas small sites yield small cooking pots and few storage vessels.[93] It is argued that the Zeewijk ceramics display the broad diversity characteristic of a large site, with different PF and AOO types, vessels decorated with fingertip imprints, and very large vessels.[94] In Zeewijk-West there are more vessels decorated with grooved lines, while in Zeewijk-East there are more fingertip and spatula imprints.[95] Hogestijn draws the preliminary conclusion that five possible house phases can be distinguished in Zeewijk-West, each with different ceramic assemblages.[96] The north part of Zeewijk-West might be younger than the south part of this site, according to Hogestijn.[97]

79 Lanting & Van der Waals 1976, 5.
80 Lanting & Van der Waals 1976, 5-9.
81 Sier 2001, 358.
82 Sier 2001.
83 Sier 2001.
84 Sier 2001, 386-388.
85 Sier 2001, for example 397.
86 Sier 2001, 410.
87 Sier 2001, 411.
88 Sier 2001, 411.
89 Sier 2001, 410.
90 Sier 2001, 411.
91 Sier 2001, 411.
92 Hogestijn 1997, 28-29.
93 Hogestijn 1997, 28-29.
94 Hogestijn 1997, 33.
95 Hogestijn 1997, 33.
96 Hogestijn 1997, 34-35.
97 Hogestijn 1997, 35.

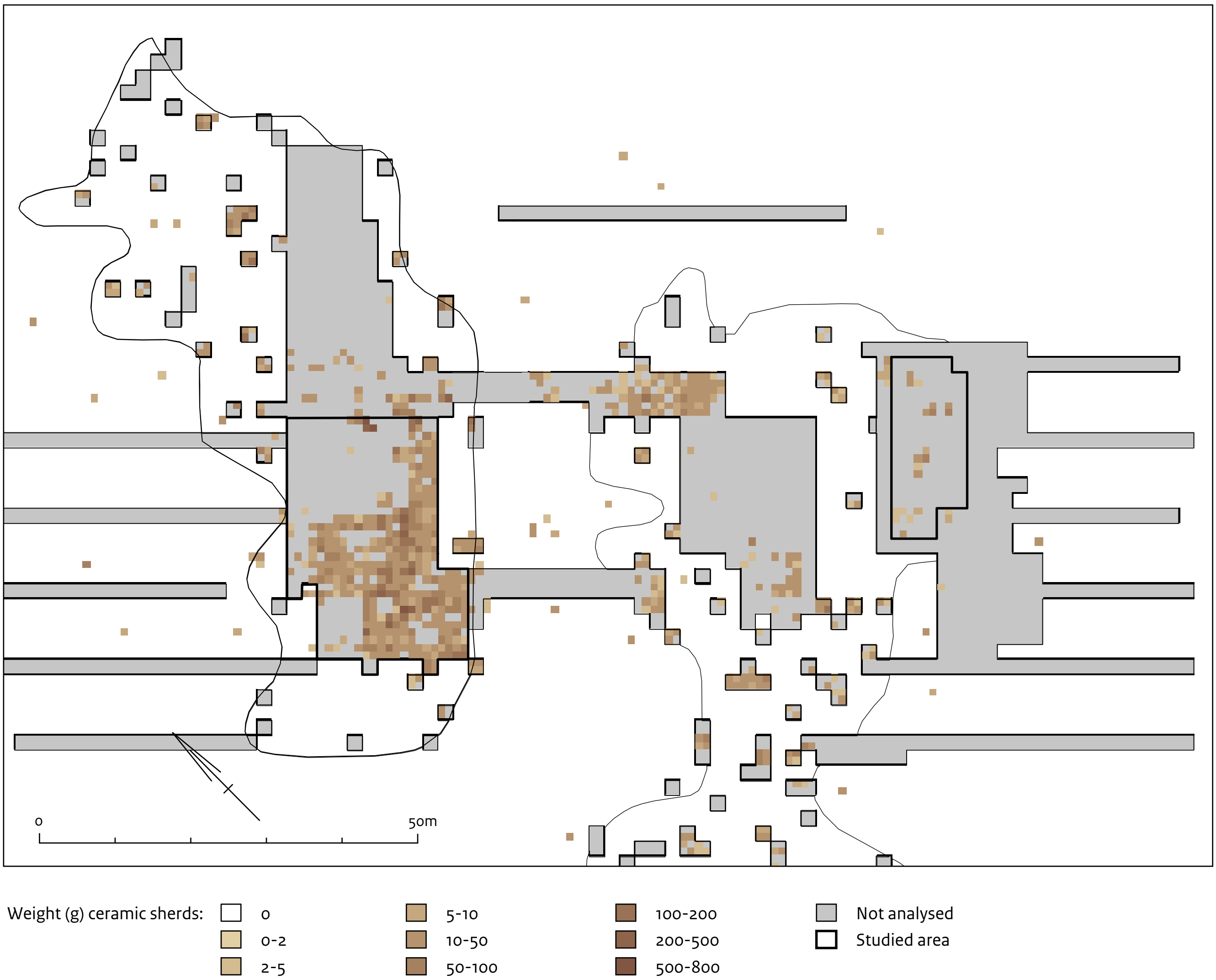


Figure 4.1 Distribution of analysed sherds over the site.

Previous research by Drenth and Hogestijn
Drenth and Hogestijn also stress the importance of the Zeewijk ceramics.[98] They highlight the fact that PF beakers are present in Zeewijk-West and Zeewijk-East and AOO beakers in Zeewijk-West.[99] Zeewijk and other SGC settlement sites are seen as very important for our understanding of the emergence of the later Bell Beaker culture. They postulate, for example, that the origin of the 'Veluwe-style Bell Beaker' can be found at SGC settlement sites.[100] In Zeewijk-West an undecorated beaker was found with a shape similar to the later Veluwe beakers. The former is therefore seen as a precursor of the latter. Another aspect that makes the Zeewijk ceramics important for Drenth and Hogestijn is the fact that sherds with zoned decoration have been found there.[101] This trait is seen as a prelude to later Bell Beakers with zoned decoration and as important for understanding the emergence of these Bell Beakers.[102]

4.4 Methodology

Sampling
Zeewijk has yielded far more finds than could be studied within this project. The project group therefore decided on a sampling strategy. During previous research the site was subdivided into an area west of the gully and an area east of the

98 Drenth & Hogestijn, 2006.
99 See table 2 in Drenth & Hogestijn, 1999.
100 Drenth & Hogestijn, 2006, 89.
101 Drenth & Hogestijn 2006, 79.
102 Drenth & Hogestijn 2006, 79.

gully. In the first phase all finds from a rectangular area of Zeewijk-West were studied.[103] One-third of the analysis time had to be dedicated to the Zeewijk-East finds. No delineated area was chosen here, and the material specialist could pick random finds from the boxes. After the initial phase it was decided that the selection area in Zeewijk-West should be expanded to the north.[104] The ceramics from this area were also studied. The selection was enlarged even further to the lowest layers in the north and northwest (Fig. 4.1). A total of 3329 sherds with a weight of 26767.9 g were analysed (2700, 22139.3 g from Zeewijk-West and 629 sherds, 4628.9 g from Zeewijk-East). The total number of sherds found in Zeewijk-West is 4014, the total found in Zeewijk-East is 1390.[105] Thus, 67% of the Zeewijk-West material and 45% of the Zeewijk-East sherds were analysed. Although the site was excavated in different layers Nobles was forced to conclude that the layer information was not sufficiently accurate and did not therefore provide an adequate basis for accurate definitions.[106]

Methodology

In order to obtain information on the use, role, function and chronological variability of the ceramics, the technological and morphological characteristics are examined, as well as the decoration. Technological analysis plays a key part, as many morphological characteristics have disappeared due to fragmentation and weathering processes. Attention is paid to the tempering materials: their quantity and size, the firing method reflected by the colours of the cross-sections, the thickness of the sherds, pot construction, and the treatment of the inner and outer surfaces of the vessels (Appendix I). These variables reflect 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.

Morphological characteristics are initially studied at sherd level. Analysis focuses on the partitioning of the pot and the shape of the rim and base. After the completion of this analysis, all rim and base sherds and the sherds that either fitted or, on the basis of their characteristics, were likely to belong to the same vessel were studied again as pot individuals. The diameter of the rim, widest belly circumference and the base diameter were measured and a description of the shape was made (Appendici I-V). Of the decorated sherds the decoration techniques and motifs were analysed. The decoration, in combination with the shape of the vessel, was also compared to the Van der Waals and Glasbergen types.[107] All vessels for which the rim was present were assigned a number (1, 2, 3). All vessels that were decorated or perforated but had no rim were assigned a capital letter (A, B, C). All vessels without a rim but with a base (or base fragment) were assigned a Roman numeral (I, II, III). Wall fragments that were not decorated or perforated and had no rim but were nonetheless interesting due to specific characteristics (such as tempering with complete grains or an exceptionally large size) were assigned two lowercase letters (aa, bb, cc).

4.5 Results

4.5.1 Technological characteristics

Tempering

What is very striking is the high number of combinations of tempering materials added to the clay. As many as twenty combinations have been distinguished throughout the entire Zeewijk site. The quantities in which the different materials were added and the combinations appear, however, to differ (Table 4.1).

A large majority (82%) of the sherds are grog- and sand-tempered. Stone grit, either quartz, granite, red granite or mica, is present in 14% of the sherds. Shell and plant material are observed in very small numbers and percentages of sherds, 0% and 1% respectively.

The thickness of the Zeewijk sherds ranges from 2-19 mm. The graph expressing these thicknesses is unimodal (Fig. 4.2). A large group of sherds (48%) are thin-walled (5-7.5 mm). Medium-thick (8-8.5 mm) sherds account for 15% of the total. Thick-walled ware is present too, 9-9.5 mm 9%, and 10-10.5 mm 5%.

There is some relationship between the tempering materials added and the thickness of the sherd (Fig. 4.3). Stone grit tempering is used more frequently to temper medium thick-walled and thick-walled sherds. 18% of the medium thick-walled, 23% of the sherds that measure 9-9.5 mm

[103] Theunissen, this volume.
[104] Theunissen, this volume.
[105] Van Heeringen & Theunissen 2001, 73.
[106] Nobles, this volume Chapter 3.
[107] Van der Waals & Glasbergen 1955.

Table 4.1 Characteristics of the ceramics.

	Keinsmer-brug		Mienakker		Zeewijk all		Zeewijk-East		Zeewijk-West south		Zeewijk-West north	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Number of sherds	512	100	5733	100	3329	100	629	100	1772	100	852	100
Analysed	291	57	654	11	3308	99	622	99	1761	99	849	100
Grit	204	40	5072	89	-	-	-	-	-	-	-	-
Indet/younger	17	3	7	0	21	0	7	1	11	1	3	0
Tempering												
Quartz	1	1	-	-	1	0	-	-	-	-	1	0
Quartz and grog	11	7	-	-	3	0	-	-	-	-	3	0
Quartz and sand	-	-	-	-	5	0	5	1	-	-	-	-
Quartz, grog and sand	-	-	-	-	85	3	12	2	3	0	69	8
Quartz, grog, sand and plant	-	-	-	-	1	0	1	0	-	-	-	-
Granite	4	2	-	-	12	0	2	0	-	-	10	1
Granite and grog	3	2	-	-	2	0	-	-	-	-	2	0
Granite and sand	1	1	-	-	155	5	40	7	52	3	63	7
Granite, grog and sand	1	1	-	-	138	4	40	6	55	3	43	5
Granite, grog, sand and plant	-	-	-	-	1	0	1	0	-	-	-	-
Granite, grog and shell	-	-	-	-	1	0	-	-	1	0	-	-
Red granite	2	1	1	0	-	-	-	-	-	-	-	-
Red granite and grog	10	6	1	0	-	-	-	-	-	-	-	-
Red granite and sand	-	-	-	-	26	1	11	2	-	-	15	2
Red granite, grog and sand	1	1	-	-	45	1	4	1	38	2	3	0
Grog	23	14	-	-	3	0	-	-	3	0	-	0
Grog and sand	96	58	595	91	2724	82	505	81	1544	88	600	71
Grog and plant	2	1	-	-	-	-	-	-	-	-	-	-
Grog, sand and plant	3	2	37	6	44	1	1	0	15	1	28	3
Grog, sand and mica	-	-	1	0	-	-	-	-	-	-	-	-
Grog, sand and shell	-	-	-	-	1	0	-	-	-	-	1	0
Grog and shell	-	-	1	0	-	-	-	-	-	-	-	-
Grog and mica	-	-	-	-	1	0	-	-	1	0	-	-
Sand	4	2	14	2	56	2	-	-	46	3	10	1
Sand and mica	-	-	-	-	1	0	-	-	1	0	-	-
Sand and plant	-	-	4	1	-	-	-	-	-	-	-	-
Plant and shell	1	1	-	-	-	-	-	-	-	-	-	-
Thickness (mm)												
less-2.5	-	-	-	-	1	0	-	-	-	-	1	0
3-3.5	-	-	4	1	38	1	3	0	18	1	1	0
4-4.5	-	-	30	6	202	7	4	1	173	10	23	3
5-5.5	22	9	120	23	454	15	56	11	315	19	78	10

Table 4.1 Characteristics of the ceramics.

	Keinsmer-brug		Mienakker		Zeewijk all		Zeewijk-East		Zeewijk-West south		Zeewijk-West north	
	n	%	n	%	n	%	n	%	n	%	n	%
Thickness (mm)												
6-6.5	59	25	166	31	599	2	82	16	372	22	140	18
7-7.5	56	23	92	18	694	23	108	21	424	25	149	2
8-8.5	41	17	30	6	454	15	106	20	178	11	161	21
9-9.5	43	18	58	11	287	9	81	15	117	7	87	11
10-10.5	20	8	16	3	174	6	49	9	43	3	81	11
11-11.5	1	0	4	1	58	2	19	4	16	1	23	3
12-12.5	-	-	-	-	29	1	10	2	14	1	5	1
13-more	-	-	-	-	24	1	4	1	3	0	16	2
Colour*												
da-da-da	103	56	290	49	2004	65	352	67	1073	63	552	69
da--da	-	-	93	15	16	1	-	-	-	-	-	-
da-da-li	12	7	38	6	208	7	27	5	156	9	25	3
da-li-da	15	8	-	0	7	0	1	0	2	0	4	1
da-li-li	1	1	1	0	40	1	6	1	17	1	17	2
li-da-da	17	9	15	2	334	11	59	11	200	12	75	9
li-da-li	22	12	114	19	376	12	61	12	216	13	99	13
li-li-da	4	2	1	0	12	1	1	0	5	0	6	1
li-li-li	10	5	42	7	69	2	19	4	33	2	17	2
li--li	-	-	15	2	-	-	-	-	-	-	-	-
Surface treatment outside												
Rough	209	86	310	69	1956	69	384	73	966	65	573	75
Smooth	33	14	138	31	872	31	145	27	514	35	189	25
Surface treatment inside												
Rough	228	91	452	76	2295	74	444	79	1144	69	660	83
Smooth	22	9	141	24	799	26	120	21	511	31	141	17
Decoration												
Undecorated rims	30	63	50	56	146	47	52	72	157	64	58	54
Decorated rims	18	38	39	44	162	53	20	28	90	36	50	46
Undecorated walls	210	74	459	75	2443	80	528	91	1214	74	669	84
Decorated walls	72	26	153	25	619	20	50	9	419	26	129	16

* From left to right: outside, core, inside; da=dark, li=light.

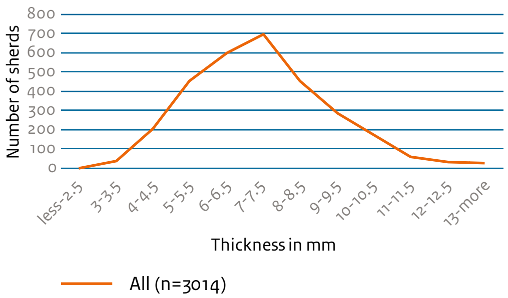


Figure 4.2 Thickness in mm of the Zeewijk sherds.

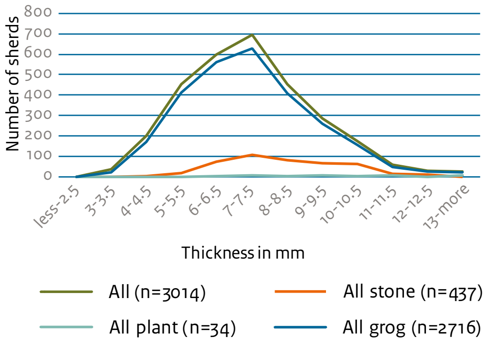


Figure 4.3 Tempering and thickness in mm of all Zeewijk sherds.

and 36% of the sherds that measure 10-10.5 mm are stone grit-tempered. Just 11% of the thin-walled ware contains this tempering agent. Plant material was added only rarely (Fig. 4.3).

Throughout the entire site the majority (65%) of sherds were fired in an oxygen-poor fire (reducing atmosphere) and have a dark interior, exterior and core (Table 4.1). A light exterior colour is visible on 26% of the sherds, so oxygen was present at least some of the time during firing. Of the sherds with a light exterior colour 42% have a dark core and interior colour and 48% have a dark core but a light interior colour. There does not seem to be a strong relationship between thickness and colour. Nor was it possible to establish any relationship between the different tempering materials and the exterior colour, except for one tempering agent: whereas a light exterior colour is present on just 26% of the sherds, 73% of the plant-tempered sherds have a light exterior colour.

A rough inner and outer surface is most common at Zeewijk. Just a small group of sherds are smoothened on one or both sides (Table 4.1). There is a relationship between surface treatment and thickness. The sherds with a smoothened surface are frequently thinner. Of the smoothened sherds 71% are thinner than 7.5 mm; among the rough sherds this percentage is 59%. Since there is a relationship between surface treatment and thickness, there also is a relationship with tempering. Stone grit-tempered sherds, which are more frequently thick-walled, are less frequently smoothened.

Although all vessels are presumably coil built, joins are visible on a very limited number of sherds. Hb-joins, reflecting the placement of coils on top of each other at an angle are visible on six sherds.[108] H-joins, the result of placing different strips of clay immediately on top of each other (resulting in joins that resemble the letter H in cross-section) are visible on one sherd.[109]

Perforations occur on a total of 22 vessels and an additional 24 wall sherds. The perforations were made secondarily and on some sherds attempts at perforations are visible. The sherds are often thin-walled. Eight of these perforated vessels are decorated, six with spatula imprints, two with cord imprints. The vast majority of the perforated sherds also show cooking residues. Although locations could not always be established it seems that the majority of the perforations are found on the upper part of the vessels.

4.5.2 Morphological characteristics and decoration

Decoration

Decoration was applied using three techniques: (1) cord imprints, (2) spatula imprints and (3) fingertip imprints. Spatula and cord decoration occurs most frequently, and a smaller number of vessels show fingertip imprints (Table 4.2). The three methods are all applied in different patterns and on different parts of the vessels (Table 4.2). There is a strong relationship between decoration and thickness (Fig. 4.4). Spatula and cord decoration are only used on thin-walled vessels, fingertip impressions are used to decorate medium thick-walled and thick-walled vessels. Consequently the thin-walled and medium thick-walled spatula- and cord-decorated beakers are almost all tempered with grog and sand, whereas the medium thick-walled and thick-walled fingertip decorated vessels also have stone grit temper.

[108] Stilborg & Bergenstråle 2000, 31.
[109] Stilborg & Bergenstråle 2000, 31.

Table 4.2 Decoration of the different areas compared. Highest percentage indicated in red; second highest in orange.

	Zeewijk all						Zeewijk-East						Zeewijk-West south						Zeewijk-West north					
	Vessels		Wall sherds		All sherds		Vessels		Wall sherds		All sherds		Vessels		Wall sherds		All sherds		Vessels		Wall sherds		All sherds	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Fingertip and nail impressions																								
On the wall	8	11	36	6	42	6	2	13	12	24	14	23	1	4	10	2	11	2	5	19	14	11	17	11
On the rim	3	4	-	-	2	-	1	6	-	-	1	2	1	45	-	-	1	-	1	4	-	-	1	-
On the rim and the wall	5	7	37	6	43	6	3	19	1	2	2	3	-	-	-	-	-	-	2	8	36	28	41	26
Subtotal	**16**	**22**	**73**	**12**	**88**	**13**	**6**	**38**	**13**	**26**	**17**	**27**	**2**	**8**	**10**	**2**	**12**	**2**	**8**	**31**	**50**	**39**	**59**	**37**
Spatula decoration																								
ZigZag	11	16	34	6	40	6	3	19	6	12	7	11	3	10	23	5	27	6	5	19	5	4	6	4
Herringbone	6	9	44	7	51	8	1	6	4	8	4	6	4	14	32	8	38	8	1	4	8	6	9	6
Oblique impressions in one direction	18	25	90	15	113	17	5	31	17	34	22	35	5	17	43	10	52	11	8	31	30	23	39	25
Herringbone motif bordered with horizontal lines	-	-	2	-	2	-	-	-	1	2	1	2	-	-	-	-	-	-	-	-	1	1	1	1
Oblique impressions in one direction bordered by horizontal lines	-	-	2	-	3	-	-	-	2	4	3	5	-	-	-	-	-	-	-	-	-	-	-	-
2IIf	1	2	53	9	63	9	-	-	-	-	-	-	1	4	52	12	62	13	-	-	1*	1	1*	1
No clear pattern/ other pattern	-	-	3	1	3	-	-	-	-	-	-	-	-	-	2	1	2	1	-	-	1	1	1	1
Subtotal	**36**	**51**	**228**	**38**	**275**	**41**	**9**	**56**	**30**	**60**	**37**	**60**	**13**	**44**	**152**	**36**	**181**	**39**	**14**	**54**	**46**	**36**	**57**	**38**
Cord decoration																								
1a	1	1	44	7	45	7	-	-	-	-	-	-	1	3	44	10	45	10	-	-	-	-	-	-
2IIb	1	1	41	7	41	6	-	-	-	-	-	-	1	3	40	10	40	9	-	-	1	1	1	1
1a/2IIb	16	23	166	28	185	27	1	6	5	10	6	10	11	38	131	31	143	31	4	15	30	23	36	23
2IId**	1	1	46	8	48	7	-	-	2	4	2	3	1	3	42	10	44	9	-	-	2	1	2	1
Subtotal	**19**	**27**	**297**	**50**	**319**	**47**	**1**	**6**	**7**	**14**	**8**	**13**	**14**	**48**	**257**	**61**	**272**	**59**	**4**	**15**	**33**	**25**	**39**	**25**
Unknown	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2	1	2	-	-	-	-	-	-	-
Total decorated	**71**	**33**	**598**	**20**	**673**	**21**	**16**	**26**	**50**	**9**	**62**	**10**	**29**	**35**	**419**	**26**	**456**	**26**	**26**	**36**	**129**	**16**	**155**	**18**
Total undecorated	**146**	**67**	**2411**	**80**	**2536**	**79**	**45**	**74**	**528**	**91**	**563**	**90**	**54**	**65**	**1214**	**74**	**1281**	**74**	**47**	**64**	**669**	**84**	**692**	**82**

* One sherd from type 2IIf vessel 29 is found in the northern area, 62 in the southern area.

** On type 2IId cord and spatula decoration are compared, this type can thus also be fitted within the spatual decorated group.

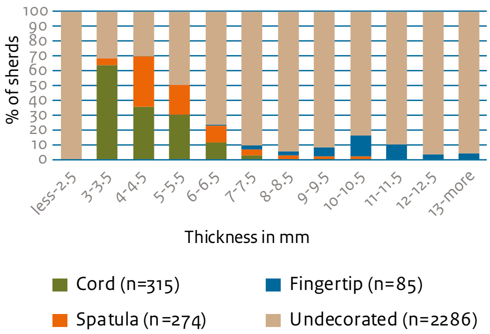


Figure 4.4 Decoration and thickness in mm of all Zeewijk sherds compared.

Vessels and sherds decorated with cord impressions

A total of 19 vessels and 297 wall sherds are decorated with cord impressions (Table 4.2). Different Van der Waals and Glasbergen types are present.[110] On type 1a the cord decoration is applied only on the upper part of the vessel. [111] One vessel (123) and 44 additional wall sherds that belong to this type have been found. Vessel 123 has a 14 cm rim diameter and 17 cm belly diameter (Appendix III). On this small beaker the decoration has been applied only on the rim, neck and shoulder zone of the vessel and consists of horizontal rows of cord impressions bordered at the rim by one row of oblique spatula impressions and at the shoulder by two rows of oblique spatula impressions in alternating directions.

On type 2IIb the cord decoration is applied all over the vessel. [112] One small beaker (124) and 41 sherds could be assigned to this type. This all-over cord-decorated vessel measures just 11.5 cm in height and has a slender S-shape (Fig. 4.5, Appendix III). A cord-decorated lower belly and base fragment (vessel XXXIV) could also be seen as a representative of type 2IIb, given the location of the decoration (Fig. 4.5h, Appendix III). The diameter of the base is 7 cm and the transition to the belly is rounded.

One vessel (131) and 48 sherds possibly belong to type 2IId. On type 2IId the decoration is also applied from the rim to the base, but here cord lines alternate with horizontal rows of oblique spatula impressions.[113] Vessel 131 is a 20 cm tall beaker with an S-shaped profile, a rim diameter measuring 13.5 cm, a diameter of 16 cm at the greatest belly circumference and an 8 cm diameter at the base (Table 4.2).

The type of the majority of the cord-decorated sherds cannot be established. These sherds are completely covered with cord imprints and do not have any undecorated parts or foot and are thus listed as type 1a/2IIb. Sixteen vessels and 166 sherds belong to this group.

We can assume that these vessels are also likely to be small beakers: all walls are thin and the rim diameters measure between 8 and 16 cm (vessel 50, 57, 84, 154, 156, Appendix IV and III). Two rim fragments and two wall fragments listed as 1a/2IIb are depicted (Fig. 4.5a, b, f and g [vessel O.61, 156, S and O.B]). The rim fragment of vessel O.61 shows decoration on the inside of the rim. The majority of the cord-decorated vessels show uninterrupted horizontal rows of cord imprints. The ten fragments of vessel S, however, have coupled cord imprints with small undecorated zones between (Fig. 4.5g).

Vessels and sherds decorated with spatula impressions

Decoration applied with the use of a spatula was very common at Zeewijk and many different Van der Waals and Glasbergen types are present (Table 4.2).[114] The different motifs present are: zigzags, herringbones, oblique impressions in one direction, oblique impressions in one direction bordered by horizontal lines and oblique impressions alternating in direction from one zone to another, bordered by horizontal lines (Fig. 4.6).

Oblique impressions in one direction seem to be the most common (Appendices II-IV). This number might be slightly too high since sherds in this category could originally have had a different pattern no longer visible due to fragmentation. Vessel 12 is the most complete vessel decorated with oblique impressions in one direction. This 15.5 cm tall beaker of Van der Waals and Glasbergen 1e type shows short half-moon shaped oblique impressions on the upper part of the beaker (Fig. 4.6i).[115] The beaker has a perforation in an unexpected location: on the lower part of the belly. Many of the sherds and vessels decorated with oblique spatula impressions show thinner oval to line-shaped oblique impressions. Vessel 58 is an example of such a vessel (Fig. 4.6n). Vessel O.5 shows three rows of oblique impressions in one direction and a fourth row in the opposite direction (Fig. 4.6b). Wall sherds of vessel F2 also show rows of oblique impressions in one direction (Fig. 4.6e).

110 Van der Waals & Glasbergen 1955, 8.
111 Van der Waals & Glasbergen 1955, 8.
112 Van der Waals & Glasbergen 1955, 28.
113 Lanting & Van der Waals 1976, 6.
114 Van der Waals & Glasbergen 1955.
115 Van der Waals & Glasbergen 1955, 12.

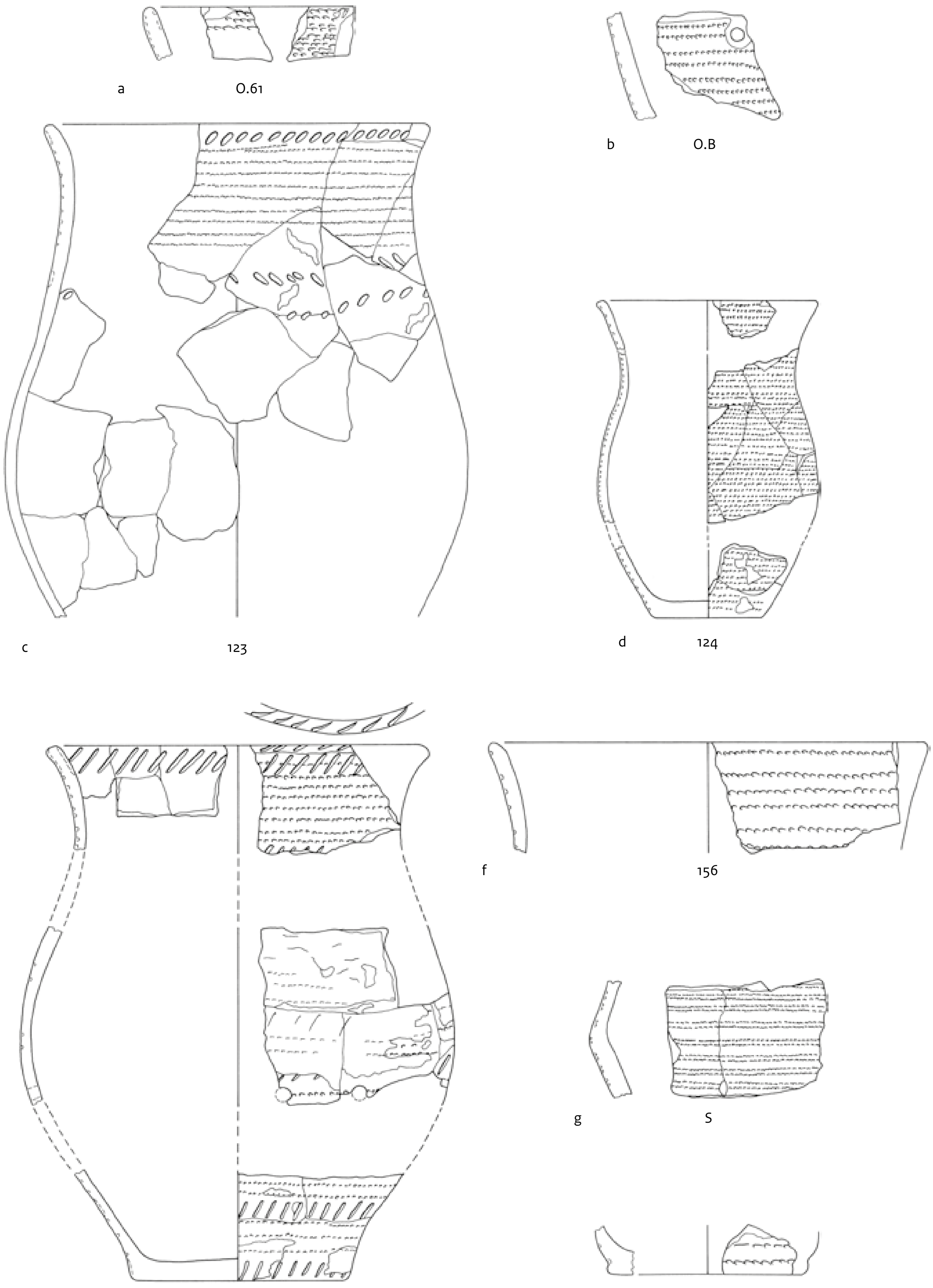


Figure 4.5 Cord decoration. Zeewijk-East: a. vessel O.61 and b. O.B, Zeewijk-West south: c. vessel 123, d. 124, e. 131, Zeewijk-West north: f. vessel 156, g. S and h. XXIV. Scale 1:2.

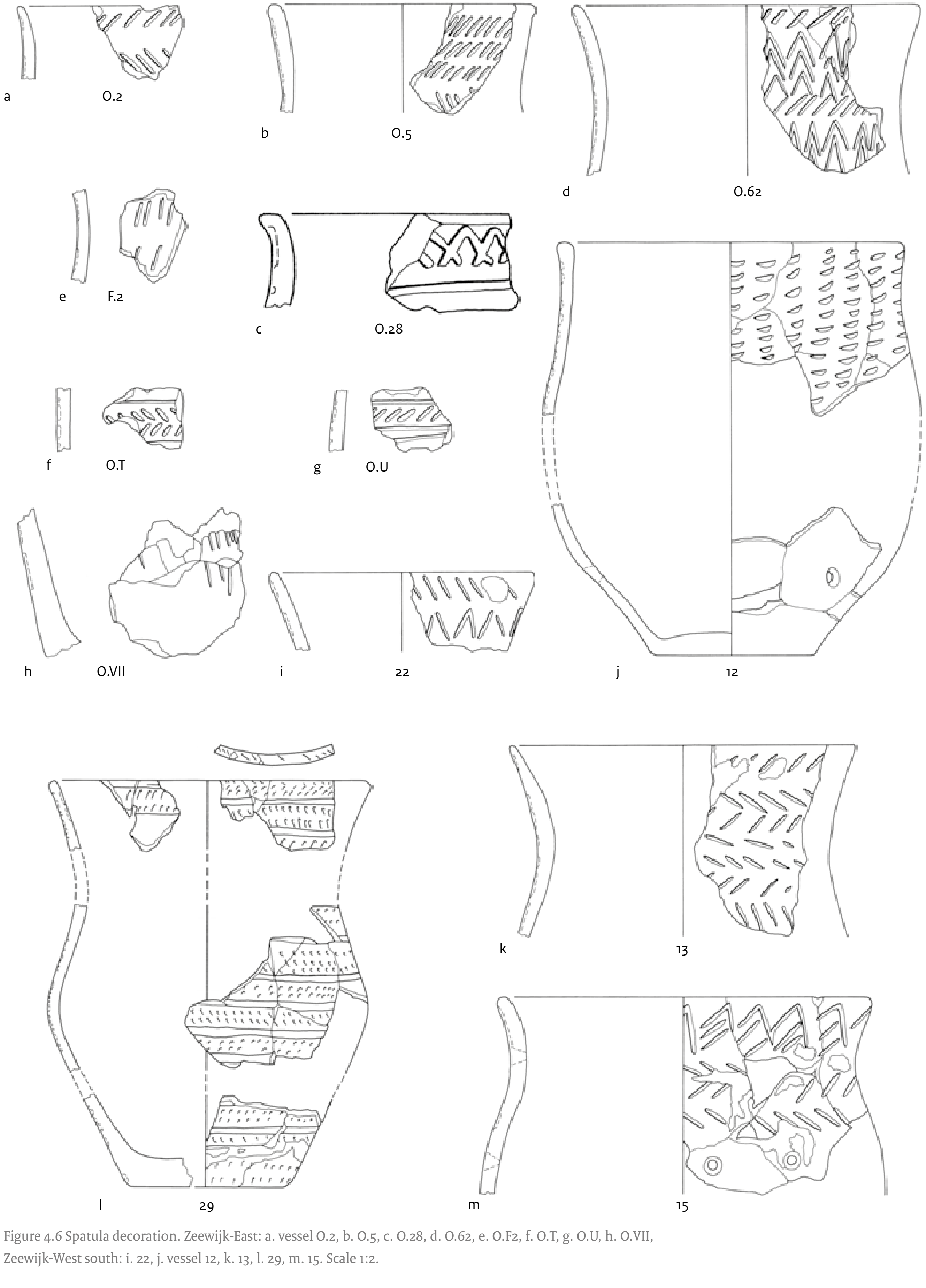


Figure 4.6 Spatula decoration. Zeewijk-East: a. vessel O.2, b. O.5, c. O.28, d. O.62, e. O.F2, f. O.T, g. O.U, h. O.VII, Zeewijk-West south: i. 22, j. vessel 12, k. 13, l. 29, m. 15. Scale 1:2.

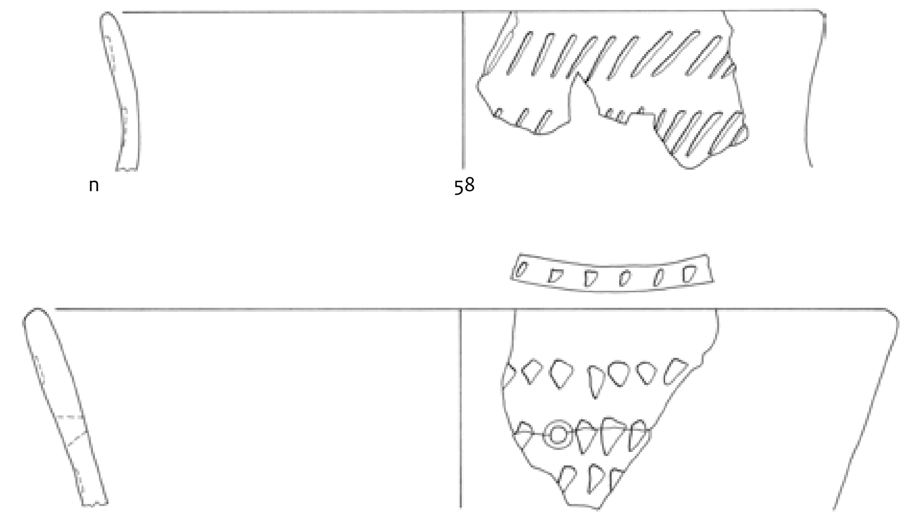


Figure 4.7 Zeewijk-West south: f. vessel 5, g. 14, h. 28, i. 30, j. C, Zeewijk-West location unknown: k. 165. Scale 1:2.

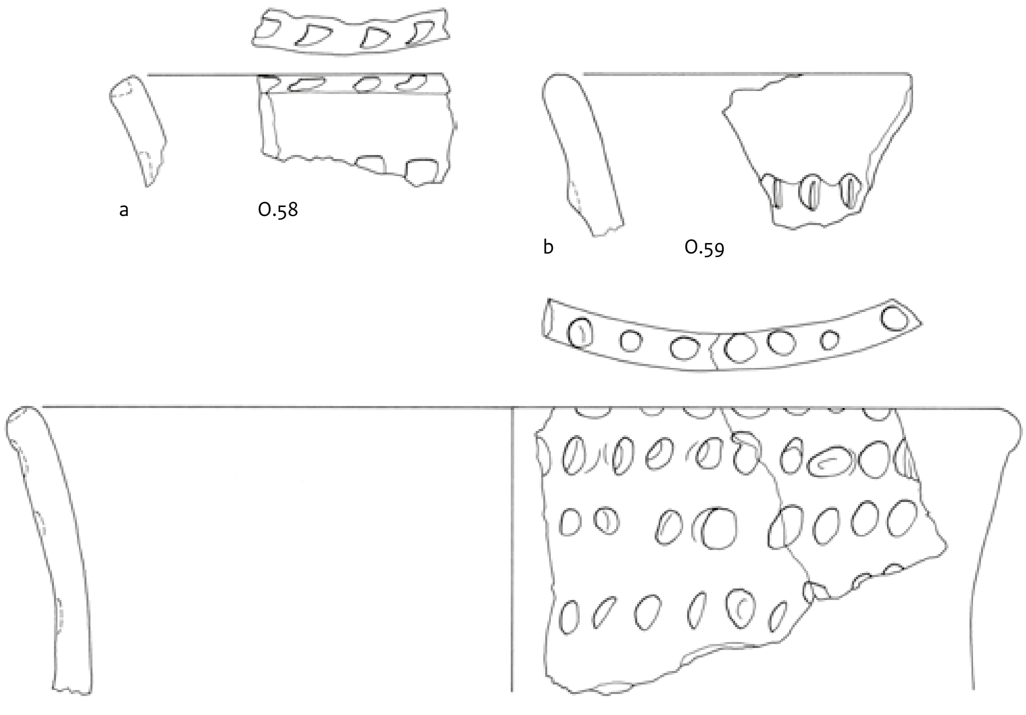


Figure 4.8 Fingertip decoration. Zeewijk-East: a. vessel O.58, b. O.59, c. Zeewijk-West north: vessel 25. Scale 1:2.

Here a small zone between the decorated sections has been left blank. Oblique impressions in one direction are also visible on vessel O.VII. The decoration continues close to the base, making it likely that this vessels belongs to AOO type 2IIc or 2IIe (Fig. 4.6h).[116] Vessel 157 constitutes an outlier as this large vessel (with a 8 mm thick wall and a rim diameter of 23) cm looks like a fingertip-imprinted vessel, yet the oblique imprints on the rim and wall are made with a spatula (Fig. 4.6o).

Oblique impressions in alternating directions also occur (Table 4.2). Vessel 13 shows these herringbone-like patterns of Van der Waals and Glasbergen type 1d (Fig. 4.6j).[117] The encrusted residue on this beaker was dated.[118]

[116] Some scholars regard oblique impressions in one direction as a belonging to AOO type 2IIc (see Glasbergen & Van der Waals 1955, 30) others name this type 2IIe (see Sier 2001, 397).

[117] Van der Waals & Glasbergen 1955, 11.

[118] For a discussion on the ^{14}C dates see section 4.8.

Vessel O.2 is another example of this pattern (Fig. 4.6a). On this beaker the decoration is zoned, and there is an empty space between the decorated rows.

Zigzag patterns also occur fairly frequently. Only the upper part of the slender beaker vessel 15 is decorated. Below the decoration two holes are visible, presumably applied to repair the vessel (Fig. 4.6k). On another beaker, O.62, rows of oblique impressions are interspersed with vertical rows of carets (Fig. 4.6d). Zigzag-decorated vessel 22 is even smaller, its rim diameter measuring just 10 cm. A small rim and neck fragment (O. 28) decorated with crosses bordered by a grooved line has also been placed in the zigzag category (Fig. 4.6c).

Oblique impressions in one direction bordered with horizontal lines and oblique impressions alternating in direction per zone bordered by horizontal lines are less common. On vessel O.T a herringbone pattern is bordered on both sides by a grooved line (Fig. 4.6f). On vessel O.U a single row of oblique impressions is bordered by one and two grooved lines (Fig. 4.6g). Vessel 29 is striking. On this beaker oblique impressions alternate direction from one zone to the next, and the zones are bordered by grooved lines (Fig. 4.6m). The complete outer surface and the inside of the rim are decorated with these motifs. Sier introduced type 2IIf to the type list for this vessel, since grooved lines had not previously been seen on AOO ceramics.[119]

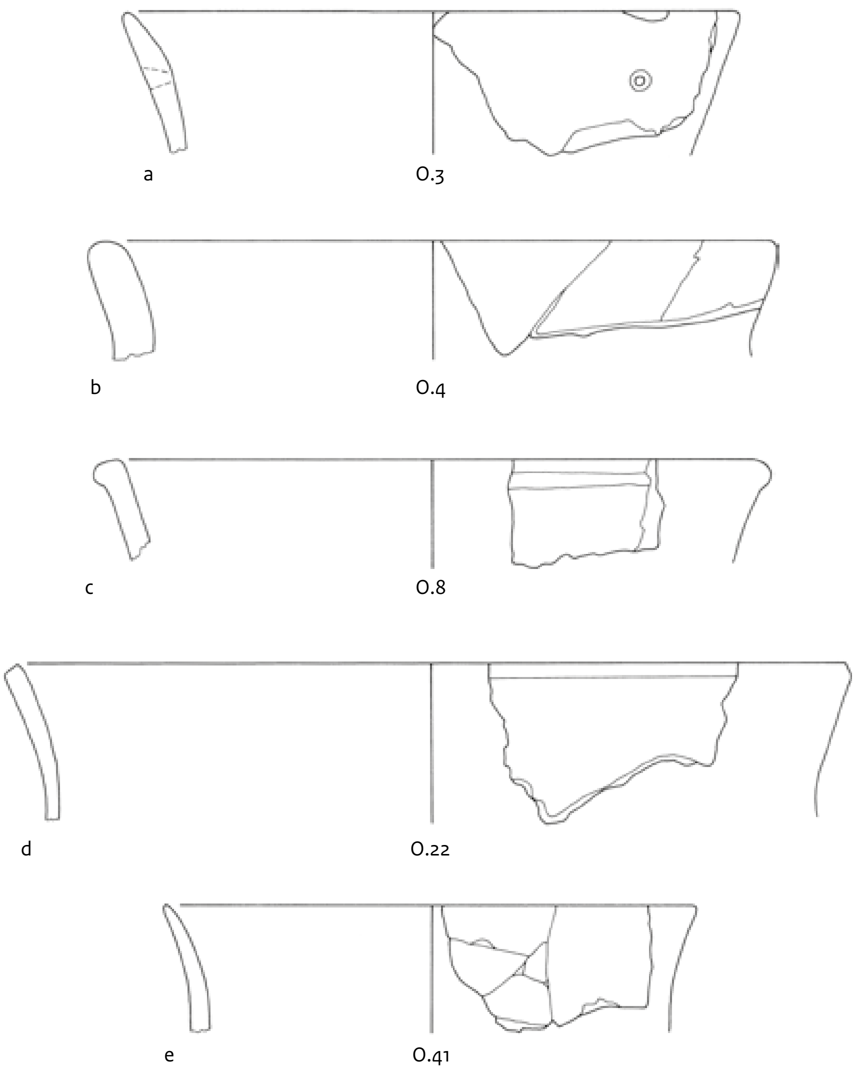


Figure 4.9 Undecorated. Zeewijk-East: a. vessel O.3, b. O.4, c. O.8, d. O.22, e. O.41. Scale 1:2.

[119] Sier 2001, 397.

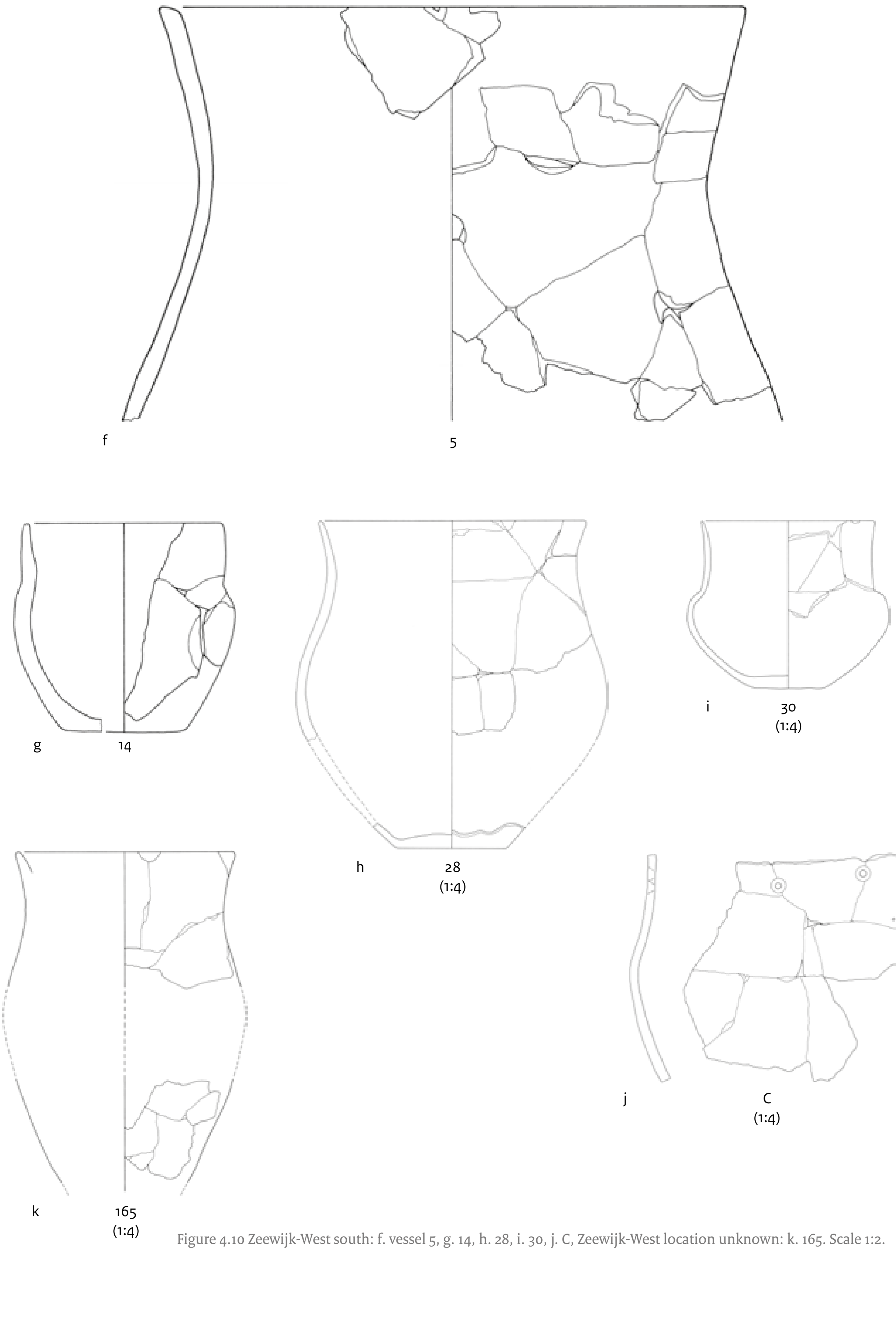


Figure 4.10 Zeewijk-West south: f. vessel 5, g. 14, h. 28, i. 30, j. C, Zeewijk-West location unknown: k. 165. Scale 1:2.

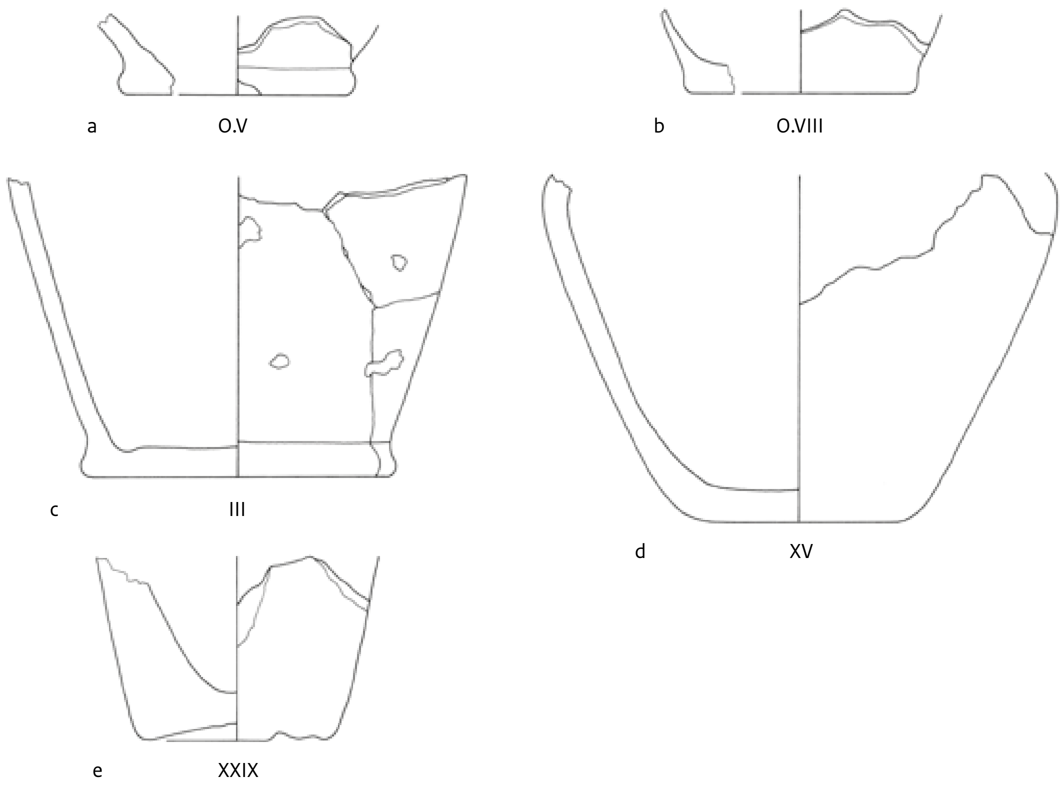


Figure 4.11 Base fragments. Zeewijk-East: a. vessel O.V and b. O.VIII, Zeewijk-West south: c. vessel III and d. XV, Zeewijk-West north: e. vessel XXIX. Scale 1:2.

Vessels and sherds decorated with fingertip imprints

Vessels decorated with fingertip imprints usually have one row of fingertip imprints placed either on the wall, on top of the rim or on both locations. Vessel O.58 has the combination of a row of fingertip impressions on top of the rim and on the shoulder (Fig. 4.8a). Vessel 25 is another example of this category. This large vessel has several rows of fingertip imprints on the rim and all over the wall (Fig. 4.8c). Vessel O.59 is also large but this vessel only has a single row of fingertip impressions on the wall (Fig. 4.8b).

Undecorated vessels

More variation in vessel morphology and size is visible in the group of undecorated vessels compared to the decorated vessels. The cord- and spatula-decorated vessels show little variation in size and morphology.

The smallest vessel, 14, is just 7.5 cm tall (Fig. 4.10g).There are many examples of medium and larger S-shaped vessels with a rounded or flat rim. Examples of these are depicted in Figures 4.9a-e and 4.10 f, h and k (vessels O.3, O.4, O.8, O.22, O.41, 5, 28 and 165). The rim diameters range between 11 and 22 cm. Due to fragmentation, it was often impossible to measure the width at the greatest belly circumference. As a result of the S-shape, this width often exceeds the width of the rim. These vessels are both dark- and light-coloured and tempered with grog and sand, yet sometimes stone grit is also added. The perforated wall sherds of vessel C were probably also from such a large S-shaped vessel (Fig. 4.10j). One vessel, 30, has a remarkable shape: the upright rim and neck are followed by a sharp nod and a thick belly. Drenth and Hogestijn regard this vessel as a precursor of the later Veluwe Bell Beakers.[120] Lanting does not agree with this theorem, however, and points to the possibility of a date in the Iron Age.[121] The encrusted residue was dated by a ^{14}C date.[122]

Other base fragments

The base fragments from Zeewijk show little variation. The majority (n=52) are flat with an angular or slightly rounded transition from the belly to the base (Fig. 4.11b and d, vessel O.VIII

120 Drenth & Hogestijn 2006, 89.
121 Lanting, personal communication.
122 For a discussion of the ^{14}C dates see Section 4.8.

and XV). Low numbers of vessels (n=7) have a slightly protruding foot (Fig. 4.11 a and c, vessel O.V and III). The diameters of the foot range between 5 and 11 cm. The lower part of a peculiar vessel, XXIX, was found. This vessel has a somewhat hollow base and weak fabric tempered with grog, sand and plant material (Fig. 4.11e).

4.5.3 Ceramic artefacts

Different types of ceramic artefacts have been found. Fragments of six spindle whorls have been identified. From above, they appear rounded with a perforation in the middle. From the side they are triangular (Fig. 4.12d-e). All spindle whorls have a light exterior colour. One of the spindle whorls has decoration; a herringbone motif has been applied with a spatula (Fig.4.12e). Two fragments of baking plates have been found (Fig. 4.12a and c). These are round ceramic plates found at Vlaardingen, TRB and Beaker sites.[123] Other specimens have been found at the nearby Zandwerven site.[124]

The last ceramic artefact may have been used as a lid or as a loom weight; it is an almost round disc with a diameter of 3.7-4 cm (Fig. 4.12b). The disc is an example of the secondary use of vessels; the fragment is made from the wall of a vessel.

4.5.4 Function and use of the ceramics

Cooking

Residues that indicate cooking were frequently observed on Zeewijk vessels and on one baking plate. There is a striking relationship between the thickness and the amount of residue present (Table 4.3, Fig. 4.13). The thin to medium thick-walled vessels were most frequently used to prepare cooked meals. The largest vessels often show no cooking residues. The vast majority (74%) of the cord-decorated beakers were used for cooking (Fig. 4.14). The spatula-and fingertip-decorated vessels were used less frequently for cooking (45% and 46%).

Twenty-five residues were analysed by Oudemans and Kubiak-Martens. [125] Their analysis suggests that a variety of often well-processed meals were prepared in the beakers and small vessels. Residues all contained heated proteins and fat, and three-quarters also contained heated polysaccharides. The lipids are of mixed plant and animal/fish/fowl origin.[126] The baking plate, an artefact whose function remained unknown for a long time,[127] was also used for preparing this type of meal.

Other uses

The thin-walled and medium thick-walled beakers that are often decorated with spatula and cord

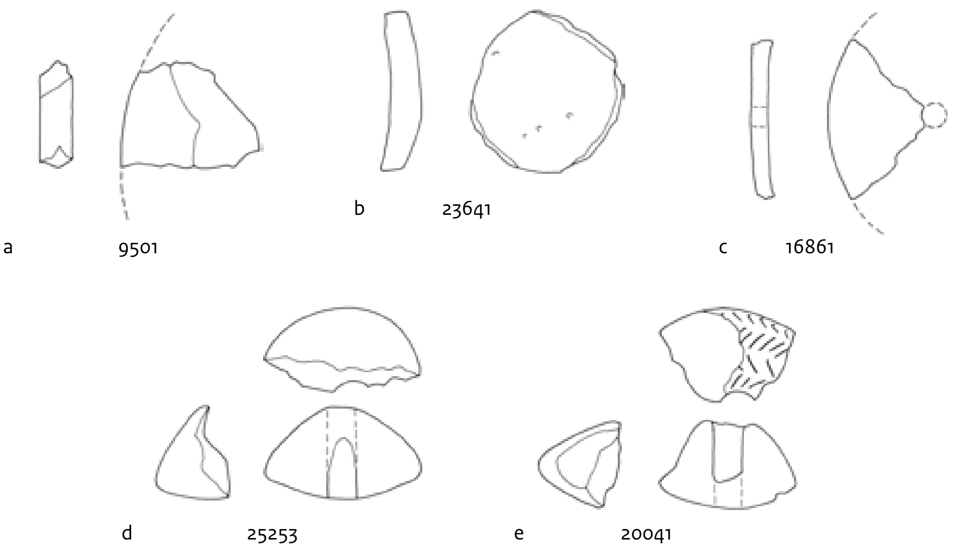


Figure 4.12 Ceramic artefacts. Zeewijk-East: a. baking plate 9501, b. lid or loom weight 23641, Zeewijk-West south: c. baking plate 16861, Zeewijk-West north: d. spindle whorls 25253 and e. 20041. Scale 1:2.

[123] Glasbergen *et al.* 1961, 47; Bakker 1979, 57.
[124] Van Regteren Altena & Bakker 1961, 36.
[125] Oudemans & Kubiak-Martens, this volume.
[126] Oudemans & Kubiak-Martens, this volume.
[127] Glasbergen *et al.* 1961, 47; Bakker 1979, 57.

Table 4.3 Characteristics of the sherds with cooking residues.

	Zeewijk all		Zeewijk-East		Zeewijk-West south		Zeewijk-West north	
	n	%	n	%	n	%	n	%
Decoration								
Cord	232	74	5	62	207	76	20	51
Spatula	123	45	16	42	85	47	22	39
Fingertip	39	46	2	13	7	58	30	51
Undecorated	893	40	131	23	533	42	229	33
Total	1287	39	154	25	832	48	301	36
Tempering								
Stone grit	143	30	18	16	43	28	82	40
Plant	9	20	-	-	-	7	8	29
Thickness (mm)								
less-2.5	1	100	-	-	-	-	1	100
3-3.5	10	26	2	67	8	44	-	-
4-4.5	94	47	3	75	83	48	8	35
5-5.5	241	53	19	34	186	59	36	46
6-6.5	302	50	17	21	224	60	61	44
7-7.5	281	40	35	32	185	44	61	41
8-8.5	146	32	19	18	67	32	60	37
9-9.5	83	29	17	21	37	32	29	33
10-10.5	53	30	7	14	20	47	26	32
11-11.5	16	28	6	32	2	13	8	35
12-12.5	3	10	1	10	1	7	1	20
13-more	4	17	1	25	0	-	3	19
Outside								
Dark	1133	50	118	31	755	60	260	43
Light	127	16	9	6	77	15	41	16

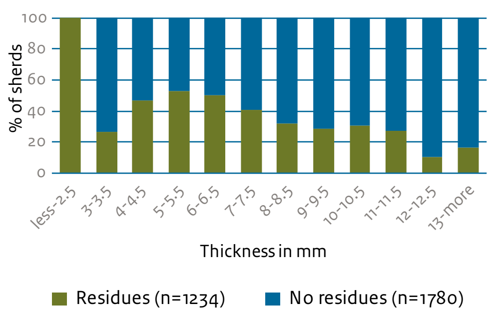


Figure 4.13 Cooking residues and thickness in mm compared.

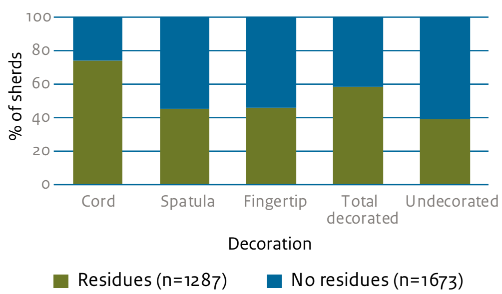


Figure 4.14 Cooking residues and decoration compared.

impressions were used for cooking, as was at least one of the two baking plates. The thicker-walled ware did not show cooking residues. Although difficult to substantiate, it seems likely that these larger vessels were used for storage. The spindle whorls indicate that spinning took place. Ceramics were also re-used. The almost round disc that was found was previously part of the wall of a vessel. The perforations visible on several vessels were all made secondarily, and tend to reflect repairs. Sometimes the perforations were positioned either side of a fracture, though this is not always the case. Some perforations could have had another function, for example as a hole for hanging the pot or for attaching a lid.

4.6 Variation in the Zeewijk ceramics between three different areas

4.6.1 Spatial definition of the three groups

During earlier studies and in this study differences were observed between the ceramics from different areas of the Zeewijk site. Besides the division into west and east, a further subdivision of Zeewijk-West is possible. Nobles studied the spatial distribution of finds and features at the site and concluded that a possible subdivision of Zeewijk-West could be reconstructed from the density distribution of postholes.[128] The postholes show a northern and a southern cluster (Fig. 4.15). A west-east line was drawn between and the ceramics from the two groups were compared (all squares with numbers above 1940 are north).

There are thus three areas of the settlement:

- Zeewijk-West north (west of the gully, northern cluster of postholes) 852 sherds analysed (of which three indet.);
- Zeewijk-West south (west of the gully, southern cluster of postholes) 1772 sherds analysed (of which eleven Medieval or indet.);
- Zeewijk-East (east of the gully), 629 sherds analysed (of which seven Medieval).

Although the border between the Zeewijk-West areas is arbitrary, one argument in favour of this subdivision is the remarkably low number of vessels of which sherds were found in both areas. On the basis of unique rim fragments, 165 vessels were found, but sherds of just one vessel were found in both areas. Of this vessel (29), one sherd was found in the north part and 62 in the south. Additionally, two of the 35 base fragments originate from the two areas. Of base XVIII, 38 sherds were found in the south and two in the north, and of base XXIV two sherds from the two areas have been glued together. The find location for 74 sherds was unclear.

An attempt was made to further subdivide Zeewijk-East into two or more areas. For example, the ceramics from the central part could be compared to the ceramics from the eastern part where a large structure was found. However, these comparisons seem to prove that there is no significant variation within this area.

The first difference between the sherds is the level of fragmentation and weathering. The Zeewijk-East sherds are smaller and more severely weathered than the sherds from the two other areas. The average weight of sherds over 3 g is 11.7 g in the south part of Zeewijk-West, 9.22 g in the north part of Zeewijk-West and just 7.5 g in Zeewijk-East.

4.6.2 Technological characteristics

In all three areas, the majority of the sherds are tempered with grog and sand (Table 4.1). There are however striking differences in the use of stone grit for tempering. In the south part of Zeewijk-West only 8% of the sherds contain stone particles. In the north part of Zeewijk-West stone has been added to about a quarter (23%) of the sherds and at Zeewijk-East to approximately a fifth (19%). There are additional smaller differences. In the north part of Zeewijk-West there is more variety in tempering combinations than in Zeewijk-West.

In Zeewijk-East and the north part of Zeewijk-West the average thickness of the sherds is higher (both 7.9 mm) than in the south part of Zeewijk-West (6.9 mm average) (Fig. 4.16). In Zeewijk-East and the north part of Zeewijk-West there is more medium thick-walled (8-8.5 mm, 20% and 21%) and thick-walled ware (9-9.5 mm, 15% and 11%), 10-10.5 mm 9% and 11%. By comparison, in the south part of Zeewijk-West, just 11% is medium thick-walled ware, 7% is 9-9.5 mm and 3% is 10-10.5 mm. Thin-walled

[128] Nobles, this volume Chapter 11.

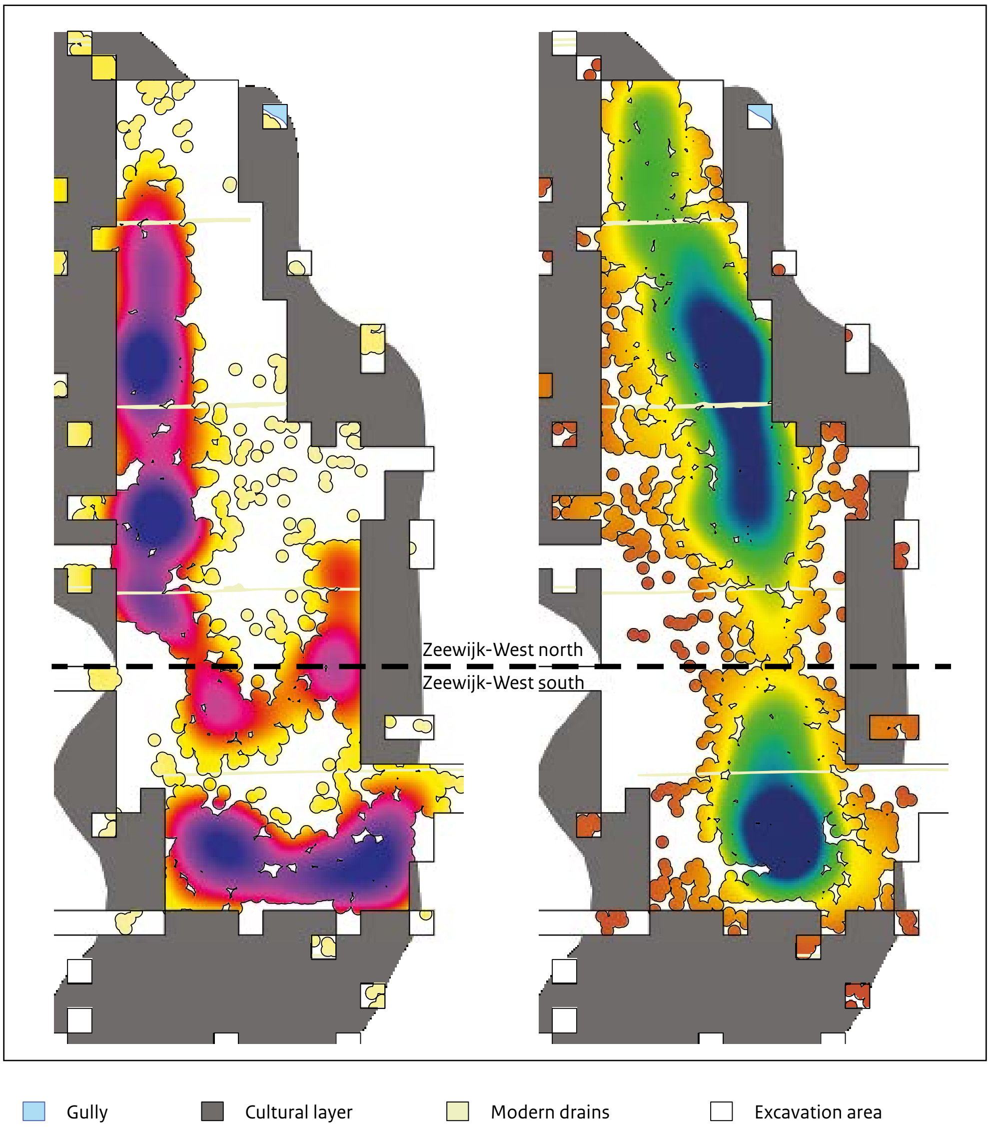


Figure 4.15 Density of cow hoof marks (left) and the density of postholes (right) in Zeewijk-West and the division into the areas north and south (based on Fig. 11.6).

ware is more common in the south part of Zeewijk-West, 66% measuring 5-7.5 mm. A group comprising 11% of the sherds is even thinner, measuring less than 5 mm. In both Zeewijk-East and the north part of Zeewijk-West 48% of the sherds are thin-walled.

In Zeewijk-East and the north part of Zeewijk-West there is a substantial group of medium thick-walled ware (15% and 30% of the total) and thick-walled ware (9-9.5 mm 22% and 36%, 10-10.5 mm 20% and 53% of the total) that is stone grit-tempered (Fig. 4.17). These kinds of sherd are far less common in the south part of Zeewijk-West (8-8.5 mm 9%, 9-9.5 mm 14% 10-10.5 mm 1%). In this area plant material is more frequently used to temper thin-walled ware, while in the north part of Zeewijk-West this temper is more frequently observed in thick-walled sherds (Fig. 4.18).

There are hardly any differences between the different areas in terms of the firing method used (Table 4.1). Furthermore, no difference was observed in the relationship between colour, tempering and thickness in any of the areas.

Differences were observed in the surface treatment of sherds from the different areas.

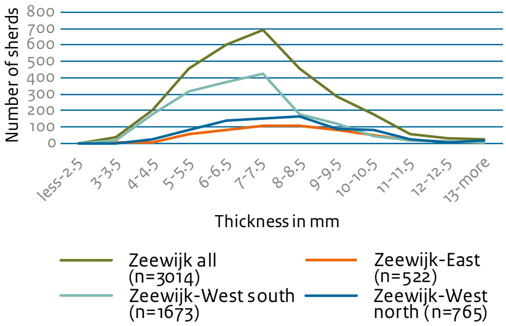


Figure 4.16 Thickness in mm in the different areas compared.

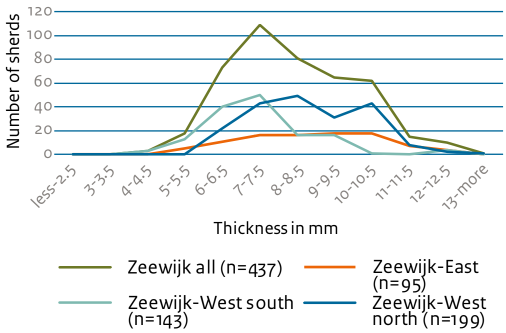


Figure 4.17 Stone grit tempering and thickness in mm in the different areas compared.

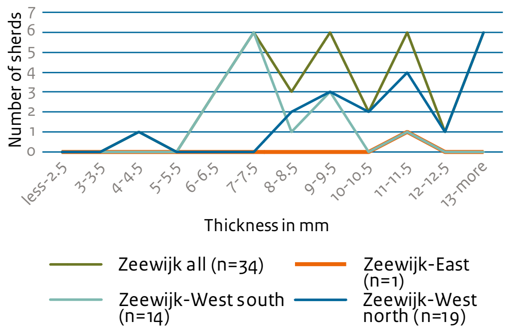


Figure 4.18 Plant tempering and thickness in mm in the different areas compared.

The sherds from the south part of Zeewijk-West are more frequently smoothened on the outside (35%) and inside (31%) (Table 4.1). Consequently, a larger proportion of the Zeewijk-East and the north part of Zeewijk-West sherds have walls that have been left rough (Table 4.1).

Perforations are present on sherds from all three areas. They seem a little less frequent in Zeewijk-East sherds, though this could be explained by the higher fragmentation and weathering of these sherds.

4.6.3 Morphological characteristics and decoration

Decoration

Thin-walled and medium thick-walled vessels, including sherds with cord decoration and spatula decoration, are present in all three areas. Medium thick-walled and thick-walled vessels, including sherds with fingertip imprints, are also found in all three areas. The ratio of decorated to undecorated sherds varies (Table 4.1 and Table 4.5). The percentages in which the different decoration methods have been applied also differ very markedly (Table 4.4).

Vessels and sherds decorated with cord impressions

In the south part of Zeewijk-West cord decoration is most frequent and the variation in motifs and length of decoration is largest. In the north part of Zeewijk-West and in Zeewijk-East this type of decoration has been applied least frequently. In all three areas it proved impossible to establish whether the majority of the cord-decorated sherds and vessels belong to the all over decorated type 2IIb or the half decorated type 1a.[129] All over ornamented type 2IId, on which horizontal cord lines and oblique spatula imprints are combined, is found in all three areas.[130] The highest number of sherds of this type are found in the south part of Zeewijk-West. In this area the highest number of sherds of the all over cord ornamented type 2IIb have also been found.[131] This type is also present in the north part of Zeewijk-West, albeit in low numbers. The presence of type 1a can only be established with certainty in the south part of Zeewijk-West.[132]

Vessels and sherds decorated with spatula impressions

In the north part of Zeewijk-West and in Zeewijk-East spatula decoration is more common in the south part of Zeewijk-West. Zigzag, herringbone and oblique impressions in one direction are present in all three areas. Oblique rows in one direction are possibly most common in the north part of Zeewijk-West. This might also be due to the smaller sizes of these sherds; these rows could be part of other patterns that are not visible on small sherds.

129 Van der Waals & Glasbergen 1955, 8, 28.
130 Van der Waals & Glasbergen 1955, 28.
131 Van der Waals & Glasbergen 1955, 28.
132 Van der Waals & Glasbergen 1955, 8.

In Zeewijk-East and the north part of Zeewijk-West sherds are found on which herringbone decoration is bordered with horizontal lines. This motif is not present in Zeewijk-West. Two sherds on which one row of oblique impressions in one direction is bordered by horizontal lines have been found only at Zeewijk-East. In this area zoned decoration is also present; a small zone between rows with oblique spatula impressions has been left blank (Fig. 4.6a and e, vessel O.2 and O.F2). Of vessel 29, 62 sherds were found in the south part of Zeewijk-West and one sherd in the north part. This vessel is decorated with rows of oblique impressions in one direction which alternates between zones. The zones are bordered by grooved lines.

Vessels and sherds decorated with fingertip imprints
Fingertip decoration is rare in the south part of Zeewijk-West but occurs on about one-third of the decorated vessels from the north part of Zeewijk-West and in Zeewijk-East (Table 4.5). In both Zeewijk-East and in the north part of Zeewijk-West the impressions are in the same positions: only on top of the rim, only on the wall or in both positions. Only specimens with fingertip imprints on top of the rim or on the wall are found in the south part of Zeewijk-West.

Undecorated vessels
Smaller undecorated beakers and medium-large and large undecorated vessels are found all three areas. In Zeewijk-East 90% of the sherds are undecorated; in the north part of Zeewijk-West this figure is 82%. In the south part of Zeewijk-West this group is relatively small, 74% of sherds there being undecorated (Table 4.1 and 4.4).

Base fragments
There are no clear differences in the shapes of the bases in the three areas. Both vessels with an angular or slightly rounded transition from the belly to the base and vessels with a slightly protruding foot are found in all three areas.

4.6.4 Ceramic artefacts

Spindle whorls are found in all three areas. The two baking plates stem from the south part of Zeewijk-West and Zeewijk-East and the disc possibly used as lid or loom weight was also found in the latter area.

4.6.5 Function and use of the ceramics

Cooking
Residues that indicate cooking are present on sherds from all three areas (Table 4.3). The percentages and quality of the residues vary. Zeewijk-East has the lowest percentage and quality, followed by the north part of Zeewijk-West. These differences are considered to be preservation differences, as the sherds in these areas are also more fragmented. A vessel can be used sequentially for different purposes, so the presence of residues on a vessel is not direct evidence of cooking at that location. However, since residues are common in the north and south part of both Zeewijk-West and Zeewijk-East, this is a strong indication that cooking occurred in all three areas. The characteristics of the vessels with cooking residues in the three areas differ slightly. However, in all three areas the thin-walled and medium-thick-walled vessels and the cord-decorated vessels were preferred for cooking (Table 4.3). The residues of eight Zeewijk-East sherds, fifteen sherds from the south part of Zeewijk-West and two sherds from the north part of Zeewijk-West were analysed.[133] In all three areas the meals prepared contained heated proteins and fat, and often also heated polysaccharides.[134] Clear differences are not observed.

Other uses
Cooking took place in all three areas (Table 4.3). Larger vessels that do not show cooking residues are also present in all three areas. These vessels do differ in terms of their morphology and decoration. In the north part of Zeewijk-West and in Zeewijk-East these vessels are often very thick-walled. In the south part of Zeewijk-West some thick-walled and many medium-thick-walled vessels that do not show cooking residues are present. However, if these vessels are indicative of storage, in all three areas the same activities were performed using the vessels. The spindle whorls also indicate spinning in all three areas.

[133] The sampling of the vessels for residue analysis took place before it was decided to expand the area of analysis to the north, so the vessels from this area are underrepresented in this study.
[134] Oudemans & Kubiak-Martens, this volume.

4.6.6 Conclusions concerning comparison of the three different areas

The same activities – cooking, storage and spinning – were carried out with different vessels and ceramic artefacts in the three areas. The north part of Zeewijk-West and Zeewijk-East are very similar, but the assemblage in the south part of Zeewijk-West differs (Table 4.3). The main differences concern the tempering, thickness and decoration of the vessel. In the north part of Zeewijk-West and in Zeewijk-East 23% and 19% are stone grit-tempered. In the south part of Zeewijk-West the figure is just 8% (Table 4.3). In the south part of Zeewijk-West the sherds are thinner on average and two-thirds are thin-walled. This thin-walled ware is less frequently found in the north part of Zeewijk-West and Zeewijk-East. There, thick-walled ware is far more frequent (22% and 24%, as opposed to 10% at the south part of Zeewijk-West). There is a relationship between stone grit tempering and thickness, as this material is more often visible in thicker sherds.

Cord imprints are visible on the majority (59%) of the decorated sherds from the south part of Zeewijk-West but on just 25% and 13% of the decorated sherds from the north part of Zeewijk-West and Zeewijk-East. By contrast, vessels with fingertip imprints are far more frequently found in the north part of Zeewijk-West and Zeewijk-East (Table 4.2). Different motifs applied with a spatula are common in all three areas, but are least frequent in the south part of Zeewijk-West (Table 4.2).

Since hardly any vessels had sherds spread over more than one area and since the same activities were performed with the ceramics in all three areas it seems that the differences between the areas do not reflect a different function but a different date. This might be three long phases of occupation, or three main phases with different temporary or seasonal sub-phases. This possibility and the chronological order for the areas will be discussed in relation to the results from the Keinsmerbrug and Mienakker sites.

4.7 Comparison of present results with previous studies

Hogestijn

In Hogestijn's publication, Zeewijk was interpreted as a large residential settlement with a ceramic assemblage that reflected this function.[135] Zeewijk-West was interpreted as multi-phased with as many as five house-phases, of which the northern ones represent a later phase. It proved impossible to isolate five house plans by means of spatial analysis.[136] There are nonetheless clear differences between the north and south parts of Zeewijk-West, and these are likely to be caused by a difference in date. The correct chronological order for the three areas remains unclear.

Hogestijn argues that the assemblage found at a site reflects the function and duration of use and the group size at the site.[137] Large residential sites feature larger cooking and storage vessels, a large diversity of shapes and secondary use of ceramics.[138] This seems to be essentially correct: there is indeed a diversity of vessels in the three different areas and there are traces of secondary use. The equation 'large site means large cooking pots' does not however seem to hold true. On the contrary: the thin-walled and medium thick-walled vessels in particular, including the majority of the cord-decorated beakers, are most frequently used to prepare meals in.

Sier

Many of the characteristics studied by Sier were also investigated in this study and the conclusions are the same. However, we have been able to draw new conclusions concerning several important aspects. Sier concluded that residues are found on both thin-walled and thick-walled ware, but that the thickest ware does not show this trait.[139] This seems to be correct, but the percentages of sherds with cooking residues presented seem to be far too low. According to Sier only 5.9% of the Zeewijk-West and 4.8% of the Zeewijk-East sherds have residues. The current re-analysis shows that cooking residues are present on 48% of the ceramics from the south part of Zeewijk-West, 36% of the ceramics from the north part of Zeewijk-West and 25% of the ceramics from Zeewijk-East.

135 Hogestijn 1997, 28-29.
136 Nobles, this volume Chapter 11.
137 Hogestijn 1997, 33.
138 Hogestijn 1997, 28-29.
139 For example Sier 2001, 406-407.

Table 4.4 Main differences of the ceramics from the different sites.

	Thickness						Average thickness	Rough outside surface		Tempering						Decoration						Undecorated
	thin (5–7.5 mm)		medium (8–8.5 mm)		thick (9–10.5 mm)					stone		plant		grog		cord		spatula		fingertip		
	n	%	n	%	n	%	mm	n	%	n	%	n	%	n	%	n	%	n	%	n	%	%
Mienakker	378	72	30	6	74	14	6.9	310	69	2	0	36	6	635	97	69	58	50	42	0	0	78
Zeewijk-West south	111	66	178	11	160	10	6.9	966	65	151	8	15	1	1160	94	250	54	203	44	12	2	74
Keinsmerbrug	137	57	41	17	63	26	7.5	209	86	34	22	6	4	150	92	1	2	35	85	5	12	76
Zeewijk-West north	367	48	161	21	168	22	7.9	573	75	209	23	29	3	749	88	38	25	57	37	59	38	82
Zeewijk-East	248	48	106	20	130	24	7.9	384	73	116	19	3	0	564	90	7	11	38	61	17	28	90

Highest percentage or largest measure indicated in red; second highest or second largest in orange.

The most important deviation from Sier lies in our interpretation of the differences between the ceramics from Zeewijk-West and Zeewijk-East. Her interpretation that the sites were inhabited at the same time by the same group and that the two areas had different functions[140] has been rejected. Sier's conclusion that Zeewijk-East was primarily used for storage proved incorrect, as cooking residues are present on 25% of the sherds.

It is not likely that the ceramics from Zeewijk-West represent a single phase of habitation. Vessels of which several sherds were found were always located in more than one square-metre locus, with the majority of the vessels being spread over areas of at least a few metres.[141] Sherds of only one vessel were found in both Zeewijk-West and Zeewijk-East (vessel 88), and sherds of just three vessels (29, XVIII and XXIV.) were found in both the north and the south part of Zeewijk-West. This can be seen as an argument against contemporaneous use of the different areas.

Drenth and Hogestijn

Drenth and Hogestijn listed Zeewijk-West as a site at which both PF and AOO-beakers were present, whereas Zeewijk-East was listed as a site with only PF beakers.[142] The present re-analysis makes it clear that all over decorated vessels are present in all three areas. In Zeewijk-East one vessel with spatula impressions near the base has been found and on two wall sherds rows of oblique spatula impressions are delimited by horizontal cord lines, the differentiating factor of AOO type 2IId (Fig. 4.6 f and g).[143]

The very intriguing hypothesis that vessel 30 is a precursor of the later Veluwe beakers was tested by means of a ^{14}C date for the encrusted residue (see below, Section 4.8 ^{14}C dates). The second hypothesis – that there are vessels with zoned decoration that can be seen as precursors of the later zoned Bell Beakers – is also hard to test at a site level.[144] This type of decoration is indeed present at Zeewijk, and especially Zeewijk-East. However, whether such pots constituted a forerunner to later pottery styles cannot be established by studying this site alone.

4.8 Comparing Zeewijk with Mienakker and Keinsmerbrug

Mienakker and the south part of Zeewijk-West

In both Mienakker and the south part of Zeewijk-West there is a very strong preference for tempering with grog and sand (Table 4.4). There is a large class of thin-walled ware, the average thickness at both sites being 6.9 mm. Stone grit tempering is very rare: 0% at Mienakker and 8% in the south part of Zeewijk-West. Cord decoration is the most frequently used technique at both sites. Different patterns applied with a spatula also occur in lower numbers at these sites (Table 4.5). In the south part of Zeewijk-West more decorative patterns were found. At Mienakker the thick-walled ware is always undecorated, while in the south part of Zeewijk-West 2% of the decorated sherds show

140 Sier 2001, 411.
141 Nobles, this volume Chapter 11.
142 Drenth & Hogestijn 1999, 102: Table 2.
143 Van der Waals & Glasbergen 1955, 28.
144 Drenth & Hogestijn 2006, 89.

fingertip impressions. It is assumed on the basis of the rim diameters that there was a preference for small beakers and little variation in vessel size. At Mienakker the rim diameters vary between 7 and 17 cm and in the south part of Zeewijk-West the rim range from 7-21 cm (Appendix III).[145]

Keinsmerbrug, Zeewijk-East and the north part of Zeewijk-West

The ceramics from Keinsmerbrug, Zeewijk-East and the north part of Zeewijk-West have a high degree of variability in common (Table 4.5). This is reflected, for example, in the tempering materials added. Several materials are used in different combinations. Stone grit is used to temper about one-fifth of the sherds. The sherds in this group are thicker on average (7.5-7.9 mm). The rim diameters also show greater variety and more thick-walled ware is present (Table 4.5). At Keinsmerbrug and Zeewijk-East the rim diameters measure between 10 and 27 cm, and in the north part of Zeewijk-West between 8-26 cm (Appendices II and IV).[146] The decoration at these sites consists of both cord and spatula impressions on the thin-walled ware and fingertip impressions on the thick-walled ware (Table 4.5). Cord impressions are far less common than at Mienakker and the south part of Zeewijk-West. Decoration is however more common on thick-walled ware. There are also differences between the sites. In Zeewijk-East, for example, more grooved lines bordering other motifs are visible.

Function

Cooking residues are present on sherds from all the different sites. A very interesting pattern emerges when the characteristics of the cooking vessels are studied. At Mienakker and Zeewijk there was a strong preference for using the thin and medium thick-walled, often cord-and spatula-decorated, beakers for cooking.[147] At Keinsmerbrug the total numbers of sherds and therefore also residues were lower. Here again there was a preference for using the thinner-walled fabric for cooking. However, there are examples of thicker-walled ware with residues.[148] This indicates that at the different sites the smaller vessels and beakers were preferably used for cooking instead of the larger vessels, yet Keinsmerbrug somehow deviated from this pattern. Residue analyses showed that at Mienakker and the south part of Zeewijk-West and Zeewijk-East a variety of meals were prepared in the vessels.[149] At Keinsmerbrug just one type of cooked meal was prepared in the vessels.[150] This dissimilarity can be explained by regarding the first group as residential settlements and Keinsmerbrug as a special activity site.

All three areas of the Zeewijk site show a large variety of vessel sizes. The larger vessels may have been used for storing supplies. Keinsmerbrug, the north part of Zeewijk-West and Zeewijk-East yielded the largest variety and the largest vessels. As noted above, at Keinsmerbrug these large vessels were also used for cooking porridge.

Ceramic artefacts, including spindle whorls and baking plates, are only found in three of the Zeewijk areas, and not at Keinsmerbrug or Mienakker. At Mienakker evidence for the production of ceramics has been found in the presence of a small stone tool with marks that indicate that it was uses for scraping of the wall of a pot.[151] No such evidence has been found at the other sites.

All these factors contribute to the idea that the Mienakker site and the different areas at Zeewijk share a similar function and that Keinsmerbrug needs to be seen as an outlier. On Mienakker and the different Zeewijk areas the pottery assemblage seems to reflect a broad range of settlement activities. At Keinsmerbrug fewer activities are reflected in the smaller ceramic assemblage. The most striking differences in the ceramics, such as the differences in tempering, thickness and the ratios of decoration techniques used, do not seem to be a direct reflection of the site's function. The variability in technology and decoration is most likely a matter of chronology.

Typological dates

On the basis of the study mainly of grave goods several authors have proposed a chronological order for different types and traits of Single Grave vessels.[152] However, these propositions only concern the decoration and morphology of the beakers, not the technological characteristics of all vessels, nor the decoration and morphology of the larger vessels. Furthermore, many of the propositions apply only to complete vessels or large fragments. Due to fragmentation these traits are not

145 Beckerman 2013, 52: Table 4.11.
146 Beckerman 2012, 239.
147 Beckerman 2013, 54-56.
148 Beckerman 2012, 55.
149 Oudemans & Kubiak-Martens, this volume.
150 Oudemans & Kubiak-Martens, this volume.
151 García-Díaz 2013, 85
152 Van der Waals & Glasbergen 1955; Lanting & Van der Waals 1976; Drenth & Hogestijn 2006.

Table 4.5 Decoration at different sites compared.

	Zeewijk-West south		Mienakker		Keinsmerbrug		Zeewijk-West north		Zeewijk-East	
	n	%	n	%	n	%	n	%	n	%
Fingertip and nail impressions										
On the wall	11	2	-	-	3	4	17	11	14	23
On the rim	1	-	-	-	-	-	1	-	1	2
On the rim and the wall	-	-	-	-	2	3	41	26	2	3
Subtotal	**12**	**2**	**-**	**-**	**5**	**7**	**59**	**37**	**17**	**27**
Spatula decoration										
ZigZag	27	6	11	9	9	13	6	4	7	11
Herringbone	38	8	2	2	31	44	9	6	4	6
Oblique impressions in one direction	52	11	37	31	24	34	39	25	22	35
Herringbone bordered with horizontal lines	-	-	-	-	-	-	1	1	1	2
Oblique impressions in one direction bordered with horizontal lines	-	-	-	-	-	-	-	-	3	5
2IIf	62	13	-	-	-	-	1*	1	-	-
No clear pattern/other pattern	2	1	-	-	1	1	1	1	-	-
Subtotal	**181**	**39**	**50**	**42**	**65**	**92**	**57**	**38**	**37**	**60**
Cord decoration										
1a	45	10	-	-	-	-	-	-	-	-
2IIb	40	9	3	3	-	-	1	1	-	-
1a/2IIb	143	31	66	55	1	1	36	23	6	10
2IId**	44	9	-	-	-	-	2	1	2	3
Subtotal	**272**	**59**	**69**	**58**	**1**	**1**	**39**	**25**	**8**	**13**
Unknown	2	-	-	-	-	-	-	-	-	-
Total decorated	**456**	**26**	**119**	**22**	**71**	**24**	**155**	**18**	**62**	**10**
Total undecorated	**1281**	**74**	**427**	**78**	**220**	**76**	**692**	**82**	**563**	**90**

* One sherd from type 2IIf vesel 29 is found in the northern area, 62 in the southern area.

** On type 2IId cord and spatula decoration are compared, this type can thus also be fitted within the spatual decorated group.

visible on settlement assemblages.

It seems, however, that based on these propositions there are several indications that Keinsmerbrug, Zeewijk-East and the north part of Zeewijk-West were inhabited during an earlier period and Mienakker and the south part of Zeewijk-West were inhabited later (Table 4.6). Types 1b, 1c, 1d, zigzag and 1e are most frequently found at Keinsmerbrug, Zeewijk-East and the north part of Zeewijk-West (Table 4.6 and Fig. 4.19). Decoration on the inside of the rim and sherds that belong to either type 1a or 2IIb are most frequently found at Mienakker and the south part of Zeewijk-West (Table 4.6). Types 2IIb and 2IIf are found only in the south part of Zeewijk-West. These latter characteristics and types have been identified by Lanting and Van der Waals, and are regarded as later than the previously mentioned characteristics and types.[153]

It must be stressed that this chronology is based on a limited number of characteristics.

[153] Lanting & Van der Waals 1976, 5-9.

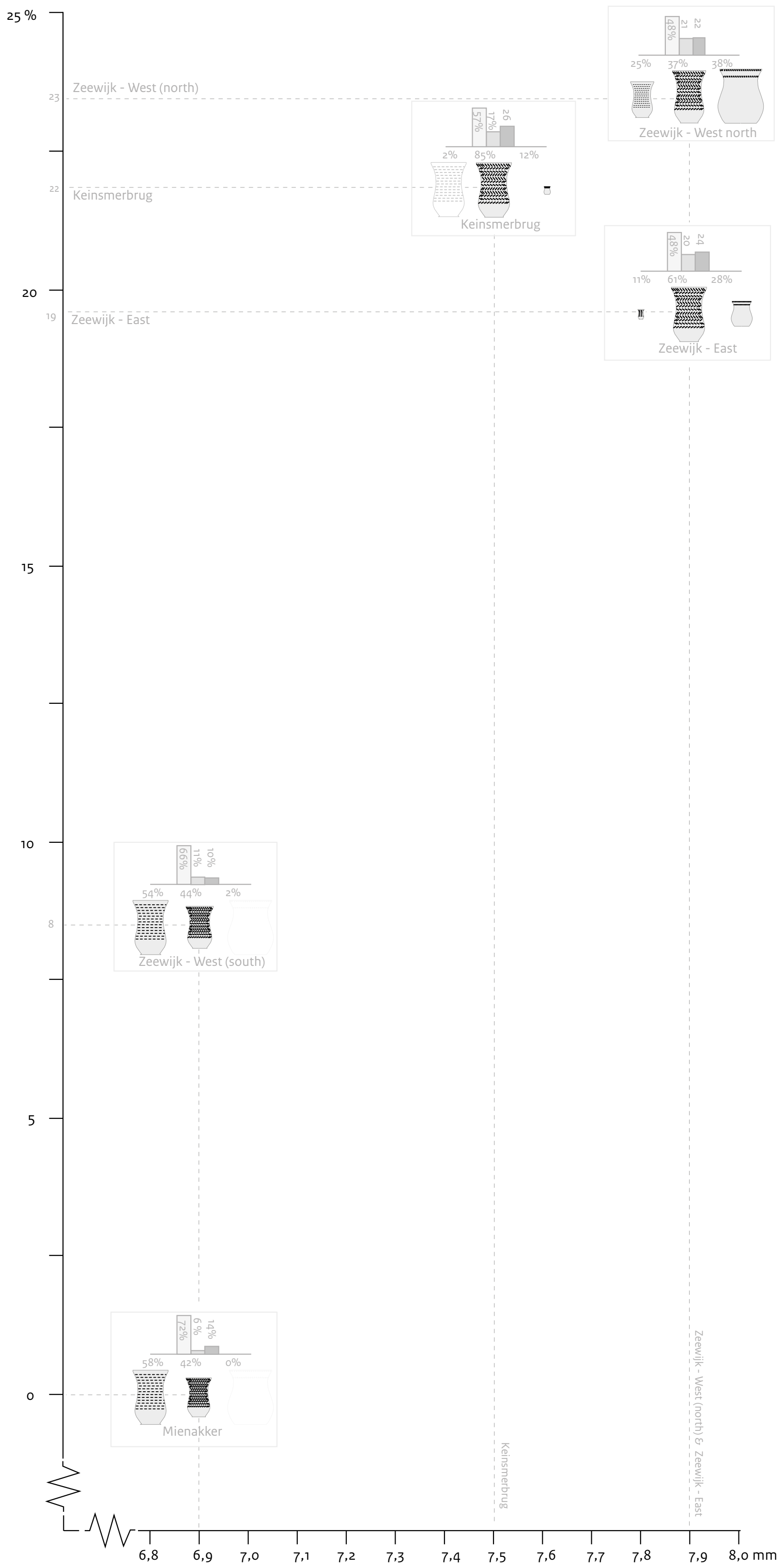


Figure 4.19 Main differences in the ceramics from the different sites (y-axis percentage of stone grit tempering, x-axis average thickness, vessels from left to right: cord decorated, spatula-decorated and fingertip-decorated).

Table 4.6 Typological dates for the different sites and areas compared.

Characteristic	Authors	Date	Site				
			Zeewijk-East	Zeewijk-West north	Keinsmer-brug	Zeewijk-West south	Mienakker
1a	Lanting & Van der Waals 1976, 5-9.	only cord: oldest PF, long lifespan	?	?	?	[yellow]	?
1b, 1c, 1d,	Lanting & Van der Waals 1976, 5-9.	middle PF?	[yellow]	[orange]	[red]	[yellow]	[yellow]
ZigZag	Lanting & Van der Waals 1976, 5-9.	young PF (related to 1d and 1e)	[orange]	[yellow]	[red]	[yellow]	[yellow]
1e	Lanting & Van der Waals 1976, 5-9.	youngest PF	[red]	[yellow]	[orange]	[yellow]	[yellow]
Protruding foot	Lanting & Van der Waals 1976, 5-9.	old	[yellow]	[yellow]	x	[yellow]	x
Flat or hollow base	Lanting & Van der Waals 1976, 5-9.	young	[yellow]	[yellow]	[yellow]	[yellow]	[yellow]
Decoration inside of the rim	Lanting & Van der Waals 1976, 6.	young	[yellow]	x	x	[orange]	[red]
1a/2IIb	Lanting & Van der Waals 1976, 6.	whole PF/ old AOO	[yellow]	[yellow]	[yellow]	[orange]	[red]
2IIb	Lanting & Van der Waals 1976, 6.	oldest AOO	?	[yellow]	?	[red]	[yellow]
2IIc/2IIe	Sier 2001, 397.	oldest AOO	[yellow]	x	x	x	x
2IIf	Sier 2001, 411.	young	x	x	x	[yellow]	x
2IIa	Lanting & Van der Waals 1976, 6.	youngest AOO	[yellow]	[yellow]	x	[red]	x
Zoned decoration	Drenth & Hogestijn 2006, 79.	young	[yellow]	x	x	x	x
Predecessor of Veluwe shape	Drenth & Hogestijn 2006, 79.	young	x	x	x	[yellow]	x

Most numerous indicated in red; second most in orange; present in yellow. x: not present; ?: unknown.

Other characteristics are not visible or offer a less clear view. Zoned decoration, for example, seen by Drenth and Hogestijn as a more recent trait, is present only at Zeewijk-East.[154]

If this proposed order is correct we can observe several chronological trends. Older sites show more variation in temper and stone grit temper is frequently used. The vessels are more frequently thick-walled and some medium and thick-walled vessels are decorated with fingertip imprints. In a later period the average thickness is lower. More vessels are decorated with cord imprints but fingertip decoration on medium and thick-walled ware becomes rare.

^{14}C dates

The ^{14}C dates for this period are problematic, as large plateaus in the calibration curve hinder any attempt to establish an accurate chronology.[155] For example, two dates from Keinsmerbrug are only five years apart in uncalibrated years, but after calibration one of the dates has a possible start 200 years earlier (Appendix VI).[156]

Furthermore, several other factors cause severe problems, such as the old-wood effect and the absence of or an unclear association between the dated material and the ceramics. Eighteen dates supposedly related to the cultural material are available for the different areas and sites discussed here (Appendix VI). The dates do not seem to support the proposed order for the areas and sites.

A good relationship between the dated material and the ceramics can be established for four dates. These are the two residue dates from the south part of Zeewijk-West and two dates from Keinsmerbrug. The residues on vessel 13, from the south part of Zeewijk-West, date to 4100 ± 40 BP (GrA-56014). The residues on vessel 30 from the same area, with the Veluwe-type shape, date a little younger, 4030 ± 40 BP (GrA-56013). A comparison of the Δ^{13}C values indicate that those for the residues do not differ from the other dates and a reservoir effect is thus not to be expected (Appendix VI). Drenth and Hogestijn proposed that vessel 30 might be seen as precursor of the Veluwe shape, and Lanting proposed that the vessel could be later.[157] This date indicates that the vessel is indeed part of this assemblage and not much later, but this is not no to say that these vessels directly or indirectly influenced the

154 Drenth & Hogestijn 2006, 79.
155 Beckerman 2011/12, 25; Furholt 2003.
156 GrA-47380 uncalibrated: 4000 ± 40 BP calibrated on 2δ: 2831-2356 cal BC, GrA-47381 uncalibrated: 3995 ± 40 BP, calibrated on 2δ: 2624-2351 cal BC.
157 Drenth & Hogestijn 2006, 89; Lanting, personal communication.

younger Veluwe shape. Both the dates with a reliable association from Keinsmerbrug are a little later, in contrast to what the typological dates might lead us to expect (Appendix VI). GrA-47383: 4025 ± 40 BP is related to one undecorated thick-walled sherd and GrA-47380: 4000 ± 40 BP is related to a rim sherd of vessel 11 which is undecorated and quartz- and grog-tempered.

Some of the dates for which the relationship between the ceramics and the date is unknown or is less certain do support the proposed sequence, while others contradict it (Appendix VI). The date on the post from the large structure in Zeewijk-East, 3910 ± 50 BP (GrN-18488), is very late. However, the ceramics may be from a different period than the large house. Three dates on charred reed from the supposedly fairly recent Mienakker site date to an early phase, 4130 ± 40 BP (GrA-108), 4100 ± 30 BP (GrA-109) and 4120 ± 30 BP (GrA-110; Appendix VI). The location where the reed was found is unclear, but a *t.a.q.* date may be possible. Three final dates from Keinsmerbrug with no strong relationship to ceramics related to a late phase, 3970 ± 40 BP (GrA-47377), 3995 ± 40 BP (GrA-47381) and 3965 ± 40 BP (GrA-47382; Appendix VI). The exact find locations of three dates from Zeewijk-West were not published, but they were found at the Centre for Isotope Studies at the University of Groningen. However, the relationship with the ceramics found near this location remains uncertain. The one date for material from the north part, 4140 ± 40 BP (GrA-114) falls between dates from the south part (Appendix VI). The ^{14}C dates do not reflect the proposed chronological order. However, on the basis of the limited dates, it is not possible to establish an alternative chronology.

4.9 Conclusions

The study of a selection of the Zeewijk ceramics has yielded some very interesting results. All over the Zeewijk site thin to medium thick-walled, sometimes cord- or spatula-decorated beakers were found that were used to cook meals. This preference for beakers for cooking purposes was also observed at Mienakker and to a lesser extent at Keinsmerbrug. Beakers are however generally regarded as drinking cups.[158] Several authors have even explained the presence of beakers in graves and the spread of the (Bell) Beaker culture in terms of alcohol consumption.[159] Although a link with alcohol remains a possibility, this study does show that these beakers are also favoured as cooking vessels. In addition to cooking, the presence of a substantial ceramic assemblage, comprising medium and large vessels (some used for storage) and ceramic artefacts like spindle whorls indicates that a variety of activities were performed, suggesting that the site was used as a settlement rather than as a special activity site.

This study has proved that the Zeewijk site can be subdivided into three areas with different ceramic assemblages. The majority of these observed differences are a reflection of different periods of occupation. The south part of Zeewijk-West is characterised by the presence of a large group of thin-walled ware (5-7.5 mm, 66%) and smaller groups of medium thick-walled (8-8.5 mm, 11%) and thick-walled ware (9-10.5 mm, 10%). The average thickness is relatively low, at 6.9 mm. Stone grit tempering is fairly rare (8%) and the vast majority (88%) is tempered with grog and sand. Decoration consists mainly of cord (59%) and spatula impressions (39%). In the north part of Zeewijk-West the group of thin-walled ware is smaller (5-7.5 mm, 48%), the class of thick-walled ware (9-10.5 mm, 22%) is larger and the average thickness of the sherds is 7.9 mm. A far lower percentage is grog- and sand-tempered (71%) and stone grit tempering is more important (23%). Cord decoration occurs only on a few sherds (25%). Spatula (38%) and fingertip decoration (37%) is more common. Zeewijk-East is broadly similar to the north part of Zeewijk-West. Here again the average sherd thickness is high, 7.9 mm, and tempering frequently consists of stone grit particles (19%). The low numbers of decorated sherds mainly show spatula (60%) and fingertip impressions (27%).

The ceramics from the south part of Zeewijk-West are similar to the Mienakker ceramics. The ceramics from Zeewijk-East and north part of Zeewijk-West show similarities with the Keinsmerbrug ceramics. Constructing a chronological sequence of the two groups of

[158] Sheratt 1987.
[159] Sheratt 1987; Vander Linden 2001; Turek 2012.

sites proved hard. ^{14}C dates do not indicate any particular order. Based on typochronological arguments Keinsmerbrug, Zeewijk-East and the north part of Zeewijk-West can be seen as the earliest and Mienakker and the south part of Zeewijk-West as the latest.

It would still be possible to enlarge the Zeewijk selection and study more ceramics from, for example, the north part of Zeewijk-West. However, as the stratigraphy is problematic and it is impossible to establish phasing based on the features, it is by no means certain this will lead to more detailed phasing of the site. To test the postulated ideas concerning chronology and function, the ceramics from Zandwerven, Slootdorp-Bouwlust, Aartswoud (trench 1) and Sijbekarspel-De Veken will be studied.

5 Flint, stones and bones: raw material selection, typology, technology and use-wear analysis

V. García-Díaz

5.1 Introduction

The site of Zeewijk was discovered in 1983. It is one of the largest documented Single Grave Culture sites in the Netherlands. However, the site was only partly excavated. Two distinct areas were defined as Zeewijk-West and Zeewijk-East, based on two large concentrations of a dark cultural layer divided by a gully. During the excavations, different methodologies were applied to recover the stone, bone and flint implements.[160]

In 1984 an amateur archaeologist, A. Wit, conducted a small-scale excavation. A test pit of 3x3 m was dug, revealing an archaeological layer 50 cm thick. A ^{14}C dating obtained from a bone fragment in the cultural layer yielded a date of 3925 ± 40 BP. [161] During the test excavation, an unknown number of flint artefacts were recovered (more than 100), including a number of scrapers and one a leaf-shaped point. Approximately 15% of the flint material was burned. In addition, a large and almost complete quern and a fragment of another quern were found.[162]

In 1986 and 1987, the *Biologisch-Archaeologisch Instituut* at the University of Groningen (BAI) performed two different campaigns of research.[163] First, 296 geological cores were taken (229 in 1986 and 68 in 1987). A total of 160 litres of sediment was obtained, 140 litres were sieved through a 3 mm mesh, while 20 litres were sieved through a 1 mm mesh to obtain botanical and zoological samples. During the excavation of the test pit, 109 flint artefacts (104 flakes, one scraper and one core fragment) were found, as well as a number of quartzite hammer stones. Thirteen of them (11.9%) showed signs of burning.

Finally, in 1992, 1993 and 1994 the *Rijksdienst voor het Oudheidkundig Bodemonderzoek* (ROB) organised a series of excavation campaigns.[164] In 1992, 270 geological corings were taken. In addition, an archaeological excavation was planned. Due to a lack of time and money, a selection of approx. 20-25% of the site was excavated. In 1992, one small excavation of 2x2 m, three larger excavations and two trenches from Zeewijk-East to Zeewijk-West were performed. In 1993, a machine excavation was performed at Zeewijk-East, until it was realized that the cultural layer was missing. In addition, an excavation in the western area was performed. And finally, in 1994, several 2 m trenches were excavated in the higher part of the levee, where the cultural layer was found. Around 7000 fragments of flint displaying very little typological variation were recovered from the excavation. They mainly included borers and scrapers, according to the descriptions. Finally, an undetermined number of stone artefacts was documented. At Zeewijk-West a concentration of quern fragments was defined.

Zeewijk-East and Zeewijk-West have been interpreted as two interrelated settlements,[165] or as the exemplification of a big settlement.[166] The plan of a large structure with a ^{14}C date of 3910 ± 50 BP was uncovered during the excavation at Zeewijk-East.[167] The function of this structure has been related to 'a ritual or a ceremonial function', given the absence of any domestic refuse and its regular shape.[168] After the excavation, some preliminary reports were published, but none of them referred to the study of the flint or stone assemblages.[169]

During the actual analysis in our project, and due to the numerous assemblages, a study sample was taken covering both areas. We decided to focus on the areas which yielded (possible) structures. The analysed materials would be the ones collected from the 1992 areas, and if extra time was available a bigger sample would be analysed. Therefore, the first step in the analysis was to enter all the available implements into a common database. In total, 7537 stone, 11 bones and 10,700 flint implements were entered in the database of the Laboratory of Artefact Studies at Leiden University. Unfortunately, after the assemblages were introduce into the database, it became apparent that the material from some excavated areas was missing. In general, most of the flint material from the 1992 was gone, and a great number of the materials from the 1993 and 1994 trenches were missing. Finally, in Zeewijk-East, flint and stone from inside the plan of the large structure are almost completely absent (Fig. 5.1). In the case of the flint, the study sample was not representative due to the absence of materials. In consequence, it was decided that the flint, stone and bone would be studied in its totality, without taking into account the sampled area. In addition, use-wear analysis would be performed to flint, bone and stone implements with

[160] Nobles, this volume Chapter 11.
[161] GrN no. 15565, Van Heeringen & Theunissen 2001b, 67.
[162] Van Heeringen & Theunissen 2001b, 67.
[163] Now Groningen Institute of Archaeology at the University of Groningen.
[164] Now Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency of the Netherlands, RCE).
[165] Drenth, Brinkkemper & Lauwerier 2008.
[166] Hogestijn 1992, Hogestijn 2001.
[167] GrN-no. 18488, Van Heeringen & Theunissen 2001b, 67.
[168] Drenth, Brinkkemper & Lauwerier 2008, 158.
[169] Van Heeringen & Theunissen 2001c, Chapters 10 and 13.

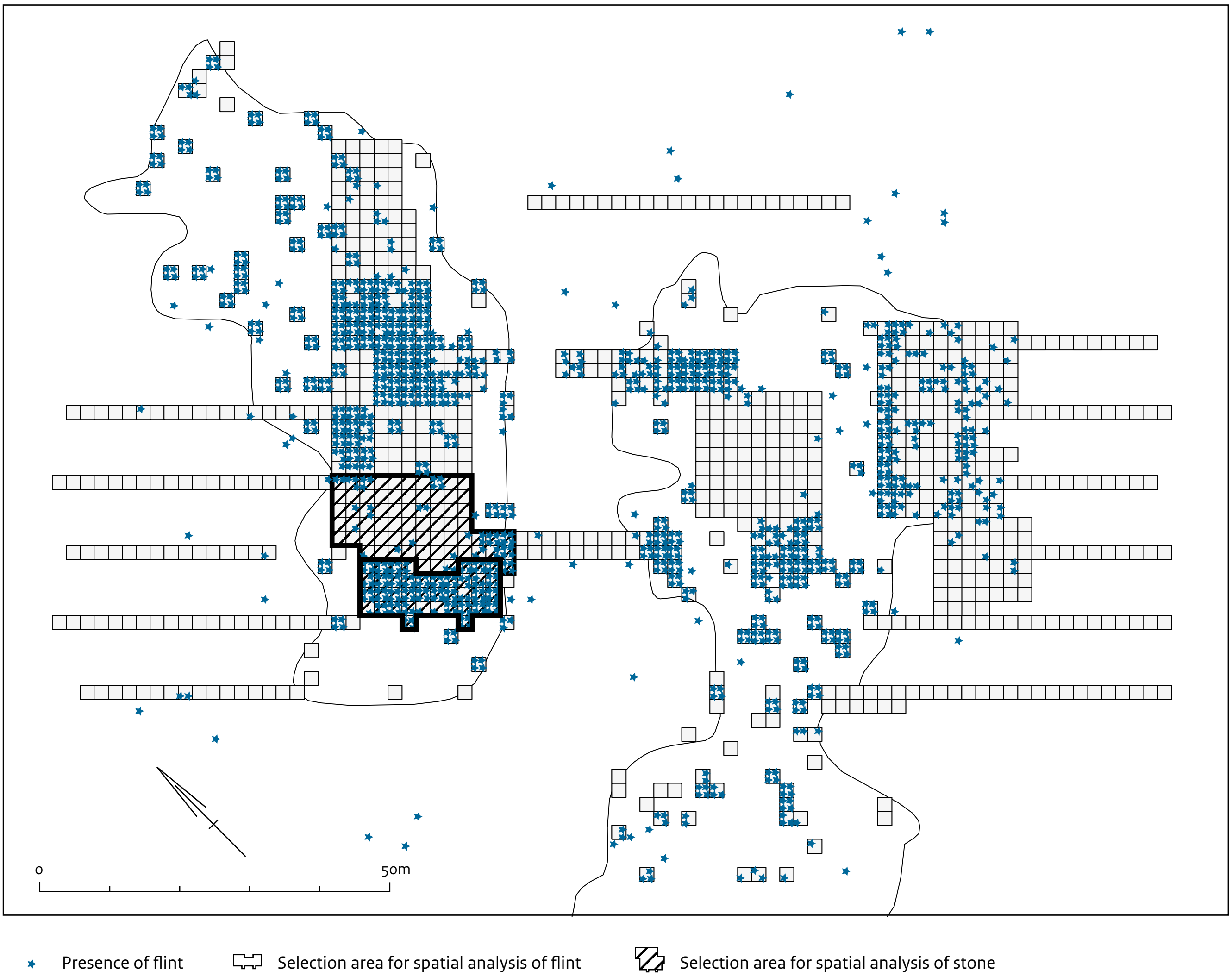


Figure 5.1 Overview of the flint distribution with the sampled area is indicated. After the spatial analysis it became evident that the flint sample was not representative. Consequently, the excavated area was treated as one entity. For the spatial analysis of the stone the sampled area is indicated.

possible traces of use. In the case of flint, where the assemblage was too numerous to perform use-wear analysis to every implement with possible traces of use, the 1992 flint assemblage would be prioritised. Therefore, in this report the flint, stone and bone implements will be presented without reference to the sampled areas, and considering both areas of the archaeological site as one entity.

The objective of the analysis was to understand the entire production process of the flint, stone and bone implements, starting with the selection of raw materials and ending with the discarding of the tools after use. The study of archaeological implements provides important information on the social structure of the group. Firstly, the analysis of flint implements provides information about the use of the landscape by the group and the social networks arranged to obtain the raw materials needed. Secondly, technological analysis reveals the degree of complexity of the techniques employed, which can help to understand the nature of the settlement, the connections of the group with other communities, or the society's ties with past technological traditions. Finally, use-wear analysis gives an insight into the range of activities performed, and helps to interpret the role of the site in the settlement system and the length of occupation. Social networks, economic organisation and settlement patterns can all therefore be interpreted through the analysis of archaeological tools. In this chapter, an analysis of flint, stone and bone implements will be presented. The results of the typological, technological and functional analyses will be discussed and interpreted. Finally, the results will be compared with other contemporaneous sites.

5.2 Methodology

5.2.1 Methodological study

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

5.2.2 Technological study

The main objective of the analysis was to understand the way tools were produced and whether different reduction strategies were associated with different raw materials. Flint, stone and bone artefacts that display technological features were studied to understand the characteristics of the production process.

5.2.3 Use-wear analysis

The use-wear analysis was performed using a stereoscopic microscope with magnifications ranging from 10-160x and an incident light microscope with magnifications between 50 and 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. Alcohol was used to remove finger grease and superficial dirt. A classification of suitable pieces for use-wear analysis was performed at low magnifications or with the naked eye. A selection of 140 flint implements was also analysed under the incident light microscope at higher magnifications (up to 500x). In addition, 53 stones and six bone implements were selected for use-wear analysis.

5.2.4 Taphonomy

The rate of fragmentation of the flint artefacts is high at Zeewijk, with only 15% of the implements being complete. Similar levels of fragmentation were present at Mienakker, where only 10% of the implements did not show any fractures. Moreover, 32% of the flint implements display different kinds of physical alterations due to contact with fire, such as red spots, a glossy appearance, or a *craquelé* surface. In addition, almost 30% of the implements show different kinds of patinas that have altered the surface.

In the case of the stone artefacts, the fragmentation is even higher, with less than 6% of the artefacts being listed as complete. Moreover, around 37% of the implements show traces of contact with fire. Various physical alterations, such as red spots or the blackening or *craquelé* of the surface, are visible.

The surface of the bone tools has been modified by several post-depositional alterations that complicate, or impede, systematic analysis. Abrasion and erosion of the surface caused by contact with the sediment, partial fractures, and animal bites are present on some of the tools. In addition, some of the bone implements were restored using glue and other chemical preservatives which covered the original surface of the tools. Consequently, the technological and functional traces on these implements could not be analysed.

5.3 Flint tools

5.3.1 Raw material

Flint was classified into three main groups based on the provenance of the raw material: northern flint, southern flint and flint with an undetermined origin. Finally, the raw material of 1.7% of the flint could not be identified due to a

Table 5.1 Overview of the tool types documented at Zeewijk.

Primary classification	Number	%
Flake	3239	30.3
Blade	138	1.3
Core	413	3.9
Pebble	81	0.8
Block	41	0.4
Waste and splinter	6221	58.1
Other	567	5.3
Total	**10700**	**100**

Table 5.3 Overview of the type of flakes documented at Zeewijk.

Flake type	Number	%
Unmodified	2884	89.0
Retouched	107	3.3
Borer	2	0.1
Core preparation	60	1.8
Core rejuvenation	1	0.0
Axe fragment	22	0.7
Point	2	0.1
Scraper	130	4.0
Core decortification flake	31	1.0
Total	**3239**	**100**

Table 5.2 Metrical data of the flakes.

Primary classification	Main type	Complete (n)	Length (mm)			Width (mm)			Thickness (mm)		
			min.	max.	average	min.	max.	average	min.	max.	average
Flake	unmodified	1126	0.6	59	11.8	0.4	44	11.12	0.1	18	2.73
Flake	borer	1	21	21	21	16	16	16	6	6	6
Flake	point	1	31	31	31	18	18	18	4	4	4
Flake	retouched	54	1.9	42	18.8	1.8	44	17.7	0.4	12	4.8
Flake	scraper	84	1.1	37	16	1.2	32	15.2	0.3	11	5.12
Flake	core preparation decortification	18	2	42	21.45	1.2	52	17.8	0.5	10	5.7
Flake	axe	7	9	35	17.8	11	34	20.8	2	9	4
Flake	rejuvenation	6	16	31	21.5	4	23	12.8	2	6	3.6

high degree of alteration of the surface caused by contact with fire.

The main group comprises flint with a northern origin (94.4%). The northern flint is mainly light grey, or black/dark grey with a fine or medium grain. However, light grey flint with bryozoan and northern translucent flint with bryozoan are also present.

Southern flint is represented by only five fragments. One unmodified flake was Valkenburg flint. The main characteristic of this flint is its coarse-grained structure. The flint is located in the Emael deposits of the Maastricht formation. Valkenburg flint is known to have been exploited since the LBK period, but exploitation was at its height during the time of the Vlaardingen groups.[170] Two fragments have a Belgian origin. One retouched flake has been classified as Light Grey Belgian, while one fragment has been classified as Rullen flint. Finally, two unmodified flakes were produced from undetermined southern flint, and the origin of 3.7% of the flint could not be determined.

5.3.2 Flint typology and technology

The flint assemblage was classified into five groups: flakes, blades, cores, blocks and pebbles, and waste and splinters (Table 5.1). The flaking techniques applied to the assemblage were determined by the irregular size and the quality

[170] De Grooth 2011.

of the available raw material. Consequently, the flint implements are characterised by their small size (Fig. 5.2). A standardised size or shape has not been documented for flint implements. In addition, the assemblage displays a low level of preservation due to several alterations.

5.3.2.1 Flakes

Tool production at Zeewijk was focused on flake production. Flakes represent 30.4% (n=3239) of the implements analysed. Most of them do not display signs of further modification. Only 107 flakes show a retouched edge. In addition, 130 scrapers, one borer and two arrowheads were made of flakes (Table 5.2; Table 5.3).

Unmodified flakes
Unmodified flakes are the most common implements in the archaeological assemblage. Around 89% of the flakes do not show any secondary modification (n=2903). The level of fragmentation among unmodified flakes is high (55.2%). Surface preservation of the unmodified flakes is good, even though 25% show a patinated surface and traces of burning are present in 21% of the artefacts. The shape of the unmodified flakes varies between 0.6 to 59 mm in length, 0.4 to 44 mm wide and 0.1 to 18 mm thick (Table 5.2). The technological characteristics of the unmodified flakes suggest that the knapping was performed with hard percussion.

Retouched flakes
A retouched edge was present on 107 flakes. Only half of them (54) are complete and have small dimensions (Table 5.2). The preservation of the retouched flakes is good. Just 12% of the flakes show traces of burning, while 17.7% of the tools show evidence of patination. Retouch, 56% of which are smaller than 1 mm, have been classified into three types: surface retouch (n=2), border retouch (n=19) and steep retouch (n=82), while four retouch could not be classified. The technological characteristics of the retouched flakes suggest that the knapping was performed with a hard hammer. In addition, two retouched flakes show evidence of bipolar flaking.

Axe flakes
The archaeological assemblage provided a small number of polished axe flakes (n=22; 0.7%). Just seven axe flakes are complete. However, the surface preservation is good, as only one shows a slight patination and just three flakes display evidence of burning. The dimensions of the axe flakes are documented in Table 5.2. The technological characteristics of the axe flakes suggest that knapping was performed with a hard hammer.

Scrapers
At Zeewijk 130 scrapers were produced from flakes. Most of the scrapers are complete (64.6%) and the surface is well preserved, without traces of patination (70.7%) or burning (84.6%). In addition, around half of the scrapers (56.1%) have different kinds of cortex (see for some examples Fig. 5.3). The average dimensions of the complete scrapers are documented in table 2. A double retouched side was found on 16 scrapers, while the rest are single scrapers. The double scrapers have similar dimensions (Table 5.2). The technological characteristics of the retouched flakes suggest that the knapping was performed with hard hammer stones. In addition, one scraper shows evidence of bipolar flaking. Finally, one scraper (22-1) was made of an axe flake.

Core rejuvenation flakes and decortification flakes
At Zeewijk 29 core rejuvenation flakes and 62 decortification flakes were documented. In the case of the rejuvenation flakes, just six of them are complete (Table 5.2). The surface preservation of the rejuvenation flakes is good as patination is present on only four flakes and evidence of burning was found on only five.

The level of fragmentation of the decortification flakes is high, as less than 30% of the flakes remain complete (Table 5.2). However, the surface preservation is good with almost no evidence of burning (4.8%) and a low number of flakes showing patina (11.2%). In both cases, the technological traits of the complete flakes suggest the use of hard percussion to produce the core rejuvenation and decortification flakes.

Points
During the present analysis of the assemblage, two arrowheads (27821-82 and 7188-1) were documented (Fig. 5.4). In 1997, Van Ginkel and Hogestijn published results on both points.[171] In addition, one arrowhead was recorded during the 1984 excavation . However, typologically the

[171] Van Ginkel & Hogestijn 1997, 87.

description of this point does not match the points presented here. The documented arrowheads were made from flakes, and their entire surface is retouched. Just one of the arrowheads (27821-82) is complete (Table 5.2). The other arrowhead shows a proximal fracture. Arrowheads are not very common in Neolithic domestic contexts in the Netherlands. TRB and Vlaardingen domestic settlements have provided some examples.[172] In addition, arrowheads have been documented in other Single Grave Culture domestic contexts.[173] Both arrowheads documented at Zeewijk are typologically similar to other Single Grave points discovered in the domestic context of Aartswoud. The arrowheads have a 'pine tree' shape, typical of the Single Grave contexts.[174] These types of points are characterised by one tag shorter than the barbs. In addition, the surface displays a bifacial retouched surface, confined mostly to the edges, without covering the central part of the arrowheads.

Borers

Two borers on flakes (23933-18 and 15224-4) were documented. One borer (23933-18) is complete and the surface is well preserved. The artefact has small dimensions (Table 5.2) and shows two elongated and rounded edges that were used for drilling. The second borer is a flake with a proximal fracture. The dorsal face of the borer is almost entirely covered by a weathered cortex suggesting that the borer was probably obtained from a small rolled pebble. Finally, the tip of the distal end is heavily rounded, probably related to its use as a borer.

Table 5.4 Overview of the type of blades documented at Zeewijk.

Blade type	Number	%
Unmodified	107	77.5
Retouched	15	10.9
Rejuvenation blades	12	8.7
Decortification blades	4	2.9
Total	**138**	**100**

5.3.2.2 Blades

Blades (n=138) represent 1.3% of the implements analysed at Zeewijk. Even though most of the blades (n=107) are unmodified, some blades (n=15) show one retouched edge. In addition, 16 blades are the result of the core preparation process (Table 5.4). The level of fragmentation of the blades is very high, as just 33.3% of the implements are complete (Table 5.5). Even though most of the documented blades were produced during flake manufacturing, the presence of blade cores and the morphological characteristics of some implements suggest that blade production was performed at the site. Blades displayed regular and parallel ridges and two straight edges which, from a functional point of view, might be suitable for some specific activities, such as cereal harvesting. Blade production is uncommon at Single Grave domestic settlements, mainly due to the small dimensions of the raw material available. However, some exceptions are known. At Mienakker, one blade core was documented during the analysis of the flint assemblage. However, the small size of the core suggested that it was exploited mainly to obtain *bladelets*.[175]

Unmodified

Most of the blades (n=107) found at Zeewijk are unmodified. The level of fragmentation of

Table 5.5 Metrical data on the blades.

Primary classification	Main type	Complete (n)	Length (mm)			Width (mm)			Thickness (mm)		
			min.	max.	average	min.	max.	average	min.	max.	average
Blade	unmodified	37	1.5	43	19.1	0.5	20	8.2	0.2	8	2.8
Blade	retouched general	8	16	42	25.8	7	22	11.3	2	7	3.3
Blade	core rejuvenation	2	2.7	23	12.8	0.8	8	4.4	0.8	3	1.9

172 Raemaekers 2005; Beuker 2010; Van Gijn 2010.
173 Van Heeringen & Theunissen 2001b; Drenth 2005; Beuker 2010; Van Gijn 2010.
174 Beuker 2010.
175 García-Díaz 2013.

Table 5.6 Metrical data on the cores.

Primary classification	Main type	Complete (n)	Length (mm)			Width (mm)			Thickness (mm)		
			min.	max.	average	min.	max.	average	min.	max.	average
Core	flake	95	1.6	40	18.3	1.3	40	13.6	0.6	29	7.1
Core	blade	1	1.4	1.4	1.4	1.7	1.7	1.7	0.9	0.9	0.9

unmodified blades is high, as only 37 (34.6%) are complete. The surface preservation is good, with only 17.5% of the blades showing some sort of patina. In addition, only 16 blades show surface modifications related to burning. The dimensions of the unmodified blades are small (Table 5.5).

Rejuvenation blades

On-site flint knapping is indicated by the presence of twelve rejuvenation blades. Two blades (20691-2 and 31522-96) are complete (Table 5.5). The preservation of the first blade is good, with no signs of patination or burning. The platform of the blade and the technological attributes of the artefact suggest the use of hard percussion. However, the second blade shows a slight glossy patina over the surface. The rest of the blades, even though they are fragmented, are well-preserved.

Decortification blades

The decortification blades found at the site (n=4) are all fragmented. Two of them show cortex on less than 50% of the surface while the other two implements show cortex on more than 50% of the surface. The first two blades show a rough cortex over their entire dorsal surface while the two others have a weathered cortex type. One of the blades shows a light patina and another displays traces of burning.

Retouched blades

Retouched edges are displayed on 15 blades. They have small dimensions (Table 5.5) and a very well preserved surface, as just three of them show any level of patination. Burning traces are present on only four of the blades. The level of fragmentation is high as only half of the retouched blades are complete. The retouches of the blades are smaller than 1 mm in nine blades. Finally, two different types of retouch have been identified: border retouch and steep retouch. The technological characteristics of the retouched blades suggest the use of a hard hammerstone in the case of 14 artefacts. In one case (19154-3) the blade shows a pointed platform that could suggest the use of a softer hammer, even though the use of hard percussion is also possible in this case.

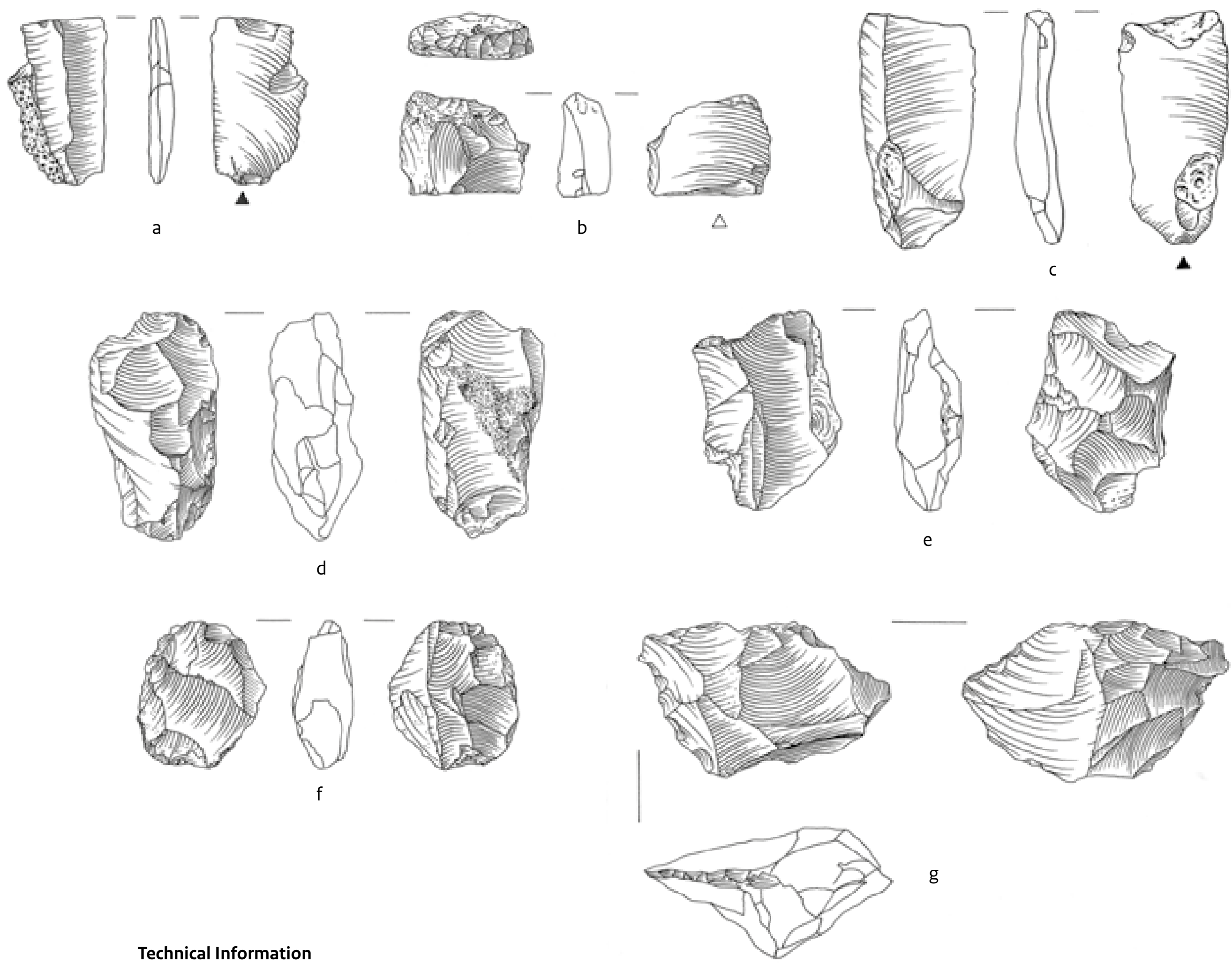
Table 5.7 Overview of the type of cores documented at Zeewijk.

Core type	Number	%
Flake core	378	91.5
Blade core	6	1.5
Unsure	29	7.0
Total	**413**	**100**

5.3.2.3 Cores, pebbles and blocks

The knapping process is documented at the site by the presence of 413 cores (Table 5.7), 317 of which are fragmented and 96 complete. The majority of the cores (91.5%; n=378) are related to flake production. However, blade production has also been documented on six cores. Finally, the production traces on 29 cores were inconclusive, so it was not possible to distinguish whether they were exploited for flake or blade production. The small dimensions of the cores (Table 5.6) are directly related to the relatively small size of the implements.

The technology applied at Zeewijk was a combination of technological approaches of diverse degree of complexity. Unidirectional flake and blade extraction was the main technique used. Three cores show more than two platforms. In addition, 4.3% (n=18) cores show technological traits that suggest their exploitation involved bipolar percussion. Bipolar percussion has been documented in other contemporaneous settlements like Mienakker



Technical Information

▲ Bulb of percussion present

Bulb of percussion absent but direction of percussion clear

Surface

Burnt

Cortex

Figure 5.2 Selection of several flint implements: a.13114-1: blade; b. 15022-23: scraper; c.15022-1: blade; d. 14362-1: core; e.23342-4: core; f.23971-5: core; g.23983-3: core. (scale 1:1)

and Keinsmerbrug. This technique is mainly linked with the exploitation of small, low-quality flint pebbles. At some domestic sites, like Mienakker, the use of this technique is also related to the production of specific tools, such as borers.[176] Finally, 15 finished cores were modified after use. Eleven cores were retouched and four were converted into scrapers taking advantage of their convex shape.

The use of pebbles as cores is a common phenomenon at Late Neolithic settlements.[177] At Zeewijk, 81 pebbles have been documented. Around half the pebbles (n=40) are complete while the rest were used to produce flakes. Even though unidirectional hard percussion was the more frequently employed technique, at least one of the pebbles (13083-33) shows traits of bipolar flaking. The dimensions of the complete pebbles vary between 1.2 to 58 mm in length, 0.9 to 46 mm wide and 0.2 to 31 mm thick.

Finally, along with the pebbles and the cores, 41 flint blocks were also found at the site.

176 Peeters 2001b; García-Díaz in press.
177 Peeters 2001b; García-Díaz 2012, 2013.

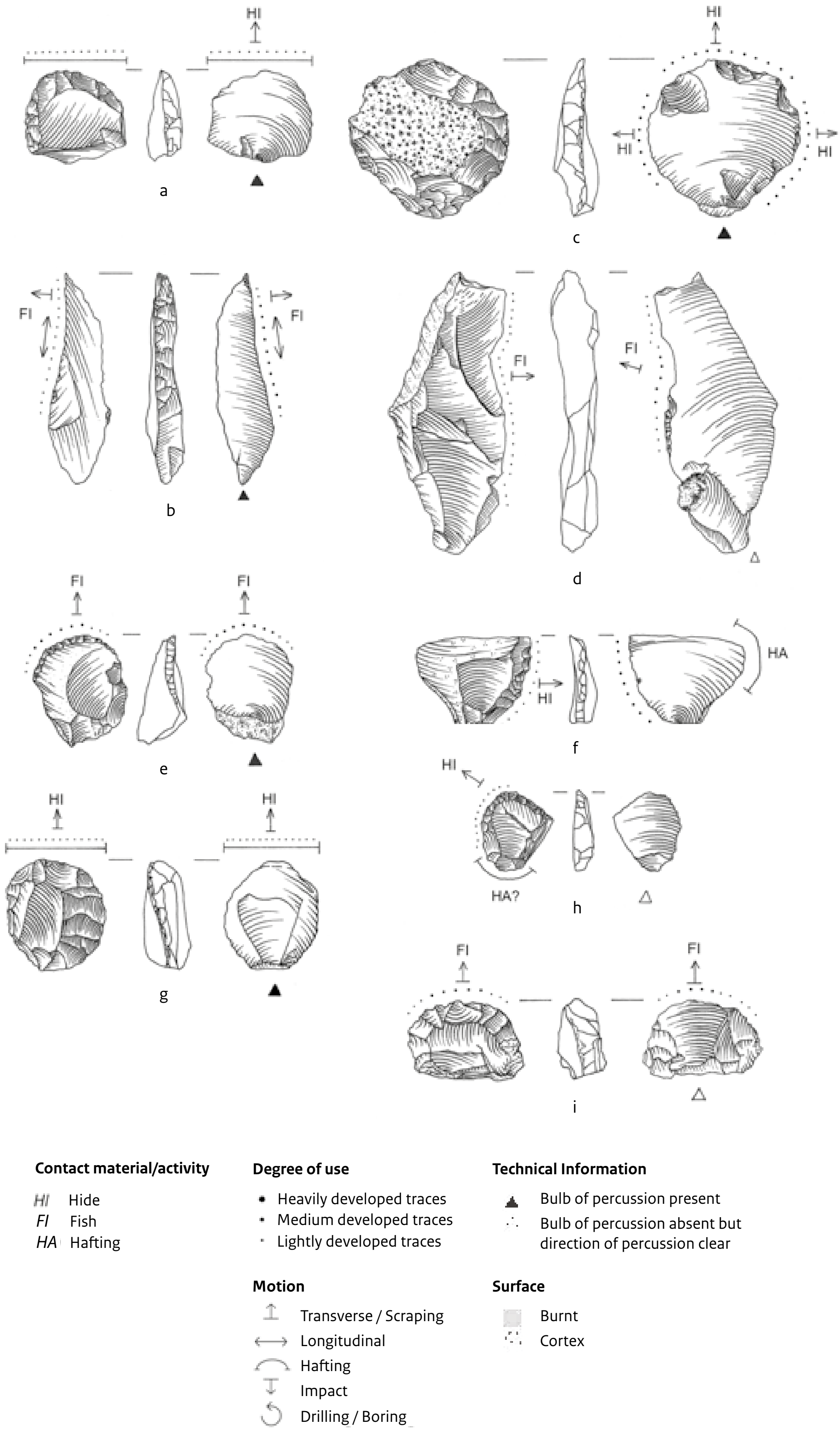


Figure 5.3 Selection of flint artefacts showing use-wear traces related to animal processing: a.22-1:scraper; b. 24241-4: retouched blade; c. 13061-10: scraper; d.13062-3: flake; e.13062-4: scraper; f.13721-6: scraper; g.14372-11: scraper; h.15022-21: scraper; i.15032-2: scraper. (scale 1:1)

5.3.2.4 Waste and splinters

Unmodified waste and splinters are the more frequently represented type (58%) within the Zeewijk assemblage. However, some of the fragments were retouched and used as tools (Table 5.8). Production waste was used to produce six borers. Three of them still preserve cortex on their surface and two of them show a glossy patina. However, none of the borers show traces of burning. The artefacts have an elongated and rounded tip that suggests they were used as borers. The dimensions of the borers are small and vary from 1.8 to 34 mm in length, 0.9 to 14 mm wide and 0.5 to 5 mm thick.

In addition, waste fragments were retouched and transformed into scrapers in 24 cases. Two of the scrapers (15022-23 and 25251-22) are double, while 12 are short-ended scrapers, four long-ended scrapers and three have been classified as side scrapers. Finally, five scrapers could not be typologically classified due to surface alterations or breakages. Half of the scrapers show cortex. The preservation of the surface is not very good as at least 14 have some degree of patination. However, just one scraper shows traces of a prolonged contact with fire. Finally, 33 flint fragments and four splinters were retouched on one of their edges.

Table 5.8 Overview of the type of waste and splinters documented at Zeewijk.

Waste and splinters	Number	%
Unmodified	6154	99.0
Borer	6	0.1
Scraper	24	0.4
Retouched	37	0.6
Total	**6221**	**100**

Others

Some of the flint remains show a high degree of post-depositional alteration such as patina or burning traits, making typological classification impossible. This is the case with 563 artefacts that have been classified under the category 'type unsure'. Most of them (n=490) are poorly preserved and the technological traits and even the raw material are difficult or impossible to recognise. However, 30 of them could have been part of a scraper and 36 show possible retouch.

5.3.3 Use-wear analysis

During the classification of the artefacts, 596 were considered suitable for use-wear analysis. The selection was performed by observing the pieces under a stereoscopic microscope at low magnifications or with the naked eye. The selection of tools was based on the presence of the following parameters:

a. rounding;
b. edge damage;
c. the presence of retouch;
d. a suitable edge for use, like a point or regular cutting edge or;
e. visible polish.

As this number was too large to examine microscopically a further selection was made. This selection was performed randomly, selecting a standard percentage for every tool type described (Table 5.10). From this sample,

Table 5.9 Overview of the tool types with possible use wear documented.

Primary classification	Unmodified	Retouched general	Scraper	Point	Borer	Axe	Core preparation	Core rejuvenation	Type unknown	Total
Flake	172	69	103	2	2	-	3	-	-	351
Blade	37	12	-	-	-	-	-	2	-	51
Core	11	11	3	-	-	-	-	-	-	25
Waste/splinter	54	23	18	-	6	1	-	-	-	102
Unsure	-	25	24	-	6	-	-	-	12	67
Total	**274**	**140**	**148**	**2**	**14**	**1**	**3**	**2**	**12**	**596**
Percentage	**46.0**	**23.5**	**24.8**	**0.3**	**2.3**	**0.2**	**0.5**	**0.3**	**2**	**100**

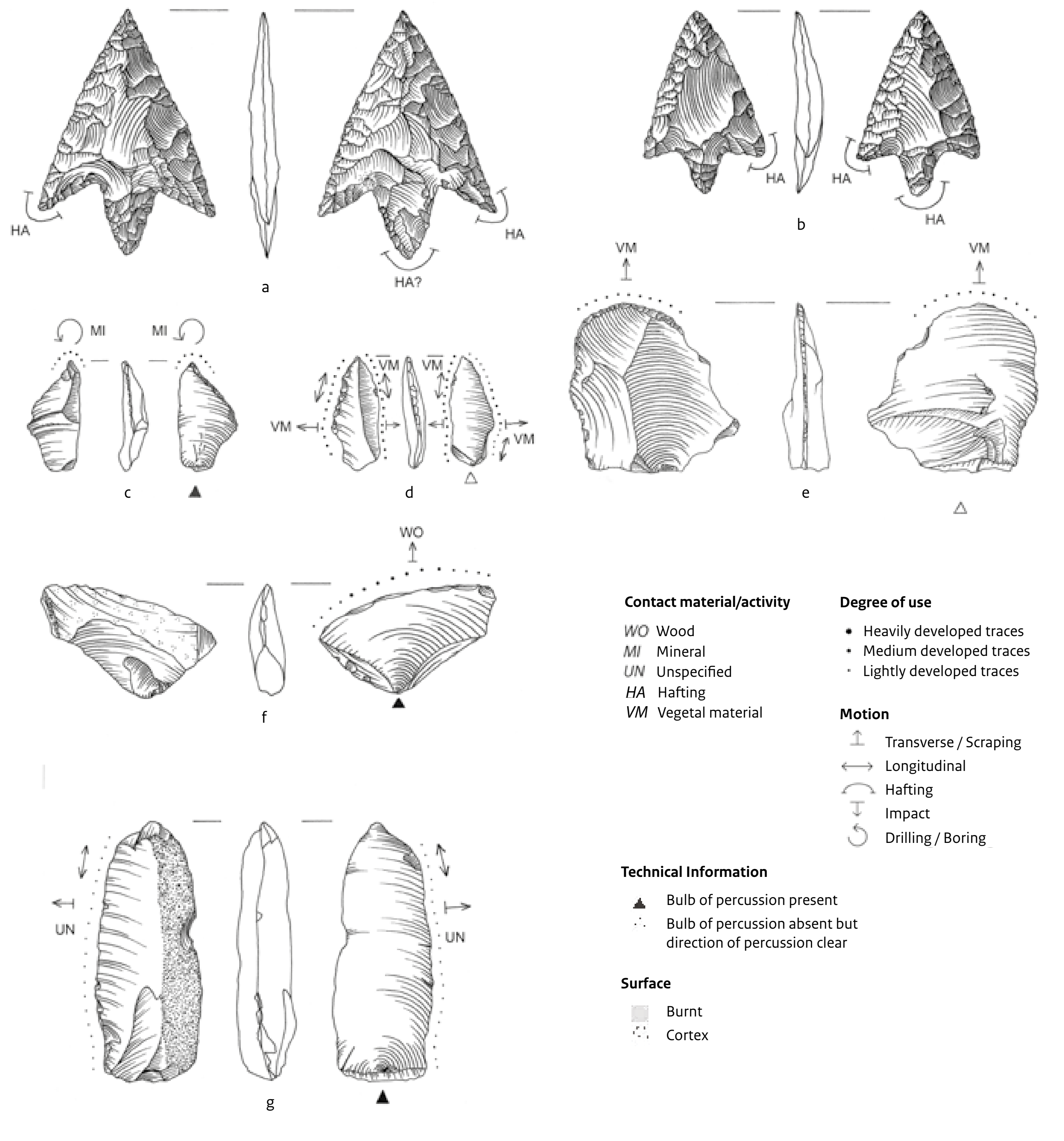


Figure 5.4 Selection of flint artefacts showing use-wear traces related to the working of different materials: a.7188-1: arrowhead; b. 27821-82: arrowhead; c.13083-30: borer; d.13091-7: retouched flake; e.13721-42: retouched flake; f. 13083-1: flake; g. 30951-1: blade. (scale 1:1)

Table 5.10 Overview of the tool types on which use-wear analysis was performed.

Tool type		Traces	No traces	No interpretation	Total
Blade	unmodified	7	8	8	23
Blade	retouched general	3	-	1	4
Core	blade core	-	1	-	1
Core	flake core	-	2	-	2
Core	scraper	1	-	-	1
Flake	unmodified	9	18	3	30
Flake	point	2	-	-	2
Flake	retouched general	9	2	2	13
Flake	scraper	19	1	7	27
Waste	unmodified	5	10	1	16
Waste	retouched general	3	1	2	6
Pebble	waste	-	1	-	1
Waste	scraper	2	-	2	4
Waste	borer	1	1	-	2
Unspecified	unmodified	-	-	2	2
Unspecified	borer	1	-	-	1
Unspecified	retouched general	-	-	1	1
Unspecified	scraper	2	-	1	3
Unspecified	retouched general/axe	1	-	-	1
Total		**65**	**45**	**30**	**140**
Percentage		**46**	**32**	**21**	**100**

23% of the implements (n=140) were selected for use-wear analysis. The selection included different tool types (Table 5.9). After the analysis of the artefacts, 45 tools (28%) did not show use-wear traces and 89 edges of 116 tools showed use-wear traces. Finally, 30 edges of 34 tools were not interpretable.[178]

5.3.3.1 Animal material

Use-wear traces from contact with animal material are the most frequently represented in the assemblage. Around 63% of the edges show use-wear traces related to working hide (n=37), bone (n=1), meat and bone (n=1), fish (n=7) or unspecified animal resources (n=10) (Table 5.11).

Hide

A total of 31 tools, mostly scrapers and retouched tools, have been used to scrape hide (Table 5.12). The used edges usually have an obtuse angle, higher than 40 degrees. In one case (13061-10), a scraper has three used areas, while in three other cases (15023-2, 15014-19 and 13073-13) the scrapers had two used areas (Fig. 5.5).

Bone

One edge of an unmodified flake (14332-1) was used to work bone. The flake is complete and the right edge of the tool, with an angle of 40 degrees, was used to scrape bone. The surface of the tool has been altered by post-depositional processes and it is difficult to determine if bone was the only material worked or whether the traces are the result of butchering. The use wear is mostly developed on the dorsal face of the tool. A thin line of polish is visible, mostly on the higher areas of the surface micro-topography.

Butchering

One edge of an unmodified flake (13081-5) displays use wear related to different animal materials. Isolated points of a hard animal polish are developed on the areas close to the edge

[178] The following figures refer to the number of used edges and not to the number of tools employed.

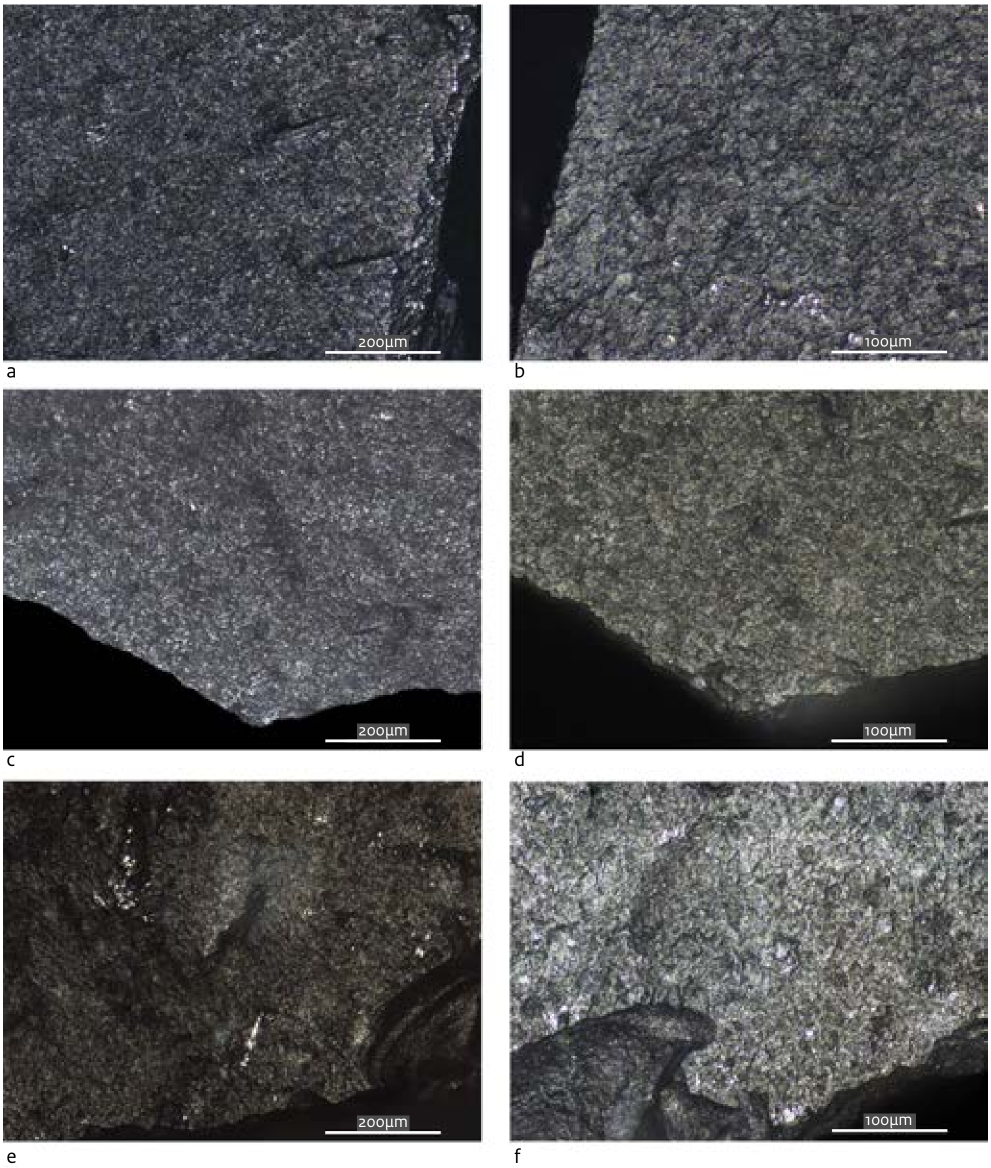


Figure 5.5 Hide scraping was the most commonly represented activity at the settlement. Hide scraping was mostly performed using scrapers. Images a-f: use-wear traces related to processing hide documented on three scrapers: a. (100x) and b. (200x) (13061-10), c. (100x) and d. (200x) and e. (100x) (13721-6) and f. (200x)(22-1).

with higher topography. Meanwhile, polish resembling experimental polish from working a softer animal material, such as meat, is present on the inner parts of the edge. This well-developed use wear has a longitudinal motion. The combination and distribution of the use wear suggest the tool was used for butchering (Table 5.11).

Fish

Use wear related to fish processing has not been well documented by researchers and has only occasionally been the subject of investigation. However, the issue of fish use wear has been discussed and documented in several publications.[179] In the Netherlands, fish polish has been recognised in Mesolithic[180] and Neolithic contexts,[181] but always in very small numbers. In the case of the Single Grave Culture, Zeewijk is the first site showing use-wear traces related to fish processing. Keinsmerbrug and Mienakker[182] did not yield any tools with use wear suggesting fish processing. At Zeewijk, however, seven edges show use wear related to

179 Semenov 1982 [1957]; Anderson 1981; Moss 1983; Plisson 1985; Van Gijn 1986, 1989; Gutiérrez Sáez 1990; Clemente 1997; Iovino 2002; Briels 2004; Clemente Conte & García-Díaz 2008; García-Díaz & Clemente Conte 2008; García-Díaz 2009.
180 Niekus *et al.* 2014.
181 Van Woerdekom 2011.
182 García-Díaz 2012, 2013.

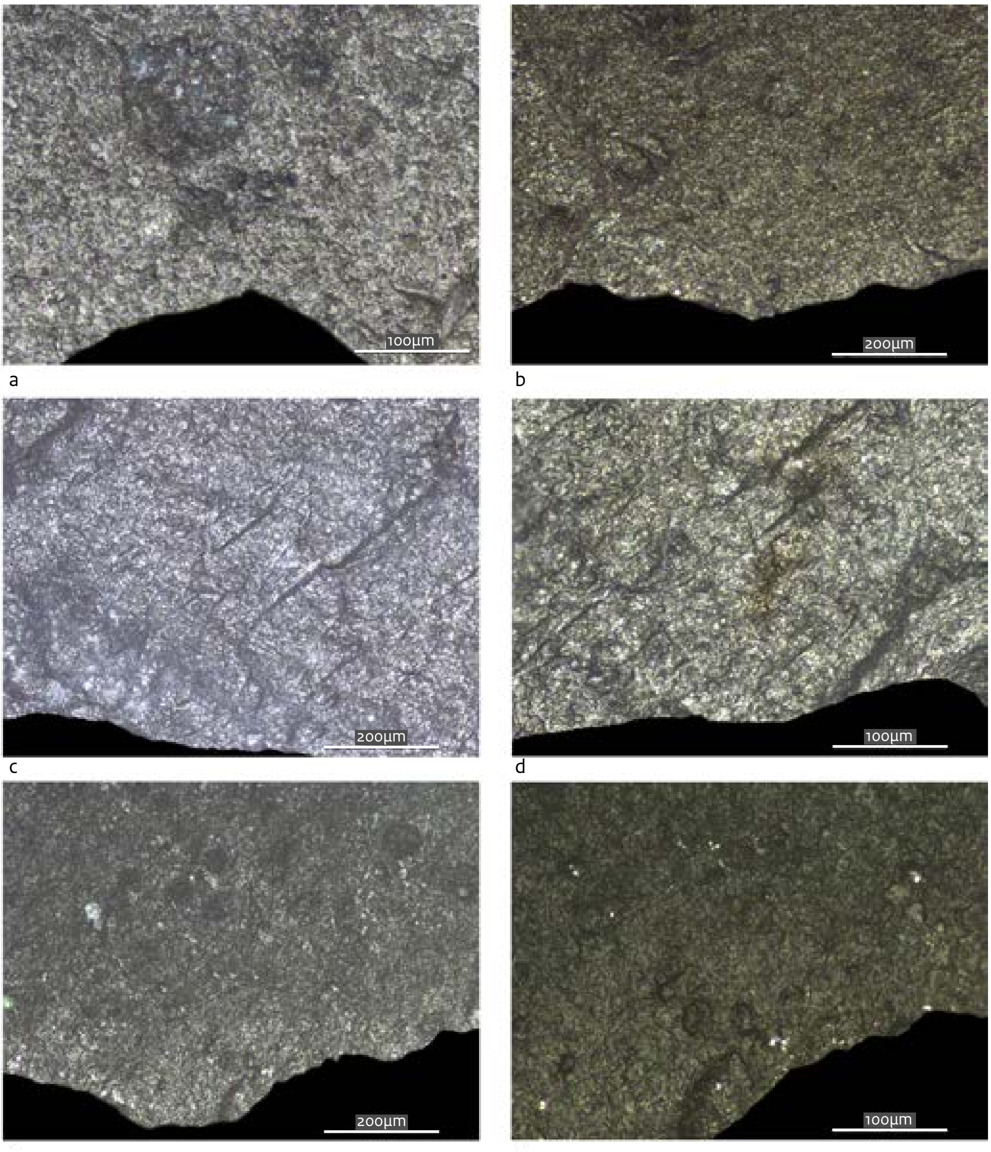


Figure 5.6 Fish processing was documented on seven edges during the analysis of the Zeewijk flint implements. Zeewijk is the first Single Grave culture context were fish processing has been documented through use-wear analysis. The polish developed on these tools has a rough and greasy aspect and it is extremely invasive. Images a-f: use-wear traces related to fish processing, probably scaling, in a. (200x) and b. (100x): one blade (24241-4); c. (200x) and d. (100x), one scraper (13062-4); e. (100x) and f. (200x) one unmodified flake (13062-3).

this work (Table 5.11, 5.12)(Fig. 5.6). Two edges show a longitudinal motion, and in five cases the use wear developed suggests use of the tools for scraping scales and fish skin. During the scaling process the active edge of the tool has to be cleaned on a regular basis. In fact, ethnographic observations in Mali show that this work was sometimes performed in or close to the waters of the Niger river to prevent the edges from blunting.[183] The scales remaining on the edges protect the edge from being polished by use. Besides polish, edge damage evenly distributed along the edge and extensive edge rounding are also visible.

Finally, one tool (15032-2) displays isolated spots of polish caused by a harder material, probably bone, in addition to the traces from fish. The distribution of the use wear and the edge damage suggest that the tool was probably also used to clean fish.

183 Clemente Conte, personal observation.

Unspecified animal resources
Ten edges were used to work unspecified animal resources (Table 5.11, 5.12). Two scrapers (15033-14 and 15021-14) display three used areas. The edges were used to scrape a medium-soft animal material. In addition, one of the scrapers (15033-14) displays use-wear traces suggesting work with a harder material. However, post-depositional alterations prevent a more detailed interpretation.

One retouched flake (13064-1) shows use wear on two edges, from contact with both a medium-soft and an abrasive animal material. One edge displays isolated spots of polish from contact with a harder animal material worked with both a transversal and a longitudinal motion. The other edge shows polish from an abrasive material worked with a longitudinal motion. However, in both cases the polish is not well developed and the worked material could not be determined.

Finally, one retouched blade (13083-22) and one retouched fragment (14392-14) display one used edge. The blade shows a slightly developed polish from contact with an unspecified material. The edge was used in a transversal motion. The used edge was rounded and scarred by edge damage. The retouched fragment has an altered surface due to burning. Use wear shows a transversal motion and poorly developed use-wear traces. As a result, the material could not be identified. However, the distribution of the polish inside the retouch suggests that the edge was used to work a soft to medium-hard animal material.

5.3.3.2 Plant material

Wood
Three tools were used to work wood (Table 5.12). Both used edges of the blade (13091-16) show a very well developed polish, mostly in the medial part of the edges. The polish is well defined and has developed mostly on the ventral face. The polish is slightly invasive and shows a combination of transversal and longitudinal motion. The distribution of the use wear suggests that the tool was used to work a medium-hard wood.

The unmodified flake (13083-1) shows use-wear traces related to scraping a medium-hard wood. The angle of the used edge is 45 degrees. The polish has developed mostly on the distal part of the edge and shows a clear transversal motion. The polish is very well developed even though it has been slightly altered by a glossy patina.

Finally, the retouched flake (13721-42) displays use-wear traces related to scraping a medium-hard wood. The used edge has an angle of 55 degrees. Both faces of the used edge show well-developed use-wear traces. However, on the dorsal face the polish has developed mostly on the higher areas of the retouch, while on the ventral edge the polish is concentrated along the edge (Fig. 5.7).

Unspecified plant material
Three edges are related to the processing of an undetermined plant material. One retouched flake (13091-7) displays two edges with use wear similar to that observed after working a medium-hard plant material. Both edges show a very bright polish, possibly caused by contact with a mineral material. The polish is well developed along the edges and inside the retouch. One of the used edges has an angle of 50 degrees while the other edge displays an angle of 40 degrees. The use wear on both edges suggests a clear combination of longitudinal and transversal motion.

Finally, one retouched flint fragment (13053-13) displays use-wear traces related to an undetermined medium-soft vegetal material. The motion related to the work is clearly transversal. The retouched flint fragment has another edge used to scrape hide.

5.3.3.3 Inorganic material

Amber
The precise contact material could be inferred for one borer (13083-30) (Fig. 5.7). The use wear documented on the borer is characterised by a rounding of the tip and the development of a bright polish. The polish has developed mostly on the very tip and the lateral edges of the borer, and is not well delimited. This type of polish strongly resembles the polish obtained experimentally from drilling amber.[184] Similar borers have been found at other contemporaneous sites[185] and their actual role in amber bead production has been demonstrated at the domestic site of Mienakker.[186] Numerous amber beads have been found at Zeewijk, along with a substantial quantity of manufacturing

[184] García-Díaz 2013.
[185] Peeters 2001a,b; Piena & Drenth 2001; Bulten 2001; García-Díaz 2012, 2013.
[186] García-Díaz 2013.

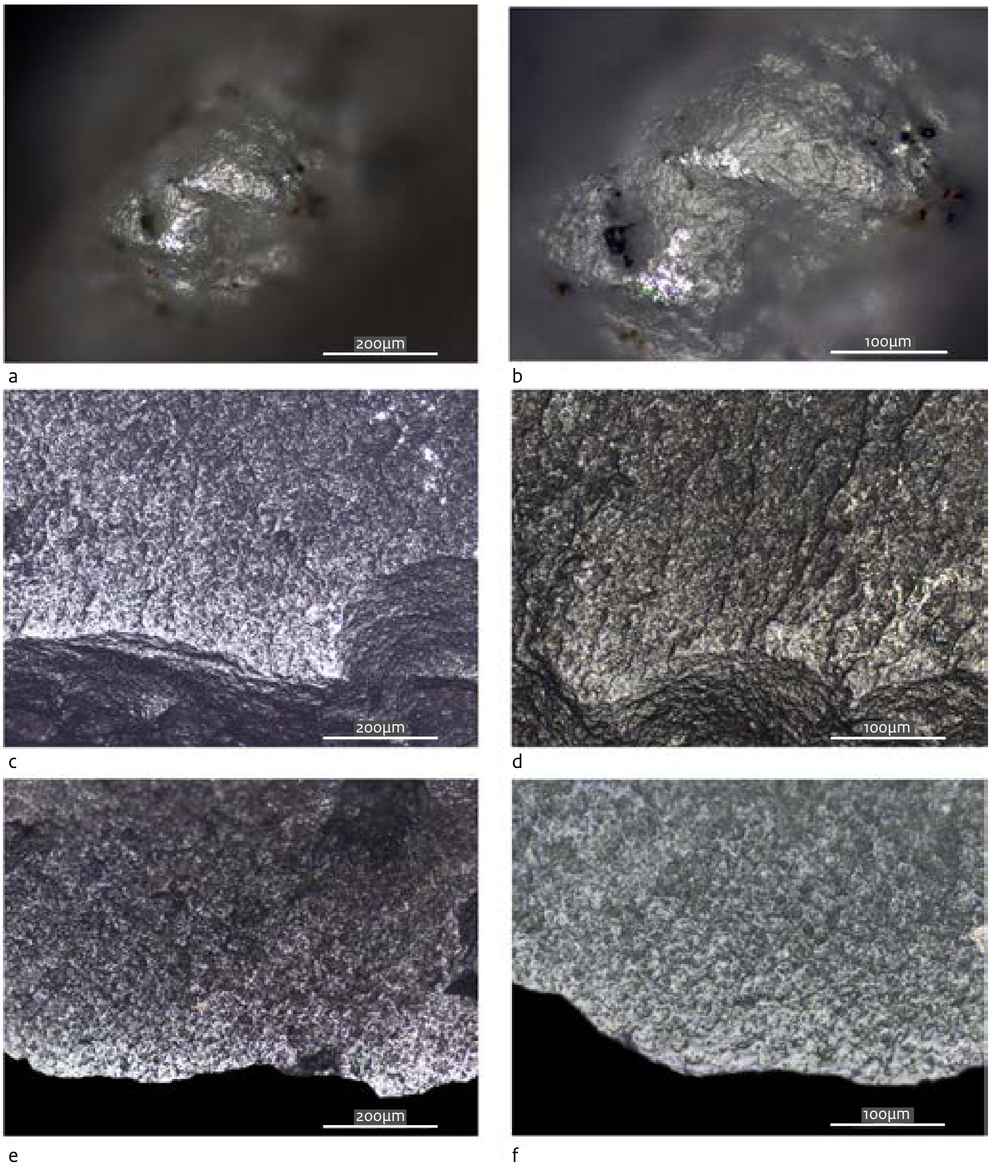


Figure 5.7 Amber beads were probably produced at the site, as suggested by the use-wear traces documented on one flint borer (13083-30), a. (100x) and b. (200x). Wood and other unspecific plant resources were also worked with flint artefacts, probably to produce other implements like wooden tools, clothes and weapons. The image shows use-wear traces related to scraping wood observed in an unmodified flake (13083-1), c. (100x) and d. (200x), and a retouched flake (13721-42), e. (100x) and f. (200x).

waste. The presence of the borer provides further proof of the local production of the beads at the site, as at Mienakker. The borer is small (17 mm x 10 mm x 4 mm) and displays one rounded edge with a very well-developed polish.

Undetermined inorganic material

One blade (23453-2) and one waste fragment (13052-1) display use-wear traces related to an undetermined mineral material. The blade displays isolated points of polish from a medium-hard material without a clear motion. The polish has developed near the edge. However, the waste fragment shows a very well developed polish on one edge. The use wear present suggests that the tool was used in both a longitudinal and a transversal motion. What activity the tool was involved in is difficult to ascertain, as a range of materials produce wear traces of a type usually described as 'mineral

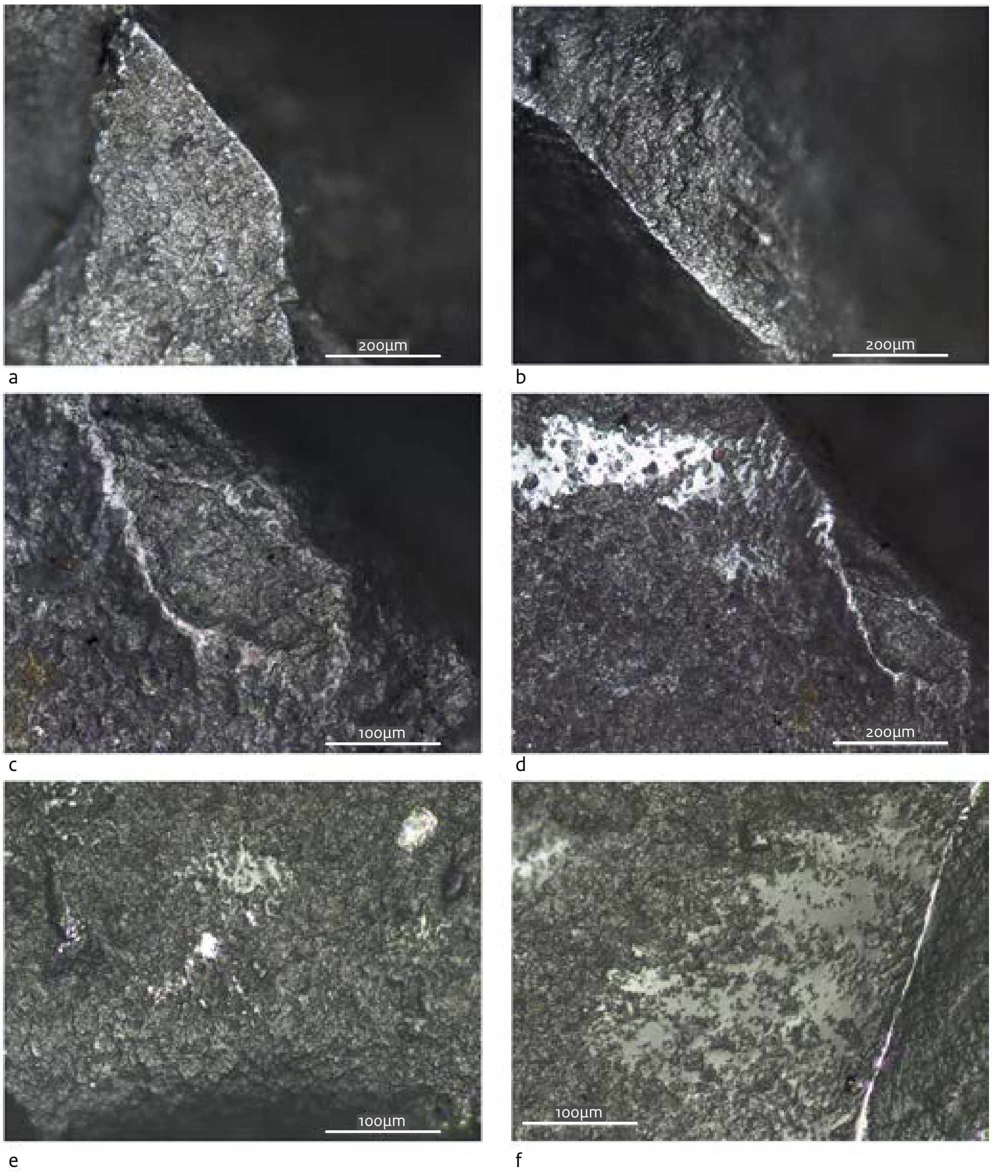


Figure 5.8 Hafting traces were documented on seven tools: a. (100x), b. (200x), c. (100x) and d. (200x). Two of the implements displaying hafting traces were the 'pine tree'-shaped arrowheads (7188-1a and 27821-82). Even though no clear traces of use were documented during analysis, hafting traces were documented on the barbs and the tag of the arrowheads. In addition, other tools, such as flakes and scrapers, were also hafted and used. Images e. (100x)-f. (200x) show hafting traces documented on a scraper (13721-6).

polish'. Mineral materials like amber or jet were commonly used to produce ornaments or pendants. In addition, minerals like ochre were also used for some domestic activities, like processing hide. Finally, flint tools were sometimes used to produce and decorate pottery. The sample of implements used to process inorganic materials suggests that mineral materials were an important and useful resource for the Single Grave communities.

Hafting traces

Finally, seven tools display traces of hafting (Table 5.11). One blade (13722-4) displays use wear on the left lateral edge. On the dorsal face of the edge, isolated points of mineral-like polish are visible inside the edge damage. The use-wear traces are similar to those described by other authors and interpreted as hafting traces.[187] The polish is also well developed on the ventral face of the edge is not very invasive, and

[187] Rots & Vermeersch 2004; Rots 2008.

Table 5.11 Flint use wear: tool type versus motion.

Tool type (edges)	Motion										Total
	boring/piercing	shooting	hafting/ haftuns	longitudinal/ sawing	longitudinal/ unspecific	transversal/ longitudinal	transversal/ scraping	transversal/ unspecific	unsure	not interpretable	
Blade unmodified	-	-	1	-	1	4	2	-	1	1	10
Borer	2	-	-	-	-	-	-	-	-	-	2
Flake unmodified	-	-	-	1	-	-	6	-	2	1	10
Point indet.	-	1	1	-	-	-	-	-	-	-	2
Retouch general axe rejuvenation	-	-		-	-	-	-	1	-	-	1
Retouch general blade	-	-	1	-	-	1	1	-	-	1	4
Retouch general flake	-	-	1	-	1	3	7	-	-	1	13
Retouch general waste	-	-	-	-	-	-	4	-	-	-	4
Scraper long end	-	-	-	-	-	-	4	1	-	-	5
Scraper short end	-	-	-	-	-	-	14	1	1	-	16
Scraper side	-	-	1	-	-	-	10	-	-	-	11
Scraper type unknown	-	-	1	-	-	-	3	-	-	-	4
Waste	-	-	1	-	-	1	3	-	2	-	7
Total	**2**	**1**	**7**	**1**	**2**	**9**	**54**	**3**	**6**	**4**	**89**

Table 5.12 Flint use wear: tool type versus contact material.

Primary classification	Tool type	Contact material								
		Bone	Fish	Dry hide	Hide unspecified	Meat/ bone	Medium animal unspecified	Amber	Hard anorganic unspecified	Medium anorganic unspecified
Blade	unmodified	-	1		2	-	-	-	-	1
Unspecific	borer	-	-	-	-	-	-	1	-	-
Flake	unmodified	1	2		3	1	-	-	-	-
Flake	point	-	-	-	-	-	-	-	-	-
Unspecific	retouched general/axe	-	-	-	-	-	-	-	-	-
Blade	retouched general	-	1	-	-	-	1	-	-	-
Flake	retouched general	-	-	-	6	-	2	-	-	-
Waste	retouched general	-	-	-	2	-	1	-	-	-
Core	scraper	-	-	-	1	-		-	-	-
Flake	scraper	-	3	-	17	-	6	-	1	-
Waste	scraper side	-	-	-	1	-	-	-	-	-
Unspecific	scraper	-	-	-	2	-	-	-	-	-
Waste	unmodified	-	-	1	2	-	-	-		-
Total		**1**	**7**	**1**	**36**	**1**	**10**	**1**	**1**	**1**

it has developed mostly near the edge. Two scrapers (13721-6 and 15022-21) display isolated points of polish from contact with a hard material, but there is no evidence of the motion employed. The polish has developed mostly close to the edge and is combined in both cases with a slight rounding of the edge. One of the arrowheads (27821-82) shows traces of hafting on the tang and one of the barbs, suggesting that the projectile point was hafted, covering the proximal part of the tool (Fig. 5.8 and 5.4). Arrowheads were hafted using tar or resin to a wooden haft. Unfortunately, no hafting residues were detected on the surface of the arrowhead.

5.3.3.4 Undetermined material

Eighteen edges display use-wear traces which could not be interpreted in terms of contact material (Table 5.11) (Table 5.12). In several cases the use wear is not developed enough to make a more detailed inference. In other cases, the tools show surface alterations that limit the interpretation of the use wear. One edge of a retouched axe fragment (27081-4) was used to scrape an undetermined soft material. Five edges show traces interpreted as the result of working medium-soft materials. In addition, two edges of a scraper (14334-2) display an abraded surface, which makes the analysis of the ventral face of the tool impossible. On the distal face, both edges show a polish with a clear transversal motion. The use-wear traces resemble those caused by working an abrasive material. However, the nature of the material has not been distinguished. Four edges show traces related to hard materials, but the motion employed could be inferred in only one case. One blade (30951-1) displays a polish related to an abrasive hard material. The polish is distributed along the edge and inside the piece. The motion is longitudinal, combined with traces of a transversal motion. However, the poor preservation of the surface, which is covered by a white patina, makes interpretation of the tool difficult. Finally, one arrowhead (7188-1) shows use-wear traces which could not be interpreted. The tips of the barbs and the tang display slight rounding. Unfortunately, the entire surface is abraded and it is not possible to determine if the rounding was produced by the use or the hafting of the arrowhead.

Primary classification	**Contact material**										**Total**
	Anorganic unspecified	**Medium plant unspecified**	**Hard wood**	**Wood unspecified**	**Unspecified**	**Unspecified friction gloss**	**Hard unspecified**	**Medium unspecified**	**Soft unspecified**	**Hide/wood**	
Blade	1	-	2	-	1	-	1	1	-	-	10
Unspecific	-	-	-	-	1	-	-	-	-	-	2
Flake	-	-	1	-	1	-	-	1	-	-	10
Flake	-	-	-	-	1	1		-	-	-	2
Unspecific	-	-	-	-	-	-	-	-	1	-	1
Blade	-	-	-	-	1	-	1	-	-	-	4
Flake	-	2	-	1	1	-	1	-	-	-	13
Waste	-	1	-	-	-	-	-	-	-	-	4
Core	-	-	-	-	-	-	-		-	-	1
Flake	1	-	-	-	1	-	-	-	-	2	31
Waste	-	-	-	-	-	-	-	1	-	-	2
Unspecific	-	-	-	-	-	-	-	-	-	-	2
Waste	1	-	-	-	-	-	1	2	-	-	7
Total	**3**	**3**	**3**	**1**	**7**	**1**	**4**	**5**	**1**	**2**	**89**

5.3.4 Initial conclusions concerning flint raw material, technology and use wear

The analysis of flint implements at Zeewijk provided useful and important information for a better understanding of the character of the site and the activities performed there. First, even though the variety of raw material is not as great as at other contemporaneous sites, such as Mienakker, southern flint is also present. The existence of five implements of flint with a southern provenance might suggest the existence of long-distance networks, as already suggested in the case of Mienakker, where different types of non-local flint, such as Grand-Pressigny, were recovered. However, as at Mienakker, local materials were probably more important for the production of implements. There is a distinction between the use of small nodules of flint and the exploitation of a better-quality flint. The reduction techniques chosen largely depend on the quality and physical characteristics of the raw material. Unidirectional and bipolar approaches were used in combination with *ad hoc* techniques. The typology of the artefacts found at Zeewijk is similar to that found at Mienakker and Keinsmerbrug. Flint knapping focused on flake production. However, incidental blades are also present. Similar again to Mienakker and Zeewijk, the number of retouched implements is low. Retouched flakes and blades, scrapers and borers constitute the majority of the retouched tool types, with the occasional retouched point.

Few artefacts display use-wear traces, but the results are significant. Both subsistence and craft activities are represented and the variety of activities performed at the site suggests prolonged use of the settlement. Hide scraping is the most frequently represented activity, mostly performed with scrapers and retouched tools. However, hide was also processed with non-retouched tools. Hide was a multifunctional resource, used to produce several daily products, as clothes, bags, ropes and hunting tools. However, hide could also be used to build canoes or houses. Although no boat remains have been found at Zeewijk, the documentation of a skin canoe at Mienakker[188] suggests the use of this type of vessel to fish, and also to travel. Even though scrapers have traditionally been linked to hide processing due to their angle, the use of other tools such as unretouched flint tools, stone pebbles or wooden and bone tools has been documented in both ethnographic and archaeological studies[189] in several contexts. Scrapers have been interpreted by some authors as a reflection of stability and long-term occupation. In the case of Zeewijk, the quantity of used scrapers, along with the other activities documented, suggests long-term occupation.

Amber bead production is suggested by the presence of several borers, one of them showing traces resembling experimental wear from drilling amber. Traces from contact with amber were also displayed on several borers at Mienakker.[190] After the analysis of Zeewijk and Mienakker, it seems plausible that amber ornaments were produced locally. In addition, local production of amber ornaments is also suggested by the presence of amber production waste. [191] Finally, even though evidence of plant processing is also present, traces of cereal harvesting are lacking. The absence of sickles is a common phenomenon in the wetlands.[192] The absence of flint sickles can probably be explained by the use of other implements, like wood or bone tools, as sickles. Unfortunately, such tools have not been recorded. In addition, ethnographic studies have also documented the harvesting of cereals without the use of sickles.[193] Cereal consumption has been indicated by palaeobotanical analysis, residue on vessels and by the use wear displayed on querns.[194] Subsistence activities documented in the Zeewijk flint assemblage include hunting, butchering and fish processing. Zeewijk is the first Single Grave site to have yielded use-wear traces related to fish processing. Even though the importance of fishing at Single Grave communities is evidenced by the large quantities of fish bones at domestic settlements,[195] the tools used to process fish are rarely found. Nor have any hooks, harpoons or fishing nets been found in connection with Single Grave settlements. However, these tools are known from other archaeological contexts in the Netherlands[196] and their use probably continued during the Single Grave period. In addition, remains of a canoe documented at Mienakker suggested the use of boats not only as a means of transport, but probably also for fishing.[197] As discussed previously, functional interpretations

188 Nobles 2013b.
189 Ibañez, Gonzáles & Moreno 2002; Sillitoe & Hardy 2003; García-Díaz 2013; Sharovskaya 2008; Beyries & Rots 2008.
190 García-Díaz 2013.
191 Bulten 2001a; Van Gijn, this volume.
192 Bakels & Van Gijn 2014.
193 Ibañez *et al*. 2000.
194 Smit *et al*. 2012a; Kleijne *et al*. 2013.
195 Zeiler & Brinkhuizen 2012, Zeiler & Brinkhuizen 2013.
196 Louwe Kooijmans 1974.
197 Nobles 2013b.

Table 5.13 Stone tool artefacts versus raw material.

Maine type	Volcanic					Sedimentary						Metamorphic				Quartz	Type un-known	Total	%
	granite	diorite	basalt	gabbro	unspecified	sandstone	quartzitic sandstone	loam	conglomerate	limestone	unspecified	amphibiolite	shale/slate	others	unspecified	quartz	indet.		
Flake	2	-	-	-	-	2	11	-	-	-	-	-	-	-	-	-	-	15	0.2
Quern *(mano)*	1	1	-	-	1	-	10	-	-	-	1	-	-	-	-	-	-	14	0.2
Quern *(metate)*	5	1	-	-	1	-	14	-	-	-	-	-	-	-	-	-	-	21	0.3
Rubbing stone	-	1	-	-		-	5	-	-	-	-	-	-	-	-	-	-	6	0.1
Flat stone	3	-	-	-		-	16	-	-	-	-	-	-	-	-	-	-	19	0.3
Adze	-	-	-	-		-	1	-	-	-	-	-	-	-	-	-	1	2	0
Hammer stone	2	3	-	-		-	13	-	-	-	-	-	-	-	1	1	1	21	0.3
Grinding stone	1	5	-	-		2	4	-	-	-	-	-	-	-	-	-	-	12	0.2
Polishing stone	-	-	-	-		-	1	-	-	-	-	-	-	-	-	-	-	1	0
Block	1	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	1	0
Unmodified (pebble)	35	1	-	-	1	22	197	-	-	-	2	7	-	-	-	391	-	656	8.7
Unmodified (broken)	3717	520	14	1	16	811	1154	-	15	2	10	11	9	1	-	257	30	6568	87
Unmodified (smooth surface)	48	19	1	-	3	17	114	1	1	-	2	-	1	-	-	2	2	211	2.8
Total	**3815**	**551**	**15**	**1**	**22**	**854**	**1540**	**1**	**16**	**2**	**15**	**18**	**10**	**1**	**1**	**651**	**34**	**7547**	**100**
Percentage	**50.5**	**7.3**	**0.2**	**0**	**0.3**	**11.3**	**20.4**	**0**	**0.2**	**0**	**0.2**	**0.2**	**0.1**	**0**	**0**	**8.6**	**0.5**	**100**	

related to fish processing have been ambiguous and limited until recently. Experimentation and the development of reference collections have provided information to recognise use wear related to fish processing in well-preserved assemblages. However, the lack of evidence could also be related to the use of several techniques to process fish that did not require regular use of flint tools, such as smoking or drying.[198] In addition, other tools could have been used to scale fish or remove their heads. Wooden or bone tools could be effective enough. Fishing was important not only for the diet of the Single Grave communities. Ethnographic documentation shows that fish skins can be used as waterproof material to produce clothes, shoes or containers.[199] In addition, fish vertebrae could be used to produce ornaments and beads.

5.4 Stone tools

A total of 7547 stone implements have been retrieved at Zeewijk. As previously mentioned, the preservation of the stones is not good. Around 95% of the implements are fragmented and broken, with a high level of surface alteration.

5.4.1 Raw material

Various raw materials are present in the stone assemblage from Zeewijk (Table 5.13). However, the most frequently occurring raw materials are volcanic rocks, more specifically granite. Other igneous rocks such as diorite and basalt occur in low numbers. The second group is the sedimentary rocks (32.1%), the majority of which

198 Stewart 1977; Rostlund 1952; Trigger 1969.
199 Newell *et al.* 1990.

are sandstone, though other kinds of sedimentary rock such as limestone and conglomerates have also been identified. In addition, quartz (8.6%) and metamorphic rocks (0.3%) are also present. Finally, 0.5% of the assemblage could not been identified due to the poor preservation of the surface.

Zeewijk is located in an area where stones are not available in close vicinity. The nearby beaches and the glacial till deposits at Wieringen, located at a distance of approximately 15 km, were the source of volcanic, metamorphic and sedimentary rocks[200] and quartz. Consequently, the stones were collected and transported to the settlement, as at Keinsmerbrug[201] and Mienakker.[202]

5.4.2 Stone typology and technology

The majority of the implements do not show any technological modifications. The stone implements have been categorised into ten groups (Table 5.13).

Flakes

A small number of stone flakes (n=15) were found at Zeewijk. Only five implements are complete. The dimensions of the complete flakes are small (Table 5.14). The majority of the flakes were made of sandstone (n=13), but two granite flakes have also been found at the site.

Axe fragments

Two fragments of polished axes have been retrieved. The first fragment (13111-5) is poorly preserved due to severe post-depositional alterations and burning, and the raw material could not be identified. However, the second fragment (27821-2) is from an axe made of fine-grained quartzitic sandstone. The axe fragment a polished surface and one rounded edge.

Blocks

One unmodified volcanic block has been found at Zeewijk. The block is altered due to burning and post-depositional alterations, such as abrasion. The presence of the block reinforces the idea of tool production at the site, as in the case of flint tools, and at other contemporaneous archaeological sites.

Grinding tools

Several grinding stones (0.19%; n=15) were encountered at Zeewijk. Nine were made of sedimentary rocks and six of volcanic rock. Only four of the implements are complete. The dimensions of the complete stones are documented in Table 5.12. Even though the majority of the implements display no traces of manufacture, four were flaked to obtain the desired shape or to revive the used surface. Similar patterns have been observed in the manufacture of the grinding tools, querns and other similar archaeological tools.[203]

Hammer stones

A small number of hammer stones (0.27%; n=21) have been found at the site. Sedimentary rock (62%; n=13) was the most frequently used raw material for hammer stones, but some were made of volcanic rock (23.8%; n=5), quartz (4.7%; n=1), metamorphic rock (4.7%; n=1) or undetermined material (4.7%; n=1). The hammer stones do not show any technological modification. The classification of the implements has been based on the presence of hammering and pounding traces on the surface. Even though most of the hammer stones show only one surface with pounding traces, several (n=5) display percussion traces on more than one surface. Only ten hammer stones are complete (Table 5.14).

Querns

Querns are easily recognisable because at least one of the faces shows a smooth, bright surface (Fig. 5.9). Two parts, the active part of the tool, or *mano*, and the passive part, or *metate*, compose the *querns*. Both parts of the tool were used together and the use-wear traces on the *mano* generally match those on the *metate*. Both *manos* (0.18%; n=14) and *metates* (0.23%; N=21) are represented in the assemblage.

The *manos* were made of sandstone (n=11) and volcanic rock (n=3). The level of fragmentation is high, with only five complete specimens present (Table 4.14). Three *manos* display technological traces on their surface in the form of flake negatives. However, the artefacts were probably selected on the basis of their natural morphology.

Metates were made of sedimentary (n=14) and volcanic (n=7) rocks. Only two implements (14344-9 and 14362-6) are complete (Table 4.14).

[200] Zandstra 1988; Houkes 2011.
[201] García-Díaz 2012.
[202] Peeters 2001b; García-Díaz in press.
[203] García-Díaz 2013.

Table 5.14 Metrical data on the stone implements.

Main type	Length (mm)			Width (mm)			Thickness (mm)			Complete (n)
	min.	max.	average	min.	max.	average	min.	max.	average	
Flake	17	38	25.4	10	35	18.2	2	7	4	5
Flaked stone	11	11	11	8	8	8	7	7	7	1
Quern (*mano*)	54	66	61.2	52	66	58.8	32	70	55.4	5
Quern (*metate*)	180	190	185	134	190	162	85	90	87.5	2
Grinding stone	46	121	80.8	44	96	67.5	31	36	33.8	4
Hammer stone	52	72	62.9	39	65	51.1	29	51	40.4	10
Rubbing stone	76	76	76	74	74	74	71	71	71	1
Unmodified (pebble)	3	27	10.2	2	20	7.5	2	13	5	199
Unmodified (smooth surface)	62	62	62	44	44	44	36	36	36	1
Polishing stone	46	46	46	26	26	26	9	9	9	1

Figure 5.9 Three metates recovered from Zeewijk displaying use-wear traces related to cereal processing.

Technological traces have been found on the surface of twelve implements. The artefacts were flaked to revive the surface, or to obtain the desired shape. Similar technological behaviour has been documented in the Netherlands in relation to several *metates* from different Neolithic contexts.[204]

Rubbing stones

Rubbing stones are characterised by a combination of hammering and grinding/polishing traces. The three rubbing stones found at Zeewijk have been considered as possible mortars due to their morphology and the disposition of the macroscopically visible traces. Two of the three implements, made of sandstone, are broken (Table 5.13). One of the broken implements (13683-4) displays flaking negatives on the surface related to manufacture. Finally, the third artefact was manufactured from diorite. No technological traces have been found. Mortars were probably selected on the basis of their natural form and only modified if the edge needed to be revived.

Flaked stones

Several stones (n=19) display flake negatives on the surface. Only one of the implements is complete (23224-1) (Table 5.14). The majority of the implements are fragments of sandstone, though three of the artefacts were made of granite.

Polishing stones

One implement (17552-6) has been classified as a polishing stone. This artefact displays an extremely rounded, flat surface. It is made of fine-grained quartzitic sandstone and it is complete (Table 5.14).

[204] Verbaas 2005; Verbaas & Van Gijn 2008; García-Díaz 2013.

Unmodified stones
Most of the stones (98.5%) found at Zeewijk do not show any technological modification of the surface. Three categories have been used to classify the unmodified stones: small pebbles (8.7%), broken stones (87%) and stones with a smooth surface (2.7%) suitable to have been used as a tool (Table 5.14).

5.4.3 Use wear

The selection of stone implements for use-wear analysis was based on the presence of several macro-traces. These included: a) a heavy edge rounding, b) a flat or polished surface, c) macroscopically visible striations, d) noticeable edge damage and e) the presence of pounding traces on the surface. A total of 69 tools were selected as suitable for use-wear analysis. Of these, a random sample of 53 (76.8%) were analysed. The selection comprised one axe, four flaked stones, two hammer stones, seven querns (two *manos* and five *metates*) and 39 unmodified stones (one broken and 38 with a smooth surface). Upon microscopic analysis, 21 tools display no use-wear traces, ten tools were classified as not interpretable and 22 tools show use-wear traces on 29 edges (Table 5.15).

5.4.3.1 Animal material

One unmodified stone with a smooth surface displays some polished areas on the dorsal surface along with a slight rounding of the edge. The polish is well developed. Its distribution suggests that it was produced by the contact with an abrasive material such as hide. The motion of the polish suggests the use of the implement to clean or process hide. Ethnographic studies have documented the use of stones to work hide.[205]

5.4.3.2 Resources

Use-wear traces related to resources have been documented on 26 edges, located on 20 tools. The worked material could not be identified in six cases. Traces from siliceous plants (n=19) were frequently seen and one edge was used to work wood.

Siliceous plants
Use wear related to cereals has been recorded on 19 surfaces of querns and unmodified stones (Table 5.15)(Fig. 5.10). Traces from milling cereals 'result *in a granular, domed polish that is spread over the surface in small linked spots*'.[206] The polish is usually concentrated on the higher parts of the surface. However, prolonged use of the tool could generate more extensive and linked development of the traces. The formation of the polish occurs firstly in the shape of small isolated spots of bright polish, which develop into more linked and compacted spots after sustained use.

Ten worked surfaces were documented on five *metates*. One *metate* (15022-1) shows traces of use on three surfaces because one of the lateral parts was also used to mill cereals. The distribution of the use wear suggests that the tool was used as a mortar, to grind and smash the cereal grains. Three *metates* (14983-1, 14344-6 and 14344-7) display two used surfaces. The surfaces show traces from contact with cereals, one related to the actual processing of the grains, the other surface constituting the bottom of the tools which came into contact with spilt cereals during the grinding process. In all three cases, the *metates* have been flaked to obtain the desired shape and to rejuvenate the edges and the surface of the implements. One *metate* (15034-6) shows a surface with use wear related to cereals. The polish is well developed on one face of the tool. Isolated points from contact with a harder material are also present on the opposite face of the implement; one interpretation is that the tool was used occasionally to process a harder material. Finally, one tool was interpreted as a *mano* (15223-1). The tool shows a highly reflective patina covering almost the entire surface. However, where the patina is not present, the tool displays a slightly developed cereal polish. The distribution of the polish indicates that the tool was used employing a transversal motion. The small size of the tool and the rounded shape suggest its use as a *mano*.

Eight unmodified stones show use wear interpreted as being from working cereals. The eight stones are fragmented and they are made of diorite (n=1) and sandstone (n=7). The stones were probably part of querns. The milling tools were probably discarded after fragmentation.

[205] Ibañez, González & Moreno 2002.
[206] Verbaas & Van Gijn 2008, 194.

Table 5.15 Stone use-wear: artefact type versus contact material.

Artefact type	Contact material					
	plant			animal	unspecified	total
	wood	cereals	unspecified	hide		
Grinding stone	-	-	-	-	0	0
Hammer stone	-	-	-	-	1	1
Quern	1	11	-	-	-	11
Flake	-	-	-	-	-	-
Unmodified stone	-	8	6	1	1	16
Total	**1**	**19**	**6**	**1**	**2**	**29**
Percantage	**4**	**66**	**21**	**4**	**7**	**100**

Wood
One *mano* (14993-1) displays use-wear traces possibly related to processing wood (Fig. 5.10). Isolated points of bright polish, probably from contact with hard wood, are present and the surface is heavily rounded. The distribution of the use wear and the morphology of the used surface suggest a transverse motion. The tool has been flaked to obtain a rounded shape. The use wear suggests that the *mano* should be regarded as a rubbing stone. Wooden tools accounted for a large proportion of the implements used by prehistoric communities. Unfortunately, such implements have been preserved in only a few exceptional contexts. Bowls, spoons, digging sticks, sickles, spears and tool hafts have been recorded in Neolithic archaeological contexts where wood has partially survived.[207] In addition, wood was used to build houses and other structures.

Unspecified plant material
Several surfaces, all on unmodified stones, display traces related to working unspecified plant material (Table 5.15). In three cases, the stones display traces related to working a medium-hard resource. Use-wear on two of the stones suggests a motion, whereas the third tool showed no indications of the motion employed. However, the surface of these tools was heavily affected by fire and post-depositional alterations, making detailed inferences impossible.

One surface of an unmodified stone (13741-2) displays traces related to processing a hard material. The use wear is related to possible percussion traces located on two edges of the implement. However, these traces are not well developed, and it is not possible to determine if they are a result of the use of the tool. Finally, one unmodified stone displays traces of processing an undetermined resource (Fig. 5.10).

5.4.3.3 Unspecified resources

Two tools, one hammerstone (18183-1) and one unmodified stone (13741-2), show traces related to pounding and hammering an undetermined material. In both cases the use wear is not developed enough and the material worked could not been interpreted.

5.4.4 Conclusions concerning stone raw material, technology and use wear

The most frequently occurring type of rock at Zeewijk is volcanic (58.3%), followed by sedimentary (32.1%) and quartz (8.6%). Zeewijk is located in an area where stones are not available. The coast and the glacial till deposits of Wieringen constitute the provenience area of the volcanic rocks, sandstone and quartz. The geological resources in the vicinity would naturally influence the technical choices of the group.[208] However, within the natural limitations, the people at Zeewijk selected the more appropriate raw material available. Some authors have argued that the selection of the raw material would have considerable implications not only for the production, but also for the productivity of the tools.[209] Volcanic and sedimentary rocks were selected to produce

207 Bosch i Lloret, Chinchilla i Sánchez & Tarrús i Galter 2006, 2011.
208 Adams 1988, 1999; Delgado Raack, Gómez Gras & Risch 2008.
209 Andrefsky 1994; Adams 1999, 2002; Delgado Raack, Gómez Gras & Risch 2008.

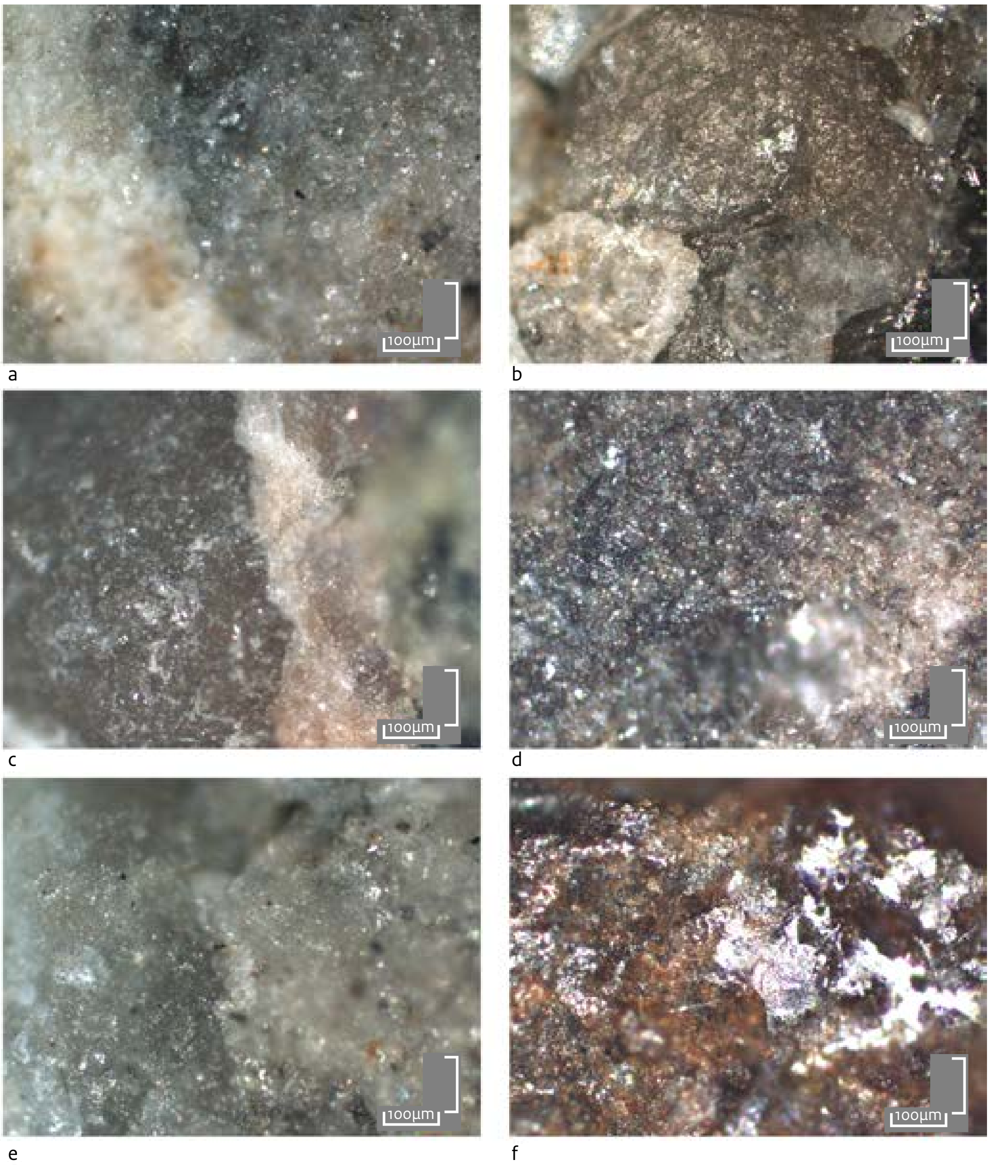


Figure 5.10 Use-wear traces related to querns and grinding stones. Processing of cereals and plant resources were the most commonly represented activities at Zeewijk. Images a-d (100x): use-wear traces related to cereal processing on three querns, a. (14983-1), b. (14361-1), c. and d. (15223-1). In addition, other plant resources were also processed with stones. Images e. (100x)-f. (200x): use-wear traces documented on an unmodified stone (14333-4) related to an undetermined plant resource and traces indicating wood processing on a *mano* (14993-1).

grinding and milling stones. However, sandstone pebbles were mostly selected for its use as hammer stones.

The majority of the stones were not modified. In most cases the implements were used taking advantage of their natural shape. However, grinding stones and querns show technological traces. Modification of tools related to milling and grinding has also been observed at the two contemporaneous sites Keinsmerbrug and Mienakker.[210] In addition, flakes interpreted as quern fragments have been found in the contemporaneous Single Grave settlement of Kolhorn, even though no evidence of flaking on the *metates* has been documented.[211]

Querns and grinding stones are the most frequently occurring tool types at the site. Use-wear analysis has shown that, with one

[210] García-Díaz 2012, García-Díaz in press.
[211] Drenth & Kars 1990.

exception, these tools were exclusively used to process plant materials, especially cereals. The importance of stones for processing vegetal resources has also been demonstrated at Mienakker, where more than 30% of the used implements were related to plant processing.[212]

The study of stone tools suggests these materials played a very important role in the economic practices of the Single Grave communities. First, specific choices were made from the range of stone types available. Hammer stones were mainly made of sedimentary rock, which has better petrographical characteristics for percussion activities, while volcanic rock and sandstone were selected for grinding and milling activities. Stone implements reflect the importance of subsistence activities at the site and the growing importance of cereals in the diet of Single Grave communities. Prehistoric communities also used stones for a range of subsistence activities that have not been documented at Zeewijk. Hammer stones could be used to crack the shells of some editable fruits or nuts, or of shellfish. In addition, stone pebbles were used to cook and to boil water. Craft activities are also represented in the stone assemblage. The use wear displayed by one *mano* suggests that stones were used to produce or repair wooden objects. In addition, hide could be worked with stone implements. The effectiveness of stone implements for processing hide has been documented in several ethnographic sources.[213] Stone played a major role in flint tool production and bones were fragmented with hammer stones to extract the marrow. The bone fragments could provide the blanks for bone tool production. And finally, pottery was tempered with several types of stone, such as quartz and granite, which could have been fragmented with hammer stones.

5.5 Bone tools and ornaments

Bone implements played an important role in the economic system of the prehistoric communities. Ethnographic and anthropological research suggests that bone tools could have been used for several activities such as hide scraping or fishing.[214] Bone could have been used as blanks for the production of daily tools, such as spoons, needles and awls. Finally, bone and teeth were also used to produce personal ornaments. However, the poor preservation of the organic materials has limited the archaeological interpretation of the bone implements. In the Netherlands, bone tools have been documented in several Mesolithic and Neolithic contexts.[215] The Single Grave settlements are no exception. Bones artefacts and ornaments have been documented at several settlements in the wetland areas.[216] However, even though some archaeozoological studies have been performed for this period,[217] the bones tools have not been systematically studied. Recently, a small sample of bone tools documented at the archaeological site of Mienakker was studied.[218]

5.5.1 Selection and methods

A sample of 11 bone implements was selected for use-wear analysis after the archaeo-zoological study. Even though functional studies of flint have been common in a European context since the 1980s, functional analysis of bone is a recent methodology. Although initial attempts were made during the 1980s[219], the high-power analysis of use wear on bone tools was developed mainly during the late 1990s and the early 21st century.[220] The methodology applied to bones is similar to that used for flint artefacts. First, implements are identified with the naked eye. Second, they are analysed at low magnifications (up to 100x) under a stereo-microscope. Finally, the materials are analysed at higher magnifications (up to 200x) under a binocular microscope. The reference collection of the Laboratory for Artefact Studies at Leiden University was used as a basis for the functional inferences. The tools from Zeewijk display an unequal degree of preservation. Some tools are not well preserved, showing several post-depositional alterations such as heavy rounding, abrasion of the surface and recent fractures. However, others have a well-preserved surface. The enigmatic bone tools with the undulating side, defined as 'ripples' or *bobbelkammen*, have a shiny surface. These implements are covered by restoration adhesive. After a preliminary analysis, one tool (14973-1) was excluded from microscopic analysis due to the high level of fragmentation and abrasion. The rest of the

212 García-Díaz in press.
213 Ibañez, González & Moreno 2002.
214 Stewart 1977; Rostlund 1952; Trigger 1969; Townsend 1981.
215 Van Gijn 2006 a b; Louwe Kooijmans *et al*. 2001; Drenth, Brinkkemper & Lauwerier 2008; Glasbergen *et al*. 1961.
216 Drenth, Brinkkemper & Lauwerier 2008; Van Heeringen & Theunissen 2001a,b.
217 Zeiler 1989, 1997; Zeiler & Brinkhuizen 2012, 2013.
218 García-Díaz 2013.
219 Campana 1980; D'Errico 1993, LeMoine 1994.
220 Christidou 1999; Maigrot 2003; Van Gijn 2006a,b.

implements were analysed at magnifications up to 200x. The implements were not chemically cleaned and no residues were taken from any sample.

5.5.2 Bone tool typology and technology

Several tool types were distinguished on the basis of morphological and functional characteristics (Table 5.16). One spatula (29714-1) made from a long bone of a large mammal was documented. The tool shows an abraded surface and no technological traces could be identified. Consequently, the classification of the tool was based on the shape of the implement. The tool shows a rounded edge and one of its surfaces seems to have been polished. Bone spatulas have been documented at other domestic Single Grave settlements such as Aartswoud.[221]

Two beads, one complete and one fragment, and one pendant were documented (Fig. 5.11). The pendant (17051-1) was made from the incisor of a dog (*Canis familiaris*). A conical perforation was made in the middle of the incisor and the tip of the tooth was slightly rounded. The use of teeth as personal ornaments has also been documented at the contemporaneous domestic site of Aarstwoud. The two beads were first published as flutes,[222] later as toggles.[223] However, functional analysis suggests that the implements were used as ornaments. The bead fragment (8834-1) was made from the diaphysis of a hollow bone. The fragment has small dimensions, measuring 25x13x10 mm. The bead was decorated on three sides with simple short incisions, probably made using a flint tool (Fig. 5.11). Similar bone ornaments have been found at other Single Grave settlements.[224] The complete bead (7188-2) was made from the diaphysis of a sheep/goat tibia. It was decorated with long narrow incisions all along its surface, probably produced with a flint tool. In addition, a perforation was made in its central surface (Fig. 5.11; Fig, 5.17). Finally, the entire surface of the bone was polished, probably to give it a uniform appearance. Similar beads, at first interpreted as small flutes, were documented at the contemporaneous site of De Vrijheid.[225]

Two needles and an awl were documented at Zeewijk (Fig. 5.12). One of the implements (7094-1) is a simple needle. The tool was produced using a diaphysis from a medium-sized mammal. The production traces displayed on the tool suggest that the surface was scraped and polished to obtain the desired shape for the implement. The second needle was also made using a diaphysis from a medium-sized mammal. The needle has a broken tip and a square head with rounded and polished edges. The production traces suggest that the tool was polished and scraped. These tool types have been found in several Single Grave Culture settlements in the wetland areas of the Netherlands, including Aartswoud.[226] A sheep/goat tibia (16272-1) was used to produce an awl. One of the edges of the tibia was broken and transformed into a tip. Unfortunately, the abrasion of the surface has covered any technological traces that may have been present. Bone awls were documented at the Single Grave site of Aartswoud.[227]

At least three cattle ribs were used to produce bone implements, defined as 'ripples' or '*bobbelkammen*' by several fauna specialists.[228] The tools were probably produced by scraping and polishing the surface, and have a shape resembling a comb with rounded teeth.[229] Only limited technological and functional information has been obtained from these tools. One of the 'ripples' (14973-1) was too abraded and fragmented and it was not possible to perform a microscopic analysis. The second 'ripple' (14984-1) and a fragment of a 'ripple' (18802-1) were restored and consolidated using a chemical preservative that has covered the technological and functional traces on the surface (Fig. 5.13). Only a small part of the surface remained unaltered. Similar tools were documented and studied at Mienakker.[230] Unfortunately, the preservation of the tools was poor and the interpretations therefore limited. Finally, one fragment (21363-1) was so eroded and altered that the tool type could not be identified. It was identified as a fragment from a long bone of a medium-sized mammal.

221 Drenth, Brinkkemper & Lauwerier 2008, 164.
222 Van Ginkel & Hogestijn 1997.
223 Lauwerier 2001.
224 Van Heeringen & Theunissen 2001a,b.
225 Van Heeringen & Theunissen 2001a, 191.
226 Van Iterson Scholten & De Vries-Metz 1981 (Fig. 13); Drenth, Brinkkemper & Lauwerier 2008, 164.
227 Van Heeringen & Theunissen 2001a,b; Drenth, Brinkkemper & Lauwerier 2008, 164.
228 Drenth, Brinkkemper & Lauwerier 2008; Lauwerier 2001.
229 Lauwerier 2001, 182.
230 García-Díaz 2013.

Figure 5.11 Two bone beads (7188-2 and 8834-1) and one pendant (17051-1) recovered at Zeewijk showed traces related to their use as ornaments.

Figure 5.12 The bone awl (16272-1) and two needles (7094-1 and 7094-3).

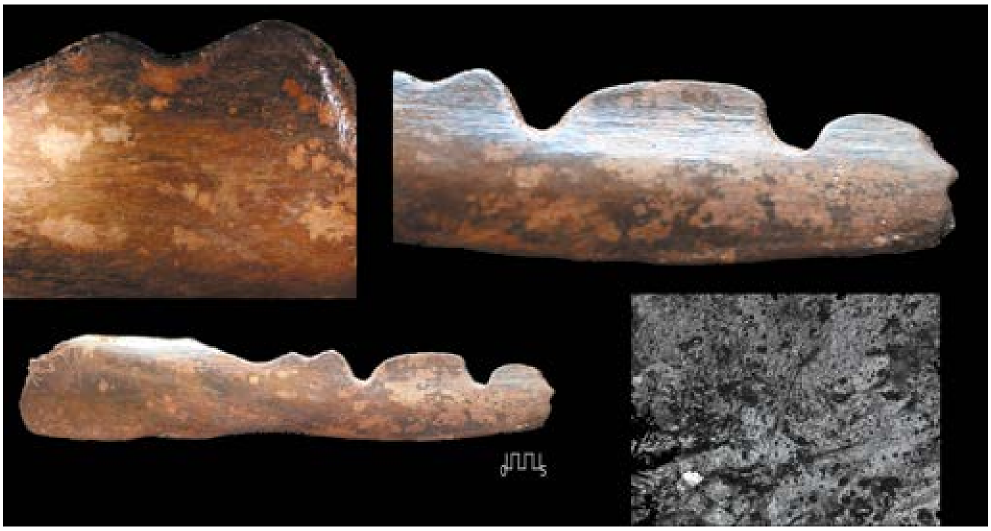


Figure 5.13 Cattle ribs were used during the Single Grave Culture period to produce tools denominated 'ripples' (*bobbelkammen* in Dutch) by fauna specialists. Three of these tools were recovered at Zeewijk. The restoration of the tools using a chemical preservative covered the technological and functional traces on the surface. This prevented a proper understanding of the function of the tools. This 'ripple' (14984-1), was probably produced by scraping and polishing.

Table 5.16 Overview of the use-wear analysis of the bone implements.

Square	Serial	Species	Element	Part	%	Weight (g)	Artefact type	Macroscopically visible modifications		
								polish	rounded	other
Use wear										
Possible hide working										
7094	3	medium mammal	long bone	diaphysis	0-10	1	needle	yes	yes	scraping marks
7094	1	medium mammal	long bone	diaphysis	0-10	2.7	needle	yes	no	scraping marks
String										
17501	1	dog (Canis familiaris)	tooth	incisor	10-25	0.3	pendant	yes	yes	conical perforation
7188	2	sheep/goat (Ovis aries/Capra hircus)	tibia	diaphysis	0-10	4.8	button	yes	yes	parallel incisions, perforations
8834	1	sheep/goat (Ovis aries/Capra hircus)	tibia	diaphysis	0-10	2.2	button	yes	no	parallel incisions
Undetermined										
16272	1	sheep/goat (Ovis aries/Capra hircus)	tibia	proximal epiphysis + diaphysis	25-50	24	awl	yes	no	-
Not interpretable										
The degree of postdepositional modification is too high to interpret the possible use-wear traces										
18802	1	cattle (Bos taurus)	costa	corpus	0-10	4.5	'ripple'	yes	yes	-
21363	1	medium mammal	long bone	indet.	0-10	1.5	unknown	no	no	scratched surface
14984	1	cattle (Bos taurus)	costa	corpus	10-25	28.7	'ripple'	yes	yes	-
14973	1	catte (Bos taurus)	costa	corpus	0-10	5.4	'ripple'	no	no	-
29714	1	large mammal	long bone	diaphysis	0-10	18.8	spatula?	?	yes	charred

5.5.3 Bone tool function

The range of activities and materials documented by use-wear analysis is limited due to the small quantity of bones analysed. After the preliminary analysis, five tools were considered unsuitable for use-wear analysis. The remaining six tools (50%) displayed traces of use (Table 5.16). However, the worked materials could not always be identified.

Interpretation of the use-wear analysis
One of the needles (7094-1) displayed traces related to the working of an abrasive material, interpreted as hide. The use-wear traces suggest that the needle was used to pierce hide. The polish is not well developed. However, striations indicating a rotational movement have been documented near the tip (Fig. 5.14). These striations are similar to the ones displayed by the second needle (7094-3). The traces on the second implement were located on the body of the needle (Fig. 5.15). Unfortunately, the tip is broken, making a detailed inference impossible. In addition, the proximal edge of the first needle shows heavy rounding, produced by contact with an undetermined material. Even though the wear traces are not heavily developed, the distribution of the use wear along the tip and body of the needle suggests that the tool could have been used as a pin. The awl (16272-1) has an abraded surface and the very end of the tip is broken off. However, it seems that the tool was used to drill some undetermined material. The lateral sides of the tip are severely rounded and a slightly developed polish displays short striations, suggesting a rotational movement.

Finally, the two beads and the pendant displayed traces related to their use as personal ornaments. In the case of the tooth-pendant (Fig. 5.16), use wear is located around the perforation, suggesting that the pendant was hung from a string. The complete bead displayed use-wear traces around the lateral hole and around the central perforation (Fig. 5.17). The distribution of the traces suggests that

Figure 5.14 Use-wear traces documented on a needle (7094-1) suggest that the tool was used to pierce hide. In addition, the distribution of the use wear among the tip and body of the awl suggests that the tool could have been used as a pin.

Figure 5.15 Needle (7094-3) displaying traces related to working an abrasive material, interpreted as hide. Use-wear traces suggest that this implement was used to pierce hide.

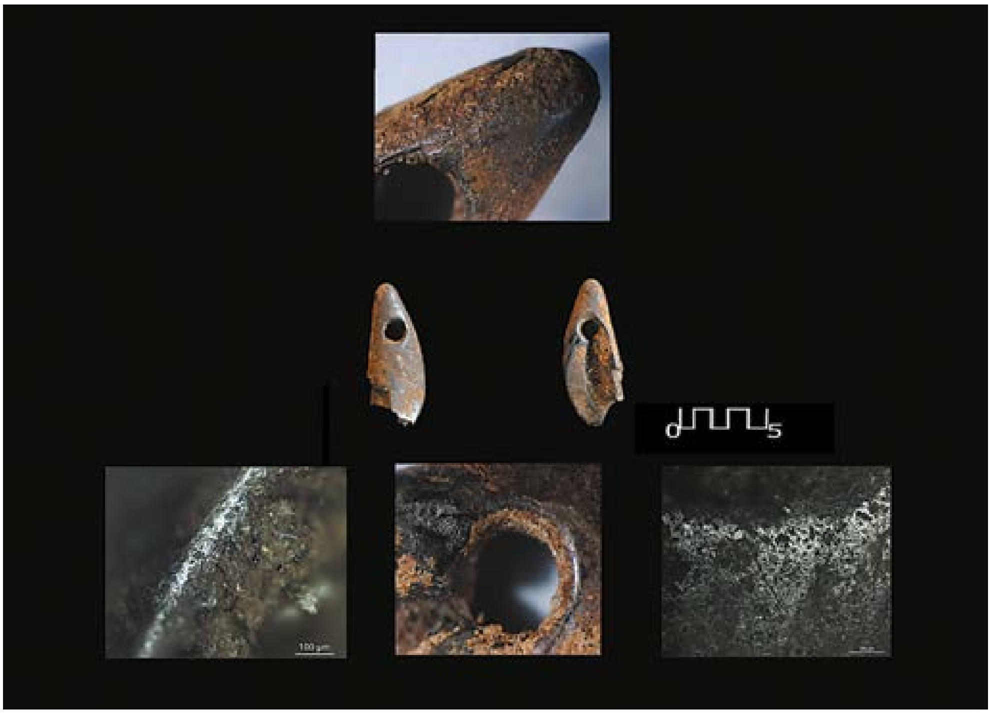


Figure 5.16 This pendant (17051-1) made from the incisor of a dog displays a conical perforation. Use-wear is located around the perforation, suggesting that the pendant was hung from a string.

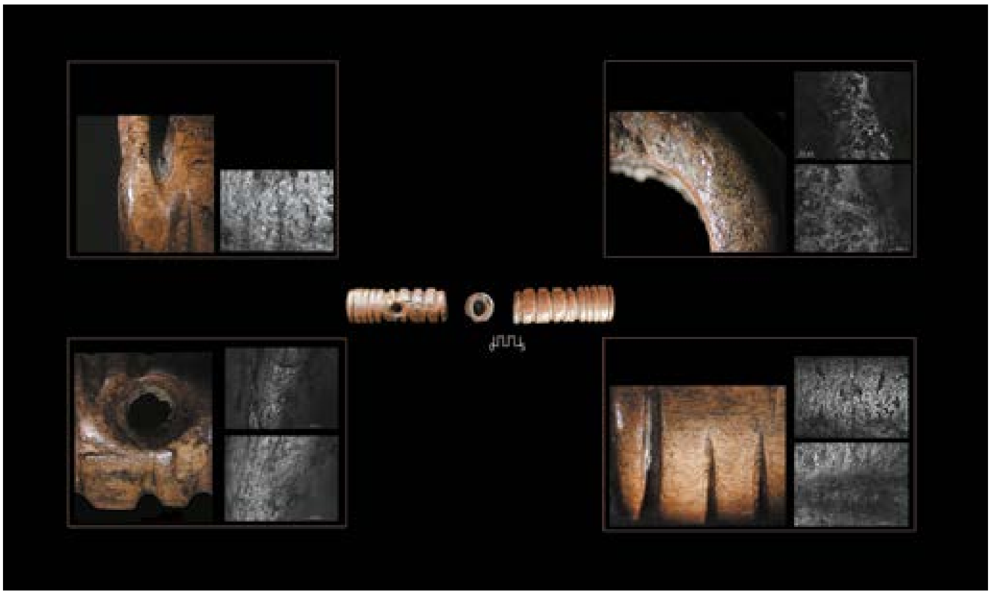


Figure 5.17 A decorated bead (7188-2) with long narrow incisions all along its surface. In addition, a perforation was made in its central surface. The bead displayed use-wear traces around the lateral hole and around the central perforation, suggesting that a string was introduced from the lateral holes into the central perforation.

a string was introduced from the lateral holes to the central perforation. The bead could have been used as a pendant, but also as a button to tie clothes. The lateral rounding of the fragmented bead suggests a similar use for this bead.

5.5.4 Conclusions

The information provided by the analysis of the bone tools is relatively limited. The number of documented tools is low. In addition, the degree of alteration of the tools and the surface preservation affected the interpretation of the sample. Nevertheless, some conclusions can be drawn from the technological and functional analysis. Single Grave communities continued to use bone tools, following the tradition of Mesolithic communities. This continuity has already been observed in the assemblages at other Neolithic settlements where bone tools have been preserved.[231] At several Single Grave settlements, Zeewijk included, bone implements display similarities in terms of technological features and selection of blanks, suggesting a standard production of the implements. Awls, 'ripples', and spatulas suggest the importance of bone implements for the daily economic activities of the Neolithic inhabitants. However, an extended study of Single Grave bone implements is needed.

5.6 Toolkits at Zeewijk: a general overview

Zeewijk was selected as an example of a long-term or permanently occupied settlement. The main goals of the project were to provide new information on the use and nature of the settlement, its role within the Single Grave Culture of Noord-Holland province and the use and exploitation of the landscape. The study of flint, stone and bone implements contributes to the discussion.

Firstly, raw material procurement suggests a use of the territory similar to the site at Mienakker. Flint and stone were collected from nearby areas, such as the coastline or the glacial deposits at Wieringen. The exploitation of nearby resources is characteristic of other Single Grave settlements of the area, like Keinsmerbrug, Mienakker and Kolhorn, but it was also a strategy used by inhabitants of Noord-Holland province during the TRB and Bell Beaker period. The presence of southern flint suggests a broader use of the territory, comparable with the use of other Single Grave settlements such as Mienakker, or sites of the Vlaardingen group.

The technological approaches employed at Zeewijk were also similar to those used generally during the Neolithic, when different technological strategies were combined. At Zeewijk, unidirectional flaking was used in combination with bipolar approaches, the latter being used mainly on poor-quality rolled pebbles. Bipolar reduction is a recurrent phenomenon in the Dutch Neolithic, being present at other Single Grave settlements, and also in Vlaardingen, TRB and Bell Beaker settlements. The raw material and the strategies employed to exploit the flint and the stone largely determined the tools obtained. Even though blades are present in the assemblage, unmodified flakes are the most frequent tool type. Retouched tools, scrapers and borers are scarce and only two arrowheads were documented. The assemblage at Zeewijk is similar in composition to other settlements, where unmodified flakes are the most common tools.

Stone tools – and the techniques used to produce them – also show great similarities with other Single Grave settlements studied. In addition, stone tools displayed also had traits in common with those of TRB and Vlaardingen settlements. *Metates* and grinding stones were flaked to rejuvenate their surface, while the instruments related to percussion activities – like hammer stones, anvils and mortars and *manos* – were usually unmodified.

Finally, bone tool typology also suggests the use of an established production of the implements. In conclusion, it seems that regularity in the production of the tool assemblage during the Neolithic period probably links them to some Mesolithic traditions, as in the case of the bone implements. On the one hand there is evidence of a standardised production sequence for awls, for example, using the metapodium technique. This technique has strong roots in the Mesolithic. On the other hand, we also observe the *ad hoc* use of production waste and pieces of bone with a suitable edge which is not or hardly modified prior to use. This too has been noted before at other Neolithic settlements like Schipluiden and Hekelingen.

Use-wear analysis suggested that craft and subsistence activities were performed at the site.

[231] Van Gijn 2006a, 2007.

Hunting and fishing made a major contribution to the diet at Zeewijk, as suggested by the faunal analysis. Flint was used to butcher animals, and to scale and process fish. Finally, even though no sickles were found, cereal processing has been well documented at Zeewijk thanks to the presence of querns with traces from processing cereals. Craft activities were dominated by hide processing and plant working. Flint, stone and bone implements were used to scrape, pierce and cut the hide of animals, probably to produce other tools, clothes or even to build houses or canoes. Wood and plant resources were processed using flint and stone, probably to produce domestic tools or dwellings. Finally, amber was processed into beads and pendants which, along with the bone beads, decorated the clothes and bodies of the inhabitants of Zeewijk.

6 Beads and pendants of amber and jet

A.L. van Gijn

6.1 Introduction

Amber is a common find category at many of the Single Grave sites located in the province of Noord-Holland. Piena and Drenth wrote a detailed account of the amber ornaments and prefabs found at Aartswoud, as Bulten did in relation to the ornaments from Mienakker.[232] All evidence points to local production of amber ornaments in this area. The Keinsmerbrug site is the exception, with only three amber finds, but this can probably be attributed to its special role in the settlement system, as it was not an ordinary permanently occupied settlement.[233] Zeewijk has produced a large number of amber finds, ranging from unmodified nodules of amber to a few heavily worn beads. Ornaments in varying stages of production predominate.

The present study is based on a biographical approach to the study of ornaments, including a characterisation of the raw material, a reconstruction of the production processes, and examination of its use life, and a study of the context of deposition.[234] Since it was obvious that ornaments in varying stages of their production dominated the assemblage, the focus was on the detection of production traces and the reconstruction of the *chaîne opératoire*. Another question was whether there was evidence of special activity sites, pointing to specific workshops for amber bead production, or whether this was a task carried out more widely within the settlement.

6.2 Sample and methods of study

All amber and jet finds, in total 269 artefacts, were first classified into broad categories (beads and bead fragments, pendants, semi-finished products, blocks, flakes and nodules). Only one jet artefact was encountered in the assemblage. All artefacts were weighed to assess the spatial distribution of amber.[235] The total weight of the amber and jet assemblage amounts to just under 38 grams. In the second stage of analysis, all beads and pendants as well as any artefacts with suspected traces of production were studied by stereomicroscope and observations were entered into an Access Dbase. Roughly half the artefacts were selected for such detailed study (n=135), revealing information on the technology used, the colour of the amber, the degree of use and indications of reworking. The selection included all the beads, pendants and semi-finished products, as well as flakes, blocks and nodules with possible traces of modification. As can be expected, small flakes (measuring less than 3 mm) were for the most part rejected as the initial counts included 125 flakes. The sample of 135 artefacts includes 89 beads or bead fragments and eight pendants (Fig. 6.1). In terms of weight the selection represents 26.3 grams of amber and 0.09 grams of jet. Considering the fact that some find material from Zeewijk could not be located (see Section 1.5), the possibility that yet another find box containing amber ornaments will surface in the future cannot be excluded.

All artefacts were examined by stereomicroscope, using magnifications of 10-160x under both oblique and reflected light. This allowed a detailed examination of the traces of production such as cut marks, traces of scraping, grinding and perforation. A metallographic microscope was also used to examine the wear traces around the perforation and on the surface of the beads. This was a Nikon Optiphot, with magnifications ranging from 100-500x. The microscope was fitted with Nomarski Differential Interference Contrast for greater contrast and depth of field. Some of the amber finds were too oxidised for traces of wear and tear to have been preserved.

6.3 Raw material

The amber nodules in the assemblage were rolled and did not display the extensive weathering commonly seen on amber that was not water-worn but retrieved from sediments.[236] It is most likely Baltic amber (succinate) that was transported along the North Sea. Amber floats in salty waters and is carried along the tidal streams of the North Sea. It is still found on the shores of the Frisian Islands today.[237] If one examines the frequency of amber finds in the Neolithic coastal sites of the Netherlands, it becomes clear that amber is much more common further north along the Dutch coast. In Schipluiden, located near the present-day city of

[232] Piena & Drenth 2001; Bulten 2001a.
[233] Garcia-Diaz 2012; Smit *et al.* 2012b.
[234] Jones 2002.
[235] See Nobles, this volume Chapter 11.
[236] Faber, Frandsen & Ploug 2000.
[237] Waterbolk & Waterbolk 1991.

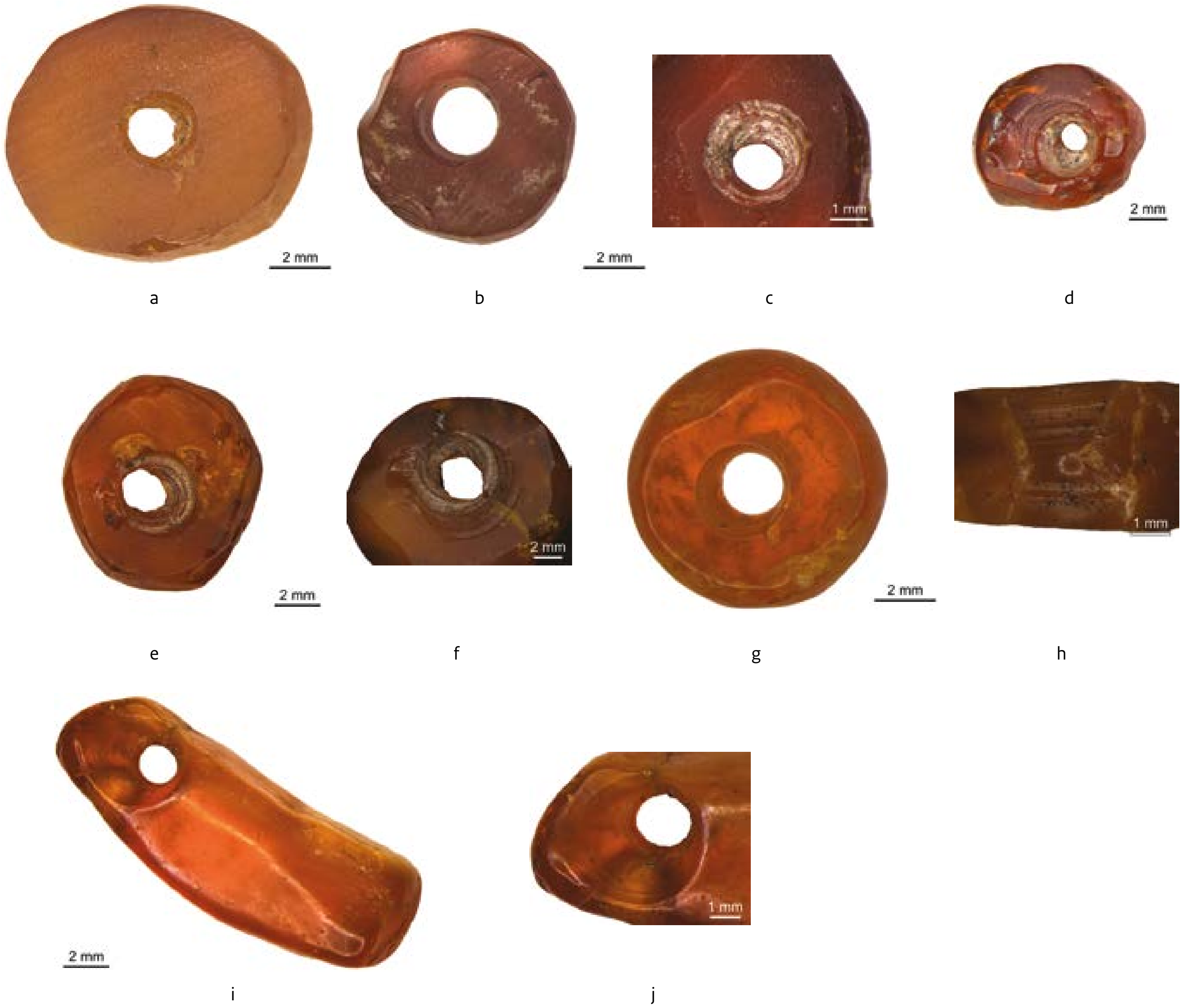


Figure 6.1 Photographs of beads and a pendant, showing traces of manufacture and use: a. freshly ground bead (17501-2) with facetted edges. The grinding traces are still clearly visible and the bead does not show traces of use; b. disc-shaped bead (15784-1) with facetted edges. The grinding traces and perforation marks are clearly visible and show that the bead was hardly used, if at all. One side of this bead consists of a flake negative. This bead does not display traces of wear; c. disc-shaped bead (17554-4) with facetted edges without traces of wear, with fresh production marks. The perforation was made by a flint drill bit; d. bead (16901-2) displaying a misplaced biconical perforation made with a flint drill. The bead lacks traces of wear; e. disc-shaped bead (17564-3-1) with facetted edges, without traces of wear. The biconical perforation, made with a flint drill, is slightly misplaced; f. detail of the perforation of bead (17564-3-1) and the adjustments made in the placing thereof; g. heavily worn disc-shaped bead (17604-8) with a rounded, worn perforation and facetted edges; h. heavily used, broken bead (17563-3). Note the worn biconical perforation; i. heavily worn and polished pendant (17504-2); j. detail of this same pendant (17504-2).

The Hague, only 17 amber finds (with a total of only 10 grams) were retrieved, as compared to 37 finds of jet, totalling 212 grams.[238] In contrast, at Zeewijk only one jet artefact was recovered amongst 269 amber finds. This indicates a much greater availability of amber in the area around Zeewijk and a relative scarcity of jet. The source area of this latter material is most likely the area around Cap Blanc Nez in the Pas de Calais area. From here small fragments may have been transported north by the tidal working of the Channel and the North Sea.[239]

The presence of numerous amber finds suggests that the raw material was collected on nearby beaches, located approx. 15 km downstream along the nearby tidal creek.[240] We cannot entirely exclude the possibility that some of the amber was obtained from the ice-pushed ridges of the boulder clay deposits located approx. 8-10 km north of the site. The other two sources of amber mentioned in the literature seem less likely as the source of amber at Zeewijk, due to the fact that they are situated at a much greater distance. These are the Pliocene lignite deposits of the northern Netherlands,[241] in which small amounts of amber are present, and the amber from tertiary sources transported by the rivers in the central Netherlands.[242]

The amber is for the most part slightly translucent (n=92), though the opaque variety is also present (n=38). In four cases the surface was so oxidised that it was impossible to determine whether or not the amber was translucent. The colour varied from yellow (n=16), via orange (n=90) to brown (n=21) with a small number of milky amber pieces (n=6). The nodules, 20 of which were present in the sample, have a mean weight of 233 mg. The largest nodule weighed 630 mg.

6.4 Production and shape

The blanks for the ornaments were either nodules, blocks or flakes (Table 6.1). It is relatively easy to flake amber due to its conchoidal fracture and generally homogeneous structure. Quite a number of flakes were found, which could probably be related to the production phase of the ornaments. Many of the blocks, forming the blank for some of the beads, also display flake negatives, indicating that flaking of amber nodules was certainly practised in the early stage of production. Blanks were also made in another way. A total of 13 artefacts display traces of sawing (Fig. 6.2a), probably related to the segmentation of larger nodules of amber into blanks. This has also been observed at Mienakker.[243] A total of 24 semi-finished products of ornaments could be distinguished, 21 beads and three pendants that were never completed because, for instance, the perforation was aborted. It was impossible to determine the kind of blank used for these semi-finished products. One bead was made from an older bead, indicating that heirlooms were occasionally refurbished for a second life. Finally, 45 beads and five pendants were completely finished, obliterating any indication as to whether they were made from a block, a flake, or a nodule.

The relatively good preservation of the ornaments allowed examination of the traces of production. Of the 89 beads, seven were made from a flake (Fig. 6.2b), ten from a block (Fig. 6.2c) and eight from a nodule (Fig. 6.2d). The blanks of the pendants could not be reconstructed. The next phase of production is variable, indicating that there was no strictly defined *chaîne opératoire*. Some blanks were subsequently facetted and ground into a preform, or else the piece was first perforated (Fig. 6.2e). Many artefacts displayed traces of grinding (n=42) (Figs. 6.1a, b and 6.3a, c), three showing traces of scraping and grinding. The grinding marks were sometimes incredibly fresh, with the grinding dust still visible. A sizable number of beads (n=24) have facetted edges, especially the small, flat, disc-shaped beads. These facets are so small that it is hard to imagine them being produced on a grinding stone. Past experiments with fixing a perforated bead on a bow drill and applying the facets with a flint blade proved successful.[244] However, the fact that several semi-finished small, flat disc-shaped beads showed no perforation, but were nevertheless facetted, indicates that another method must have been practised. They may indeed have been applied to a grinding stone, but our experiments show that this is not an easy task, especially on small beads of 5-7 mm in diameter. Holding the bead firmly enough and switching positions in order to obtain the tiny facets requires a dexterity

238 Van Gijn 2006a, 195.
239 Van Gijn 2006a, 2008.
240 Smit this volume, Fig. 2.1.
241 Huisman 1977.
242 Van der Valk 2007.
243 Bulten 2001a.
244 Drenth, Meurkens & Van Gijn 2011.

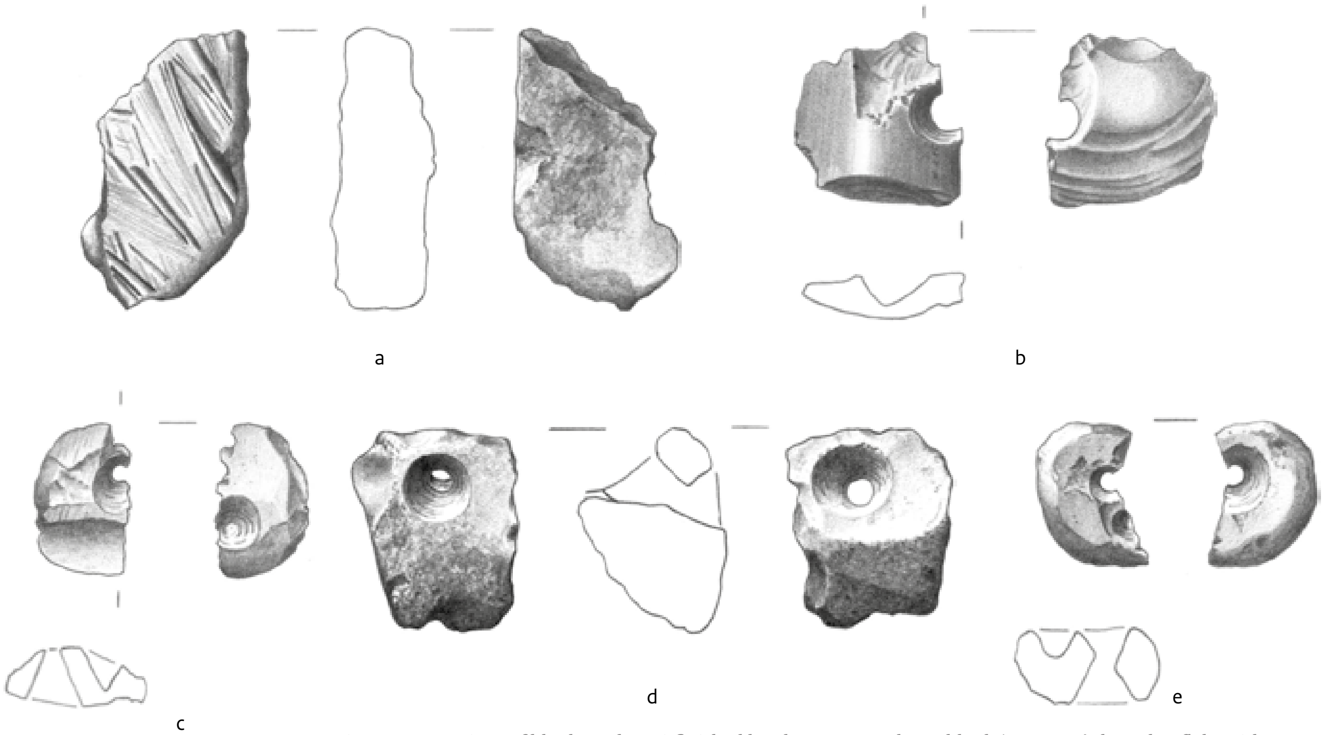


Figure 6.2 Drawings of blanks and semi-finished beads: a. saw marks on blank (19423-6-7); b. amber flake with perforation, probably aborted when the flake broke (21321-5-8); c. semi-finished bead on a block with biconical perforation which does not match (16233); d. perforated nodule (18141-2); e. broken semi-finished bead, probably broken during the perforation, with edges that are only partially finished. Note the aborted attempt at perforation just below the finished one (11803-4). Scale 2:1.

that we experimenters do not at any rate possess. After faceting, which is mainly visible on the sides, the top and the bottom of the disc-shaped bead were ground flat. The fine scratches indicate that the grinding was probably performed using a fine-grained sandstone. A number of beads and pendants have a very shiny surface, suggesting that after grinding the surfaces were polished (Fig. 6.1g). However, the fact that this shininess was observed only on ornaments that were interpreted as heavily used, indicates that this polish is due to use, not to manufacturing (see below under Section 6.5).

Perforations were applied either directly in the blanks (Fig. 6.4a), or in the shaped and ground preforms (Fig. 6.2b). They were for the most part biconical (Table 6.2). This pertained both to the beads (n=35) and to the pendants (n=3). Often, the placing of the two conical perforations was badly judged so that the makers had to improvise in order for the two sides of the perforation to meet (Figs. 6.1d,e). On a number of artefacts only one conical perforation is visible, with the perforation being

Table 6.1 Primary classification and type: frequencies.

Typology	Primary classification	Number
Bead	block	10
Bead	flake	7
Bead	nodule	8
Bead	old bead	1
bead	unknown	42
Semi-finished bead	unknown	21
Subtotal		**89**
Pendant	unknown	4
Semi-finished pendant	unknown	4
Subtotal		**8**
Unmodified	nodule	12
Unmodified	block	6
Unmodified	flake	20
Total		**135**

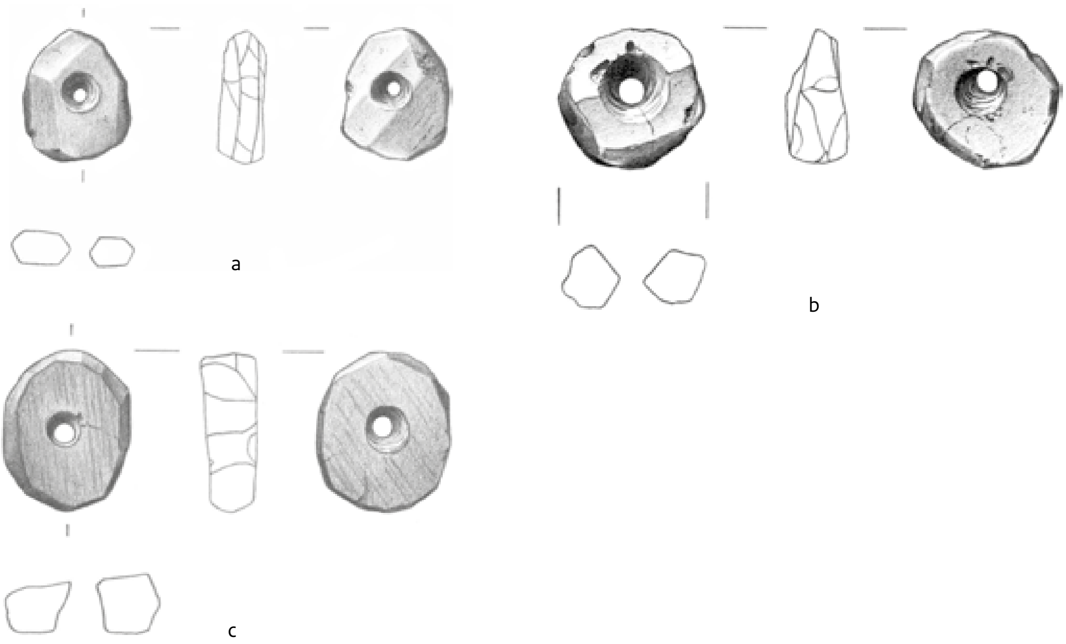


Figure 6.3 Small disc-shaped beads, often with facetted edges: a. bead with prominent grinding traces on both flat sides displaying no traces of wear (17544-4); b. very fresh bead without traces of use but displaying fresh grinding traces, a slightly misplaced biconical perforation and facetted edges (17564-3-1); c. disc-shaped bead with facetted edges and perfectly preserved grinding traces. It lacks any traces of use. The grinding occurred after the faceting (17501-2). Scale 2:1.

Table 6.2 Type of perforations seen on the beads and pendants.

Typology	Type of perforation	Number
Beads	conical one-sided	5
	biconical	35
	conical indet.	3
	cylindrical one-sided	1
	cylindrical two-sided	1
	cylindrical indet.	9
	unfinished perforation	12
	not perforated	21
	indeterminate	2
Subtotal		**89**
Pendants	biconical	3
	cylindrical	1
	unfinished perforation	2
	not perforated	2
Subtotal		**8**

aborted, possibly because the placing of the first perforation was wrong (Fig. 6.4a). A small number of beads (n=11) and one pendant displayed a straight, cylindrical perforation. A total of 12 beads showed perforations that were not finished. Finally, 21 beads and two pendants were completely shaped, but lacked a perforation. The conical and biconical perforations displayed very prominent rills (Figs. 6.1c,d), suggesting that flint drills were used. Microwear analysis of the flint tools from Mienakker by Garcia-Diaz has revealed the presence of small flint drills with traces of drilling amber.[245] Garcia-Diaz was able to experimentally replicate these traces with exact copies of the small archaeological flint drills. The presence of these drill bits constitutes yet another indication that the amber beads were produced locally. However, some of the perforations display circular scratches that are so regularly spaced that it is unlikely that they come from use of a flint drill (Fig. 6.6c). Most likely they were made with a pointed piece of wood or antler, using a fine slurry; experiments show this to be an effective drilling method, resulting in

[245] García-Díaz 2013, Fig. 5.5.

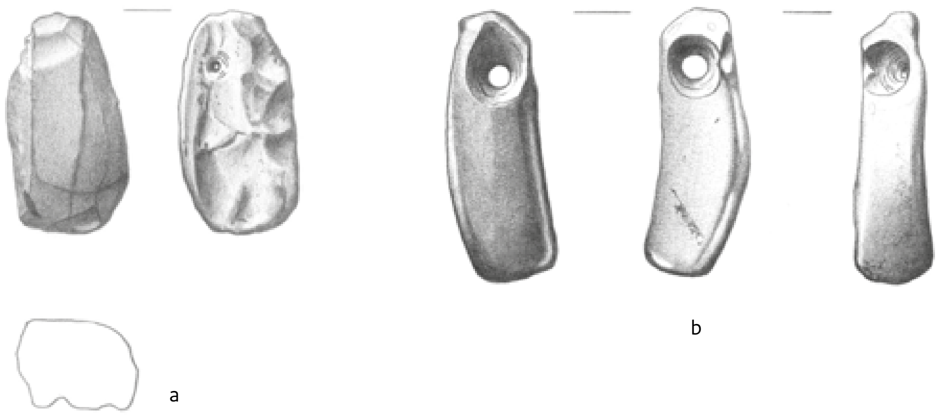


Figure 6.4 Pendants: prefab and finished ornament: a. prefab for a pendant with an initial perforation attempt which was abandoned (20074-2); b. finished pendant, heavily worn and displaying a strange secondary but unfinished perforation (right) (17504-2). Scale 2:1.

fine, regular circular scratches.[246]

If we look at the end products – the finished beads and pendants – several types can be distinguished (Table 6.3). Among the beads the disc-shaped variety predominates (n=33). These are round, relatively flat ornaments, often with facetted sides, measuring 6-8 mm in diameter and 2-4 mm thick. They are usually biconically perforated. Two barrel-shaped and one globular bead complement the picture. The remaining beads could not be assigned to a specific type (n=53). Among the pendants two were irregularly shaped, and the other six could not be classified typologically (Fig. 6.4).

Table 6.3 Typological classification of the beads and pendants.

Typology	Ornament type	Number
Beads	barrel-shaped	2
	disc-shaped	32
	globular	1
	indeterminate	21
	type unknown	33
Pendants	irregular	2
	indeterminate	3
	type unknown	3
Total		**97**

6.5 Use

All ornaments were studied by stereomicroscope to determine the extent to which the perforations were worn. This was the main indication of the intensity of use. Many of the beads did not display traces of wear (n=27), three were slightly worn, five displayed intermediate wear and 14 displayed heavily developed traces of use (Figs. 6.1g,h and 6.5). In three cases the extent of wear could not be assessed. Of the five finished pendants, four were heavily worn, considering the considerable rounding of the perforations (Fig. 6.1i, j and 6.4b). One was worn only slightly, whereas the remaining three pendants were actually prefabs without perforations. The four pendants interpreted as having been heavily worn, also displayed a well-developed polish over their entire surface (Figs. 6.1i,j). A polished surface was relatively rare in the assemblage: besides the pendants only 19 beads showed evidence of polishing (Fig. 6.1g). Considering the association with heavily worn perforations, I have interpreted the well-developed sheen as having been caused by prolonged use, rather than intentional modification. Many of the beads with a heavily polished surface are broken (Fig. 6.5), and may have been discarded after they broke. However, one broken bead (no. 15032-3) (Fig. 6.5c) with heavy traces of use displayed two biconical perforations, both of which display only moderately developed wear around their rims. This may suggest that old beads were

[246] Personal observation by author.

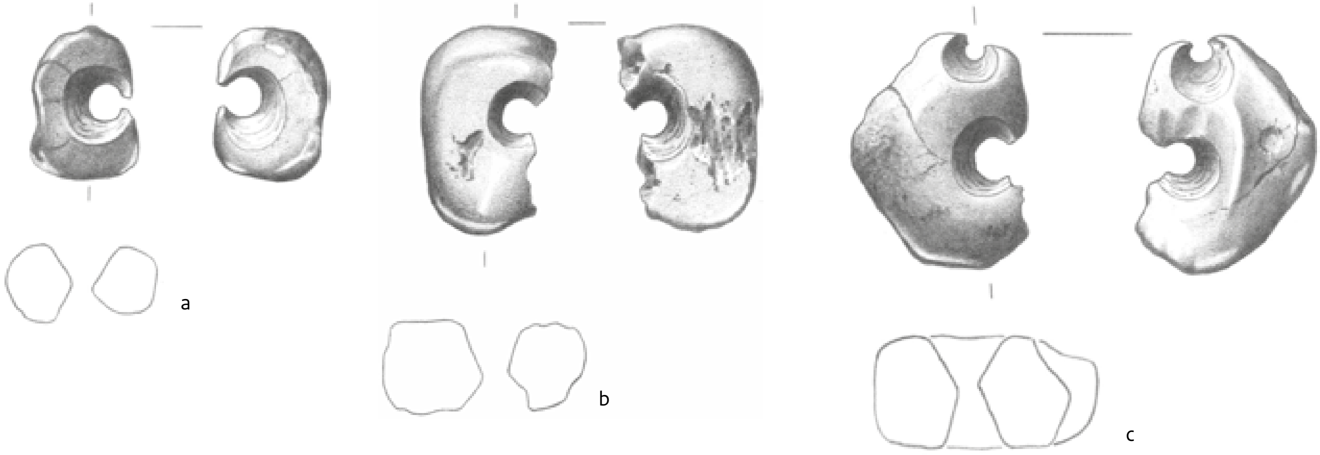


Figure 6.5 Broken beads, all displaying extensive traces of wear: a. no. 14984-3, broken at perforation; b. no. 17564-3-2, broken at perforation; c. no. 15032-3, broken at perforation. The bead surface is highly worn but in contrast both perforations are only moderately worn. This may be a reworked old bead. Scale 2:1.

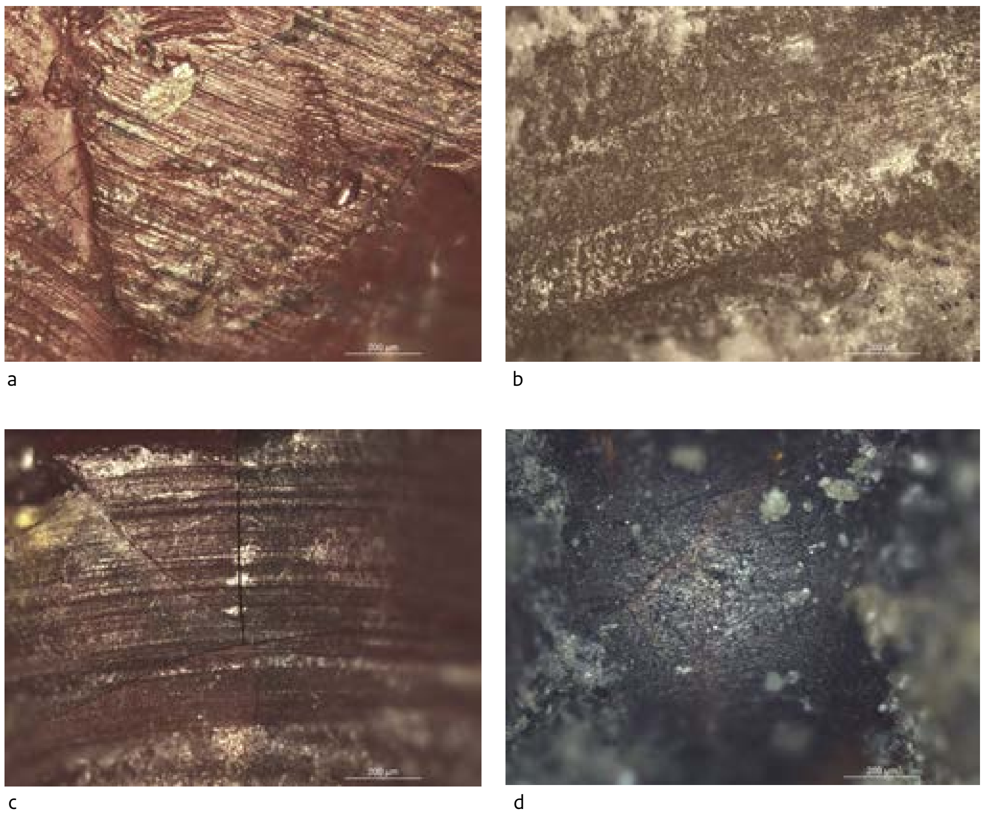


Figure 6.6 Microwear pictures of bead surfaces: a. fresh grinding marks (15003-1; 100x); b. scratches from grinding (13691-6; 100x); c. circular scratches on the inside of a perforation. The regularity of the scratches suggests a tool other than a flint drill (13724-9; 100x); d. extensive abrasion from a cord on the inside of an amber bead (22684-1; 100x).

reworked, something that was also noted in a child's burial at the Middle Neolithic site of Ypenburg, for example.[247]

The number of worn beads is therefore quite limited. This is not unusual at settlement sites. The beads that are found in such a context were either accidentally lost or were discarded because they were broken.[248] It is rare to find finished, still usable beads in living areas. They do, however, appear in funerary contexts like Ypenburg or in the Funnel Beaker megaliths.[249]

6.6 Spatial distribution

Nobles performed a spatial analysis of the ornaments as far as they were located within the sampled areas.[250] He found that the amber is concentrated on the higher ground of Zeewijk-West where habitation seems to have occurred.[251] Although there is a concentration of amber in the northeastern part of the area sampled by all researchers, it would be premature to interpret this as evidence of the former presence of a workshop as amber is present throughout most of the excavated area.

6.7 Conclusions

The analysis of the beads and pendants from Zeewijk has confirmed the conclusions of Piena and Drenth for Aartswoud[252] and Bulten for Mienakker[253] that the production of amber ornaments occurred locally in this area, i.e. within the settlements. Ample evidence of the presence of production waste like flakes, blocks, nodules and semi-finished beads supports this. Moreover, microwear analysis of flint drills at both Mienakker and Zeewijkhas shown them to have been used on mineral materials, probably amber.[254] The amber, most likely Baltic amber or succinate, was washed ashore by the North Sea. It is also possible that small amounts of amber were collected in the glacial deposits at Wieringen, located north of the settlement. Regardless of the exact provenance, the supply of amber must have been sufficient to meet the need, considering the rather careless way in which the raw material was treated. Jet on the other hand, abundant further south, is very rare, represented by only one artefact. Whether this was obtained as rare find on the beach, or by exchange, is impossible to determine.

Beads and pendants were made from flakes, sawn blocks or flaked nodules. The exact production sequence varied: in some cases the perforation was applied prior to the grinding into shape of the ornament, in others the order was reversed. This variability in the exact production sequence supports the assumed domestic production of the beads, with different people having slightly different techniques. If the amber beads had been produced in workshops, a more standardised production sequence would be expected. A certain lack of standardisation and expertise (or care) is also visible in the way the biconical perforations were applied: on many beads the two sides of the perforations do not match perfectly. On the other hand, however, many of the beads are very much alike in terms of their shape and dimensions and seem to be based on a similar concept of what a bead should look like. The presence of a large number of unfinished beads, prefabs and especially the numerous finished beads without traces of wear, seem to indicate that more beads were produced than were necessary for the personal use of the inhabitants. It may therefore be proposed that the inhabitants of these coastal settlements produced beads for Single Grave communities further inland. However, amber beads have so far been found exclusively in burial contexts, settlements from this period being exceedingly rare. One such example is a series of 39 amber beads from burial mound 4 near Garderen, in the Veluwe region.[255] These beads appear to be shaped rather haphazardly, certainly not displaying the more standardised disc shape of many of the beads from Zeewijk. Moreover, they were made from an opaque, yellowish amber, unlike the more transparent, orange-coloured amber found at Zeewijk. Many of the beads from the Garderen burial mound are heavily worn, sometimes reworked. A few fresh beads are also included in this assemblage[256] but again, they do not resemble the Zeewijk beads in terms of their morphology. It is thus not very likely that the beads from the Single Grave burial contexts in the central part of the Netherlands were produced by the Single Grave inhabitants of coastal Noord-Holland. The question of who the amber beads produced at Zeewijk were intended

247 Van Gijn 2008.
248 See for instance Van Gijn 2006a.
249 Van Gijn 2008; Verschoof 2011.
250 Nobles, this volume Chapter 11.
251 See Nobles, this volume Chapter 11, Figs. 11.34 and 11.35.
252 Piena & Drenth 2001.
253 Bulten 2001a.
254 García-Díaz 2013, García-Díaz, this volume.
255 Lanting & Van der Waals 1976.
256 Van Gijn, personal observation.

for therefore remains unanswered. The number of beads seems considerable, but we should remember that amber necklaces can consist of hundreds of beads. From that point of view, the amber ornaments recovered archaeologically are actually not all that numerous and the finds can be interpreted as leftovers, rejects or specimens that were lost accidentally. Domestic production for personal use is thus the most likely explanation. In conclusion, the relative abundance of amber on the coast enabled the inhabitants of Zeewijk and other nearby settlements to produce amber ornaments in considerable quantities, probably for personal use only, and most likely for incorporation into composite jewellery like necklaces or bracelets.

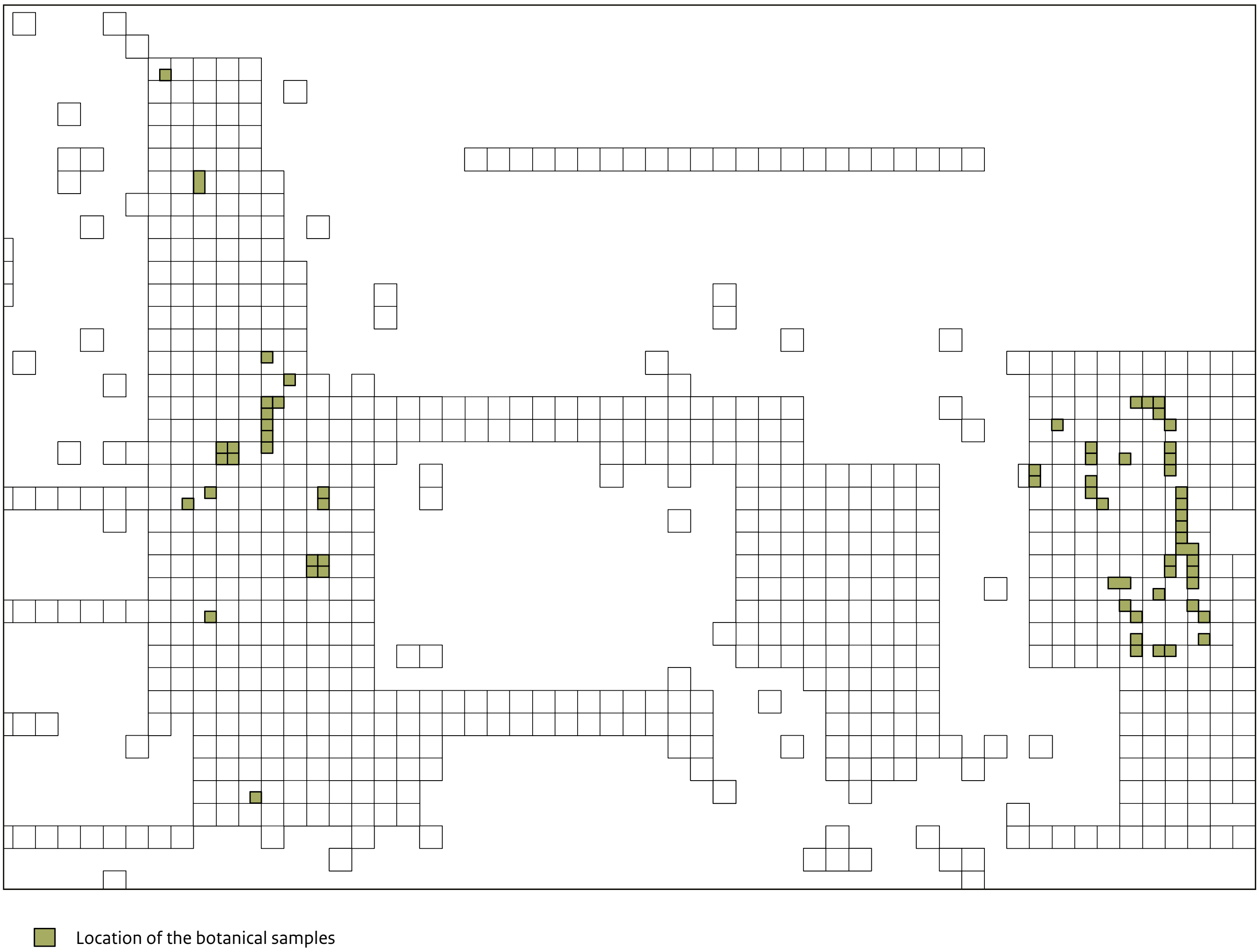


Figure 7.1 Location of the one-meter squares (in the two-metre squares of the excavation grid) from which the botanical samples were taken.

7 Botany: local vegetation and crop cultivation

L. Kubiak-Martens

7.1 Introduction

The site at Zeewijk is located 9 km southeast of Keinsmerbrug and 4 km north of Mienakker. It is the third (and the last) site of the Late Neolithic Single Grave Culture which has been the subject of interest during the multidisciplinary NWO Odyssey project in the province of Noord-Holland. When these Late Neolithic sites were occupied, the region was located in a large tidal area with high salt marshes and natural sandy levees that formed along tidal creeks. These slightly elevated grounds in an otherwise low-lying tidal basin were obviously favoured as settlement locations.[257]

In this chapter we will focus on the reconstruction of the local vegetation and discuss various aspects of the site's economy and economic activities such as food production and food processing which took place at the site. Furthermore, we will participate in the ongoing debate concerning crop cultivation in the coastal area during early prehistory. We will present botanical evidence of crop cultivation at Zeewijk. All of these aspects emerged from the recent analysis of the plant macro-remains obtained from the samples collected during the field season in 1992 from two excavated areas, Zeewijk-West and Zeewijk-East. The results of the plant macro-remains analysis completed and published by De Man and Brinkkemper have been incorporated into the current work.[258]

7.2 Methods

Most of the archaeobotanical samples were taken either from the fill of pits or from the postholes; archaeobotanical samples taken from an unspecified context were defined according to cultural layer. For the purpose of archaeobotanical research, 70 soil samples were selected from the entire Zeewijk excavation area. In agreement with the other specialists involved in the project, 46 samples were taken from Zeewijk-West and 24 from Zeewijk-East (to adhere to a 2:1 ratio). The bulk soil samples were stored in the provisional RCE repository in Lelystad and were available for the current research. The location of the squares (on the 1m²-excavation grid) from which the botanical samples were taken is given in Figure 7.1.[259]

Soil sample sizes ranged from approximately 1.5 to 3 litres. The samples were wet-sieved at BIAX *Consult* using a series of sieves with mesh sizes of 2.0 mm, 1.0 mm and 0.5 mm. In addition, a control volume of 0.5 litres from each bulk sample was sieved through a 0.25 mm-mesh to check for very small seeds and chaff remains. All selected samples were sieved and then assessed. During the assessment, the botanical value of each sample was ascertained in terms of the preservation of plant remains and diversity of plant species, and the presence of charred vegetative and non-vegetative parenchyma, and processed plant food remains. The samples from Zeewijk-West revealed far more plant remains and thus had much higher botanical value than the Zeewijk-East samples, which were neither rich nor diverse in plant remains. Subsequently, 21 samples were selected for further analysis (19 from Zeewijk-West and 2 from Zeewijk-East). The seed and fruit remains were studied under a binocular incident light microscope at magnifications of 6x to 50x. With the exception of a few dozen mineralised and only a few waterlogged plant remains, all other remains were preserved by charring (carbonized).

A summary of the data on seeds and fruits, based on a complete analysis, is presented in Appendix VII.

In addition to soil samples, several hundred dried residues collected at Zeewijk and stored in the provincial repository in Wormer were assessed for the presence of plant food remains, particularly those of charred parenchyma and processed plant food.

Potentially identifiable remains of charred parenchyma and specimens of charred processed plant material were subjected to scanning electron microscope examination at the SEM laboratory of the Naturalis Biodiversity Center 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 750x. The specimens were photographed and described. A summary of the data for charred parenchyma and processed plant material is given in Appendix VIII.

[257] De Mulder & Bosch 1982; Van Ginkel & Hogestijn 1997; Smit 2012.
[258] De Man & Brinkkemper 2001.
[259] Theunissen, this volume; Nobles, this volume Chapter 3; Bulten 2001.

7.3 Natural vegetation

The macro-remains assemblage of plants which grew in and around the settlement at Zeewijk is mainly dominated by charred seeds; only a few waterlogged remains are present in the record. Charred assemblages are usually associated with human activities and may therefore reflect only selected taxa, so charred plant remains are often of limited interest if a reconstruction of the former vegetation is to be performed. Nevertheless, they can help to identify the nature of the former vegetation in the vicinity of the settlement, provided that it is clear that they are contemporaneous with the archaeological assemblage. For the reconstruction of the vegetation at Zeewijk, we also used evidence from the pollen record available for a nearby site at Mienakker.[260]

The pollen spectra from Mienakker, synchronised with the time of the Neolithic occupation, suggest an open landscape influenced by brackish water. Herbaceous vegetation was dominated by members of the goosefoot family (Chenopodiaceae, probably mostly represented by orache, *Atriplex* and glasswort, *Salicornia*) and accompanied by Poaceae (grasses) and Compositae Tubuliflorae (probably mostly represented by sea aster, *Aster tripolium*). Vegetation including thrift (*Armeria*), common sea-lavender (*Limonium vulgare*), mugwort (*Artemisia*), arrow-grass (*Triglochin*) and sea-spurrey (*Spergularia* type) was also present. Evidence for an open tidal landscape was also documented in the macro-remains analysis. The charred assemblage included seeds of plants which often dominate the vegetation of mudflats and are also found in the lower parts of salt marshes: glasswort (*Salicornia europaea*) and sea-blite (*Suaeda maritima*). Seeds from species of plants growing in higher areas of salt marshes dominated the non-cereal remains. In this group, seeds of marshmallow (*Althaea officinalis*) and sea purslane (*Atriplex portulacoides*) were particularly well represented. They were accompanied by charred seeds of sea aster (*Aster tripolium*), various grasses (*Puccinellia distans, Hordeum marinum, Agrostis, Bromus* possibly *hordeaceus* and *Festuca/Lolium*), and sedges (*Carex distans*, *Carex otrubae*). It can be assumed that high salt marshes with a great diversity of grasses and other herbaceous plants were exploited as grazing pastures, not only near Zeewijk but around all Neolithic sites in the region. The presence of sea purslane (*Atriplex portulacoides*) in the Zeewijk record is particularly interesting, as this species is seldom recorded in archaeobotanical remains. It seems that it was quite common in prehistory in the area studied; the charred seeds were also found at Mienakker. Sea purslane is sometimes referred to as 'the tree of the coast' because of its height (the plant can grow up to 150 cm tall) and tough, woody-like stems. Many charred seeds of shore orache (*Atriplex littoralis*) were also present in the samples. Shore orache, together with occasionally recorded sea beet (*Beta vulgaris* subsp. *maritima*) form strong evidence for the presence of drift deposit near the settlement, which would have accumulated after storm surges.

The frequent occurrence of sea club-rush (*Bolboschoenus maritimus*) seeds in the Zeewijk archaeobotanical assemblage and also at other Neolithic sites in the region may indicate that the species would have been commonly found along streams or tidal creeks with brackish water. The abundant presence of charred tubers of sea club-rush in the Zeewijk remains may indicate that they were of economic value (discussed later in the text).

The environmental implications of these results include the fact that during the Neolithic occupation there were also places at and near the settlement where fresh water accumulated. Plants which would have been confined to freshwater wetlands/marshes included great sedge (*Cladium mariscus*) and branched bur-reed (*Sparganium erectum*). Even though freshwater habitats are favourable for broad-leaved pondweed (*Potamogeton natans*), it tolerates some salinity in the water. Two other species, grey club-rush (*Schoenoplectus tabernaemontani*) and common reed (*Phragmites australis*), would have grown in both brackish and freshwater wetland environments. In this otherwise open landscape, there were patches or scatters of small trees or shrubs of willow, alder and aspen growing around the places where fresh water accumulates such as backswamps and gullies.

The Zeewijk seed assemblage also includes species that favour habitats influenced by the presence of man or animals. For example, well-trodden areas around the houses and along the

[260] Van Smeerdijk 2001.

paths would attract plants such as knotgrass (*Polygonum aviculare*). Increased nitrogen in the soil surrounding watering places for domestic animals, or waste deposits and dung heaps would certainly be favourable for species such as fig-leaved goosefoot (*Chenopodium ficifolium*) and common orache (*Atriplex patula*).

7.4 Cereals and other crops

7.4.1 Cereals

It can be seen in Appendix VII that almost every botanical sample contained remains of cereals.

In all the samples analysed, the charred cereals are dominated by emmer (*Triticum dicoccon*) remains, including grains, spikelet forks, glume bases and basal rachis segments. The emmer remains were almost always mixed with those of naked barley (*Hordeum vulgare* var. *nudum*), represented by grains and rachis fragments (including rachis segments and basal rachis). In addition to grain and chaff remains, cereal straw (most likely belonging to both cereals) was found in many samples.

Even though the total numbers of emmer grain and barley grain are similar, emmer chaff clearly predominates over barley chaff. The predominance of emmer chaff in any charred archaeobotanical assemblage (and thus also here at Zeewijk) may result from the fact that in cereal remains preserved by charring, glume wheats – such as emmer – have a tendency to be over-represented in comparison with free-threshing cereals such as naked wheats and barleys. This is due largely to the fact that spikelets of glume wheats have to be parched prior to dehusking (an operation which releases the grain from the glumes), and that during parching they are often accidently charred. Parching is not necessary for free-threshing cereals, the ears of which, when threshed, disintegrate into free grain and chaff.[261] It is therefore probable that at Zeewijk, barley was grown as intensively as emmer, even though the proportions of threshing remains might seem to imply otherwise.

Perhaps the lower quantities of barley chaff are indeed the result of its free-threshing qualities. The chaff of free-threshing cereals (mainly represented by rachis remains) is removed early in the processing sequence, often off-site. As a consequence it is relatively rarely represented in archaeobotanical assemblages.[262] What is significant about the threshing remains of barley found at Zeewijk, however, is that in addition to single rachis segments there were also remains consisting of at least two parts of rachis segments still linked together. Another significant feature is the basal rachis segments of the ear found among the threshing remains (Fig. 7.2a). Such an assemblage of chaff remains, clearly removed early in the processing sequence, suggests that complete ears of barley (or, perhaps, entire plants) were most likely carried into the settlement at Zeewijk and that they were threshed at the site rather than off-site. Furthermore, many samples were rich in straw (most likely derived from both cereals), which cannot be interpreted otherwise than as waste products of the early processing. The

a b

Figure 7.2 a. Charred remains of basal rachis segments of barley ear recovered from Zeewijk-West square 18782, feature 5; b. basal rachis remains of emmer recovered from square 22034.

261 Van der Veen & Jones 2007.
262 Van der Veen & Jones 2007.

same was probably true of emmer. The remains of emmer clearly show that spikelet dehusking was a practice taking place at the settlement. Even though the chaff of emmer is largely composed of glume bases and spikelet forks, which are removed at the later stage of processing (and are not persuasive evidence of local cultivation), basal rachis segments were also found in some samples (Fig. 7.2b). This suggests that emmer might also have been brought into the settlement as whole ears or even as entire plants after harvest and then both threshed and dehusked at the settlement.

Residues of cereal processing

At most settlements, the processing remains of cereals (cereal chaff, straw and weed seeds) are recovered either because the processing of the crops took place there or because the threshing by-products were brought into the settlement for various purposes such as fodder, bedding, fuel and building material.[263] At Zeewijk, it is clear that processing took place at the settlement. It seems relevant that the charred seed assemblage of wild taxa from Zeewijk largely comprises plants characteristic of high salt marsh vegetation (see Appendix VII). At least some of these halophytes are likely to have been harvested as arable weeds and then to have arrived on site with harvested cereals. One characteristic feature of the weed assemblage observed in the experimentally cultivated plots in the coastal area of the northern Netherlands was that various halophytes, including annual sea-blite (*Suaeda maritima*), sea milkwort (*Glaux maritima*), glasswort (*Salicornia europaea*) and sea-spurrey (*Spergularia marina/media*), grew in the fields together with weeds characteristic of a freshwater environment such as knotgrass (*Polygonum aviculare*), redshank (*Persicaria maculosa*) and black nightshade (*Solanum nigrum*).[264] At Zeewijk, if we look at the rather scarce assemblage of potential arable weeds from freshwater habitats (incl. *Chenopodium album*, *Persicaria lapathifolia*, *Solanum nigrum*), represented by as few as one or two charred seeds in some samples, we might conclude that if the crop fields were infested by any weeds, they were actually wild plants characteristic of salt marshes, including marshmallow (*Althaea officinalis*), various species from the orache group (*Atriplex portulacoides*, *Atriplex patula/prostrata*, *Atriplex littoralis*), sea aster (*Aster tripolium*), possible various grasses (*Hordeum marinum*, *Puccinellia distans*, *Bromus* and *Festuca/Lolium*) and possible other halophytes. The seeds of the orache group were particularly abundant in the charred assemblage. At any other location, species from the group *Atriplex patula/prostrata* would have been considered potential arable weeds. Here in the coastal area, however, they also occur naturally. Still, some seeds of the orache group may have entered the assemblage as potential arable weeds.

If we are correct in interpreting the charred seed assemblage of halophytic plants as at least partly representing arable weeds at Zeewijk, this would be an indication that the cultivated fields were located in a salt marsh area, most likely on the highest parts of salt marshes and on the levees.

The model of intensive agriculture proposed for Zeewijk

We could not have wished for better supporting evidence for local crop cultivation than plough marks (or ard marks), many of which were found at Zeewijk-East (Fig. 7.3).[265] The Zeewijk plough marks were recorded on the same levels as the Neolithic features; there is therefore no doubt that they are contemporaneous with the Late Neolithic settlement. This would indicate that people who lived at Zeewijk had small fields (or cultivated plots) located close to the settlement and that they were ploughed by ard. The type of agriculture practised at Zeewijk may have resembled one of the models proposed for Neolithic farming in central and southeast Europe, referred to as *intensive* or *garden* cultivation integrated with small-scale animal husbandry practices.[266] In this model, the terms *intensive* or *garden* cultivation are used to indicate the small size of the cultivated fields or plots (located *close to home*) and the high labour input. In this model of *small-scale intensive farming* a relatively small number of animals would be kept – primarily for their meat – close to the settlement.[267] Crop cultivation in this system is relatively high-yielding due to the high input of labour (for example weeding, careful tillage, manuring, etc.), and is small-scale, within the labour capacity of a household rather than extended family groups.[268]

At Zeewijk, sandy levees near the settlement were probably more than sufficient for small-scale, intensive cultivation. The cereal

263 Cf. Van der Veen 2007.
264 Van Zeist *et al.* 1976.
265 Nobles, this volume Chapter 3.
266 Bogaard 2005; Jones 2005.
267 Neolithic cattle hoof marks were found at Zeewijk, Mienakker and Keinsmerbrug.
268 Bogaard 2005.

Figure 7.3 Plough marks in the form of a criss-cross arrangement at Zeewijk-East in 1992.

crops appear to have been sown in spring in order to avoid flooding with salt water during autumn and winter. The use of cattle as tracking animals at Zeewijk should not be ruled out, as the best evidence for the use of the ox-drawn ard dates to the Corded Ware phase (c. 2800-2400 BC) at the end of the Neolithic in the Alpine Foreland.[269] This practice would not alter the scale of cultivation significantly, however.[270]

If we combine all the evidence from Zeewijk – the relatively rich charred crop and weed assemblage, the location of cultivated plots near the settlement, the use of the ard for ploughing – it appears that Zeewijk reflects small-scale, intensively maintained cultivation, and represents the usual pattern of mixed intensive farming practised across much of Neolithic Europe.

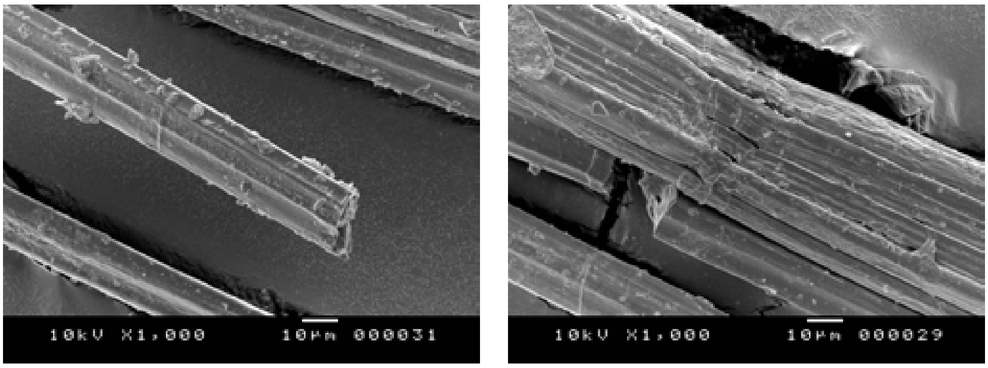
7.4.2 Flax *(Linum usitatissimum)*

Although the cultivation of cereals was the main agricultural activity at Zeewijk, it seems that flax was also important for the settlers. Charred flax seeds were found in most of the samples (Fig. 7.4a) and in one sample a concentration of mineralised seeds was found in addition to the charred seeds. Astonishingly large numbers of charred seeds were also encountered at Aartswoud, another site of the Single Grave Culture in the area.[271] No capsule remains or stem remains were found. At Zeewijk, however, in addition to seed remains, there were also remains of charred cordage (or string) made of flax fibres in which a number of fibres are twined around each other (recovered from trench/square 22704, feature 55) (Fig. 7.4b). Recent

269 Schibler & Jacomet 1999.
270 Halstead 1995; Bogaard 2005.
271 Pals 1984.

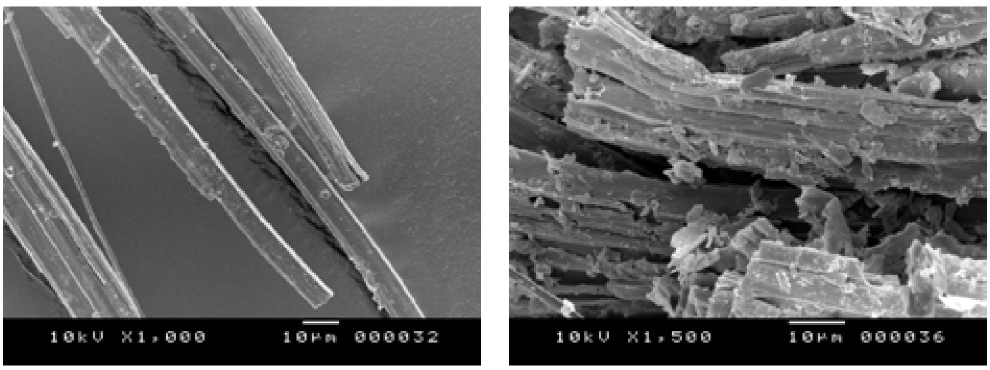
a b

Figure 7.4 a. Remains of charred flax seeds recovered from Zeewijk-West square 18782, feature 5; b. charred cordage or string of flax fibres in which a number of fibres are twined around each other, recovered from square 22704, feature 55, botanical sample. Unfortunately, after the recovery from the archaeobotanical sample and through the process of drying, the individual elements loosened and separated from each other.



a b

Figure 7.5 a. SEM micrographs of experimentally charred flax fibres: individual fibres; b. a group of fibres lumped together; fibre nodes (or dislocations) characteristic of flax fibres are visible on individual fibres.



a b

Figure 7.6 a. SEM micrographs of charred flax fibres from archaeological remains of cordage or string; b. group of flax fibres lumped together (from Zeewijk-West, square 22704, feature 55).

work on Neolithic flax assemblages from Europe provides evidence of the cultivation of different forms of flax for its oil-rich seeds and for fibre production since at least the 3rd millennium BC.[272] Even though the remains of flax found at Zeewijk suggest that flax was used there for

272 Maier & Schlichtherle 2011.

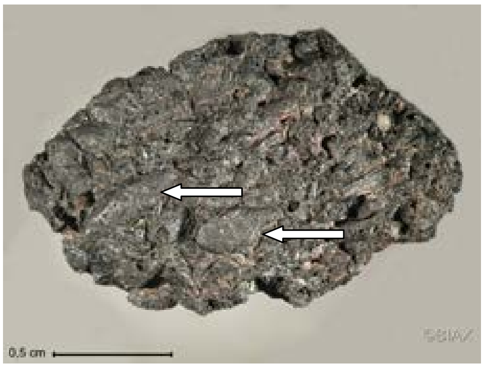


Figure 7.7 Remains of charred processed emmer food (fragmented emmer grains are embedded in the lump , marked by arrows) from Zeewijk-West square 1491, dried residue.

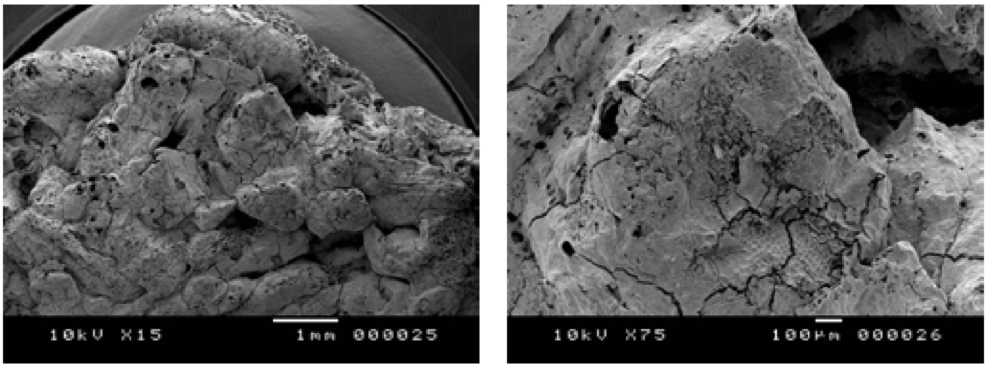
both the seeds and the fibres, it is difficult to specify whether different forms of flax plants were cultivated for different uses. The identification of archaeobotanical fibres was based on comparison with experimentally charred flax fibres (both viewed under an SEM microscope) (Figs 7.5 and 7.6).

7.5 Processed cereal food

At Zeewijk, some 30 charred remains (or lumps) of processed food products were found, which clearly indicates that food was prepared at the settlement. Binocular incident light analysis, accompanied by an SEM microscope, revealed that these consist of cereals. At least two different types of cereal products were identified. Some of the specimens studied revealed fragmented cereal grains lumped together (examples are illustrated in Figs. 7.7 and 7.8), suggesting porridge-like food made of coarsely crushed or ground cereal grains. One of the specimens of this porridge-like food studied was clearly made of emmer grains, which were still recognisable in the lump (Fig. 7.7). The other remains of cereal products showed rather compact or *mushy* matrices suggesting food made of finely ground grain. In one of the specimens studied from this group, the presence of emmer chaff (i.e. glume base) embedded in an otherwise featureless and compact matrix suggests food, possibly mush made of emmer grain (Fig. 7.9).

7.6 Wild plant foods

In addition to the crop plants, a number of wild edible plants were identified at Zeewijk, suggesting that gathering activities also played a role in the economy of the site. These gathered plants included crab apples (*Malus sylvestris*), acorns (*Quercus*), hazelnuts (*Corylus avellana*) and two types of root foods: tubers of sea-club rush (*Bolboschoenus maritimus*) and rhizome of a knotgrass (*Polygonum*). As they were all found in charred remains, they display obvious signs of having been processed by people.



a b

Figure 7.8 a. SEM micrographs of processed cereal food (outlines of fragmented grains are still visible) from Zeewijk-West, square 1498, dried residue; b. possibly orache seed embedded in cereal matrix.

Figure 7.9 a. Processed cereal food (probably emmer mush) with emmer glume base embedded in the matrix; b. detail, recovered from Zeewijk-West, square 22034, feature 7, botanical sample.

7.6.1 Root foods

Tubers of sea club-rush *(Bolboschoenus maritimus)*
More than a few hundred charred intact and fragmented tubers and a few rhizome fragments of sea club-rush (*Bolboschoenus maritimus*) were found at Zeewijk (examples are presented in Fig. 7.10). This is an exceptional number of specimens. The identification of the fragmented tubers, sometimes preserved as isolated parenchyma, was based on the anatomy of parenchymatous and vascular tissue examined under an SEM microscope (Fig. 7.11).

The numerous remains of sea club-rush from Zeewijk inspired the question as to whether such a numerous assemblage might indicate substantial human exploitation of this wild root food. Charred tuber remains of the sea club-rush had been found earlier at the Neolithic coastal site in the Netherlands, where they were considered a source of starchy food in addition to cereals and other edible roots.[273] The plant is also frequently recovered from ancient sites in the Levant and Anatolia.[274] Particularly noteworthy are the high frequencies of both tubers and seeds recovered from domestic contexts of Neolithic Çatalhöyük.[275] Also, charred rhizome remains of a closely related species, common club-rush (*Schoenoplectus lacustris*), were found together with other edible plants at two hunter-gatherer sites in the Netherlands; there they were considered root foods.[276]

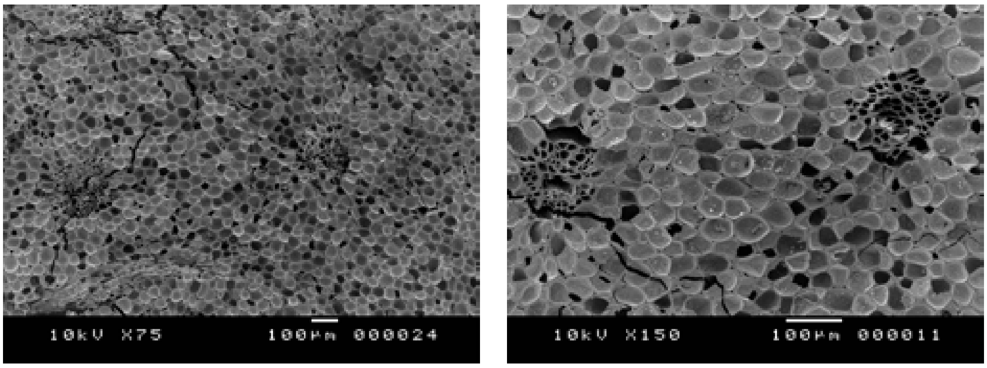
Sea club-rush is a semi-aquatic plant of the sedge family (Cyperaceae) whose optimum conditions are in brackish marsh vegetation, though it can also grow along the edges of fresh water.[277] It is a perennial plant in which the tubers are formed as terminal swellings of the rhizome. The tubers are ovoid, measuring approximately 3 cm in diameter. The tubers and the rhizomes grow in the soil or mud below the water table, while the stems and the leaves protrude above the water.[278] The plant grows in stands that can vary from small patches to stands that cover extensive areas. Sea club-rush must have been quite common around all the sites studied at Keinsmerbrug, Mienakker and Zeewijk during the time of the Neolithic occupation, as the charred seeds of this species were well represented in the macro-remains assemblages.[279] The fact that many charred tubers were found at Zeewijk suggests that they must have been dug out from their muddy habitats and then brought to the site where they were exposed to domestic fires.

The tubers of sea-club rush fit a number of the criteria that make wild root foods suitable for intensive human exploitation.[280] Firstly, the mature tubers are relatively rich in carbohydrates and other nutrients (20% carbohydrate including fibre and starch, 1.4% protein, 0.2% lipid and 0.8% minerals).[281] Secondly, the tubers of sea-club rush are easily accessible and many tubers can be collected from just one plant (personal experience) and from stands that vary in size. Even though the tubers can be collected year-round, their highest nutritional values are found in late summer and early autumn. Wollstonecroft[282] addressed in detail the potential role of sea club-rush tubers in the early human diet, and in conjunction with processing experiments assessed the methods

273 Kubiak-Martens 2006.
274 Wollstonecroft 2009.
275 Fairbairn *et al.* 2002, Wollstonecroft 2009.
276 Perry 1999, 2002; Kubiak-Martens, Kooistra & Verbruggen, in press, 2014.
277 Van der Meijden 2005.
278 Clevering *et al.* 1995.
279 Kubiak-Martens 2012; Kubiak-Martens 2013.
280 Wollstonecroft 2009.
281 Kirk & Sawyer 1991; Wollstonecroft 2009.
282 Wollstonecroft *et al.* 2008; Wollstonecroft 2009.

a b

Figure 7.10 a. Sea club-rush (*Bolboschoenus maritimus*) tuber recovered from Zeewijk-West square 13721, dried residue. The tuber is somewhat flattened, possible crushed before charring; b. sea club-rush tuber from square 22674, dried residue.



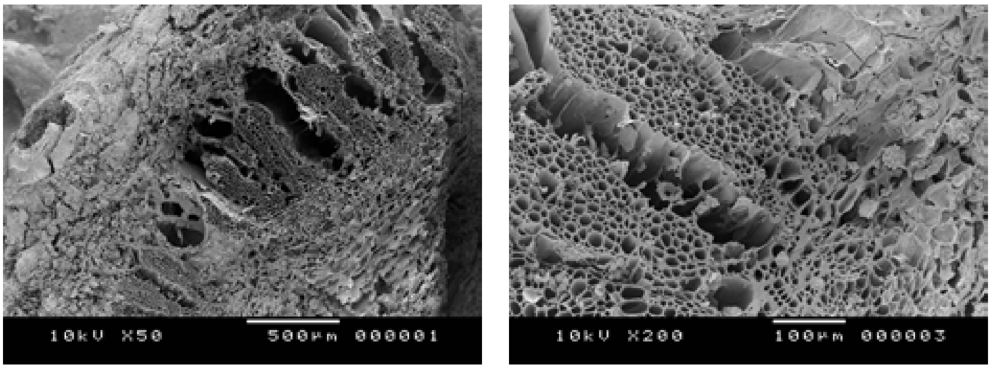
a b

Figure 7.11 a. SEM micrographs of the sea club-rush (*Bolboschoenus maritimus*) tuber parenchyma with vascular bundles randomly arranged within the parenchymatous tissue; b. two individual vascular bundles with fibre sheath surrounding the xylem and phloem tissue (from Zeewijk-West square 22674, dried residue).

which may have been used in the past to prepare the tubers for consumption. The results of this experimental work show that sea club-rush tubers can be prepared to give edible products by applying sequences of processing techniques, including pulverising. This step is necessary in order to disrupt the parenchyma cell walls and consequently to make intercellular nutrients accessible. Cooking alone, even though necessary to make the starches palatable and digestible, does not promote the softening of the tubers. Only tubers which were pulverised (into a kind of flour) and subsequently cooked with water to make a mush or gruel, or baked as bread, produced an edible meal.

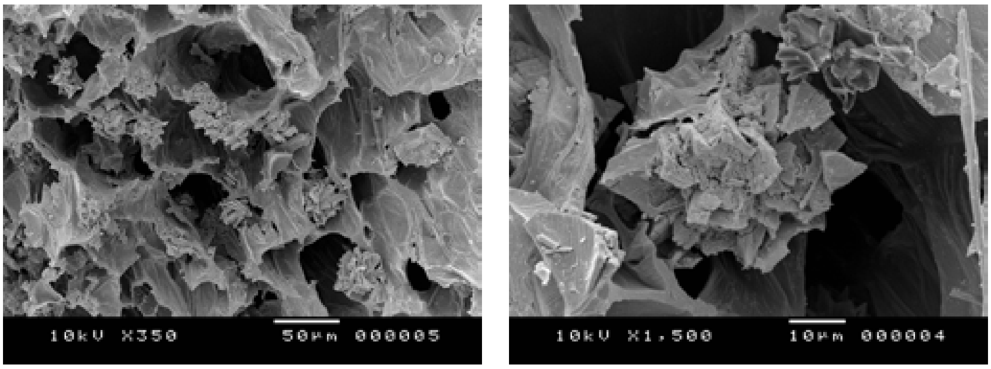
At Zeewijk, the abundant occurrence of sea-club rush tuber remains is significant if we consider their use as food. Whether the tubers were processed in a way similar to that proposed by Wollstonecroft and co-workers is difficult to assess. When we looked at the stone assemblage, we were struck by the fact that many of the stone artefacts recovered at the site appeared to have been used primarily for the processing (pounding or pulverising) of plant material.[283] Even more interesting is that some of the organic residues encrusted on pottery revealed a truly mushy nature, suggesting that the food prepared in at least some of the vessels was well processed (possibly crushed, pounded or even pulverised) and subsequently cooked.[284] All the mushy residues share the well-defined chemical signals for the presence of proteins and polysaccharides, often with the addition of lipids, suggesting that both plant and animal components were used in the cooking of these mushy meals. Sea club-rush tubers might have been one of the starchy foods

283 García-Díaz, this volume.
284 Oudemans & Kubiak-Martens, this volume.



a b

Figure 7.12 SEM micrographs of charred rhizome of knotgrass (*Polygonum*), TS section, recovered from Zeewijk-West, square 19484, dried residue; a. parenchymatous central part with vascular bundles arranged in a ring across the radius of the rhizome; b. radially elongated xylem tissue.



a b

Figure 7.13 a. Parenchymatous tissue with druses (detail of Figure 7.12); b. individual druse.

(besides cereals and acorns) that was processed and then subsequently cooked in ceramic vessels at Zeewijk.

Rhizome of knotgrass *(Polygonum)*
One charred rhizome fragment of a knotgrass (*Polygonum* sp.), approx. 3 cm across was found in one of the dried residue samples from Zeewijk-West (trench/square 19484). The identification was based on anatomical features of vascular tissue observed under an SEM microscope. The vascular tissue was arranged in a ring across the radius of the rhizome (Fig. 7.12a). The vascular bundles were in collateral arrangements with xylem tissue adjacent to the phloem. Radially elongated xylem elements were preserved almost intact, while phloem tissue was reduced to an amorphous mass (Fig. 7.12b).

Many compound crystals consisting of calcium salts (druses) had been preserved within the parenchyma cells of the cortex (Fig. 7.13).

The probability that rhizomes of a knotgrass (*Polygonum* sp) were introduced to the site at Zeewijk as a gathered starchy food is supported by archaeobotanical finds recovered from other archaeological sites. Charred remains of *Polygonum* sp. rhizome were found together with charred remains of other starchy food at Całowanie, an early Mesolithic site in Poland.[285]

There are also historical claims that the rhizomes of various *Polygonum* species are edible. Pierpoint Johanson (1862) reports of bistort (*Polygonum bistorta*):[286] 'Although very bitter and astringent to the taste in the raw state, the root contains an abundance of starch, and, after being steeped in water and subsequently roasted, becomes both edible and nutritious'. The ethnographic records also reveal that several species from the knotgrass family (Polygonaceae) were used as food by the northern people of Canada, and also as

[285] Kubiak-Martens 1996.
[286] Mears & Hillman 2007.

a

b

Figure 7.14 a. Fragment of charred crab apple (*Malus sylvestris*) fruit with partially preserved calyx from Zeewijk-West, square 13053, dried residue; b. recent wild crab apples (Wikimedia Commons). Crab apples are very tart but after the first frost or after cooking they become soft and taste sweeter.

emergency food in historical times in Scandinavia and Germany. Bistort (*Polygonum bisorta/Persicaria bistorta*) and alpine bistort (*Polygonum viviparum*) were gathered for their edible young leaves and stems and also for their rhizomes. The rhizomes were eaten either raw or cooked, or roasted over a fire.[287]

Even though the identification of the Zeewijk remains does not reach species level we can predict that neither *Polygonum bistorta* nor *Polygonum viviparum* can be expected in the landscape surrounding the Neolithic site at Zeewijk. One *Polygonum* species – knotgrass (*Polygonum aviculare*) – was found in the macro-remains assemblage. This plant grows very fine rhizomes, however, and should not therefore be considered in our search for a species which grows rhizomes approx. 3 cm in diameter. There is one more *Polygonum* species which might have grown in the coastal area of the Noord-Holland in the Neolithic (even though very rare today) and which might have been collected for its rhizomes: sea knotgrass (*Polygonum maritimum*). Until we have the species in our reference collection of experimentally charred parenchymatous tissue, this will remain no more than a supposition.

7.6.2 Wild fruits and nuts

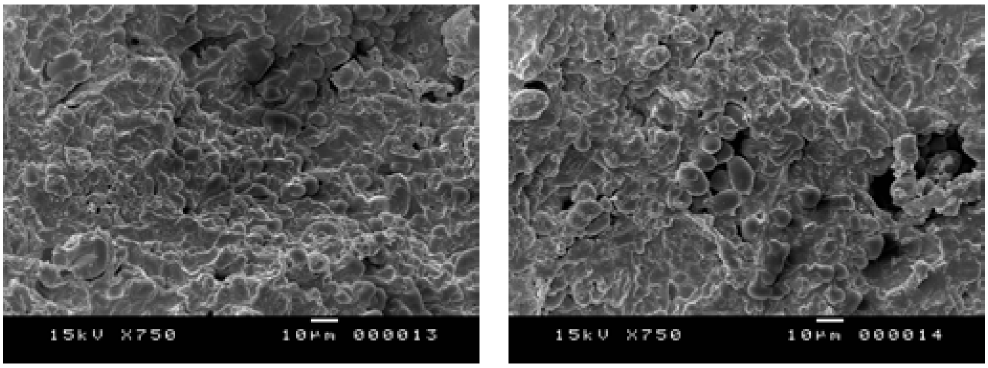
The group of gathered fruits and nuts is represented by crab apple (*Malus sylvestris*), hazelnut (*Corylus avellana*) and acorns of oak (*Quercus*). The remains of crab apple were found in two samples from Zeewijk-West. They were represented by charred fruit flesh fragments; in one of these samples, a partially preserved calyx was found (Fig. 7.14). Charred remains of crab apple were also found at other Single Grave Culture sites in the region: Aartswoud, Kolhorn and Mienakker.[288] The apple halves found at Aartswoud revealed concave margins and wrinkled skin, suggesting that the fruits were dried, possibly for prolonged storage and later use.[289] This feature was also observed on apple remains from other Neolithic sites in the Dutch coastal area.[290] Charred apple remains may also indicate some methods of cooking the crab apples in order to enhance their palatability, such as baking in hot ashes.[291]

The charred remains of acorn (*Quercus*), preserved at Zeewijk as fragmented cotyledons (Fig. 7.15a) and isolated remains of cotyledon parenchyma, suggest that they were also processed at the site (Fig. 7.15b). No pericarp remains were found, suggesting that the acorns' shells were peeled off prior to contact with fire. Charred acorn remains were also found at other Single Grave Culture sites in the region.[292] Unfortunately, the identification of the acorn remains, when based solely on morphological or anatomical features, cannot be specified to the species level. We can only suggest that the acorn remains preserved here derived from one of the two native species in the Netherlands, either from the pedunculate oak (*Quercus robur*) or from the sessile oak (*Quercus petraea*). Both species represent different ecological preferences. Pedunculate oak would prefer nutrient-rich, moist soil, while sessile oak would prefer dry to

287 Kuhlein & Turner 1991; Maurizio 1926; Eidlitz 1969.
288 Pals 1984; Drenth, Brinkkemper & Lauwerier 2008, Kubiak-Martens 2013.
289 Pals 1984.
290 Kubiak-Martens 2006.
291 Kuhnlein & Turner 1991.
292 Pals 1984; Drenth, Brinkkemper & Lauwerier 2008; Kubiak-Martens 2013.

a b

Figure 7.15 a. Charred oak acorn fragment from Zeewijk-West, square 13103, dried residue; b. SEM micrograph of acorn parenchyma from square 20752, dried residue.



a b

Figure 7.16 a.b. SEM micrographs of acorn parenchyma (un-charred) to illustrate how densely packed with starch granules the acorn parenchyma cells are.

fairly moist, acidic, nutrient-poor sandy soils.

The acorns from both species are edible when properly prepared and they are rich in carbohydrates, unlike other nuts, such as hazelnuts, which are mainly rich in fat. Acorns' nutritional content is similar to that of cereals, being largely a source of carbohydrates (mainly starch, Fig. 7.16) with a small amount of protein and fat.[293] Acorns, however, contain varying amounts of tannic acid – depending on the species of oak – which gives them a bitter taste, and which needs to be removed before the acorns can be used for food.[294] Various methods of processing acorns have been described in the ethnographic literature. Acorns can be pounded into flour or gruel, then cooked (with meat) as soup or mush, be used to make acorn bread, or they can be roasted in hot ashes.[295] The detection of acorn parenchyma in organic residues on ceramic vessels from Zeewijk suggests that cooking acorn mush or soup was one of the methods used to prepare acorn meal at Zeewijk.[296] The charred cotyledon remains (fragmented acorn halves) may indicate some method of processing using contact with fire prior to cooking.

7.7 Plants used as raw material

Various grasses, rushes and sedges would have served many purposes such as building materials or furnishings for the dwellings. The stems and leaves of reed (*Phragmites*), great sedge (*Cladium mariscus*) and sea club-rush (*Bolboschoenus maritimus*) may all have been used for thatching roofs and making the walls of shelters and/or houses. Grey club-rush (*Schoenoplectus tabernaemontani*) stems may have been used to make sitting and sleeping mats, floor coverings and to insulate the walls of the houses. Dried

293 Kuhnlein &Turner 1991.
294 Mason 1995.
295 Chestnut 1974, Kuhnlein &Turner 1991.
296 Oudemans & Kubiak-Martens, this volume.

stands of reed, rushes, sedges, and even glasswort (*Salicornia europaea*) and sea aster (*Aster tripolium*) may have been collected for fuel.[297] It would have been poor-quality fuel for domestic fires, but nonetheless a welcome addition to firewood, which was far from abundant near the site, located as it was in an open tidal landscape.

7.8 Conclusions

Like the two other sites studied, at Keinsmerbrug and Mienakker, Zeewijk was located in an open landscape influenced by brackish water. Herbaceous plants characteristic of tidal flats and salt marshes dominated the local vegetation. In this otherwise open landscape, patches or scatters of small trees or shrubs of willow, alder and aspen and possibly birch grew around the places where fresh water accumulated.

The principle crops at Zeewijk were naked barley and emmer. In addition, flax appears to have been an important crop, cultivated both for its oil-rich seeds and for its fibres. The botanical evidence suggests that both barley and emmer were brought to the site as ears of grain and possibly as complete plants. The botanical evidence also suggests that the people who lived at Zeewijk grew, harvested and threshed their own cereal crops.

The charred seed assemblage of wild taxa largely comprises plants characteristic of salt marsh vegetation. At least some of these halophytes are likely to have arrived at the settlement with harvested cereals. If we are correct in interpreting the charred seed assemblage of halophytic plants as (at least partly) representing arable weeds, this would be an indication that the cultivated fields were located in salt marsh areas, most likely on the natural levees. This suggests that people living at Zeewijk had small fields (or cultivated plots) located close or next to their houses.

Various wild plant foods may have supplemented the cereal-based diet. Some might have been collected at some distance from the settlement, possibly on the sandy outcrops at Wieringen to the northeast of Zeewijk (crab apples, acorns, hazelnuts), while others might have been collected near the site (sea-club rush tubers and knotgrass rhizomes, and orache seeds). As these wild plant foods were all found in the charred remains, they carry obvious signs of having been processed by people.

The nature of the agriculture that was practised at Zeewijk may have resembled one of the models proposed for Neolithic farming in Europe referred to as *intensive* or *garden* cultivation. In this model, small plots located close to the settlement were cultivated using the ard. Crop cultivation might have provided relatively high yields due to the high input of labour. At the same time, gathering activities also played a role in the economy of the site. Zeewijk appears to be a settlement site with all the activities characteristic of mixed intensive farming, and bears close similarity to Mienakker.

[297] See Kubiak-Martens 2012.

8 Mixed food dishes in Corded Ware ceramics. Botanical and chemical study of charred organic residues

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

8.1 Introduction

Even though ceramic vessels are frequently discovered in archaeological excavations, much remains unclear about the actual daily use of ancient pottery. It is often assumed, without further presentation of evidence, that ceramic vessels were used for the preparation, storage or consumption of food. Since the 1980s renewed interest in the functional aspects of vessels has encouraged specialists from different fields to pay more attention to organic residues found in association with ceramics.

It is extremely challenging to determine actual prehistoric vessel use, to find out what mixtures of edible materials people prepared in ceramics, what pots they used for what kind of foods, or whether they used the same pots for the same foods all the time. Recently, botanists and chemists have started to join forces in order to identifying remaining traces of the original vessel contents preserved after thousands of years of burial.

It was exactly this kind of combined botanical and chemical organic residue analysis that was performed on Zeewijk ceramics in order to identify what foods or non-foods were prepared in the vessels found at this site. Each discipline used its own highly sensitive technique to identify informative characteristics in the remaining crusts. Archaeobotanical analysis combined with scanning electron microscopy (SEM) facilitated the study of anatomical features of very small fragments of plant tissues preserved in organic residues. Chemical analysis using direct temperature-resolved mass spectrometry (DTMS) enabled the identification of a wide range of chemical components (e.g. lipids, proteins, polysaccharides, plant waxes) in the residues. By combining the two disciplines it was possible to obtain an insight into the Neolithic food preparation methods practised at Zeewijk. Such a combined analysis had been successfully applied earlier to a number of pottery assemblages from various archaeological sites,[298] including two other sites from the Single Grave Culture (Keinsmerbrug and Mienakker).[299] The combined archaeobotanical and chemical approach aims to afford a more detailed insight into the practices of food preparation and cooking in the Single Grave Culture in general, and into the subsistence at Zeewijk in particular.

8.2 Materials and methods

8.2.1 Ceramics

Beckerman divided the Zeewijk ceramic assemblage into three sub-assemblages: Zeewijk-West (northern section); Zeewijk-West (southern section) and Zeewijk-East. Beckerman shows that the sub-assemblages of Zeewijk differ in composition (especially in the temper and the frequency and type of decoration), and interprets this difference as an indication of chronological difference between the areas within the site.[300]

The three sub-assemblages are also different in terms of the frequency with which visible surface residues occur on ceramic sherds. In Zeewijk-West (southern section) 48% of the sherds contained surface residues, while in Zeewijk-West (northern section) the percentage was 36% and in Zeewijk-East only 25% of the sherds contained residues. The differences are quite large and it might be argued that this indicates a difference in function between the different sections of the site. Sier suggests that Zeewijk-East may have been used as a food-storage area while Zeewijk-West was used for more daily activities such as cooking food.[301] However, the cause may also lie in the overall lower quality of the ceramics in Zeewijk-East and the northern section of Zeewijk-West. In Zeewijk-East in particular, the degree of fragmentation was higher and residue preservation was significantly poorer.

There is also a correlation between the occurrence of surface residues and the thickness of the sherd. Thin and medium thin sherds tend to contain surface residues, and vessels decorated with cord impressions (which are almost always thin-walled) almost always contained residues. In spite of this, samples of residues were taken from as broad a selection of sherds as possible.

298 E.g. Kubiak-Martens 2006, 2008; Kubiak-Martens & Oudemans 2007, 2008, 2009.
299 Oudemans & Kubiak-Martens 2012, 2013.
300 Beckerman, this volume.
301 Sier 2001.

Table 8.1 Overview of sampled residues from Zeewijk with description and location of the residues on the vessel.

Residue no.	Vessel	Thickness (mm)	Decorated	In/ex	Rim/ wall/ bottom	Residue colour	Residue thickness (mm)	Fig. no.
ZW01 (s)	aa	6.5-7	no	in	w	brown black	3	8.1a
ZW02 (s)	C	7-8	no (perforated)	in	w	brown black	1	8.1b
ZW03 (s)	S	5.5-6	yes (type 1a/2IIb)	in	w	brown	2	8.1c
ZW04 (s)	III	5.5	no	ex	b	black	1	8.1d
ZW05 (s)	gg	9.5-11	no (protruding foot)	in	w	brown black	3	8.1e
ZW06 (s)	5	5.5-8	no	in	r	black	<1	8.1f
ZW07 (s)	13	6-7	yes (type 1d)	in	r	brown black	2	8.1g
ZW08 (s)	15	6-6.5	yes (type zigzag)	in	r	brown black	2	8.1h
ZW09 (s)	20	5.5-7.5	yes (type 1a/2IIb)	in	w	brown black	2	8.1i
ZW10 (s)	22	6	yes (type zigzag) (perforated)	in	r	black	1	8.1j
ZW11 (s)	15	6	yes (type zigzag)	in	r	black	3	8.2a
ZW12 (s)	25	8.5-11.5	yes (type 2IIf)	in	r	black	2	8.2b
ZW13 (s)	28	5-8	no (perforated)	in	r	black	2	8.2c
ZW14 (s)	29	4-4.5	yes (sp)	in	w	black	1	8.2d
ZW15 (s)	30	4-6.5	no	in	w	black	1	8.2e
ZW16 (n)	25	8.5-11.5	yes (fing)	in	w	black	1	8.2f
ZW17 (n)	35	6.5	no (perforated)	in	r	black	< 1	8.2g
ZO01	disc	9.5	no	in	w	brown black	< 1	8.2h
ZO02	baking plate	10.5	no	in	r	black	< 1	8.2i
ZO03	O.3	6.5	no (perforated)	in	r	black	1	8.2j
ZO04	O.4	11.5-12.5	no	in	r	brown black	1	8.3a
ZO05	O.5	5.5	yes (type 1d/1e)	in	r	black	2	8.3b
ZO06	O.4	11.5-12.5	no	in	r	black	< 1	8.3c
ZO07	O.7	9	no	in	r	black	< 1	8.3d
ZO08	O.8	7	no	in	r	black	< 1	8.3e

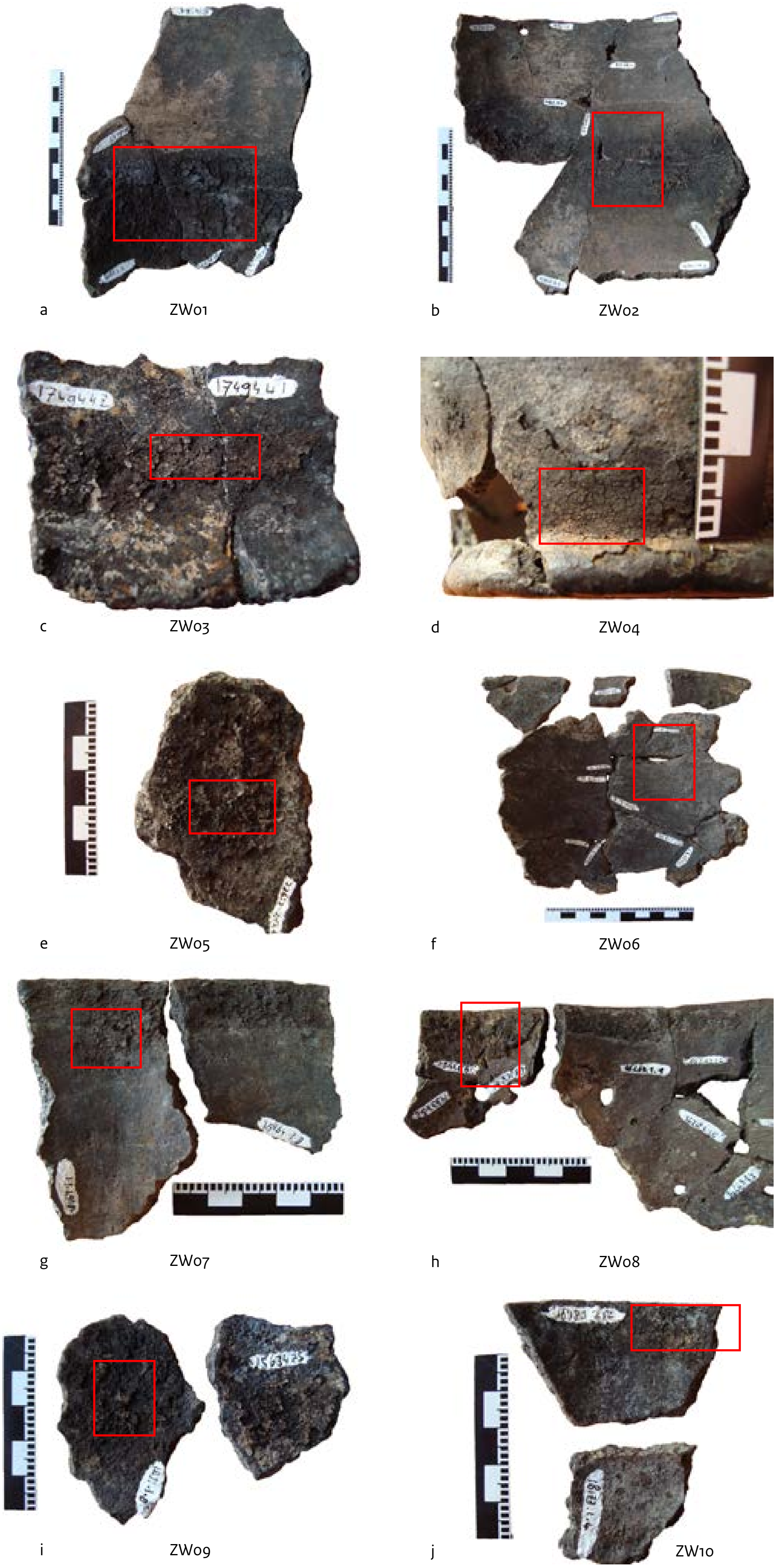
ZW = Zeewijk-West where (s) = Zeewijk-West south and (n) = Zeewijk-West north; ZO = Zeewijk-East). Type of decoration according to Beckerman, this volume. In/Ex indicates the position of the residue on interior or exterior vessel wall.

8.2.2 Sampling the organic residues

The material available for sampling consisted of groups of ceramic fragments packaged in plastic bags containing a plastic label. The ceramics had 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. Sometimes fragments with different find numbers had been glued together (see also Figures 8.1-8.3), indicating that vessel fragments were found as part of different find numbers.

During ceramic studies performed in the context of this publication, new vessel numbers or letters were given to individual vessels based on rim or bottom fragments.[302] The sampling for residues was performed after vessel individuals were determined and is based on the new vessel coding (Table 8.1). Later during the ceramic studies, some vessel parts that originally had separate vessel numbers were fitted together, and a few vessel numbers became redundant (doubles), including vessel 23 (=vessel 15), vessel 31 (=vessel 25) and vessel O.6 (=O.4). However, the residues had already been named, sampled and processed as separate units and will further be treated as such.

302 New vessel numbers are based on vessel individuals as determined by S.M. Beckerman: Beckerman, this volume Appendix II.



Figures 8.1a-j Ten residues on vessels from Zeewijk-West. The red rectangle shows the location of the sample.

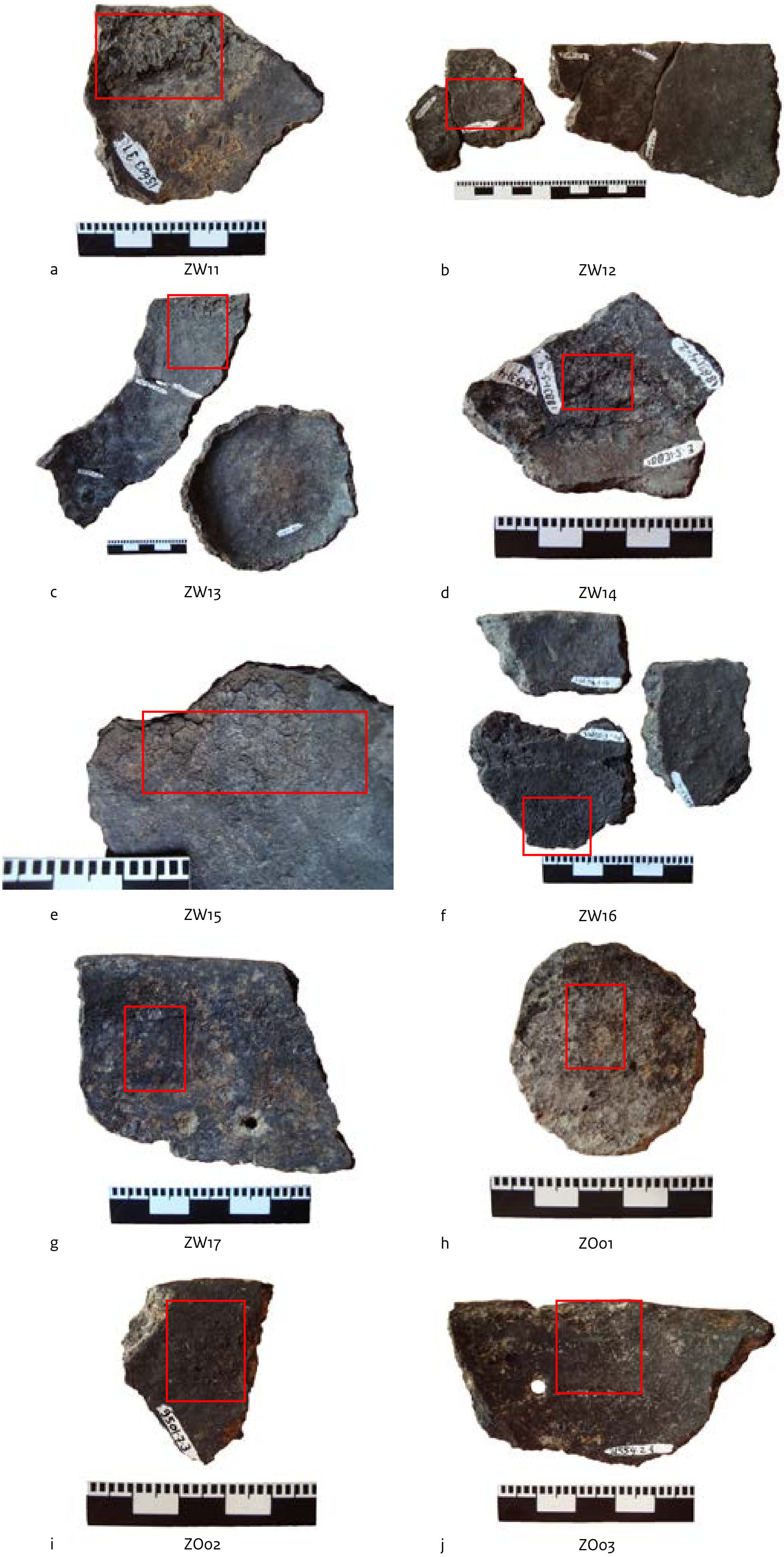


Figure 8.2a-j Seven residues on vessels from Zeewijk-West and three from Zeewijk-East. The red rectangle shows the location of the sample.

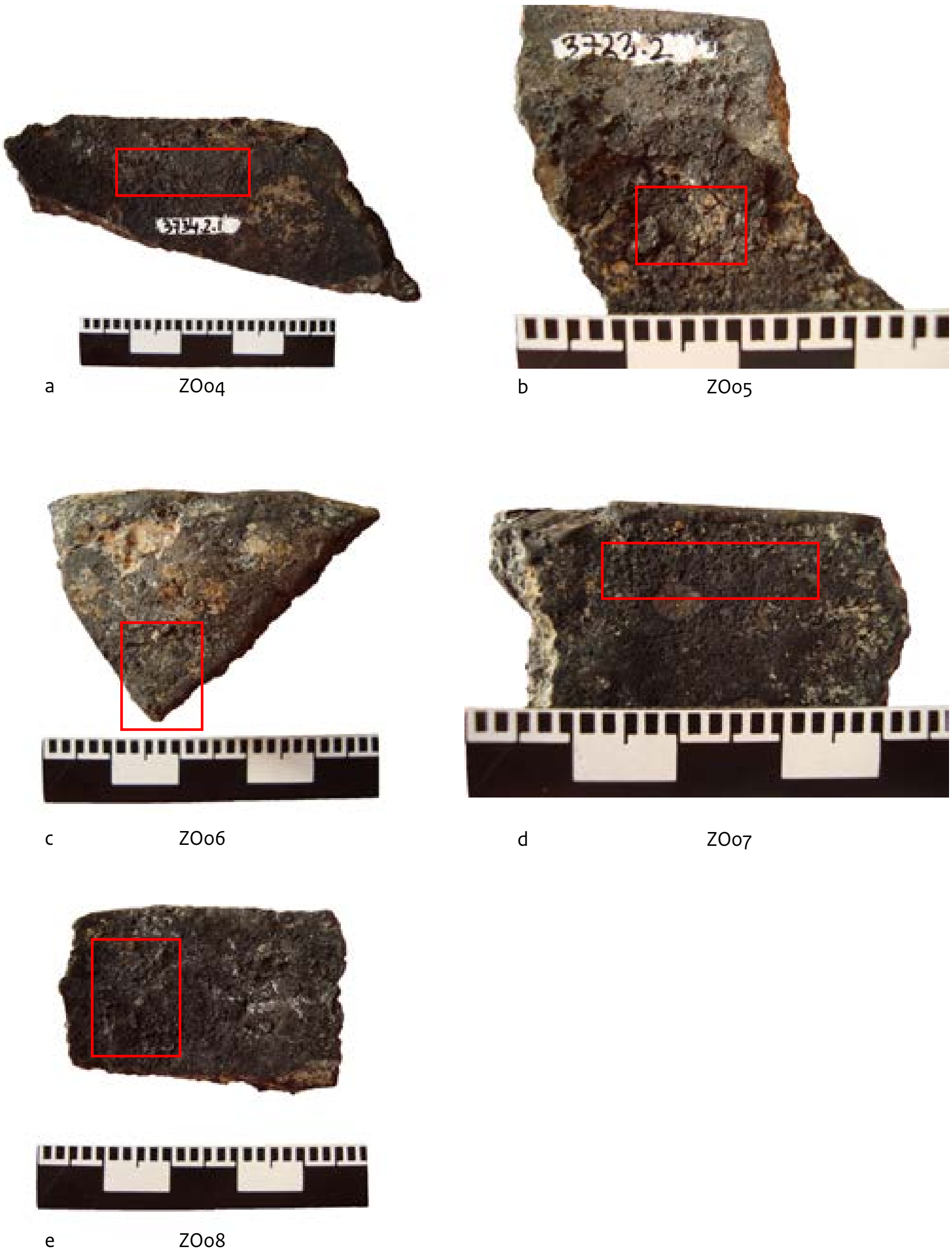


Figure 8.3a-e Five residues on vessels from Zeewijk-East. The red rectangle shows the location of the sample.

8.2.3 Botanical methods

The identification of the morphological characteristics of charred remains of processed plant food such as residues encrusted on pottery vessels, isolated lumps of plant mushes or bread-like food requires the use of the scanning electron microscope (SEM). This is necessary because the food processing techniques, which often involve grinding or pounding followed by cooking, destroy much of the morphologically recognisable plant remains. The use of an SEM microscope is therefore essential as it provides an opportunity to study both micromorphological and anatomical features of very small fragments of plant tissues that occasionally survive the process of food preparation and cooking.

The examinations discussed here were carried out at the SEM laboratory of the Naturalis Biodiversity Center in Leiden. Specimens of selected organic residues were first detached from the potsherds and 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 150 to 1500x. For reliability, different areas of several specimens from each organic residue were examined. The specimens were photographed and described.

8.2.4 Chemical methods

Small samples of complex solid organic materials are notoriously hard to identify by chemical analysis. However, even extremely small samples of ancient organic materials can render a great deal of information. The use of pyrolysis techniques such as direct temperature-resolved mass spectrometry (DTMS) makes it possible to characterise the complete composition of the material. The chemical DTMS 'fingerprint' gives information about a broad range of compounds interesting to archaeologists, including lipids (common in fats and oils), waxes (such as occur in beeswax or waxy plant leaves), terpenoids (major components of resins, pitches and tars), poly- and oligosaccharides (components of sugars and starches), small peptides and protein fragments (components of meat, fish, milk products, and some seeds and nuts), polycyclic aromatic compounds (such as occur in 'soot' and smoke condensates), and a broad range of thermally stable polymeric components (commonly called 'charred', or 'carbonised' materials).

Although pyrolysis techniques such as direct temperature-resolved mass spectrometry (DTMS) were originally developed for the study of organic materials in medicine and geochemistry, they have been applied in archaeological research since the early 1990s.[303] Applications for archaeological research include the study of complex organic solids such as amber,[304] perfumes and oils,[305] carbonised grains and pulses,[306] pitches and tars,[307] food remains[308] and other coatings on ceramics.[309]

During DTMS analysis heat is added to the organic material without the presence of oxygen (so the compounds cannot 'burn'). The added energy causes the fragmentation of large molecules into smaller fragments. The fragments are monitored in the mass spectrometer as they are released from the organic matrix.

The compounds are identified by their mass measured in the MS detector. The DTMS measurement shows the mass of all organic compounds released as a function of time (and thus of temperature, as the temperature is increased during measurement).

The DTMS measurement lasts roughly two minutes (120 scans) and usually consists of two phases: the desorption phase and the pyrolysis phase.

During the desorption phase (roughly scan 25-60) 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 due to evaporation or desorption. Some contaminants such as phthalate esters and sulphur-containing compounds are also released during this phase.

As the temperature increases during the pyrolysis phase (roughly scan 60-110), solid non-volatile compounds are released due to thermal fragmentation (breakdown of larger molecules into smaller ones). Due to the controlled circumstances in the mass spectrometer, fragments are indicative of the original

303 Shedrinksi, Stone & Baer 1991; Oudemans & Boon 1991.
304 Shedrinski *et al.* 1993.
305 Shedrinksi, Stone & Baer 1991.
306 Braadbaart *et al.* 2004.
307 Van Gijn & Boon 2006; Kubiak-Martens & Oudemans 2007; Oudemans 2007, 2009a, 2009b.
308 Oudemans & Boon 1991; Oudemans, Boon & Botto 2007; Oudemans 2008; Oudemans & Kubiak-Martens 2012, 2013
309 Boon 2006.

compounds. Important compounds 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.

Sample preparation
Prior to DTMS analysis a small amount of sample (50 micrograms) 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 vacuum) and subsequently analysed.

Instruments
The mass spectrometer was a JEOL JMS SX/SX 102 A tandem mass spectrometer. The following MS conditions were applied: 16 eV electron ionisation voltage, 8kV acceleration voltage, a scanning range of mass *m/z* 20 – 1000, and a scanning speed of 1 scan per second with a resolution of 1000. Data were collected and analysed with the use of a JEOL MS-MP9021D/UPD data system and appropriate software.

8.3 Results

In this paragraph the results from the botanical study will be presented followed by results from the chemical DTMS study.

8.3.1 Botany, scanning electron microscope

The results of the SEM analyses are presented here in scanning micrographs (Figs. 8.4-9) and summarised in Table 8.2. Nine of the 25 residues (36%) from Zeewijk analysed in this study revealed evidence of plant components initially cooked in ceramic vessels. These nine residues were often described as 'medium or thick crusts, loose, porous' or 'spongy', and in only a few cases as a 'solid or spongy' to 'solid crust'. Unfortunately, the extent of identification of microscopic plant tissues in these residues was rather limited. This is largely due to the poor preservation of residue components caused by the initial processes of food preparation and cooking and subsequent carbonisation/charring. Nonetheless, nine of the Zeewijk residues were divided into three groups representing various plant food components – identified to varying degrees – initially cooked in the vessels.

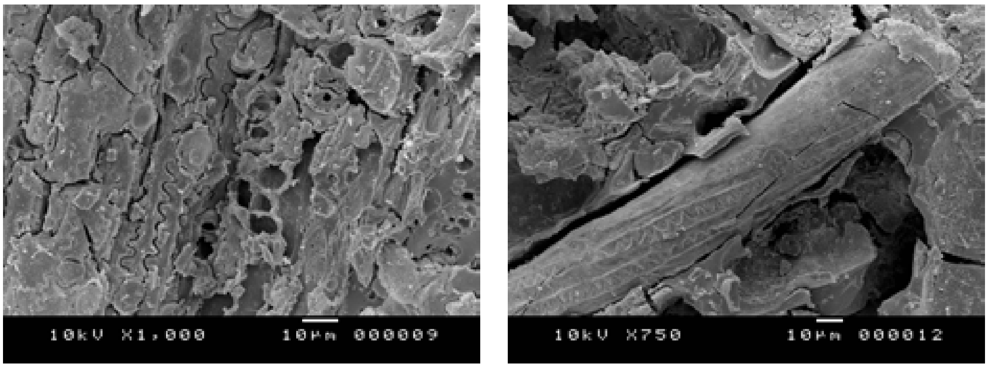
Group A: residues with epidermal fragments of emmer (*Triticum dicoccon*) chaff (ZW04 and ZW07), suggesting food at least partly made of emmer grain;
Group B: residues with cotyledon and cotyledon/seed parenchymatous tissue (ZW01, ZW03 and ZW08), suggesting food made of cotyledon component, most likely acorn (ZW08) and cotyledon/seed component (ZW01 and ZW03);
Group C: residues with plant component, but no further identification (ZW02, ZW09, ZW17 and ZO08).

In the remaining residues (ZW05, ZW06, ZW10, ZW11, ZW12, ZW13, ZW14, ZW15, ZW16 and ZO01, ZO02, ZO03, ZO04, ZO05, ZO06, ZO07), often described as 'fine' or 'thick' to 'medium rather solid' 'food crusts', no plant tissue was observed, thus no interpretation regarding botanical components could be made. (Only selected residues from this remaining group were SEM-photographed).

The three groups of residues which revealed information about food cooked in the ceramic vessels are discussed below in more detail, using one of the better-preserved residues from each group as an example.

Group A: residues with chaff epidermal fragments of emmer - residues ZW04 and ZW07, suggesting food that comprised emmer grain.

Two of the Zeewijk residues – ZW04 and ZW07 – encrusted on the interior surfaces of vessel III and vessel 13 respectively provided evidence of cooking emmer. Under the scanning electron microscope, a small silicified chaff epidermal fragment and an awn fragment of emmer (*Triticum dicoccon*) were observed in the ZW04 residue matrix (Fig. 8.4a, b). Both remains were embedded in an otherwise featureless fused residue matrix. It is assumed that the epidermal remains derive from fine emmer chaff such as glumes, lemma and/or palea.



a b

Figure 8.4 SEM micrographs of ZW04 (vessel III) organic residue (Group A), showing remains of fine emmer chaff embedded in residue matrix: a. Silicified epidermal long-cells embedded in an otherwise featureless fused residue matrix; b. Tiny fragment of silicified emmer awn embedded in featureless/ fused residue matrix.

Even though the epidermal fragment offered no possibility of measuring the length of individual epidermal long-cells (as no short cells were present within the epidermal tissue), there is no doubt about the identification. The material observed here can be compared with other well-preserved examples of silicified emmer epidermis encrusted in organic residues on pottery from other recently studied Neolithic sites such as Ypenburg, Keinsmerbrug and Swifterbant.[310]

Group B: residues with cotyledon and cotyledon/ seed parenchymatous tissue (ZW01, ZW03 and ZW08): suggesting food made of cotyledon component, most likely acorn (ZW08) and cotyledon/seed component but no further identification (ZW01 and ZW03).

Under the SEM microscope, the residues from this group revealed the presence of parenchyma tissue which resembles the parenchyma observed in cotyledon and/or fruit. In the Zeewijk ZW08 residue, the individual cells are thin-walled, polygonal in shape and their average size is 15-20 µm (Fig. 8.5). They are anatomically similar to archaeologically preserved acorn parenchyma observed in charred acorn remains (in Fig. 8.6a).[311] Even though the similarities are clear, the question is whether the process of preparation and cooking would leave any of the acorn parenchyma intact.

In order to study the effect of cooking on acorn parenchyma, a cooking experiment was carried out. The acorns were crushed in a stone mortar and then boiled in water for two hours.

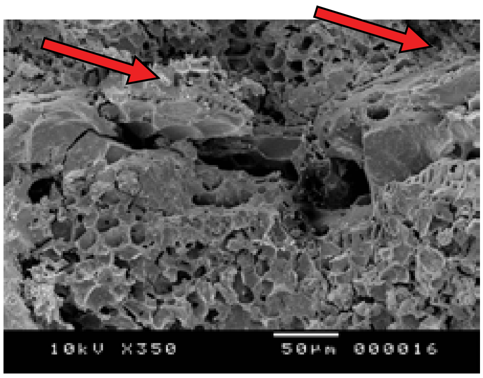
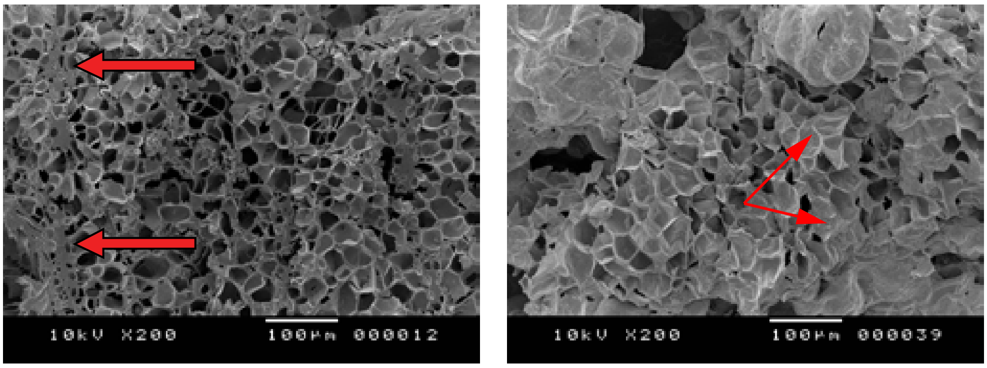


Figure 8.5 SEM micrograph of ZW08 (vessel 15) organic residue (Group B), showing a concentration of parenchyma tissue of acorn cotyledon. Individual parenchyma cells are thin-walled, polygonal in shape and on average 15-20 µm across. Possible remains of vascular tissue are marked by red arrows.

Our experiment showed that some acorn parenchyma survives the process of preparation and subsequent cooking, and was observed under the SEM microscope as concentrations of parenchyma tissue embedded in otherwise featureless matrix (Fig. 8.6b). This experimental approach created a strong additional link between the Zeewijk residues and the interpretation of cooked acorn mush.

Two other residues from Group B (ZW01 and ZW03) revealed fragments of parenchymatous tissue embedded in otherwise homogenous, rather porous to solid matrices. An isolated fragment of parenchyma was well observed in ZW03 residue (Fig. 8.7). Individual parenchyma cells are thin-walled, polygonal to

310 Kubiak-Martens 2008; Oudemans & Kubiak-Martens 2012; Raemaekers, Kubiak-Martens & Oudemans 2013.
311 Kubiak-Martens, Kooistra & Verbruggen 2014.



a b

Figure 8.6a. SEM micrograph of archaeological acorn parenchyma, showing polygonal parenchyma cells, 15-25 µm in size. The vascular tissue is preserved as fine sinuous lines, fairly solid due to carbonisation, positioned randomly within acorn parenchyma (marked by red arrows); b. SEM micrograph of experimentally cooked acorn mush, showing fragment of acorn parenchyma embedded in otherwise featureless matrix.

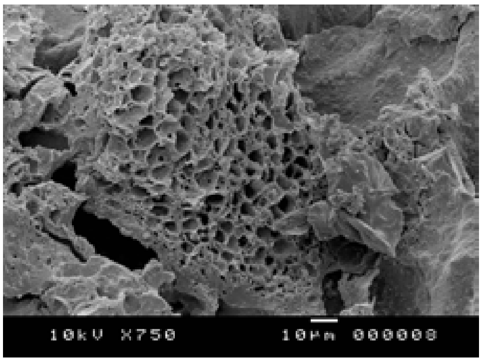


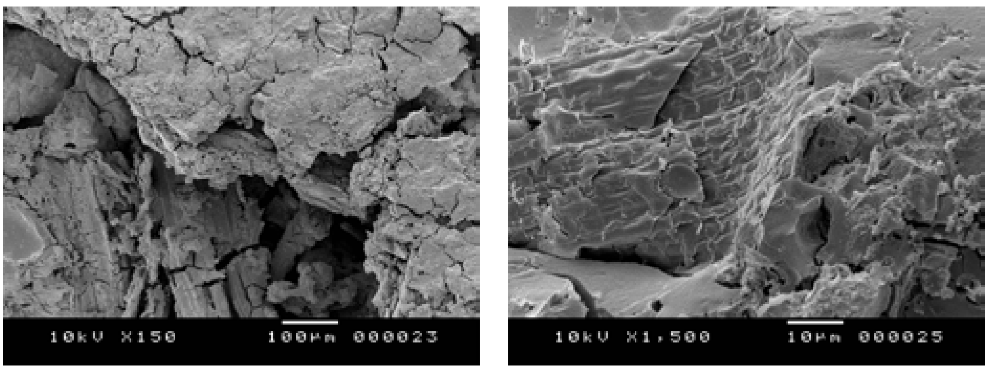
Figure 8.7 SEM micrograph of ZW03 (vessel S) organic residue (Group B), showing fragment of isolated parenchyma tissue, possibly of cotyledon or seed parenchyma.

more or less spherical and on average 8-10µm across. Small parenchyma cells suggest that the tissue observed in both residues might have derived either from cotyledon or seed parenchyma. Unfortunately, no further identification is possible.

Group C: Residues with plant component but no further identification (ZW02, ZW17 and ZO08).

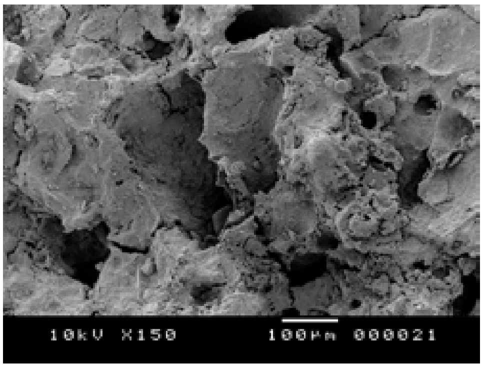
Under the SEM microscope, this group of residues clearly revealed the presence of plant tissue within the residue matrices but, due to extensive processing in prehistoric times or poor post-depositional preservation, no further identification was possible (see Fig. 8.8).

What is striking about some of the Zeewijk residues is their truly 'mushy' nature (observed

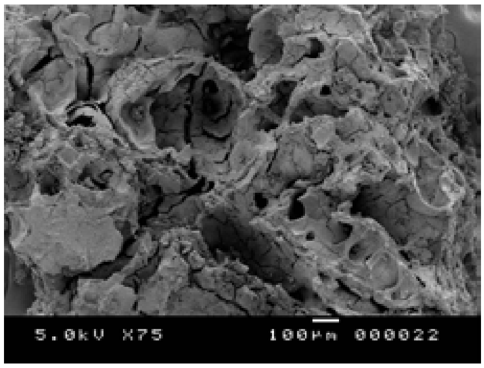


a b

Figure 8.8 SEM micrographs of two organic residues from Group C showing remains of plant tissue (possibly stem) embedded in featureless residue matrices: a. ZW17 (vessel 35) and b. ZO08 (vessel 47). No further identification.



a



b

Figure 8.9 SEM micrographs of two organic residues showing rather mushy matrices: a. Zeewijk residue ZW14 (vessel 29); b. Mienakker residue (MA10) (find number 7668). Both SEM images suggest well-processed and/or well-cooked food of possibly mixed plant and animal origin. No further identification.

in eight residues, see Table 8.2), suggesting that food prepared in at least some of the Zeewijk vessels was well processed prior to cooking: possibly crushed, pounded or even pulverised and subsequently cooked (Fig. 8.9a). The group of residues which represent well-processed and/or well-cooked food or food mushes was also characteristic of organic residues in ceramic vessels from Mienakker (see Fig. 8.9b).[312] Interestingly all the mushy residues from Mienakker and Zeewijk share the well-defined chemical signals for the presence of proteins and polysaccharides, often with addition of lipids.

Discussion of botanical results

As already discussed in the volumes on Keinsmerbrug and Mienakker, and in other studies on organic residues, in the case of glume wheat, some fine chaff such as glumes, lemma and/or palea will always survive the process of de-husking the grain – as they are firmly fused to the grain – and will make their way into the cooking pot along with supposedly clean grain.[313] The presence of fine emmer chaff epidermis in two residues from Zeewijk (ZW04 and ZW07) indicates that food cooked in these pots was at least partly prepared from emmer grain. Cooking of emmer grain with animal fat or fish oil in ceramic vessels was particularly well documented at Keinsmerbrug. The clear dominance of emmer in Keinsmerbrug residues led to the conclusion that the site had a special function. Only one specific kind of food (porridge with fat) was cooked at the site in different types of vessels.[314] At Mienakker[315] and Zeewijk, however, cooking emmer grain was obviously just one of the cooking activities performed using ceramic vessels.

The evidence for the processing of acorn food found in the content of ceramic vessels at Zeewijk (ZW08) is particularly noteworthy. The archaeobotanical analysis carried out on plant macro-remain samples from Zeewijk revealed numerous charred acorn remains, suggesting that acorns were an important source of starch-rich food in the Single Grave Culture.[316] Various possible methods can be proposed for the preparation of acorns for consumption at Zeewijk, such as roasting in hot ashes to remove (or neutralise) bitter tannins. However, botanical evidence of acorn cotyledon parenchyma in residue at Zeewijk now shows that acorns were processed in ceramic vessels (or at least this was one of the methods used to make acorn meal). The Zeewijk evidence for the processing of acorns in ceramic vessels corresponds with the identification of acorn-like starch granules extracted from carbonised residues encrusted on the Early Neolithic (Funnel Beaker) vessels from the site of Neustadt in northern Germany.[317] Obviously, the cooking of acorns in ceramic vessels in Zeewijk suggests that this wild starchy food, which is believed to have been a potential staple food in Mesolithic Europe, retained its importance beyond the transition to agriculture (evidence from Neustadt) and into the late Neolithic tradition as indicated by the Zeewijk cooking residues.

As mentioned earlier, it seems than many of the Zeewijk residues show evidence of processing prior to cooking. The featureless matrices of many Zeewijk residues suggest that

[312] Oudemans & Kubiak-Martens 2013.
[313] Oudemans & Kubiak-Martens 2012.
[314] Oudemans & Kubiak-Martens 2012.
[315] Oudemans & Kubiak-Martens 2013.
[316] Kubiak-Martens, this volume.
[317] Saul *et al.* 2012.

Table 8.2 Overview of SEM results from Zeewijk residues with a description of plant and non-plant tissues and a brief interpretation of food components.

Residue no.	Vessel no.	Residue type	SEM no.	Fig. no.	Results of SEM examination	Interpretation
ZW01	aa	thick crust, porous, loose	1, 3	-	parenchymatous tissue, possibly cotyledon /seed parenchyma	well-processed/-cooked food, possibly with cotyledon/seed component
ZW02	C	fine, thin to medium crust	5	-	possibly traces of parenchymatous tissue, otherwise rather solid homogenous matrix	food with plant component, well-processed/-cooked food, no further identification
ZW03	S	thick porous to solid crust	6, 8	8.7	fragments of parenchymatous (possibly cotyledon/ seed) tissue with polygonal to more or less spherical thin-walled cells, c. 8-10µm across embedded in otherwise homogenous, rather porous to solid matrix	well-processed/-cooked food, possibly with cotyledon/seed component
ZW04* ex	III	medium crust, rather solid	9, 12	8.4	silicified emmer chaff epidermis and emmer awn embedded in residue matrix	food made at least partly of emmer
ZW05	gg	a lot of spongy crust, loose	13	-	loose to solid matrix	no further identification
ZW06	5 (north)	very fine crust, powder-like	no SEM	-	no identification	-
ZW07	13	fine, kind of spongy, not glassy	14	-	silicified emmer chaff epidermis	food made at least partly of emmer
ZW08	15	rather solid thick crust	16	8.5	concentrations of parenchymatous tissue (acorn parenchyma), polygonal thin-walled cells, c. 15-20µ across embedded in otherwise homogenous, rather solid to porous matrix	acorn mush (shows similarity with experimentally charred acorn mush)
ZW09	20	medium crust, spongy to solid	17	-	porous to solid, irregular matrix, remnants of plant tissue, no further identification	food with plant component, well processed/-cooked food, no further identification
ZW10	22	medium crust, rather solid, some spongy	18	-	porous to solid, irregular matrix	well processed/-cooked food, no further identification
ZW11	15 (=23)	thick to medium crust, rather solid	19	-	porous to solid, irregular matrix	well processed/-cooked food, no further identification
ZW12	25	very fine crust	no SEM	-	no identification	-
ZW13	28	thick to medium crust, rather solid	20	-	rather solid, irregular matrix	no further identification
ZW14	29	medium porous crust, like pumas	21	8.9a	fine, porous matrix	well processed/-cooked mush like food, no further identification
ZW15	30	medium crust, solid to spongy	22	8.9b	fine, porous matrix; resemble ZW14	well processed/-cooked mush like food, no further identification
ZW16	25 (=31)	thick to medium crust, rather solid	no SEM	-	no identification	-
ZW17* (SEM ex)	35 (north)	IN crust very fine, soft, not able to take SEM sample; EX crust - thick, soft, not solid, possibly the same as IN crust	23	8.8a	homogenous, porous matrix, remains of plant (stem?) tissue	food with plant component, no further identification
ZO01	disk	fine, solid crust	no SEM	-	no identification	-
ZO02	baking plate	fine, solid crust	no SEM	-	no identification	-
ZO03	O.2 (=42)	fine, solid crust	no SEM	-	no identification	-
ZO04	O.4 (=43)	fine, solid crust	no SEM	-	no SEM sample	-
ZO05	O.5 (=44)	solid to porous crust	24	-	no identification	-
ZO06	O.4 (=45)	fine, solid crust	no SEM	-	no identification	-
ZO07	O.7 (=46)	fine, solid crust	no SEM	-	no identification	-
ZO08	O.8 (=47)	solid to porous crust	25	8.8b	fragment of plant (stem?) tissue	food with plant component, no further identification

food components were either crushed, pounded or even pulverised. The key point of interest is that many of these well-processed residues show chemical indicators of polysaccharides (see Table 8.4), meaning that starchy plant foods were included in the original vessel content. One of the possible reasons for using various processing techniques prior to cooking might be to transform starchy plants or plant parts into an edible product. For example, Wollstonecroft and co-workers [318] showed the necessity of processing sea club-rush (*Bolboschoenus maritimus*) tubers in order to transform them into meal. Sea club-rush is a plant that is frequently recovered from early sites in the Near East that provides edible starch-rich seeds and tubers. The experiments carried out by Wollstonecroft and co-workers show that pulverising the tubers was a necessary step which would facilitate tissue softening and rupture of the parenchyma cell walls, making intercellular nutrients such as starch accessible. Cooking alone, even though necessary to make the starches palatable and digestible, does not promote the softening of the tubers. Pulverised and subsequently boiled or baked tubers produce distinctly different results. Several hundred charred, complete but mainly fragmented tubers of sea club-rush were found in the archaeobotanical remains from Zeewijk. Interestingly, some tubers were somewhat flattened, as they would have been crushed before charring. [319] Tubers of sea club-rush have also been found at other early sites in the Netherlands, for example Middle Neolithic Schipluiden on the North Sea coast.[320] The archaeobotanical remains of sea club-rush suggest that the tubers of this marsh plant must have been dug out and brought to the settlements, where they were most likely processed for food. If they did indeed require extensive processing before they could be eaten, they might be considered one of the starchy foods processed and then subsequently cooked in ceramic vessels at Zeewijk.

8.3.2 Chemical results

The results of the DTMS analyses are presented in mass spectra (Figs. 8.10-17) and summarised in Table 8.3. Fifteen of the 25 residues analysed in this study (60%), contain enough organic material to obtain an informative result. One sample contained no identifiable compounds (ZW08) and four residues showed only very low organic signals (ZW07, ZW10, ZW14, ZO05) without many identifying compounds. Five additional residues primarily contained indicators of condensates originating from wood smoke (ZO03, ZO04, ZO06, ZO07, ZO08).

The 15 residues with adequate organic contents can be divided into two groups (one with three subgroups) based on their chemical characteristics:

- Group A: Residues containing mildly to severely heated proteins, mixed with some relatively degraded lipids, usually of unknown origin (ZW04, ZW05, ZW011, ZO03);
- Group B: Residues containing medium to severely charred mixtures of proteins and polysaccharides and lipids.
  - AP. Containing relatively well-preserved lipids of animal and plant origin (ZW01, ZW06, ZW09, ZW15, ZW16, ZO02).
  - A. Containing relatively well-preserved lipids of animal origin (ZW03).
  - U. Containing less well-preserved lipids of unknown origin due to contamination with sterols from human skin fat (ZW02, ZW12, ZW17, ZO01.

Both groups are discussed below in more detail using one well-preserved residue as an example.

Group A: Charred proteins with degraded hydrolysed lipids.

The DTMS total ion current (TIC) of sample ZW04 (DTMS-code 1december2011018) shows a signal of relatively low intensity (4.10^{6}) indicating that the residue contains a low amount of organic material (Fig. 8.10). In spite of this, the TIC shows a clear peak at an average temperature in pyrolysis phase B (peaking at scan 83). This kind of TIC is typical of a mixed polymeric fraction of medium condensation. In desorption phase A (scan 25-60), almost no increase is visible in the TIC intensity, indicating the presence of a small quantity of volatile compounds in the residue. The mass spectrum (Fig. 8.11) of desorption phase A (scan 25-60) shows a small amount of saturated free fatty acids, identifiable by the fragment ion *m/z* 129 and their molecular ions *m/z* 256 and 284 (for C16:0 and C18:0), and unsaturated free fatty acids (*m/z* 264 for C18:1). No indications can be

[318] Wollstonecroft *et al.* 2008.
[319] Kubiak-Martens, this volume.
[320] Kubiak-Martens 2006.

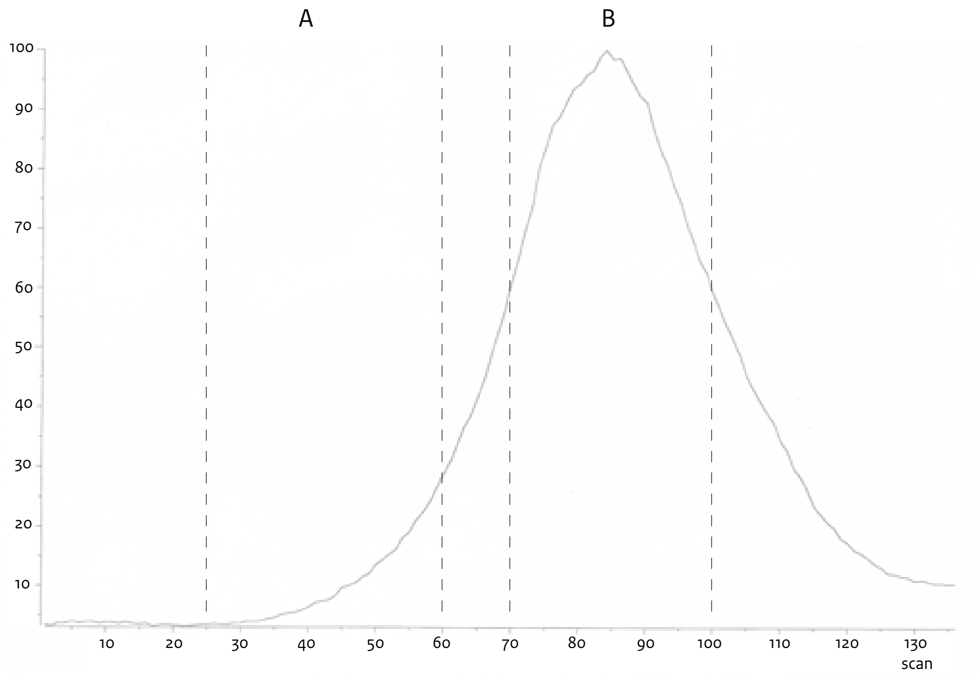


Figure 8.10 Total ion current (TIC) of residue ZW04 showing a clear peak in pyrolysis phase B (scan 70-100) and almost no increase in desorption phase A (scan 25-60).

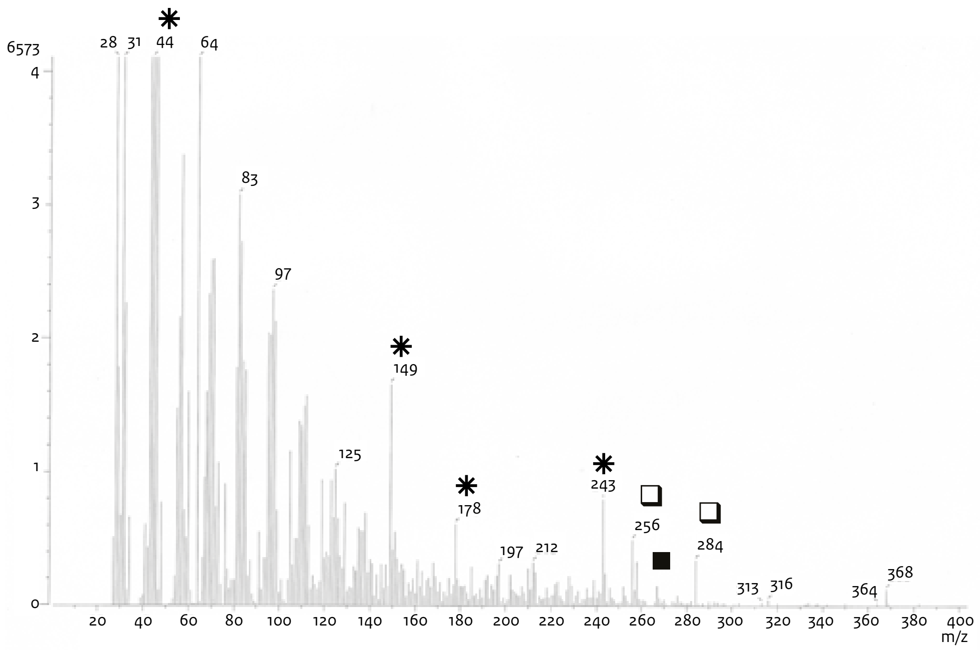


Figure 8.11 The mass spectrum of the desorption phase A of residue ZW04 is characterised by the presence of saturated fatty acids (white square), unsaturated fatty acids (black square) and contaminants (star) such as phthalates, solvent (ethanol) and an unknown contaminant (*m/z* 243). Two prominent peaks (*m/z* 44 and 28) show the gases CO_2 and CO, probably originating from carbonates.

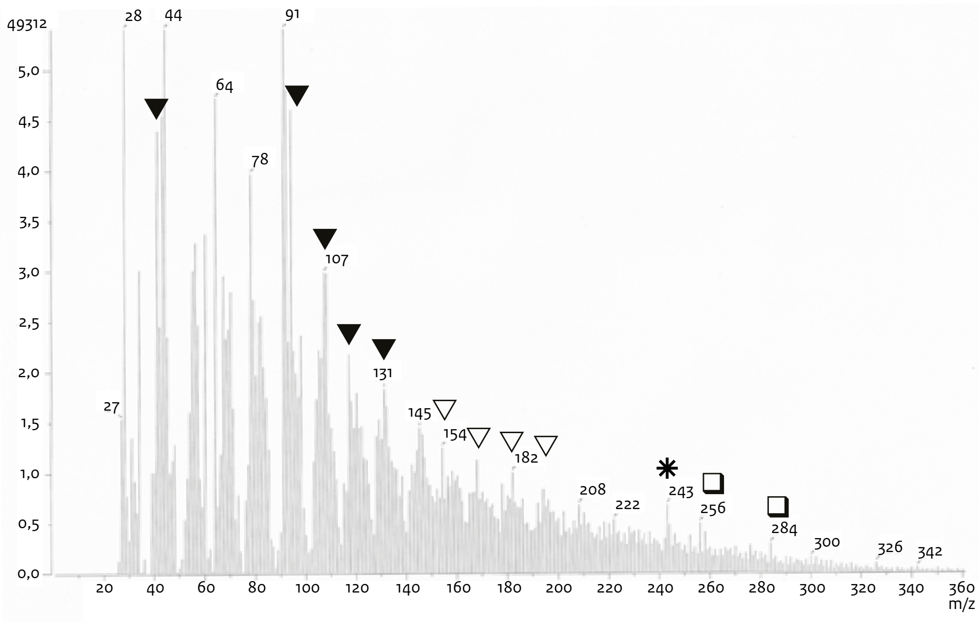


Figure 8.12 Mass spectrum of pyrolysis phase B (scan 70-100) of residue ZW04 still shows saturated free fatty acids (white squares) and also clearly shows indicators of intact proteins and peptides (white triangles) as well as amino acids and charred proteins (black triangles), plus an unknown contaminant (*m/z* 243).

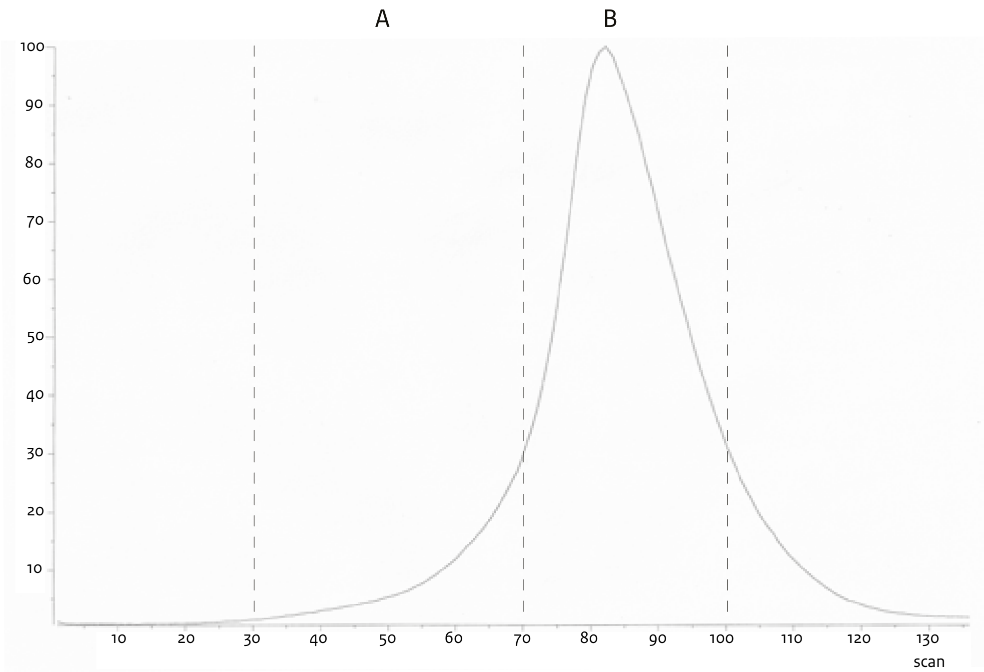


Figure 8.13 Total ion current (TIC) of residue ZW16 showing a fairly narrow peak in pyrolysis phase B (scan 70-100) and a smooth increase in the signal in desorption phase A (scan 30-70).

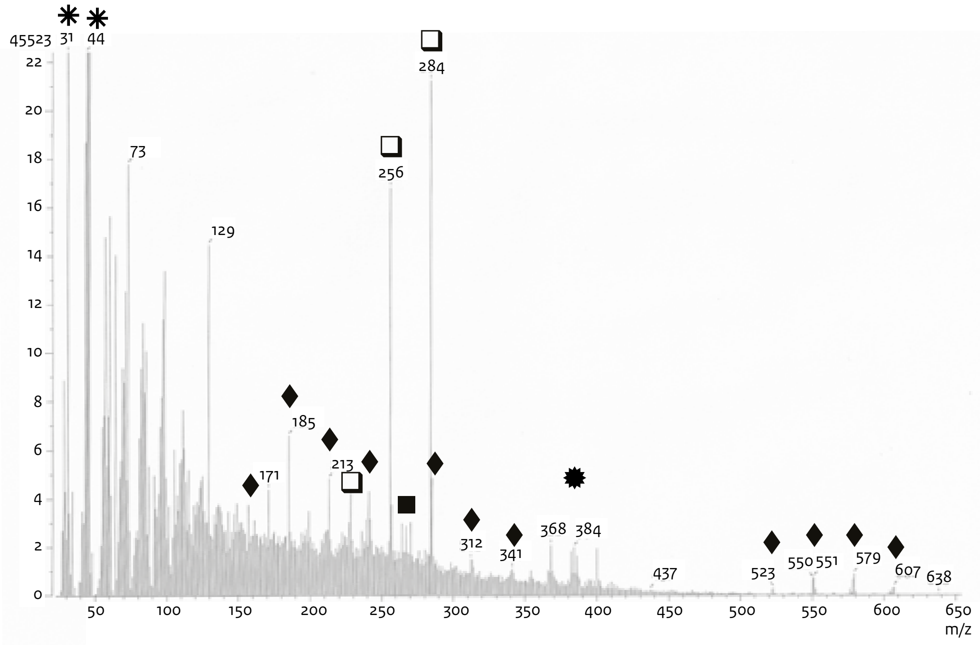


Figure 8.14 The mass spectrum of desorption phase A (scan 30-70) of residue ZW16 is characterised by a well-preserved lipid profile including saturated and unsaturated fatty acids (white and black squares respectively), fragments of intact acyllipids (diamonds), and sterols (sun). Some contaminants (stars) such as solvent (ethanol) are visible.

seen for the presence of intact di- or triacylglycerols (*m/z* 551, 579, 607). Nor were any indicators of sterols of plant or animal origin detected. All these signals indicate a fairly degraded and completely hydrolysed lipid fraction. The absence of sterols makes it impossible to determine the origin of the residue as animal or vegetable.

The high peaks for compounds CO (*m/z* 28) and CO_2 (*m/z* 44) probably originate from decarboxylation of inorganic carbonates such as calcium carbonate. Calcium carbonate may have been introduced by groundwater during burial. A number of contaminating compounds such as phthalates (*m/z* 149, 179) used as plasticizers in packaging materials, and ethanol (*m/z* 45 and *m/z* 31) used to apply the sample to the wire, can also be seen in the mass spectrum. Ethanol was not part of the original residue.

The mass spectrum (Fig. 8.12) for pyrolysis area B (scan 70-100) still shows the same saturated fatty acids seen in the desorption phase. Their presence in the pyrolysis phase indicates that the fatty acids were partly incorporated in, or chemically bound to, the charred matrix and could not all be released through simple evaporation. In addition, the mass spectrum shows indicators of proteins. Some markers for intact peptides and protein fragments (*m/z* 154, 166, 182, 192,194) are still clearly visible, as well as markers for charred amino acids (*m/z* 43, 69, 70, 94, 117, 131, 154, 194). Such markers originate from mildly heated proteinaceous materials. Clearly, proteins formed a significant proportion of the original vessel's content. No indications were found for the presence of a significant amount of polysaccharide material.

In summary, residue ZW04 shows a medium to severely heated proteinaceous material, mixed with a small amount of degraded and hydrolysed fat of unknown origin.

Group B - AP: Charred mixtures of proteins, polysaccharides and lipids of animal and plant origin

The DTMS total ion current (TIC) signal of sample ZW16 (DTMS-code 1december2011037) shows a high intensity (29.10^6), indicating that the residue contains a large amount of organic material (Fig. 8.13). The TIC shows a relatively narrow peak at an average temperature (scan 82), indicating a relatively homogeneous polymeric fraction with an average degree of condensation. In desorption phase A (scan 30-70), a smooth increase is visible in the TIC

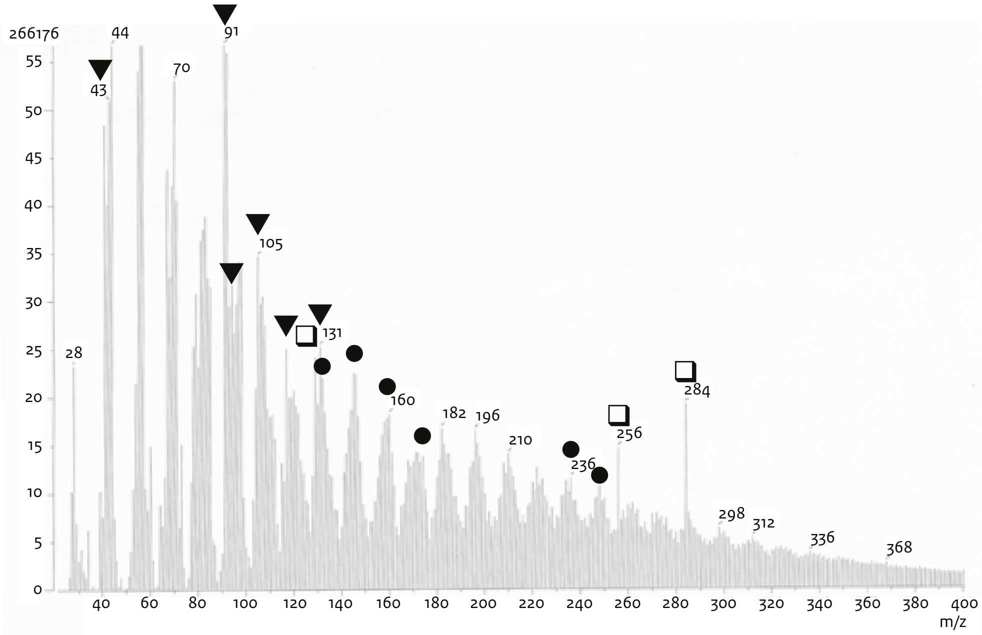


Figure 8.15 The mass spectrum of pyrolysis phase B (scan 70-100) of residue ZW16 is characterised by indicators of charred polysaccharides (black circles), markers for amino acids and charred protein (black triangles) and a few remaining free fatty acids (white squares). No indicators of intact peptides or proteins can be seen.

intensity, suggesting the presence of a small quantity of volatile compounds.

Contrary to what one might expect on the basis of the TIC, the mass spectrum (Fig. 8.14) of desorption area A (scan 30-50) shows a relatively well-preserved lipid profile. Lipids are clearly present as free fatty acids as well as intact acylglycerides. The most common free fatty acids occur in the form of molecular ions of saturated free fatty acids (*m/z* 256 and 284 for C16:0 and C18:0) and unsaturated free fatty acids (*m/z* 264 for C18:1). The presence of intact acylglycerols is indicated most clearly by small peaks for the diacylglycerol fragments $[M\text{-}RCOO]^+$ with DG ranging from 30 to 36 carbon atoms (*m/z* 523, 551, 579, 607). The triacylglycerols are not visible in this residue. Additional markers for mono- or diacylglycerides can be seen in the $[RCO+74]^+$ (*m/z* 285, 313, 341 for C14:0 C16:0 and C18:0).

Sterols of both animal and plant origin are present. Cholesterol (*m/z* 368, 386) can originate from animal or fish material, while pythosterols such as campesterol (*m/z* 382 and 400), beta-sitostrol (*m/z* 396, 414) originate from plant oils. The presence of the unsaturated free fatty acid C18:1 also suggests a plant oil origin.

The mass spectrum (Fig. 8.15) for pyrolysis phase B (scan 70-100) shows a mixture of markers for charred polysaccharides and proteins and a few lipids.

Markers for polysaccharides heated to 250 - 310 °C for two hours [321] can be seen as alkylated benzofurans (*m/z* 132, 146, 160, 174). Highly condensed aromatic structures indicative of severely thermally degraded polysaccharides (heated to over 300 °C for more than two hours) are visible as an envelop of even masses above mass *m/z* 200.

Markers for mildly heated proteins are also absent from the spectrum (Fig. 8.15). More thoroughly heated proteins can be seen in the form of amino acid fragments such as alkylated phenols (*m/z* 91, 92, 94, 107, 108) and nitrogen-containing heterocyclic components (*m/z* 117, 131, 147, 161). The proteins may be of either animal or plant origin.

In summary, residue ZW16 shows a medium to severely heated polysaccharide, protein and lipid mixture with a relatively well-preserved lipid profile. The lipids suggest a mixed origin, with animal/fish fat and plant oils.

[321] Pastorova, Oudemans & Boon 1993; Pastorova *et al.* 1994.

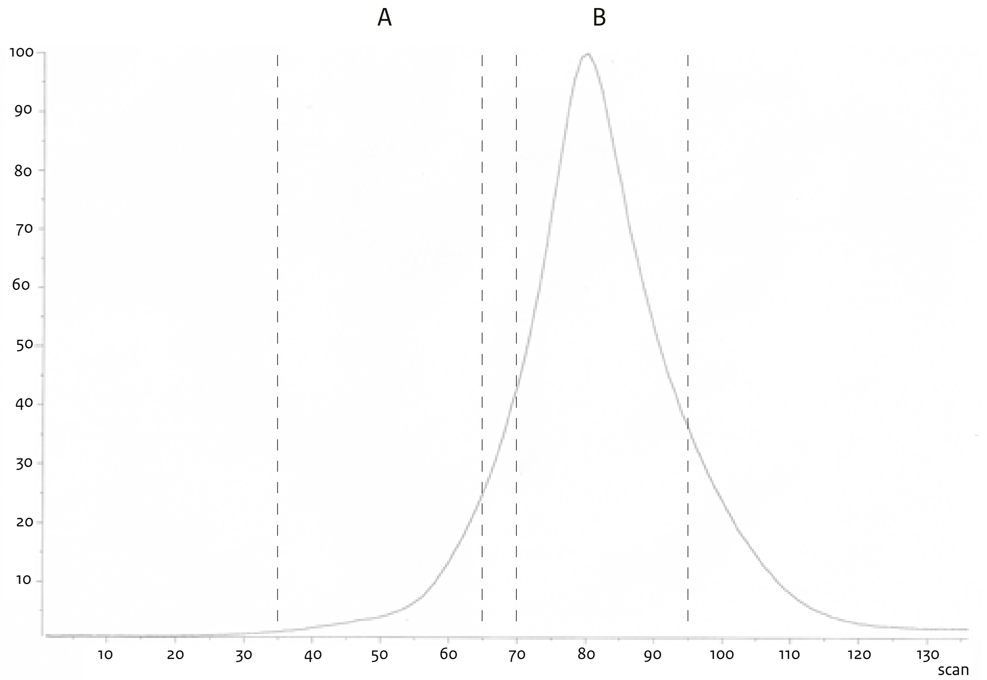


Figure 8.16 Total ion current (TIC) of residue ZW12 showing a fairly narrow peak in pyrolysis phase B (scan 70-95) and a smooth increase in signal in desorption phase A (scan 35-65).

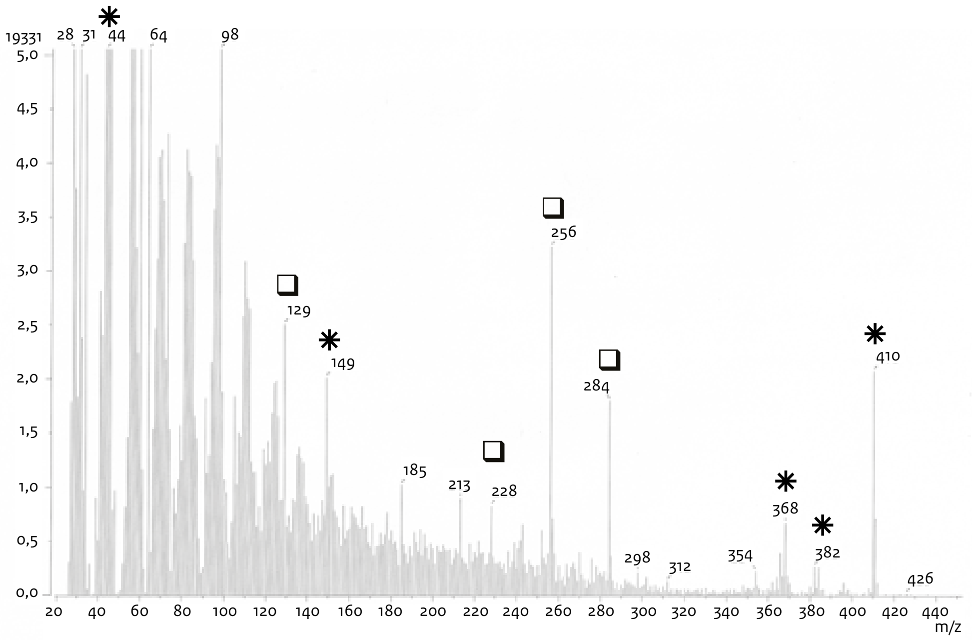


Figure 8.17 The mass spectrum of desorption phase A (scan 35-65) of residue ZW12 is characterised by a severely hydrolysed lipid profile with saturated fatty acids (white squares). Some contaminants (stars) such as solvent (ethanol) and squalene are visible.

Table 8.3 DTMS results of residues from Zeewijk.

Res. no.	DTMS Code 1dec 2011	TIC	Tot Int (10^6)	Lipids			Proteins		Poly-saccharides		Sterols	Soot	Con	Group	Description of material
				FAS	FAU	DG TG	PP	P Ch	PS	PS Ch					
ZW01	015	85	M (17)	+	+/-	-	-	++	-	++	AP	-		B-AP	medium to highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin)
ZW02	016	80	M (12)	++	+/-	+	-	++	-	++	-	-	Sq	B-U	medium to highly charred protein and polysaccharide mixture. Lipids of unknown origin
ZW03	017	92	M (12)	+/-	-	-	-	+	-	+	A	-	S8	B-A	medium to highly charred protein and polysaccharide mixture. Lipids of animal origin
ZW04	018	83	L (4)	+/-	-	-	+	+	-	+/-	-	-		A	mildly charred proteinaceous material. Few lipids of unknown origin
ZW05	019	90	(M) 14	+/-	-	-	+	+	-	+/-	AP	-		A	mildly charred proteinaceous material. Few lipids (animal and plant origin)
ZW06	025	86	H (33)	+/-	-	-	-	++	+	+	AP	-	Sq	B-AP	medium to highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin)
ZW07	026	80	L (4)	+/-	-	-	-	+	-	+	-	-		-	severely charred material of unknown origin
ZW08	027	77	L (2)	-	-	-	-	-	-	-	-	-	-	-	-
ZW09	029	76	L (5)	+	+/-	+/-	-	++	-	+	-	-	Sq	B-AP	medium to highly charred protein and polysaccharide mixture. Lipids of unknown origin
ZW10	031	80	L (5)	+/-	-	-	-	+	+/-	+	-	-	Sq	-	severely charred material of unknown origin
ZW11	032	90	L (4)	+/-	-	-	+	+	-	+/-	-	+	S	A	mildly charred proteinaceous material with soot traces. Few lipids of unknown origin
ZW12	033	80	H (26)	+	-	-	-	++	+	++	-	-	Sq	B-U	mildly charred protein and polysaccharide mixture. Few lipids of unknown origin
ZW13	034	85	H (35)	+	-	-	-	++	-	++	AP	+/-	Sq	A	soot traces. Few lipids (animal and plant origin)
ZW14	035	78	L (7)	+/-	-	-	-	+	+/-	+/-	-	-	-	-	severely charred material of unknown origin
ZW15	036	80	L (7)	+	+/-	+/-	-	+	-	+	AP	-		B-AP	highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin)
ZW16	037	82	H (29)	++	-	+	-	+++	-	+	AP	-		B-AP	medium to highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin)
ZW17	038	81	H (46)	+	-	-	-	++	-	+	-	-	Sq	B-U	highly charred protein and polysaccharide mixture. Some lipids of unknown origin
ZO01	006	78	H (22)	+	+/-	-	-	++	-	++	-	-	Sq	B-U	highly charred protein and polysaccharide mixture. Some lipids of unknown origin
ZO02	043	77	H (21)	+	+/-	-	-	++	-	+	AP	-		B-AP	highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin)
ZO03	042	90	M (15)	+	-	-	-	+	-	+	-	++	S; Sq	-	soot
ZO04	007	92	H (66)	+	+/-	-	-	++	-	+	-	+	Sq	-	soot
ZO05	008	77	L (8)	+	+/-	-	-	+	-	+	-	+	S; Sq	-	severely charred material of unknown origin and soot traces
ZO06	009	80	H (39)	+	+/-	-	-	++	+/-	+	-	++	S; Sq	-	soot
ZO07	013	79	H (22)	+	+/-	-	-	++	-	+	-	++		-	soot
ZO08	014	79	H (40)	++	+/-	+	-	++	+/-	+	-	++	Sq	-	soot

The intensity of the total ion current (TIC) is a measure of the amount of organic material present in the sample. Blank measurements prior to this series of measurements have an intensity of 0.02 x 106. H (= high) is defined as a minimum of 80x the intensity of a blank measurement; M (= medium) is 30 to 80x the value of a blank measurement; M/L (= medium/low) is 20 to 30x the value; and L (= low) is less then 20x the intensity of a blank measurement.
Tot Int = Total intensity of the TIC signal during the analysis; FA = Fatty Acids (S for saturated and U for unsaturated); DG = diacylglycerols; Pp = proteins and peptides; PC = indicators for charred proteins; PS = Polysaccharide markers; PS Ch = markers for condensed polysaccharides; Con = Contamination such as: S for sulphur-containing compounds, Sq for squalene, P for phthalates.

Group B-A: Charred mixtures of proteins, polysaccharides and lipids of animal origin
In this group we see only one residue (ZW03) that is in many ways similar to the residues from B-AP, except that it lacks the indicative phytosterols. The presence of cholesterol confirms that the lipids have an animal or fish origin.

Group B-U: Charred mixtures of proteins, polysaccharides and lipids of unknown origin due to contamination with human skin fat
The chemical characteristics of the residues from group B-U are very similar to those from Group B-AP, as can been seen in residue ZW12. The DTMS total ion current (TIC) signal (DTMS-code 1december2011033) shows a high intensity (26.10^6), indicating that the residue contains a large amount of organic material (Fig. 8.16). The TIC shows a relatively narrow peak at an average temperature (scan 80), indicating a relatively homogeneous polymeric fraction with an average degree of condensation. In desorption phase A (scan 35-65), a smooth increase is visible in the TIC intensity, suggesting the presence of a small quantity of volatile compounds.

However, the mass spectrum (Fig. 8.17) of desorption area A (scan 35-65) shows a much more degraded (and completely hydrolysed) lipid profile contaminated with human skin lipids. Although lipids are clearly present as free fatty acids, only the most common free fatty acids are present (C14:0, C16:0 and C18:0). No intact acylglycerols are present. In the sterol area, high markers can be seen for cholesterol (*m/z* 368, 386) and squalene (*m/z* 69, 81, 136, 410). Since squalene is a component that occurs in human skin lipids in combination with cholesterol, it must be seen as a recent contamination. Their presence makes it impossible to identify original sterols.

The pyrolysis phase B of residue ZW12 is very similar to that of ZW16 (Group B-AP) and will not therefore be discussed further. In summary, residue ZW12 shows a medium to severely heated polysaccharide, protein and lipid mixture with a lipid profile of unknown origin and contamination with human skin lipids.

Discussion of chemical results
The organic residues from Zeewijk contain significant amounts of organic material. Twenty-four out of 25 residues (96%) contained some organics, and 15 of these residues (60%) contained enough organic material to make a significant statement about the original vessel contents (Table 8.4). This indicates a better preservation then in Keinsmerbrug[322] or Mienakker. In spite of this overall better preservation, it is clear that in Zeewijk-East a large number of residues contain only soot. It is not clear if the soot residues are a result of primary use (dry baking above the fire), secondary use (for instance of ceramic fragments in fireplaces) or the result of deposition method (sherds were thrown away with ash and soot).

These 15 residues from Zeewijk with significant organics, all contained (partially) charred proteins and (some amount of) degraded oil or fat. In addition all but four residues also contained additional (partially) charred polysaccharides. The combination of charred proteins, polysaccharides and lipids strongly suggest food preparation.

It is significant to note that one of the fragments containing such a mixed residue of charred proteins, polysaccharides and lipids (of both animal and plant origin) is a ceramic fragment of a baking plate (ZO02) originating from Zeewijk-East. This is the first Dutch Neolithic baking plate to have rendered a chemically well-preserved organic residue. The significance of this residue lies not only in its uniqueness, but also in the mixed nature of the residue. Obviously, this baking plate from Zeewijk was not used for just one kind of food but for heating a mixed food.

When proteins occur in human food, they commonly originate from animals (including mammals, fish, shellfish or birds) in the form of meat. Other animal products such as milk, blood, eggs, skin, bone and cartilage also contain proteins. However, some edible plants or plant parts (such as pulses, nuts and some seeds) also contain proteins, usually in combination with polysaccharides. The chemical characteristics of heated proteins are complex and can rarely be traced back to a specific animal or plant origin.[323]

Lipids from oils, fats and waxes usually show more informative markers. Many lipid profiles detected in archaeological food residues originate from 'hard fats' from the meat of land mammals (cattle, sheep, pig, dear, wild boar)

322 Oudemans & Kubiak-Martens 2012; Oudemans & Kubiak-Martens 2013.
323 Braadbaart *et al.* 2004, Oudemans *et al.* 2007.

Table 8.4 DTMS results for three SGC sites compared.

	Number of samples	Samples with some organics		Samples with indicative organics		Number of samples with soot	
		n	%	n	%	n	%
Keinsmerbrug	16	7	44	4	25	1	6
Mienakker	16	9	56	7	44	1	6
Zeewijk total	25	24	96	15	60	5	20
Zeewijk-West	17	16	94	13	76	0	0
Zeewijk-East	8	8	100	2	25	5	63

because they are most easily preserved. Sometimes abundant quantities of short chain fatty acids occur in lipid profiles, indicating the presence of milk fats from goats or sheep.[324] In some cases, lipid profiles contain a lot of unsaturated fatty acids, which can indicate the presence of a plant oil or fat. Fish oils and fats from marine mammals also contain significant amounts of unsaturated or polyunsaturated fatty acids. [325] However, degradation due to severe or extended heating or oxidation causes lipids to lose their specific characteristics. It is therefore often difficult to identify fish fat, plant oils and marine mammal fats in archaeological residues. The residues from Zeewijk contain lipids, but their overall preservation is not exceptional. Only a few residues have a lipid profile including unsaturated fatty acids or large amounts of intact acyl-lipids. In the residues from Zeewijk, no indications were found for the presence of milk fats or plant oils. On the other hand, sterols are relatively well preserved in residues from Zeewijk-West. Animal and plant sterols (and their degradation products) can give useful additional information about the origin of residues. Cholesterol (sometimes in combination with its oxidation products) is an indicator of animal origin (including birds, fish and shellfish). Phytosterols (i.e. brassicasterol, campersterol, sitosterol, stigmasterol) and their dehydrogenation products indicate lipids originating from a plant source. Lipids from animal meat fat (mammal, fish or bird), as well as lipids from plants (vegetable oils or fatty plant-parts such as seeds or nuts) were obviously used in Zeewijk as a source of food.

Intact polysaccharides have relatively little chance of surviving in charred archaeological residues, because they are relatively sensitive to heating. At temperatures above 220 °C carbohydrates tend to lose specific characteristics and at temperatures above 300 °C it is virtually impossible to determine a carbohydrate component. Polysaccharides in human food originate primarily from plant materials (although milk does contain polysaccharides). Most carbohydrates consumed in prehistoric times were consumed in the form of starches (although prehistoric diets may have contained some simpler sugars from honey, fruits, berries or bulbs). Starches occur only in plants (in cereals, roots and tubers, nuts, pulses and some fruits). Many residues from Zeewijk show the presence of charred polysaccharides (all residues from DTMS group B) indicating the presence of a significant amount of starch in the original vessel content.

8.4 General discussion and conclusions

The organic surface residues from Zeewijk are relatively well preserved, both chemically (96% showed some organics and 60% showed significant amounts of organic compounds) and botanically (36% showed identifiable plant remains). The preservation of chemical and botanical characteristics is better than in the residues from Keinsmerbrug or Mienakker.

The chemical evidence from the well-preserved residues showed that all residues contained heated proteins and some quantity of fat (albeit sometimes very little), and three-quarters of the residues also contained heated polysaccharides. All the lipids that contained indicative sterols were of mixed plant and animal/fish/fowl origin, with one exception where no plant influence was detected.

Plant polysaccharides in prehistoric cooking

[324] Oudemans & Boon 2007.
[325] Regert 2011.

residues either originate from cereals or from other starch-rich plant parts (roots, tubers, acorns and other nuts or seeds), or from the sugars in fruits. No indications (such as the presence of milk lipids) were found to suggest that the polysaccharides had an animal origin (Table 8.5).

As indicated by the presence of emmer and naked barley remains in archaeobotanical assemblage from Zeewijk,[326] it is clear that some of the polysaccharides (starch) detected in chemical spectra must have come from these two cereals. Two of the Zeewijk residues are botanically defined by the presence of emmer chaff remains, suggesting that emmer grain was probably cooked as porridge, with the addition of protein and some fats. Though not identified in SEM-studied residues, naked barley may have also been used in these starch-rich meals. In contrast to emmer grain, however, naked barley (with grains that thresh easily out of their husks or hulls) would enter the cooking pots as truly clean grain and would therefore be difficult to trace in food residues.

There were other plant foods that contributed starch to the diet in Zeewijk. The botanical evidence of acorn cotyledon parenchyma in context of organic residues is particularly noteworthy. It shows that in Zeewijk acorns were cooked in ceramic vessels, possibly as mush or soup (this was at least one of the methods used to make acorn meal). The Zeewijk evidence also suggests that acorns – which are often considered a pre-agrarian staple food – maintained their importance into the late Neolithic tradition and they may have been an important food processed in ceramic vessels.

What is striking about some of the Zeewijk residues is their truly mushy nature, suggesting that food prepared in at least some of the Zeewijk vessels was well processed, possibly crushed, pounded or even pulverised, and subsequently cooked. Interestingly, many of the stone artefacts recovered at Zeewijk appear to have been used primarily for processing (pounding?) of plant material.[327] The group of residues which represents well-processed and/or well-cooked food mushes was also characteristic for organic residues in ceramic vessels from Mienakker.[328] All the mushy residues from Mienakker and from Zeewijk share the well-defined chemical signals for the presence of proteins and polysaccharides, often with addition of lipids. Both plant and animal components may have been used in cooking of these mushy meals. In consequence, it seems that at least some cooking practices were quite similar at both Mienakker and Zeewijk (clearly at Zeewijk-West). Even though SEM examination revealed no plant tissue in these 'mushy' residues, it can be assumed that starch- (and possibly protein-) rich plant foods were used in these cooking activities. At least a few species can be proposed as possible starchy components of these organic 'mushy' residues, namely tubers of sea club-rush (which is particularly well represented in the Zeewijk macro-remains record) and seeds of various orache species (well represented in the macro-remains assemblage at Zeewijk and Mienakker). There is another starchy food – sea beet – which might also have been used as a root vegetable. Sea beet was certainly known to the people at both sites, as charred perianths were found in macro-remains assemblages, but no direct evidence of the processing of sea beet root was found.

In general, it can be said that the people of the Single Grave Culture in Zeewijk must have prepared quite a broad range of meals in their ceramic vessels. They must have had a cooking tradition that included a lot of mixed food dishes. These meals contained starches, proteins and fats or oils. It is most likely that the protein/lipid combinations originated primarily from animals, fish or fowl and only rarely from plants. In all the residues where original sterols could be identified it could be established that they at least partially originated from an animal source. Obviously the inhabitants of Zeewijk cooked mixed food dishes that usually contained both animal, fish or fowl and some plants or plant parts.

There is a big difference in preservation between Zeewijk-East and Zeewijk-West (northern and southern section together). The residues from Zeewijk-East were poor in botanical and chemical information, while Zeewijk-West rendered very diverse and occasionally well-preserved residues.

The cause may well lie in the overall poor quality of the Zeewijk-East ceramic assemblage. Only small fragments with residues were found in Zeewijk-East which suggests severe post-depositional fragmentation (or a different excavation technique). However, the chemical composition of the residues from Zeewijk-East was also different. Five of the eight residues

326 Kubiak-Martens, this volume.
327 García-Díaz, this volume.
328 Oudemans & Kubiak-Martens 2013.

Table 8.5 Overview of combined botanical and chemical evidence from residues.

Residue	Vessel no.	Botanical interpretation	Chemical interpretation	Group SEM	Group DTMS
ZW01	aa	well-processed/-cooked food , possibly with cotyledon/seed component	medium to highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin).	B	B-AP
ZW02	C	food with plant component, well-processed/-cooked food, no further identification	medium to highly charred protein and polysaccharide mixture. Lipids of unknown origin	C	B-U
ZW03	S	well-processed/-cooked food, possibly with cotyledon/seed component	medium to highly charred protein and polysaccharide mixture. Lipids of animal origin.	B	B-A
ZW04* ex	III	food made at least partly of emmer	mildly charred. Proteinaceous material. Few lipids of unknown origin	A	A
ZW05	gg	no further identification	mildly charred. Proteinaceous material. Few lipids (animal and plant origin).	-	A
ZW06	5	-	medium to highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin).	-	B-AP
ZW07	13	food made at least partly of emmer	Severely charred material of unknown origin	A	-
ZW08	15	acorn mush (shows similarity with experimentally charred acorn mush)	-	B	-
ZW09	20	food with plant component, well processed/-cooked food, no further identification	medium to highly charred protein and polysaccharide mixture. Lipids of unknown origin	C	B-AP
ZW10	22	well processed/-cooked food, no further identification	severely charred material of unknown origin	-	-
ZW11	23	well processed/-cooked food, no further identification	mildly charred proteinaceous material with soot traces. Few lipids of unknown origin	-	A
ZW12	25	-	mildly charred protein and polysaccharide mixture. Few lipids of unknown origin	-	B-U
ZW13	28	no further identification	soot traces. few lipids (animal and plant origin)	-	A
ZW14	29	well processed/-cooked mush like food, no further identification	severely charred material of unknown origin	cf. B	-
ZW15	30	well processed/-cooked mush like food, no further identification	highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin).	cf. B	B-AP
ZW16	31	-	medium to highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin).	-	B-AP
ZW17	35	food with plant component, no further identification	highly charred protein and polysaccharide mixture. Some lipids of unknown origin	-	B-U
ZO01	disk	-	highly charred protein and polysaccharide mixture. Some lipids of unknown origin	-	B-U
ZO02	baking plate	-	highly charred protein and polysaccharide mixture. Few lipids (animal and plant origin).	-	B-AP
ZO03	42	-	soot	-	-
ZO04	43	-	soot	-	-
ZO05	44	-	severely charred material of unknown origin and soot traces	-	-
ZO06	45	-	soot	-	-
ZO07	46	-	soot	-	-
ZO08	47	food with plant component, no further identification	soot	C	-

showed the presence of some kind of soot residue, suggesting a different prehistoric (secondary) use for the ceramics. Soot depositions on the interior wall of ceramic cooking vessels are relatively unusual, but may occur when ceramics have been used for dry-roasting above wood-fires or have been deposited in, or around, hearths for other reasons. The preservation of botanical components was also very poor in Zeewijk-East residues. Actually, only one studied residue revealed presence of plant tissue, suggesting that a plant component was used in this particular cooking event. No further interpretation is possible, however (no chemical components were found in this residue).

Food was cooked at Zeewijk using a broad range of ceramics, but there is a correlation between the thin- and medium thick-walled (and thus often decorated) ware and the occurrence of surface residues on the interior wall of the vessels.[329] Because most of the surface residues in Zeewijk originated from food, it is becoming obvious that the thinner-walled vessels (beakers) were used for the mundane everyday activity of preparing food.

329 See also Beckerman, this volume.

9 Charcoal and wood

O. Brinkkemper & M. van den Hof

9.1 Introduction

This chapter considers the analysis of charcoal and five waterlogged wooden posts found at Zeewijk. During the excavation, remains of one clear structure were found, known as the 'large structure of Zeewijk-East.[330] The five wooden posts were central roof-bearing posts in this structure. Besides this structure, it is highly probable that several other structures remain hidden in the multitude of postholes found during excavation.[331] Differences in the composition of charcoal can potentially assist in the unravelling of such structures, for instance if they were built of different wood species and the charcoal reflects this, either because the buildings burnt down, or because waste wood from the structures was used as firewood. However, in the case of Zeewijk, this does not help because the samples cannot be related to their origin within each excavation square and quadrant. Feature numbers are available, but find layers were also considered features, and the feature number information could not be retrieved.

Charcoal found at an archaeological site reflects both the natural landscape and anthropogenic activities. Firewood is often gathered in the surrounding environment. It might therefore be possible to reconstruct the forest composition of the environment based on the analysis of charcoal. Anthropogenic activities involve the use of wood for construction or as fuel, either specifically selected or randomly collected for these purposes.

Charcoal therefore represents specific activities at the site. Considering this, the Zeewijk charcoal assemblage allows us to answer four main research questions set out at the start of the Odyssey project:

- What activities are represented in the characteristics of the archaeozoological and archaeobotanical remains?
- What do indicators tell us about the duration and seasonality of occupation?
- What ecozones are represented in the archaeozoological and archaeobotanical assemblages?
- How do the characteristics of the SGC settlements in Noord-Holland compare to SGC/Corded Ware phenomena in the wider geographical setting?

Since this is also the final monograph on the three sites studied in the Odyssey project, the results of the charcoal investigations at Zeewijk will also be compared to those at Keinsmerbrug and Mienakker. The waterlogged wooden posts found within the 'large structure' at Zeewijk are unique for the Single Grave Culture in this area and cannot therefore be compared directly to the other sites.

9.2 Methods

A large number of samples was collected for the analysis of botanical remains during the excavation of Zeewijk. A selection of 70 samples was sieved and their suitability for archaeobotanical analysis assessed. The quantity of charcoal was estimated during this process. On the basis of this assessment, 20 samples were selected for charcoal analysis. These were the same samples selected for archaeobotanical analysis.[332] All sample numbers consist of a square number (four digits), a quadrant number 1-4 for the quadrant within the square, a find number (unique within each unit) and a feature number (unique within each square). However, as already observed, the features list for the excavation is missing, so at this moment, the information obtained cannot be related to individual features or find layers, with the exception of one sample (2050/3, feature no. 129) from a wall post of the 'large structure' at Zeewijk-East.

Charcoal fragments from the sieve fractions >2mm and >4mm were examined. In each sample, 50 fragments were examined after the last identification of a new species.

To assess the adequacy of the sampling, the floristic diversity of the charcoal sample was plotted against the number of charcoal identifications as a saturation curve. If the curve shows a flattening off, this implies that the total number of taxa available in the sample has been retrieved. If the curve continues to increase, more taxa could be expected if more charcoal had been available for analysis.

Fragments are broken or cut in three directions to identify the type of wood. In each of the three

330 Nobles, this volume Chapter 3: Fig. 3.5.
331 Nobles, this volume Chapter 11.
332 Kubiak-Martens, this volume.

sections different characteristics of the wood are visible when examined through a microscope.

A Zeiss Discovery V8 stereomicroscope was used for the examination of the transversal section, with magnifications of 5-40x was used. A stronger binocular microscope was needed to examine the radial and tangential sections. In this case, an Olympus BHM microscope with magnifications of 50-500x was used.

The identification keys for wood published by Schweingruber *et al*. were used for the identification of the charcoal.[333] These identification keys are based on fresh wood but can be used for charred wood because wood undergoes few changes during the charring process, except that spiral thickenings in the vessels are regularly obscured by carbonisation.

Besides the species of wood, several other characteristics were recorded during identification. On the basis of the curving of the growth ring boundaries in the radial section, a distinction was drawn between wood originating from either branch or trunk. Furthermore, explosion holes can sometimes be identified.[334] These may indicate the burning of fresh wood or water-saturated deadwood.[335] However, this relationship between explosion holes and the water content of the burning wood could not be proved experimentally.[336] The samples were also checked for the presence of fungal hyphae during the identification process, to demonstrate the use of moulding deadwood.

Apart from charcoal, the excavation of Zeewijk yielded five waterlogged pieces of wood. The species was identified as oak in all cases and studied dendrochronologically by E. Hanraets in 1990 (RING) and by E. Jansma in 2013 (RCE).

9.3 Results

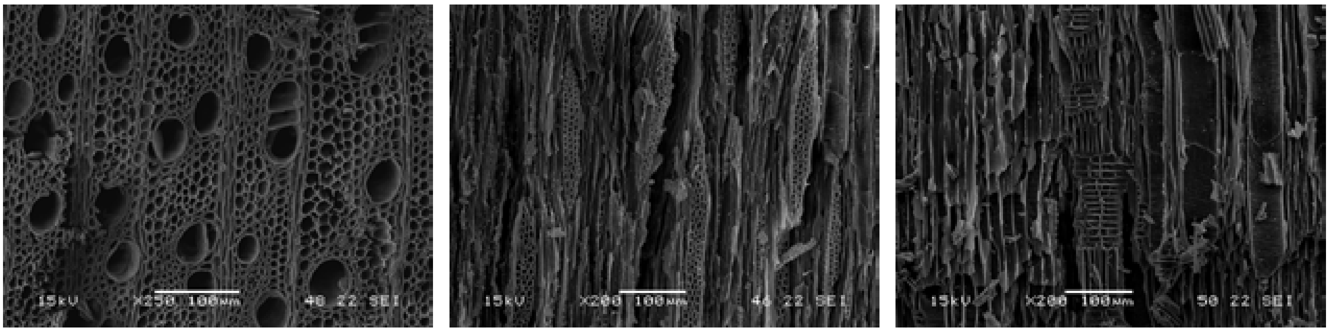
Twenty samples from Zeewijk were analysed. As well as charred wood, the samples also contain charred plant remains, seeds and grains. Appendix IX shows the charcoal and other findings, specified by sample. The quantity refers to the individual pieces of identified charcoal found in the sample. The weight refers to the weight in milligrams. Remains other than charcoal were only counted, not weighed. One sample did not contain any identifiable charcoal, only carbonised stems of what is believed to be reeds. Unfortunately, this sample was the only one that could be traced to a feature, a wall post of the large structure in Zeewijk-East.

Thirteen types of wood were found. Four types could be identified to species level: *Corylus avellana* (hazel), *Fraxinus excelsior* (ash), *Hedera helix* (ivy) and *Taxus baccata* (yew). Two of the identified taxa comprise a group of two or three species: *Acer campestre*-type (most likely field maple, but *Acer pseudoplatanus* and *Acer platanoides* cannot be excluded with certainty on the basis of the wood anatomy) and *Prunus padus*-type (bird cherry, which includes *Prunus padus*, *P. petraea*, *P. mahaleb* and *P. fruticosus*). Of these, only *Prunus padus* can be considered a native species in the Netherlands.[337] The other types of wood found were *Alnus* spec. (alder), *Betula* spec. (birch), *Cornus* spec. (dogwood), *Lonicera* spec. (honeysuckle), *Populus* spec. (poplar/aspen), *Quercus* spec. (oak) and *Salix* spec. (willow). The ecological requirements of the possible species allow a most likely species to be indicated in several of these cases. Characteristics of the various taxa are given below in alphabetical order.

Acer campestre grows slowly and prefers semi-moist, calcareous soils. The more calcareous the soil, the more it is able to endure shade.[338] Compared to *Acer platanoides/pseudoplatanus*, it has a smaller ray width (2-4 seriate). In one case, clearly 4-seriate wood of *Acer* with few or no 2-3 seriate rays was at first identified as *Acer platanoides/pseudoplatanus*, but later included in *Acer campestre*-type (see Fig. 9.1).

Two species of *Alnus* are indigenous to the Netherlands, *Alnus incana* and *Alnus glutinosa*. The most widely occurring, and therefore the most likely species to occur in Zeewijk, is *Alnus glutinosa* (common alder). This is a low tree or high bush that requires soils that are permanently moist and rich in nutrients and humus. *Alnus glutinosa* can be a pioneer and often dominates peat forests. It can endure flooding and salty sea winds. *Alnus incana* (grey alder) is a possible native species in the Netherlands, but is less common than *Alnus glutinosa*. It is therefore less likely, though still possible, that the species will be found in Zeewijk. *Alnus incana* is a low tree or bush. It grows in much drier soils than *Alnus glutinosa*. This is evident from the fact that it is often found

333 Schweingruber 1978; Schweingruber *et al*. 1990.
334 Braadbaart & Poole 2008.
335 E.g. Figueiral 1995, 98.
336 Henry 2011, 39.
337 Maes *et al*. 2013, 198-205.
338 Weeda *et al*. 1988, 25.



a b c

Figure 9.1 Scanning electron microscope (SEM) photographs of *Acer campestre*-type (sample 2270/4 v.2-2 S41): a. cross section; b. tangential section with 4-seriate rays; c. radial section. Scale bar is 100 µm.

on poor, light, calcareous soils. *Alnus incana* can also occur as a pioneer.[339] *Alnus glutinosa* has poor durability when used for construction wood, unless it is used under permanently waterlogged conditions. As firewood it can be used for special applications, such as smoking fish.[340] The wood of *Alnus incana* is even lower in quality than that of *Alnus glutinosa*.[341]

Betula spec. (birch) is a fast-growing tree that often grows in groups. It can grow in a wide range of environments and is seen as a typical pioneer that requires a lot of sunlight. The wood is flexible and can withstand sea winds. Two *Betula* species are native in the Netherlands: *Betula pendula* and *Betula pubescens. Betula pendula* (silver birch) occurs on poor sandy soils while *Betula pubescens* (downy birch) prefers moist soils that are rich in humus, mostly found in raised bogs. The environmental conditions of Zeewijk make *Betula pendula* more likely.

Cornus spec. (dogwood) is a very hard type of wood. *Cornus sanguinea* (common dogwood) is the most likely in this area. It is a bush that grows in moist to dry, calcareous soils that are often rich in humus. Archaeological excavations show the occurrence of this species in the province of Zuid-Holland.[342] *Cornus mas* (cornelian cherry) is considered native only in the southeastern part of the Netherlands and *Cornus suecica* (dwarf cornel) is not woody.[343]

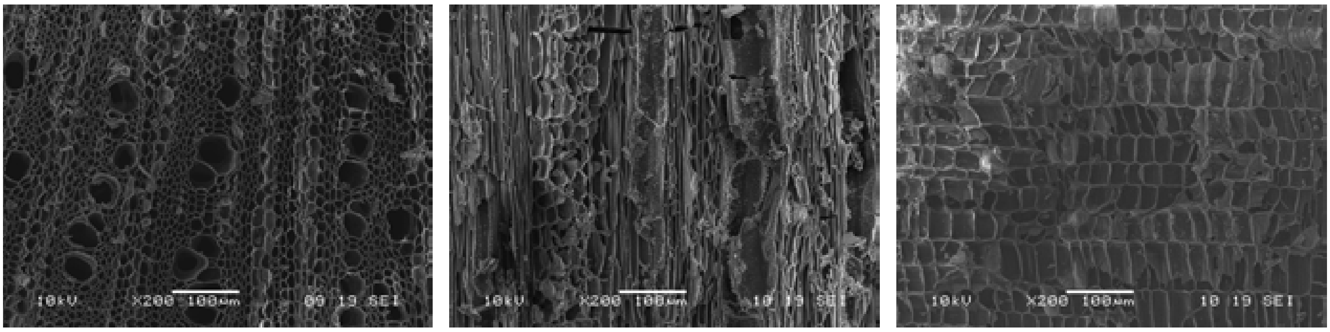
Corylus avellana (hazel) is the only representative of this genus in the Dutch flora. It grows in slightly moist, calcareous soils. Hazel occurs in the dune area, but not on sea clay or peat.[344] Hazel provides good firewood.

One species of *Fraxinus sp*. is indigenous to the Netherlands, *Fraxinus excelsior* (common ash). This is a large tree that has a specific demand on the soil. It needs an aerated, moist, calcareous soil high in phosphate. It cannot withstand regular flooding but is able to endure winter floods. It is sensitive to droughts and salty sea wind. The wood of ash is flexible and very hard. It is very durable, except in moist conditions, and can be used as construction wood, but is also highly favoured for the handles of implements.[345]

Hedera helix (ivy) is a climber that attaches itself to trees (or the stone walls of present-day buildings). It grows in dry to semi-moist conditions and requires a soil that is relatively rich in nutrients and humus. It cannot withstand constant moist conditions or floods.[346] Ivy probably accidentally came along with the firewood that was selected. It is not likely to have been selected for its own qualities. Anatomical features of ivy charcoal are illustrated in figure 9.2.

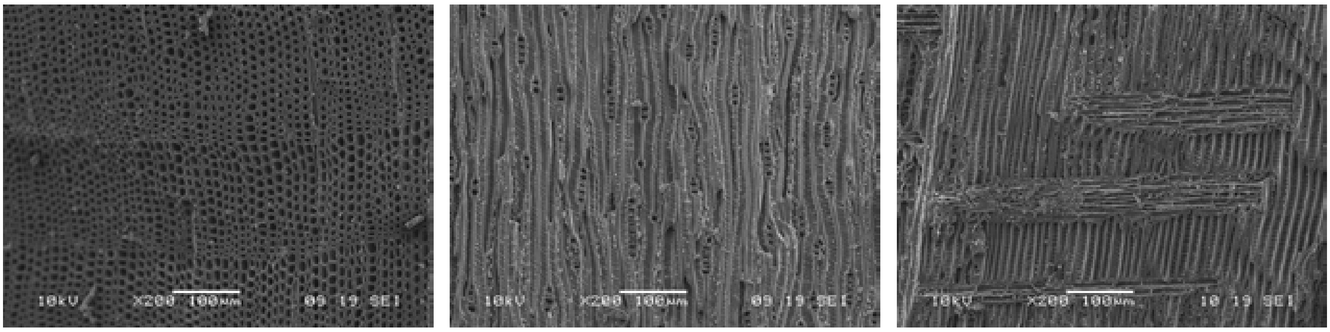
Two species of *Lonicera sp*. are indigenous to the Netherlands, *Lonicera periclymenum* and *Lonicera xylosteum. Lonicera periclymenum* (common honeysuckle) is a climber that grows around small trees.[347] It appears in most areas, but especially on sandy soils, loamy clay or peaty soils. It prefers a slightly nutrient-rich, acidic soil. It generally avoids calcareous conditions but can grow on sandy soils that contain a certain amount of shells.[348] *Lonicera xylosteum* (fly honeysuckle) is a free-standing plant that appears in light deciduous forests on dry, calcareous and slightly nutrient-rich soils.[349] Like ivy, it is unlikely that this wood was selected for its own qualities, but rather came to the site in connection with other firewood. The presence of these species makes it likely that the firewood was not all recycled construction wood, as in

339 Weeda *et al*. 1985, 98.
340 Weeda *et al*. 1985, 94.
341 Weeda *et al*. 1985, 98.
342 Weeda *et al*. 1991, 238.
343 Weeda *et al*. 1991, 239.
344 Weeda *et al*. 1985, 100-101.
345 Weeda *et al*. 1988, 77.
346 Weeda *et al*. 1991, 240.
347 Weeda *et al*. 1988, 271.
348 Weeda *et al*. 1988, 273-274.
349 Weeda *et al*. 1988, 275.



a b c

Figure 9.2 Scanning electron microscope (SEM) photographs of *Hedera helix* (sample 2203/2 v.4 S7): a. cross section; b. tangential section; c. radial section. Scale bar is 100 µm.



a b c

Figure 9.3 Scanning electron microscope (SEM) photographs of *Taxus baccata* (sample 1878/2 v.5 S5): a. cross section; b. tangential section; c. radial section. Scale bar is 100 µm.

these cases the climbers would have dried out and become detached from the construction wood during the life of the building.

Three species of *Populus* are currently indigenous to the Netherlands: *Populus nigra* (black poplar), *Populus tremula* (aspen) and *Populus alba* (silver poplar). *Populus alba* is not likely to have reached the Netherlands before post-Medieval times.[350] *Populus nigra* and *Populus tremula* could both have appeared in this area during the Neolithic Single Grave Culture. They are typical pioneers that require a lot of sunlight. The wood is soft and cannot be used for construction. It provides poor firewood because it burns quickly, without giving off a lot of heat.[351] Black poplar occurs in river valleys and is sensitive to saline conditions. Aspen is more widespread in the Netherlands nowadays, and can also withstand salt spray in coastal areas.

Prunus padus (bird cherry) is a small tree. It grows in sandy and loamy clay soils that are rich in nutrients and humus. It can also grow on dry grounds, like dunes. It grows well under trees such as *Salix alba* or *Alnus glutinosa*.[352]

Two species of *Quercus* spec. (oak) occur naturally in the Netherlands, *Quercus robur* (common oak) and *Quercus petraea* (sessile oak). Common oak is by far the most prevalent in large parts of the Netherlands. This tree can grow in various conditions, but struggles in peat. It cannot withstand inundation during the growing season, but can grow on levees that are only inundated in winter. In dunes it follows up after birch has made the conditions less calcareous.[353] Sessile oak is mainly restricted to the Pleistocene area of the Netherlands, but also grows in the present-day dune area. Both types of oak provide a very durable type of wood that makes for good construction wood or firewood.

A dozen indigenous species of the genus *Salix* spec. (willow) grow in the Netherlands, as well as many hybrids. Most species grow in wet habitats as trees or large shrubs. *Salix repens* (creeping willow) is common in the dry sandy dune areas of the Dutch coast, but the twigs of this species are very slender, too slender for most of the specimens found at Zeewijk.

Taxus is a coniferous type of wood. One

350 See www.verspreidingsatlas.nl/0980, accessed 13th of January 2014.
351 Bartosiewicz, Zapata & Bonsall 2010, 220; Taylor 1981; Firewood Ratings on http://mb-soft.com/juca/print/firewood.html), accessed 27 December 2013.
352 Weeda *et al*. 1987, 101.
353 Weeda *et al*. 1985, 113.

species of *Taxus* is indigenous to the Netherlands, *Taxus baccata* (yew). It grows very slowly in light and calcareous soils. The wood is strong and flexible and can be used as construction wood.[354] It provides the best wood of all western European species for making bows.[355] Anatomical features of yew are illustrated in Figure 9.3.

As well as charcoal, every sample contained large quantities of *Phragmites australis* (reed) stems. Reed is very common in eutrophic marshes and beside various bodies of water. It tolerates brackish conditions, but does not grow in more saline environments.

Figure 9.4 shows the saturation curves for those samples that yielded an adequate number of pieces of charcoal. With the exception of sample 2203-4 v.5 S7, all curves end in a prolonged horizontal plateau, which indicates that it is unlikely that more taxa occur in the samples. In the samples with sufficient remains of charcoal, the number of taxa varies between four and seven. The sample with the highest species-richness is (unfortunately) sample 2203-4 v. 5 S 7, which is the only sample where even more taxa might be expected on the basis of the saturation curve. Since this sample did not yield any single species that exclusively occurred in this sample, it is highly unlikely that completely new taxa might be discovered in this or any other sample.

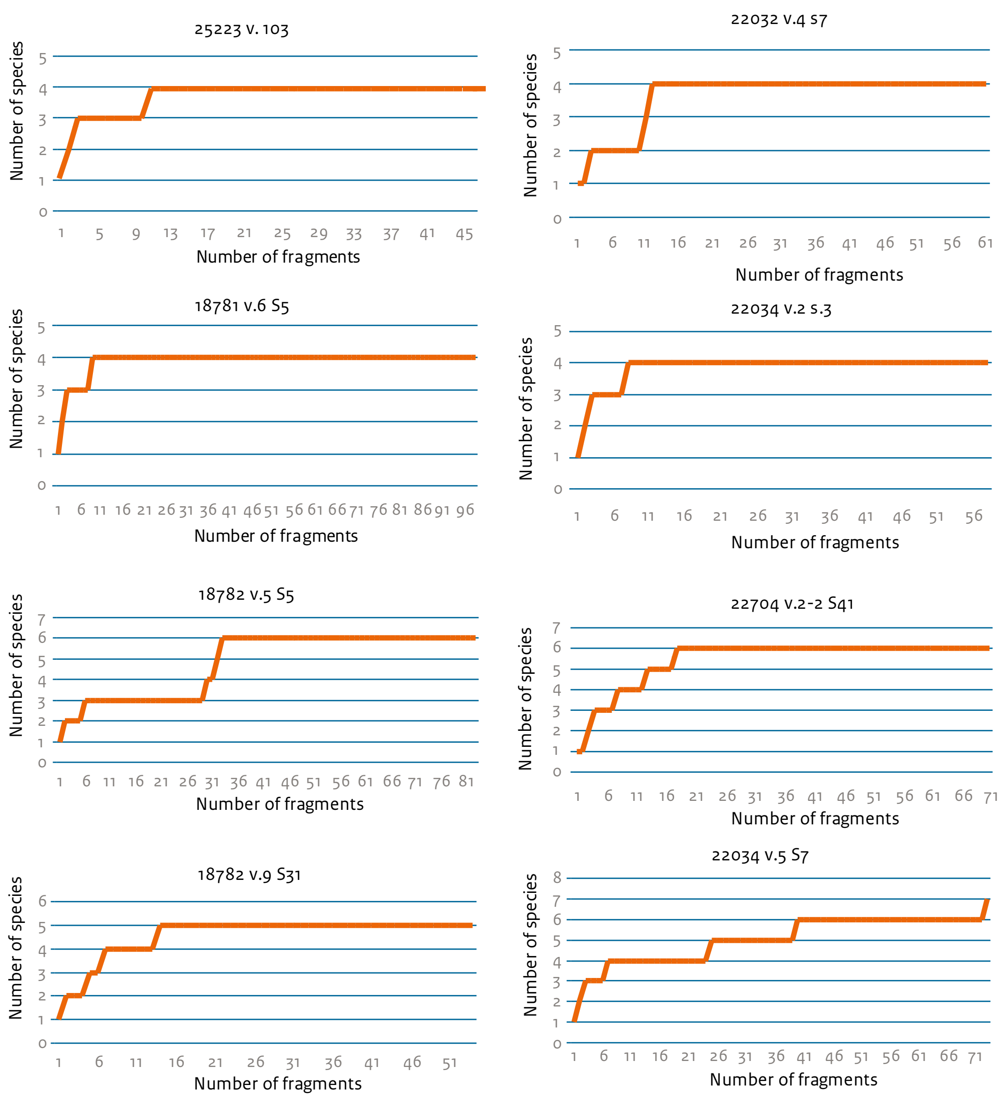


Figure 9.4 Saturation curves of the charcoal samples (for explanation see Methods, Section 9.2)

354 Weeda *et al.* 1985, 59.
355 Beckhoff 1968.

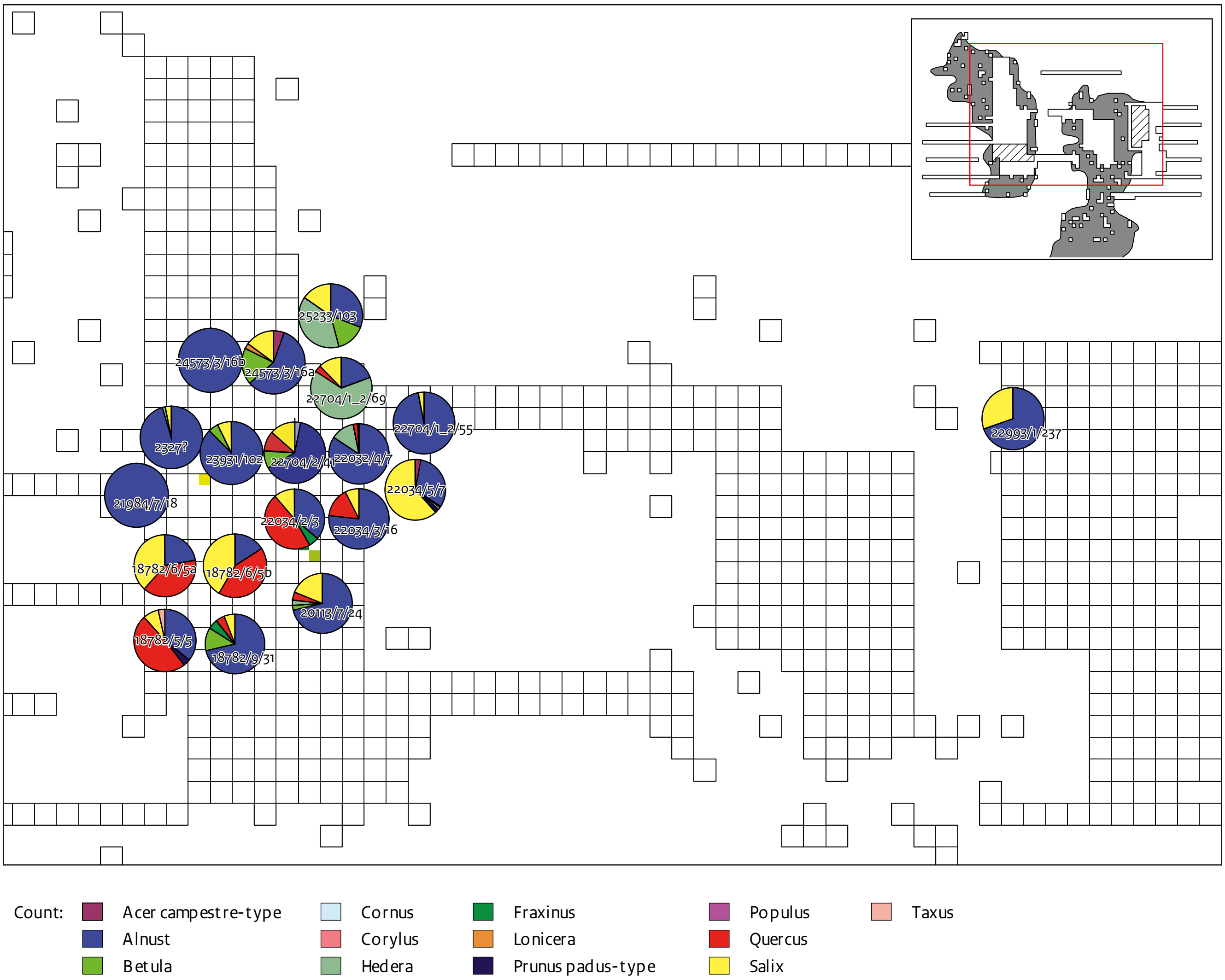


Figure 9.5 Distribution of the taxa (by weight) in the 19 samples with charcoal from Zeewijk.

The distribution of the various taxa was not uniform in the samples studied (Fig. 9.5). The share of the various taxa is measured in weight here, since different taxa have different chances of fragmentation. If numbers had been used, easily fragmenting species would be overrepresented. By using weight, the species that have thin stems (ivy, honeysuckle) will be underrepresented, but their proportion in weight will be related to the proportion of firewood they supplied.

All but one sample derive from Zeewijk-West. Three out of four samples from square 1878 in Zeewijk-West have oak as the most common species (in one case together with willow), and no other sample yielded so much oak. It is also remarkable that the pieces of oak are predominantly trunk wood, while the other species found in these samples are dominated by branch wood. Willow and alder is the next important taxon in these three samples, and alder is the dominant species in the remaining sample from square 1878. Ash and yew are also mainly found in this square (only nearby square 2203 contains some more ash), but both occur in low numbers.

Alder is the most common taxon in many of the remaining samples, with the exception of three (out of six) samples from square 2203, which have oak, willow and ivy as the most common taxa, and one more sample from the northern part of the investigated area, where ivy is the most common species (square 2523).

Two samples from the same feature in

square 2457 are very different in composition, one exclusively containing alder, the other containing five different taxa. The first one, however, yielded only five pieces of identifiable charcoal (alongside 34 pieces of bark and 17 pieces of reed stem). The total number of taxa represented in the sample is not therefore reliable. The same applies to the second sample consisting exclusively of alder, where only two pieces could be identified, besides one piece of bark and twelve reed stems.

Explosion holes were observed only in some pieces of alder charcoal, two large heavy ones from square 1878 and two small pieces from square 2270. Fungal hyphae were not observed at all.

The single sample from Zeewijk-East (square 2299) also yielded insufficient pieces of charcoal (14 pieces of alder, seven of willow and five of bark) for a reliable picture. The only waterlogged pieces of wood that have resisted decay since deposition are five oak central posts from the 'large house' in Zeewijk-East (Fig. 9.6). These are also the deepest features at the site,[356] which will have contributed to their preservation. Dendrochronological investigations of these pieces did not result in a reliable calendar age, either in the 1990s (Elsemieke Hanraets, RING) or recently, despite the availability of more reference material for the Late Neolithic (Esther Jansma, RCE).

The plant macrofossils that have been observed during the identification of charcoal were naked barley (*Hordeum vulgare* var. *nudum*), emmer wheat (*Triticum dicoccon*), hazelnut shell fragments (*Corylus avellana*) and marsh mallow (*Althaea officinalis*). All remains were charred and came from species regularly encountered during the investigation of botanical macroremains in Zeewijk.[357]

9.4 Discussion

Alder is the most common species in most of the samples, both in number and in weight. Alder is also one of the few woody taxa that are likely to grow in the near vicinity of the site. Oak is second in abundance, and restricted to the southwestern part of the excavated area. The waterlogged central posts of the house in

Figure 9.6 One of the central posts of the large structure of Zeewijk-Ease, made of oak (*Quercus* spec.) with abundant tool marks.

Zeewijk-East are also of this highly durable type of wood. The environment of Zeewijk, with a strong marine influence according to the archaeobotanical analysis,[358] does not provide a landscape where oaks can be expected. It is more likely that the oak wood was obtained from the Pleistocene boulder clay outcrops at Wieringen, around 12 km from the site,[359] or perhaps from closer levees outside the reach of saline or brackish water. Willow is also more common in the southwestern part of the site. Willows might well have grown in the surroundings of Neolithic Zeewijk, together with alder on the levees of creeks situated in the freshwater range. Ash, bird cherry and field maple can be expected on such levees too. Silver birch, aspen and possibly also dogwood, oak and yew may have either derived from sandy coastal beach barriers (not too exposed to salt spray, with the probable exception of aspen which is more salt tolerant) or from Wieringen.

The dominance by weight of ivy in two samples is remarkable. Its presence is considered a by-product of the burning of another species of wood to which ivy was attached. It is however hard to imagine that this

356 Nobles, this volume Chapter 3: especially Fig. 3.3.
357 Kubiak-Martens, this volume.
358 Kubiak-Martens, this volume.
359 Smit, this volume: Fig. 2.1.

would result in dominance by weight of ivy charcoal, not least because all ivy finds were branch wood. The relatively low number of available remains may have influenced the dominance of ivy. Both ivy and honeysuckle may have climbed into the trees on the levees in the surroundings of Zeewijk.

Charcoal, mainly derived from cultural layers at Zeewijk, does not represent single activities at the site, because the layers consist of a palimpsest of settlement activities. However, the presence of charcoal in itself does attest to the activity of collecting wood. Charcoal with 'explosion' holes is very rare, which points to the use of dry deadwood. Only sample 9 from square 1878-2 contained a majority of this type of charcoal (from alder) that might point to burning of wood with a high moisture content. Although such conclusions are often drawn from explosion holes, experimental research was unable to create such charcoal from fresh wood.

The results from Zeewijk can be compared directly to those from Keinsmerbrug and Mienakker, the other two sites in the Odyssey project.

The diversity in the species composition of the samples might yield information on the duration of habitation, assuming that during more prolonged habitation, a greater variety of wood sources will be exploited (for instance as a result of the exhaustion of nearby sources) and the higher the diversity in taxa that dominate samples.

Twenty samples from Zeewijk were analysed. Alder dominates the assemblage (by weight) in ten and alder plus willow in another five. Oak is the most abundant in four samples (three of which are from the same square and unit 1878-2) and ivy in one. The total number of woody taxa in Zeewijk is 13.

At Mienakker, six of the nine samples are dominated by poplar/aspen (all from phase 1) and one sample shows a mixture of oak, birch and hazel (from phase 2). The remaining two samples did not yield wood charcoal. The total number of woody taxa at Mienakker is five.[360]

At Keinsmerbrug, 147 samples from squares and 15 from pits were analysed.[361] Data on individual samples have not been published, so it is impossible to judge the diversity in species composition in the samples, and the large number of analysed samples also hampers the comparison of the total species list for the site with Zeewijk and Mienakker. The total number of woody taxa at Keinsmerbrug is eleven, but three of these (dogwood, buckthorn (*Rhamnus cathartica*) and elder (*Sambucus nigra*)) yielded only a single piece in one sample and would not have been found if the intensity of the research had been the same as at Mienakker and Zeewijk. Considering this, the large number of taxa at Zeewijk contrasts with the much lower numbers at both Mienakker and Keinsmerbrug. This may be seen as an indication that the collection of firewood at Zeewijk took place over a more prolonged period, during which more diverse biotopes were exploited. Since Zeewijk is a large site and Mienakker and Keinsmerbrug are small sites, the size of the site may also be related to the longevity of the habitation. This could imply that the large site at Zeewijk might be regarded as a palimpsest of small sites like Mienakker.

The oak wood used for the construction of the 'large structure' at Zeewijk suggests the building may have been very durable, lasting 25-50 years.[362] However, we do not know whether other, less durable species of wood were also used in the structure. Since no waterlogged wood has been preserved at the other two sites under discussion, a direct comparison of wood used for construction purposes is impossible.

The average weight of charcoal pieces might also be related to duration of habitation. More prolonged habitation results in more trampling and more frequent use of hearth locations. Both result in ongoing fragmentation of charcoal. The average weight of the charcoal pieces identified at Zeewijk in the individual samples ranges from 4 to 43 milligrams, at Mienakker from 3 to 30 milligrams and at Keinsmerbrug it is 510 milligrams for 'squares' and 310 milligrams for pits. No data on individual samples are available from Keinsmerbrug. From these data, we can infer that Keinsmerbrug will have been inhabited for a shorter period, resulting in less fragmentation of the charcoal. The degrees of fragmentation at Zeewijk and Mienakker are similar, suggesting that the length of habitation was also similar at these two sites.

Charcoal data for the Mesolithic and Neolithic are available for 952 samples from 55 sites in the WODAN database. Among these, only one other sample with a dating range that overlaps with

[360] Van den Hof & Brinkkemper 2013.
[361] Kooistra 2001.
[362] Vermeeren & Brinkkemper 2005.

the Single Grave Culture has been investigated, from the Knooppunt-Hattemerbroek site in the valley of the river IJssel in the eastern part of the Netherlands (province of Overijssel), although pottery suggests the presence of the older Funnel Beaker Culture and the younger Bell Beaker Culture here, rather than the Single Grave Culture. Only two taxa (besides Indet.) were recovered there: oak and alder.[363] These are also dominant at Zeewijk. The only other site in the vicinity of Zeewijk in WODAN is Wieringen-Bouwlust, which belong to the Funnel Beaker Culture (TRB). Eleven samples from Bouwlust have been analysed for charcoal, and again oak and alder dominate the samples. Some birch, willow, field maple and yew were also recovered, plus 13 pieces of pine (*Pinus* spec.) in one sample and one possibly of lime (cf. *Tilia* spec.).[364] The latter two species have not been recovered from the three SGC sites discussed here.

9.5 Conclusions

In this section, the general research questions will be answered as far as possible using the results of the charcoal investigations.

Natural environment (ecozones)
The charcoal in Zeewijk comes from wood that was collected in four different parts of the environment, some close to the settlement in alder carr forests and on levees along the creeks (within the range of the freshwater tidal area), some at a greater distance on beach barriers to the west or the Pleistocene boulder clay outcrop at Wieringen to the north.

The charcoal assemblage at Zeewijk derives mainly from forests on wet soils consisting of alder carr. Willow and ivy may occur in such forests too. Carbonised reed stems are abundant, regularly exceeding charcoal in weight. Reed may have grown in many places in the vicinity of the site, but not in excessively saline conditions. Bird cherry, field maple and ash may have grown on the levees bordering the creeks in the tidal landscape, but only within reach of the freshwater tidal area.

The samples from square 1878 (quadrant 2) are clearly different, with oak dominating in three of the four samples. This square is the most southwestern square that has been analysed. The remaining five samples with oak are all from squares 2203 and 2270. The ratio of trunk to branch wood leans much more towards trunk wood for oak than for alder and willow. Five samples with the rare species ivy are clustered in the northeastern part of Zeewijk-West. The two samples from Zeewijk-East are very monotonous, one only yielding charred remains of reeds, the other charred seed remains in combination with charcoal of alder and willow.

Activity areas
Due to the lack of data on individual features, including find layers, it proved impossible to locate clear activity areas in the charcoal assemblages of Zeewijk. However, the presence of a cluster of samples dominated by oak in the southwestern part of Zeewijk might be related to the presence of a sturdy structure made of oak, as in Zeewijk-East.

Duration and seasonality of habitation
The large variety of taxa in the wood spectrum of Zeewijk in comparison to the much smaller variation at Mienakker and Keinsmerbrug (also considering the high number of samples studied from the latter site) may be regarded as evidence of longer-lasting habitation at Zeewijk. The much smaller degree of fragmentation in the charcoal from Keinsmerbrug is most likely the result of much shorter habitation (less trampling and less recycling of charcoal within hearths). The use of oak wood as roof-bearing components in the 'large structure' of Zeewijk-East suggests a durable building, that may have lasted 25-50 years.

Seasonality cannot be inferred from the available charcoal data.

Comparison with other sites
The only possible contemporaneous settlement that has been investigated for charcoal is Knooppunt-Hattemerbroek near Zwolle. Alder and oak have been found there, which are also the dominant taxa at Zeewijk. However, it is likely that Funnel Beaker and Bell Beaker settlements were located here, but no Single Grave Culture. These two taxa also prevail at the nearby earlier site of Wieringen-Bouwlust, dating to the Funnel Beaker Culture. From these data it is clear that the charcoal investigations of the three sites in our Odyssey project provide a unique dataset.

[363] Kooistra 2013.
[364] De Man 2002.

10 Faunal remains

J.T. Zeiler & D.C. Brinkhuizen

10.1 Introduction

The numerous faunal remains from Zeewijk constitute an important source of information in the study of the Late Neolithic occupation of West-Friesland. In the early 1990s a small proportion of the material was analysed.[365] The present study was aimed at broadening our knowledge of this site by analysing a considerably larger quantity of zoological material.

The research focused on the following topics and 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 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 about the former landscape (including the aquatic environment) in the vicinity of the site and the ecozones exploited?

10.2 Methods

During the excavation of the site, bone material was collected by layer (approx. 3 cm thick) in units of 100x100 cm and sieved through a 4 mm mesh.[366] In the previous study part of the material from Zeewijk-West was analysed by De Vries.[367]

In the present study, bones were analysed from the squares of both Zeewijk-West and Zeewijk-East, having been selected as described in Section 1.5. This selection included some of the remains analysed in the previous study.[368] The fish remains were studied by the second author. 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. The bird and mammal bones were analysed by the first author with the aid of the reference collection of the Groningen Archaeological Institute (GIA), except for some of the vole remains, which were identified by Bekker.[369] Due to the large amount of material, characteristics such as traces of burning were recorded for the identifiable remains only. The data were entered into an Access database in accordance with the specifications developed by the *Projectgroep Archeologie AHR*.[370]

For this report, the data published by Habermehl were used to analyse the information on the ages at which the mammals were slaughtered.[371] The slaughter age of the category sheep/goat is determined using the age data on sheep. Information on butchering methods was obtained from the ratios of skeletal elements and from the positions of the traces of butchering on the bones. The criteria devised by Uerpmann were used to estimate the quality of the cattle meat consumed.[372] Measurements were taken according to the method developed by Von den Driesch.[373] Matolcsi's data were used to calculate the withers height of cattle.[374]

The pig remains were first grouped under the heading 'pig or wild boar'. Then the metric data published by Albarella, Dobney & Rowley-Conwy were used to distinguish the wild form from the domesticated one.[375]

10.3 Results from Zeewijk-West

10.3.1 General results

Apart from its volume, the bone material from Zeewijk-West is characterised by heavy fragmentation and generally moderate preservation. The latter applies especially to the mammal bones. As a result, slaughtering traces are still visible on only a limited number of remains. The fact that, with one exception, they are absent from the bird remains is a common phenomenon: cut and chop marks are rarely found, even on very well preserved complete bird bones.

The strong fragmentation is reflected in the mean weight of the identified remains: 0.26 g for bird bones and 11.7 g for mammal bones. These values are almost the same as at Mienakker: 0.25 g and 12.5 g.[376] At Keinsmerbrug, another site where the animal

[365] De Vries 1996, 2001. This analysis comprised 688 mammal remains, 3678 bird remains and an unknown number of fish remains.
[366] Theunissen, this volume; Nobles, this volume Chapter 3; Bulten 2001b.
[367] De Vries 1996; 2001.
[368] These remains were re-analysed in the present research.
[369] Dick Bekker Zoogdiervereniging, Groningen.
[370] Projectgroep Archeologie AHR 2003.
[371] Habermehl 1975.
[372] Uerpmann 1973.
[373] Von den Driesch 1976.
[374] Matolcsi 1970.
[375] Albarella, Dobney & Rowley-Conwy 2009.
[376] Zeiler & Brinkhuizen 2013.

remains were heavily fragmented, the average weight of identified bird remains is almost the same (0.2 g), but that of the mammal bones is twice as high (24.6 g).[377]

Burning appears to have been an important factor in the taphonomic processes, particularly for the bird bones. More than 40% of the identified bird remains are burnt to a certain degree, as compared to 9% of the identified mammal bones (Table 10.1).

Table 10.1 Frequency of traces of burning, slaughtering and gnawing on identified birds and mammal bones.

Taxon	Burning		Slaughtering		Gnawing	
	NR	%	NR	%	NR	%
Mammals	99	9.3	23	2.2	24	2.3
Birds	526	43.5	1	0.1	8	0.7

NR = number of remains.

Table 10.2 Number of remains and weight of identified mammals, birds, fish, molluscs and amphibians.

	NR	%	BW	%
Mammals	1137	17.8	13292.4	97.7
Birds	1192	18.6	311.3	2.3
Fish	3998	62.4	-	-
Molluscs	72	1.1	1.3	-
Amphibians	8	0.1	-	-
Total	**6407**	**100**	**13605.0**	**100**

NR = number of remains; BW = weight in g. Mammals excluding *Homo sapiens*. The remains of fish and amphibians were not weighed.

[377] Zeiler & Brinkhuizen 2012.

Table 10.3 Worked bone.

Square	Serial	Species	Element	Part	%	Weight (g)	Artefact	Macroscopically visible modifications		
								polish	rounded	other
18802	1	Bos taurus	costa	corpus	0-10	4.5	'ripples'	yes	yes	
21363	1	medium mammal	long bone	indet.	0-10	1.5		no	no	scratched surface
14984	1	Bos taurus	costa	corpus	10-25	28.7	'ripples'	yes	yes	
16272	1	Ovis aries/Capra hircus	tibia	proximal epiphysis + diaphysis	25-50	24.0	awl?	yes	no	
7094	1	medium mammal	long bone	diaphysis	0-10	2.7	needle	yes	no	scraping marks
7094	3	medium mammal	long bone	diaphysis	0-10	1.0	needle	yes	yes	scraping marks
17501	1	Canis familiaris	tooth	incisor	10-25	0.3	pendant	yes	yes	conical perforation
14973	1	Bos taurus	costa	corpus	0-10	5.4	'ripples'	no	no	
7188	2	Ovis aries/Capra hircus	tibia	diaphysis	0-10	4.8	button	yes	yes	parallel incisions, perforations
8834	1	Ovis aries/Capra hircus	tibia	diaphysis	0-10	2.2	button	yes	no	parallel incisions
29714	1	large mammal	long bone	diaphysis	0-10	18.8	spatula?	?	yes	charred

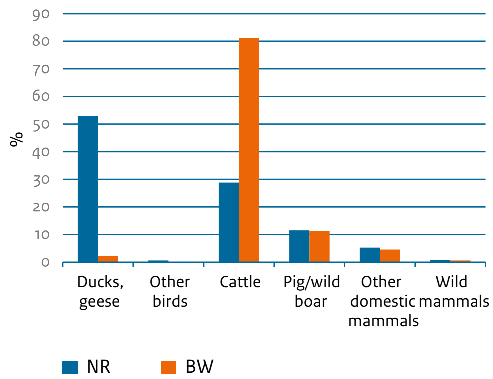
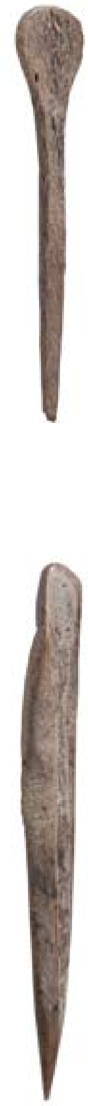


Figure 10.1 Frequency of different categories of identified bird and mammal bones. NR = number of remains; BW = weight in g.

There are considerable differences between the different categories of animals in terms of identification rate. It is highest among the amphibians, all eight remains having been identified to species or family level. As for fish and molluscs, the rates were 78.7% and 41.6% respectively. When it came to the bird remains, 14.3% could be identified, while for mammals this was the case with only 5.2%.

Fish make up the largest proportion of the identified remains (Table 10.2). Bird bones slightly outnumber mammal bones. However, in terms of weight, mammal bones (especially those of cattle) are far more important, accounting for 98% of the overall weight of bird and mammal remains. Most bird bones come from ducks; other groups like waders are only represented in small numbers. Birds of prey are conspicuously absent. Among the wild mammals, wild boar (*Sus scrofa*) are relatively numerous (Table 10.2, 10.4; Fig. 10.1). The fish remains are mainly from flatfish. Molluscs – mostly mussels (*Mytilus edulis*) – are represented by very tiny fragments. The human remains comprise five stray teeth.

Eleven pieces of worked bone were found among the material. These comprise several types of artefacts, such as needles (Fig. 10.2), buttons (Fig. 10.3), objects known as bone



a

b

Figure 10.2 Two needles from the same one meter square 7094 , find number 7094-1 (a), 7094-3 (b). Scale 1:1.

a

b

Figure 10.3 Two buttons (toggles) decorated with incisions, made of the diaphysis of sheep/goat, find number 7188-2 (a), 8834-1 (b). Scale 1:1.

a

b

Figure 10.4 Two 'ripples' (*bobbelkammen*), made of ribs of cattle, find number 14984 (a), 18802 (b). Scale 1:1.

Figure 10.5 Pendant made from the incisor of a dog, find number 17501. Scale 2:1.

'ripples' (Dutch: *bobbelkammen*) (Fig. 10.4) and a pendant (Fig. 10.5). This last object was made of a dog tooth; the other objects were made of long bones and ribs of mammals, including sheep/goat and cattle (see Table 10.3).

10.3.2 Mammals

Out of five measurable pig/wild boar bones, two could be positively identified as wild boar (*Sus scrofa*) and one as domestic pig. The remaining

Table 10.4 Mammal remains (excluding *Homo sapiens* and small rodents).

Species	NR	%	BW	%
Livestock				
Cattle (*Bos taurus*)	678	63.8	10672.5	83.7
Sheep/goat (*Ovis/Capra*)	72	6.8	235.1	1.8
Sheep (*Ovis aries*)	12	1.1	201.6	1.6
Pig (*Sus domesticus*)	86*	8.1	471.6	3.7
Subtotal	**848**	**79.8**	**11580.8**	**90.8**
Dog (*Canis familiaris*)	25	2.3	123.0	1.0
Wild ungulates				
Red deer (*Cervus elaphus*)	1	0.1	9.9	0.1
Roe deer (*Capreolus capreolus*)	2	0.2	43.5	0.3
Wild boar (*Sus scrofa*)	171*	16.1	943.3	7.4
Subtotal	**174**	**16.4**	**996.7**	**7.8**
Fur animals				
Beaver (*Castor fiber*)	5	0.5	17.1	0.1
Brown bear (*Ursus arctos*)	1	0.1	1.1	-
Stoat (*Mustela nivalis*)	1	0.1	0.1	-
Wildcat (*Felis silvestris*)	4	0.4	0.8	-
Subtotal	**11**	**1.1**	**19.1**	**0.1**
Sea mammals				
Common seal (*Phoca vitulina*)	1	0.1	2.1	-
Grey seal (*Halichoerus grypus*)	4	0.4	22.0	0.2
Subtotal	**5**	**0.5**	**24.1**	**0.2**
Total mammals, identified	**1063**	**100.0**	**12743.7**	**100**
Large mammal	252		1421.2	
Medium mammal	237		548.7	
Small mammal	19		9.1	
Mammal, indet.	20350		4563.1	
Total mammals, indet.	**20858**		**6542.1**	

NR = number of remains; BW = weight in g. * Extrapolated numbers based on finds of one pig bone and two wild boar bones. Most of the remains (n= 254) have been identified as pig or wild boar.

Table 10.5 Distribution of skeletal elements of cattle, sheep/goat and pig/wild boar.

Element	Cattle	Sheep/goat	Pig/wild boar
Cranium	60	4	1
Horn core	11	-	-
Maxilla	4	2	6
Mandibula	25	2	7
Stray teeth	368	27	101
Vertebra	16	1	27
Sacrum	-	1	-
Ribs	22	4	39
Scapula	10	-	6
Humerus	9	1	9
Radius	14	6	2
Ulna	2	-	1
Pelvis	9	3	5
Femur	9	2	2
Patella	2	-	2
Tibia	16	5	6
Metacarpus	20	2	1
Metatarsus	15	-	-
Metapodia	4	2	5
Carpalia	13	3	2
Tarsalia	12	5	2
Phalanges	21	5	24
Sesamoid	16	9	9
Total	**678**	**84**	**257**

bones could not be unambiguously attributed to either of the two on the basis of measurements (Appendix X). Although three identifications do not provide a firm basis for extrapolating the ratio of wild to domesticated (2:1) to the unidentified Suidae specimens (a total of 254 remains), for lack of a better method we have chosen to do so anyway (Table 10.3). The percentages mentioned in the text are extrapolated values.

Among the mammal bones, those of cattle (*Bos taurus*) are by far the most numerous, exceeding pig (*Sus domesticus*) and sheep/goat (*Ovis/Capra*) both in number and in weight (Table 10.4).[378] A considerable proportion (22.5%) of the pig/wild boar bones come from one individual, represented by a number of ribs and vertebrae.[379] All vertebra discs were still unfused, which means the animal must have been younger than 4-6 years. Cut marks on a lumbar vertebra indicate that the meat was cut loose from the bone.

The cattle bones come from all parts of the body (Table 10.5): head, fore and hind legs (lower legs included), shoulder, pelvis and trunk (vertebrae and ribs). The representation of the skeletal elements once more corroborates the presence of cattle at the site. The same applies to sheep/goat, be it to a slightly lesser extent.

In general, the remains of livestock can be regarded as a mixture of consumption and slaughtering waste. As for cattle, the consumption waste (category A and B) is the most numerous (approx. 64%). This does not mean that most elements are rich in meat, because the elements poor(er) in meat (category B and C) are more than twice as numerous as those rich in meat (Table 10.6). Most cut marks, appearing on fragments of scapula, rib, pelvis, femur and thoracic vertebra, indicate that the meat was cut loose from the bone. Cut marks on the proximal part of a metacarpus indicate skinning, while those on the proximal epiphysis of a tibia point to dismemberment of the carcass. Cut marks on the ramus of a sheep's mandible and just below the proximal epiphysis of a radius of sheep/goat are also caused by dismemberment. As for pig/wild boar, apart from the lumbar vertebra already mentioned, cut marks can be seen on three fragments. Those on the *collum* of a scapula indicate dismemberment; the cut marks on the cranium and tibia are caused by cutting the meat from the bone.

The fourth domestic mammal is the dog (*Canis familiaris*). Most remains (15 out of 25) are stray teeth, one of which, a canine, was worked into a pendant (Fig. 10.5).[380] Cut marks can be seen just below the proximal epiphysis on a femur, indicating dismemberment. This could mean that the animal was eaten.

The age data for cattle, based on the fusion of the epiphyses in the postcranial bones, suggest that only a few animals younger than 2-2.5 years were slaughtered. More than 70% of the cattle

[378] In so far as the sheep/goat bones could be identified to species level, only sheep were identified.

[379] This partial skeleton comes from square 16294 (square number 1629, subdivision 4; serial number 102).

[380] Square number 1750, subdivision 14; serial number 4.

Table 10.6 Remains of cattle divided into main processing categories (after Uerpmann 1973).

Category	NR	% (1)	% (2)
Consumption waste			
A, rich in meat	55	18	28
B, poor(er) in meat	143	46	72
Total consumption waste	**198**	**64**	**100**
Butchery waste			
C, poor in meat/meatless	112	36	-
Total butchery waste	**112**	**36**	**-**

(1) = all remains, (2) = consumption waste. Category A: vertebra, scapula, humerus, pelvis, femur (incl. patella); Category B: head (excl. horn cores), radius, ulna, tibia; Category C: horn core, metapodia, carpalia, tarsalia, phalanges. Stray teeth excluded.

were slaughtered after the age of 2-3, while 60% lived beyond the age of 3.5-5 (Table 10.7, 10.8). According to the dental data, however, the proportion of animals that were slaughtered before the end of their second year was much higher. Of the nine jaws that could be used for ageing, five are from animals younger than two years (among them a mandible from a 5-6 months old calf), which means a culling rate of 56% (Table 10.9). This discrepancy illustrates the margin that should be considered in such calculations and the restrictions of the method; we must also bear in mind that the dataset is very limited.

The age data for pig/wild boar and sheep/goat are scarcer than for cattle and comprise both younger and older individuals. This also applies to the dog remains. One metapodial is from a puppy of less than 5-6 months old, while the already mentioned femur with cut marks comes from a mature dog aged approx. 18 months.

Measurements were taken from bones of cattle, dog, sheep, pig and wild boar (Appendix X). The withers height (133.5 cm) could be inferred from the greatest length (GL) of a cattle metacarpus. This is larger than the withers heights established for Mienakker (126.6 cm) and Keinsmerbrug (125.6 cm). It is also larger than

Table 10.7 Age class determinations of cattle, sheep/goat, pig/wild boar and dog, based on the stages of fusion in postcranial bones.

Skeletal element/part	Age (months)	FU	UF
Cattle			
Scapula d., pelvis acetabulum	7-10	2	-
Radius p.	12-15	3	-
Phalanx II p.	15-18	11	-
Humerus d.	15-20	3	-
Phalanx I p.	20-24	5	-
Metapodia d., tibia d.	24-30	10	3
Calcaneus p.	36	-	1
Radius d., ulna p., tibia p.	42-48	2	3
Vertebra discs	48-60	4	1
Sheep/goat			
Humerus d., radius p.	3-4	4	-
Phalanx II p.	5-7	1	-
Phalanx I p.	7-10	1	-
Tibia d.	15-20	3	-
Metapodia d.	20-24	-	1
Calcaneus p.	36	-	2
Radius d.	42	1	-
Vertebra discs	48-60	1	-
Pig/wild boar			
Radius p., scapula d., phalanx II p., pelvis acetabulum	12	11	3
humerus d.	15-20	2	2
Tibia d., metapodia d., phalanx I p.	24	-	10
Femur d.	42	-	1
Vertebra discs	48-72	-	9
Dog			
Metapodia d., phalanx II p.	5-6	1	1
Radius p.	6-8	1	-
Femur p.	18	-	1
Vertebra discs	18-24	2	-

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

Table 10.8 Age classes and culling rates of cattle based on the stages of fusion in postcranial bones.

Age (months)	FU	% killed after age	UF	% killed before age	% killed between 2 ages
7-24	24	100	-	0	-
24-36	10	71	4	29	29
42-60	6	60	4	40	11

FU = (epiphysis) fused = older than indicated age (n); UF = (epiphysis) unfused = younger than indicated age (n).

Table 10.9 Age class determinations of cattle, sheep/goat and pig/wild boar based on eruption patterns of dental elements.

Criterion	Age (months)	Number
Cattle		
Pd3, Pd4 present, M1 erupting (½)	c. 5-6	1
Pd3, Pd4, M1 present	> 5-6	1
M1 present, slightly worn (b)	> 5-6	1
Pd2-Pd4 present	< 24	3
P2-4 erupting; Pd4 still present, heavily worn (m)	c. 24	1
P2, P3 present	> 24	1
M2, M3 present	> 24	1
Sheep/goat		
P2-M2 present	> 24	1
P4-M3 present	> 24	1
Pig/wild boar		
M2 present	> 13	1
P2-M2 present	> 16	1
P4-M2 present	> 16	2
M1-3 present, M3 unworn	c. 20	1
M1-3 present	> 20	1
M2, M3 present	> 20	1

those from Kolhorn, Schipluiden and Vlaardingen, with withers height of 129, 129.4 and 130 cm respectively.[381]

Among the wild mammals (microfauna not included), wild boar are relatively well represented. The other wild ungulates are red deer (*Cervus elaphus*) and roe deer (*Capreolus*

Figure 10.6 Beaver (photo: Wikimedia Commons).

capreolus). Their remains, a phalanx II for both and an antler fragment of roe deer, do not necessarily come from locally hunted animals. The antler could have been shed and collected, while the phalanges might have been part of imported hides.

Fur animals are represented by four species: beaver (*Castor fiber*; Fig. 10.6), stoat (*Mustela nivalis*) – rarely found in archaeological contexts but also present at Mienakker – brown bear (*Ursus arctos*) and wildcat (*Felis silvestris*). The remains of the last three species – stray teeth (wildcat), mandible (stoat) and phalanx II (brown bear) – could all have been brought to the site attached to skins. The beaver bones, representing at least two individuals, tell another story. Since only long bones from beaver have been found they may come from locally hunted animals. We were able to use one of these, a radius, for determining age. The proximal epiphysis had not yet fused with the diaphysis, which means that it comes from an animal less than two years old.

The remains of grey seal (*Halichoerus grypus*) also indicate local hunting, since besides phalanges I and II they include a fragment of pelvis and a patella (kneecap). The other seal species, common seal (*Phoca vitulina*), could also

[381] Zeiler & Brinkhuizen 2012, 2013; Zeiler 1997, 2006a; Clason 1967.

have been hunted locally, but the only bone identified as coming from this species (a metacarpus 2) could also have been brought to the site attached to an imported skin.

10.3.3 Birds

The vast majority of the bird bones (Table 10.10) come from ducks, especially mallard (*Anas platyrhynchos*) and teal/garganey (*Anas crecca/A. querquedula*). As the remains of teal/garganey can be relatively easily distinguished from the larger duck species, and larger ducks other than mallard are scarce, the 'duck' category will mainly consist of mallard. Other waterfowl species, all present in low numbers, are: swan (*Cygnus* sp.), brent goose (*Branta bernicla*), barnacle goose (*Branta leucopsis*), greylag goose (*Anser anser*), shoveler (*Anas clypeata*), northern pintail (*Anas acuta*), wigeon (*Mareca penelope*) and great crested grebe (*Podiceps cristatus*; Fig. 10.7). This last species was also found at the Late Neolithic site of Kolhorn, not far from Zeewijk, but is rare in archaeological contexts in the Netherlands. The Dutch archaeozoological database *BoneInfo* mentions only three other finds.

Apart from ducks and geese, a number of wader species could also be identified: curlew (*Numenius arquata*), bar-tailed godwit (*Limosa lapponica*), bar-tailed or black-tailed godwit (*Limosa lapponica/L. limosa*), ruff (*Philomachus pugnax*), red knot (*Calidris canutus*) and common sandpiper (*Calidris alpina*). A bone fragment of plover (*Pluvialis* sp.) and another one of plover or snipe (Charadriidae/Scolopacidae) could not be identified to species or genus level. Other bird species represented are guillemot (*Uria aalge*) and a small songbird (Passeriformes). The presence of guillemot is quite special in the Netherlands. According to *BoneInfo* it is known from only three other sites, all situated near the coast.

Considering the faunal spectra of Dutch Neolithic sites, birds of prey are conspicuously absent. However, a falcon (*Falco* sp.) bone was found during the previous study.[382]

As mentioned above (Section 10.3.1), only one bird bone had butchering traces on it: a humerus of a swan on which cut marks can be seen. A bone fragment of a duck bears the bite marks of a dog. Bite marks of a small carnivore, probably a polecat or a marten, can be seen on seven duck bones.[383] Apparently, part of the consumption waste was accessible to scavengers.

Figure 10.7 Great crested grebe on its nest (photo: Wikimedia Commons).

Most of the bird species will have been consumed. Because traces of butchering are almost entirely absent, another source of evidence can be used to support this: the distribution of the skeletal parts. It appears that the great majority of the duck and geese remains are wing bones and elements from the pectoral girdle (clavicle, scapula, coracoid and sternum). Wing bones clearly predominate over leg bones (Table 10.11). This is a phenomenon often found in bone assemblages, but the underlying processes causing it are still unclear. Differential survival of bird remains due to bone density is likely to have an influence, as is human selection. So both cultural and post-depositional factors can 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.[384]

The predominance of wing bones over leg bones at Zeewijk 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 shows the same predominance of wing bones (Table 10.12). The meatless lower leg bone, the tarsometatarsus, is heavily underrepresented compared to the

[382] De Vries 1996, 2001.
[383] The same phenomenon was found on duck bones from Mienakker.
[384] Ericson 1987; Livingston 1989; Bovy 2002; Bochenski 2005; Serjeantson 2009.

Table 10.10 Bird remains.

Species	NR	%	BW	%
Swans, geese and ducks				
Swan (*Cygnus* sp.)	1		2.5	
Brent goose (*Branta bernicla*)	3		3.0	
Barnacle goose (*Branta leucopsis*)	11		7.8	
Brent/Barnacle goose (*Branta bernicla/B. leucopsis*)	11		10.3	
Greylag goose (*Anser anser*)	2		1.4	
Goose (*Anser* sp.)	10		5.8	
Mallard (*Anas platyrhynchos*)	219		98.4	
Teal/garganey (*Anas crecca/A. querquedula*)	180		25.1	
Shoveler (*Anas clypeata*)	16		7.1	
Northern pintail (*Anas acuta*)	1		0.3	
Wigeon (*Mareca penelope*)	2		1.6	
Duck (*Anatidae*)	721		144.8	
Subtotal	**1177**	**98.7**	**308.1**	**99.0**
Waders				
Curlew (*Numenius arquata*)	1		0.1	
Bar-tailed godwit (*Limosa lapponica*)	2		0.3	
Bar-tailed/black-tailed godwit (*Limosa lapponica/L. limosa*)	2		0.2	
Ruff (*Philomachus pugnax*)	1		0.6	
Red knot (*Calidris canutus*)	1		0.1	
Common sandpiper (*Calidris alpina*)	2		0.1	
Plover (*Pluvialis* sp.)	1		0.2	
Plover/snipe (Charadriidae/Scolopacidae)	1		0.3	
Subtotal	**11**	**0.9**	**1.9**	**0.6**
Other species				
Great crested grebe (*Podiceps cristatus*)	1		0.3	
Guillemot (*Uria aalge*)	2		1.0	
Small songbird (Passeriformes)	1		-	
Subtotal	**4**	**0.4**	**1.3**	**0.4**
Total	**1192**	**100**	**311.3**	**100**
Bird, indet.	7140		584.3	

NR = number of remains; BW = weight in g. No percentages per species were calculated because of the preponderance of ducks.

carpometacarpus from the wing. This corresponds with the almost complete absence of posterior phalanges. The numbers are higher for the (more meaty) tibiotarsus. So 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. They could also have been fed to the dogs. What is surprising, however, is that the other meaty leg bone, the femur, is

Table 10.11 Duck and goose remains: skeletal elements of body parts (numbers) versus species.

Species	Head	Body	Wings			Legs			Totals
			long bones	carpalia phalanges	total	long bones	phalanges	total	
(Greylag) goose	1	6	4	-	4	1	-	1	12
Brent/barnacle goose	-	7	12	3	15	3	-	3	25
Mallard	1	138	61	15	76	4	-	4	219
Teal/garganey	7	101	56	4	60	12	-	12	180
Shoveler	-	10	5	-	5	1	-	1	16
Pintail	-	1	-	-	-	-	-	-	1
Wigeon	-	1	1	-	-	-	-	-	2
Duck	4	333	225	114	339	44	1	45	721
Total	**13**	**597**	**364**	**136**	**499**	**65**	**1**	**67**	**1176**

NR = number of remains; BW = weight in g. No percentages per species were calculated because of the preponderance of ducks.

Table 10.12 Duck remains, three most numerous species: proportions of wing and leg bones (numbers) versus species.

Species	Hu – fe	Ra/ul – tit	Cmc – tmt	Tit – tmt
Mallard	38 – 0	6 – 4	17 – 0	4 – 0
Teal/garganey	33 – 2	10 – 8	13 – 2	8 – 2
Duck	142 – 6	50 – 31	33 – 7	31 – 7

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

heavily underrepresented compared to the tibiotarsus. The same phenomenon was found at the sites of Mienakker and Keinsmerbrug.[385]

From an overview given by Bochenski of natural and human deposits it appears that humeri and femora predominate in the latter.[386] 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 on the Baltic sea shore,[387] but is clearly also more widespread, as the results from Zeewijk, Mienakker and Keinsmerbrug demonstrate. The underlying processes are still unclear, however.

It is likely that waders were also caught for consumption. The distribution of the skeletal parts is similar to that for ducks and geese, with the exception of body parts that are clearly underrepresented. Seven out of 11 remains are wing bones; only two are leg bones. However, we must also consider the fact that the number of remains may be too small for a reliable analysis.

Besides active fowling, people might have gathered dead birds washed up on shore after storms, for their feathers and down and – if they still were fresh enough – for their meat. The guillemot, a bird of the open sea, is the most likely candidate for this, but waders – especially small ones that are relatively difficult to catch, such as sandpipers – could also have been gathered in this way.

To get an idea of the number of birds that were caught, the minimum number of individuals (MNI) was estimated for the three main categories: duck, teal/garganey and mallard. The MNI figures, based on the most numerously represented element, the coracoid, are 65, 26 and 36 respectively. These numbers do not represent the total number of ducks, considering the fact that only part of the material was analysed and, of that selection, only 14.3% of the bird bones

385 Zeiler & Brinkhuizen 2012, 2013.
386 Bochenski 2005.
387 Bochenski, pers. comm.

could be identified. With this in mind, the MNI for duck, teal/garganey and mallard might be seven times higher: 455, 182 and 252 respectively.

Ducks (and geese) are relatively easy to catch in summer (July-August). During this period they moult and are unable to fly, and can be caught in relatively large numbers. One can easily imagine that the people of Zeewijk might have done this by encircling groups of swimming ducks using small boats, and throwing a net over them when they were close enough. This technique is still used today, by field biologists studying brent geese in northern Russia, for example. Besides this, there must have been other ways to catch birds, most probably using nets placed at well-chosen spots. Waders such as godwits 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.[388]

10.3.4 Fish

The species spectrum

Eleven species were identified in the total quantity of fish remains (Table 10.13). The spectrum includes fish species from saline and fresh water, some of which migrate between the two. Marine species dominate. Most remains (87.6%) are from species which were in the past all placed in the genus *Pleuronectes*. These species are plaice (*Pleuronectes platessa*), flounder (*Platichthys flesus*) and dab (*Limanda limanda*). A number of remains which were initially identified as plaice/flounder (*Pleuronectes platessa/Platichthys flesus*) could be determined to species level using the criteria devised by Wouters, Muylaert & Van Neer.[389]

Remains of eel (*Anguilla anguilla*) and the carp family (bream, *Abramis brama*, included) come second, at approx. 3%. The combined proportion of the other species is approx. 6%. Except for pike (*Esox lucius*), the proportion of each of the other species is less than 2%.

As can be seen in Table 10.13, two species of sturgeon were identified. The European sturgeon (*Acipenser sturio*) has traditionally been considered to be the only indigenous sturgeon species in the West-European countries along the Atlantic coast. However, recent studies have shown that the North-American Atlantic sturgeon (*Acipenser oxyrinchus*) arrived in the Baltic Sea between 1200 and 800 years ago.[390] Magnin found that the surface morphology of the scutes of *A. sturio* differs from that of *A. oxyrinchus*.[391] Using these differences Desse-Berset was able to distinguish archaeological

Table 10.13 Fish remains.

Species	NR	%
Fresh water (stationary)		
Bream (*Abramis brama*)	22	0.5
Carp family (Cyprinidae)	98	2.5
Pike (*Esox lucius*)	79	2.0
Subtotal	**199**	**5.0**
Anadromous/catadromous		
Atlantic sturgeon (*Acipenser oxyrinchus*)	29	0.7
European sturgeon (*Acipenser sturio*)	16	0.4
Atlantic/European sturgeon (*Acipenser oxyrinchus/A. sturio*)	14	0.4
Eel (*Anguilla anguilla*)	125	3.1
Flounder (*Pleuronectes flesus*)	277	6.9
Subtotal	**461**	**11.5**
Marine		
Cod (*Gadus morhua*)	33	0.8
Haddock (*Melanogrammus aeglefinus*)	2	0 .1
Whiting (*Merlangius merlangus*)	15	0.4
Codfishes (Gadidae)	14	0.3
Thin-lipped grey mullet (*Liza ramada*)	30	0.8
Grey mullets (*Mugilidae*)	17	0.4
Plaice (*Pleuronectes platessa*)	13	0.3
Plaice/Flounder (*Pleuronectes platessa/P. flesus*)	2819	70.5
Right-eyed flatfishes (Pleuronectidae)	395	9.9
Subtotal	**3338**	**83.5**
Total fish, identified	**3998**	**100**
Fish, not identified	1080	
Total	**5078**	

NR = number of remains.

[388] Van der Ploeg 1977.
[389] Wouters, Muylaert & Van Neer 2007.
[390] Ludwig *et al.* 2002.
[391] Magnin 1964.

remains of *A. sturio* from *A. oxyrinchus*.[392] As a result, she found the presence of *A. oxyrinchus* in ten French archaeological sites located along the Atlantic coast, with the most finds in the Gironde, Loire and Seine estuaries. Two French sites yielded *A. oxyrinchus* in contexts dating to the 4th millennium BC, and at one of them there was a co-occurrence of *A. sturio*. These finds indicate that western Europe was colonised much earlier than initially assumed. For the moment, important chronological hiatuses in the archaeozoological record make it impossible to speculate whether multiple colonisations took place during the Holocene. Spatially, only the Baltic region and the French Atlantic region have been studied, with virtually no data for the North Sea region. In 2011 the Royal Belgian Institute of Natural Sciences in Brussels, Belgium started a research project to investigate which species of sturgeon occurred historically in Belgium, the Netherlands and the United Kingdom.[393] Mounted sturgeon specimens in different European museums are being examined to define valid criteria that distinguish the two species on the basis of their isolated scutes.[394] Moreover, the possible effect of the position of the scute on the body or the effect of the size of the animal on the surface ornamentation of the scutes has never been verified. The research project also involves morphological and genetic analysis of sturgeon remains from archaeological excavations. The 59 sturgeon bones from Zeewijk-West and the nine sturgeon bones from Zeewijk-East will also be included in the project. At both sites, some were identified on the basis of the surface ornamentation of the scute as Atlantic sturgeon (*Acipenser oxyrinchus*), and some as European sturgeon (*Acipenser sturio*).[395]

Taphonomy

Cut marks

In general, cut marks and surfaces formed by cutting are not usually observed on fish bones. If present, they can usually be found on the largest elements of large individuals. No cut marks were found on the material we studied.

Traces of burning

Of the 5078 remains from Zeewijk-West, 380 show traces of burning, charring or calcination. Forty-two of them are indeterminable. The number of unburnt remains far exceeds the burnt remains, which suggests that burning was a minor factor 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 on mammal bones, for example. From our own experience we know that thorough burning results in predominantly very fine crumbs. Such minute fragments will be easily blown away by the wind.

Traces of gnawing

No traces of gnawing were found.

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.[396] The aforementioned authors illustrated this with some photographs of distorted vertebrae from Medieval cesspits. They assume that the bones were flattened during the time they spent in the stomach and intestines. In these cases, Beerenhout refers to vertebrae showing 'metabolic distortion'.[397]

At the Zeewijk-West site, 714 of the 3126 vertebrae (including atlases and *urostyl* vertebrae) show traces of metabolic distortion. This feature was found on two vertebrae of the carp family, eight pike vertebrae, 18 eel vertebrae, one cod vertebra, one thin-lipped grey mullet vertebra and 684 vertebrae of species belonging to the former genus *Pleuronectes*. Sixty-four of the 714 vertebrae with distortion are burned, charred or calcified.

The 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*).[398] Apart from gnawing traces on larger bones, not a single vertebra showed metabolic distortion. It is therefore probable that metabolic distortion is not a result of passage through the gastrointestinal tract. In our opinion, it occurs in a vertebra that is embedded in clayey sediment that is frequently

392 Desse-Berset 2009, 2011.
393 Under the direction of Prof. W. Van Neer (Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Laboratory of Biodiversity and Evolutionary Genomics, Centre for Archaeological Sciences, University of Leuven, Belgium).
394 See *e.g.* Van Neer, Thieren & Brinkhuizen 2012.
395 The determination was carried out by Ms. Els Thieren MSc. (Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Laboratory of Biodiversity and Evolutionary Genomics, Centre for Archaeological Sciences, University of Leuven, Belgium).
396 Wheeler & Jones 1989.
397 Beerenhout 1996.
398 Brinkhuizen 1992.

trodden (trampling). It can clearly be seen under the binocular microscope that many fragments from Zeewijk are rounded (some heavily). It is therefore more appropriate to refer to this as distortion rather than metabolic distortion.

Size of the fish

The total lengths of one or more specimens of the species were also calculated or estimated on the basis of the dimensions of the corresponding skeletal elements of recent specimens with known total length. From the size of the remains of bream is clear that individuals with a total length of 20-50 cm were caught. Pike measured from 40 to 95 cm in length, with an average of 55-70 cm. The thickness of one of the scutes from Atlantic sturgeon points to the presence of an adult fish. The individuals of cod measured 35 to 40 cm, but fish measuring 100 cm were also caught. The total length of the thin-lipped grey mullet caught all exceeded the total length (478 mm) of the recent comparative specimen. The total lengths of four individuals of this species were calculated more precisely. Their total lengths were 570, 524, 515 and 504 mm. The sizes of the right-eyed flatfish of the former genus *Pleuronectes* caught vary range from 15 to 20 cm and from 50 to 55 cm.

These calculated and estimated fish lengths suggest that the inhabitants of Zeewijk knew fishing techniques that enabled them to catch both small fish (small cyprinids and flatfish) and large fish (cod and large mullet).

10.3.5 Background fauna

Apart from birds and mammals whose remains represent consumption and slaughtering waste, other species end up at the site without human intervention, or secondarily via owl pellets (Table 10.14). They represent the site's background fauna, indicators of the local environmental conditions. At Zeewijk, this category is represented by small rodents and amphibians. As for the first category, in most cases the remains come from voles, with root vole (*Microtus oeconomus*) as the most numerous species. It is a clear indicator of a wet, dynamic environment, which also applies to the ground vole (*Arvicola terrestris*).

The only identifiable species of amphibian is the natterjack (*Bufo calamita*; Fig.10.8), which is still a common species in the coastal area.

Figure 10.8 A natterjack (photo: Wikimedia Commons).

Table 10.14 Background fauna: small mammals and amphibians.

Species	NR
Ground vole (*Arvicola terrestris*)	1
Root vole (*Microtus oeconomus*)	43
Vole (*Microtus* sp.)	18
Small rodent (*Rodentia*)	12
Subtotal	**74**
Natterjack (*Bufo calamita*)	1
Frog or toad (Anura)	7
Subtotal	**8**

NR = number of remains.

10.4 Results from Zeewijk-East

10.4.1 General results

The characteristics of the bone material from Zeewijk-East are similar to those in Zeewijk-West: heavy fragmentation and generally moderate preservation. In spite of the much smaller quantity of material, the differences in the rates of identification between the different categories are also more or less the same. The highest rates are to be found among the fish and mollusc remains (78.8% and 75% respectively). When it came to the bird remains, 16.5% could be identified, while for the mammals this was the case with only 4%. Slaughtering traces are

Table 10.15 Frequency of traces of burning, slaughtering and gnawing on identified bird and mammal bones.

	Burning		Slaughtering		Gnawing	
	NR	%	NR	%	NR	%
Mammals	11	7.2	2	1.3	5	3.3
Birds	15	6.2	-	-	2	0.8

NR = number of remains.

Table 10.16 Number of remains and weight of identified mammals, birds, fish and molluscs.

Taxon	NR	%	BW	%
Mammals	153	25.8	1768.9	96.9
Birds	241	40.7	56.0	3.1
Fish	189	31.9	-	-
Molluscs	9	1.5	0.5	-
Total	**592**	**100**	**1825.4**	**100**

NR = number of remains; BW = weight in g. The fish remains were not weighed.

visible on only a few mammal remains, which is probably due to the state of preservation. The strong fragmentation is reflected in the mean weight of the identified remains: 0.23 g for bird bones and 11.4 g for mammal bones, almost the same values as at Zeewijk-West.

Burning appears to have been a far less important factor in the taphonomic processes than at Zeewijk-West, particularly for the bird bones. Only 6% of the identified bird remains are burnt to a certain degree, as opposed to more than 40% at Zeewijk-West. This could point to a difference in activities between the sub-sites. As for the mammal bones, approx. 7% are burnt, which is almost the same as at Zeewijk-West, where the figure was 9% (Table 10.15).

Birds and fish make up the largest proportion of the identified remains, in equal proportions (37.5%). Mammal bones come second at approx. 24%, but outnumber the other categories in weight, at approx. 97% of the overall weight of bird and mammal remains (Table 10.16).

Table 10.17 Mammal remains (excluding small rodents).

Species	NR	%	BW	%
Livestock				
Cattle (*Bos taurus*)	101	68.2	1473.0	83.3
Sheep/goat (*Ovis/Capra*)	3	2.0	55.1	3.1
Subtotal	**104**	**70.2**	**1528.1**	**86.4**
Dog (*Canis familiaris*)	1	0.7	0.5	-
Pig/wild boar (*Sus domesticus/S. scrofa*)	43	29.1	240.3	13.6
Total mammals. identified	**148**	**100**	**1768.9**	**100**
Large mammal	32		213.8	
Medium mammal	11		25.4	
Mammal, indet.	3639		887.4	
Total mammals, indet.	**3683**		**1126.6**	

NR = number of remains; BW = weight in g.

Due to the far smaller numbers of remains, the species spectrum is more limited than at Zeewijk-West. In spite of that this, the general picture is the same, with ducks, flatfish, cattle and pig/wild boar the most numerous. As no measurements could be taken, it was not possible to discriminate between remains of wild boar and domestic pig. Molluscs – mostly mussels – are represented by very tiny fragments.

Remains of background fauna consist of three remains of root vole and two of vole.

Table 10.18 Distribution of skeletal elements of cattle and pig/wild boar.

Element	Cattle	Pig/wild boar
Cranium	4	1
Horn core	1	-
Maxilla	5	2
Mandibula	2	2
Stray teeth	62	22
Vertebra	4	-
Ribs	1	-
Scapula	1	-
Radius	2	-
Ulna	1	-
Pelvis	1	-
Femur	1	3
Patella	1	1
Tibia	3	2
Metacarpus	3	-
Metatarsus	3	2
Metapodia	-	1
Carpalia	2	-
Tarsalia	-	1
Phalanges	4	4
Sesamoid	-	2
Total	101	43

NR = number of remains; BW = weight in g.

10.4.2 Mammals

Among the mammal bones, those of cattle are the most numerous, exceeding pig/wild boar. Sheep/goat and dog are represented by only a few remains (Table 10.17). The cattle bones come from all parts of the body (Table 10.18): head, fore and hind legs (lower legs included), shoulder, pelvis and trunk (vertebrae and ribs). As for pig/wild boar, the representation of the skeletal elements is less complete, which can be attributed to the small number of remains.

As at Zeewijk-West, the remains of livestock can be regarded as a mixture of consumption and slaughtering waste. In the case of cattle, the consumption waste (category A and B) is the most numerous, and better represented than at Zeewijk-West, at approx. 83%. This does not mean that most elements are rich in meat, because the elements poor(er) in meat (category B and C) are far more numerous than those rich in meat (Table 10.19). Cut marks on the shafts of a sheep/goat tibia and a pig/wild boar femur indicate that the meat was cut from the bones. Gnawing marks made by a dog can be seen on three cattle and two pig bones.

Age data are very scarce and comprise only bones of cattle and pig/wild boar, from both younger and older individuals (Tables 10.20, 10.21).

Table 10.19 Remains of cattle divided into main processing categories (after Uerpmann 1973).

Category	NR	% (1)	% (2)
Consumption waste			
A, rich in meat	7	18	22
B, poor(er) in meat	25	64	78
Total consumption waste	32	82	100
Butchery waste			
C, poor in meat/meatless	7	18	-
Total butchery waste	**7**	**18**	**-**

(1) = all remains, (2) = consumption waste; Category A: vertebra, scapula, humerus, pelvis, femur (incl. patella); Category B: head (excl. horn cores), radius, ulna, tibia; Category C: horn core, metapodia, carpalia, tarsalia, phalanges. stray teeth. Stray teeth excluded.

Table 10.20 Age class determinations of cattle and pig/wild boar, based on the stages of fusion in postcranial bones.

Skeletal element/part	Age (months)	FU	UF
Cattle			
Femur p.	42	1	-
Vertebra discs	48-60	-	1
Pig/wild boar			
Tibia d., metapodia d., phalanx I p.	24	1	3
Calcaneus p.	24-30	-	1

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

Table 10.21 Age class determinations of cattle, sheep/goat and pig/wild boar based on eruption patterns of dental elements.

Criterion	Age	Number
Cattle		
Pd3, Pd4, M1 present	> 5-6	1
Pd2-Pd4 present	< 24	2
Pig/wild boar		
P4-M2 present	> 16	1
M3 present	> 20	1

10.4.3 Birds

Apart from a small number of goose bones – brent/barnacle goose and *Anser* sp. – and two bones from waders – curlew and common sandpiper – all remains are from ducks. As at Zeewijk-West, mallard and teal/garganey are the main species (Table 10.22).

There are no bones with slaughtering traces, but bite marks made by a small carnivore, probably a polecat or marten, can be seen on two remains (a clavicle of brent goose and a humerus of mallard).

The distribution of the skeletal parts strongly resembles that at Zeewijk-West. The great majority of the duck and goose remains are wing bones and elements from the pectoral girdle (clavicle, scapula, coracoid and sternum). Wing bones clearly predominate over leg bones. Parts of the head and posterior phalanges – scarce at Zeewijk-West – are entirely absent here (Table 10.23).

Comparison of the frequency of individual wing and leg bones gives the same picture (Table 10.24). The (meatless) tarsometatarsus is heavily underrepresented compared to the wing bones, which corresponds with the absence of posterior phalanges. The tibiotarsus is slightly better represented, while the femur – found in low numbers at Zeewijk-West – is completely absent.

10.4.4 Fish

Eight species were identified in the total quantity of fish remains (Table 10.25). The spectrum comprises fish species from saline and fresh water, some of which migrate between the two. Marine species dominate. In view of the low number of identified remains (189) we are unable to draw far-reaching conclusions. It is however clear that the species composition is similar to that at Zeewijk-West, with a preponderance of species belonging to the former *Pleuronectes* genus (74.6% of the total number of identified remains, flounder included).

10.5 Discussion

The archaeozoological data make it clear that subsistence at Zeewijk was based on stock breeding (mainly cattle), fowling (mainly ducks) and fishing (mainly flatfish). Hunting mammals was of minor importance, though hunting wild boar may have played a larger role than at other Late Neolithic sites in the region (Fig. 10.9).[399]

Considering the fact that at both Zeewijk-West and Zeewijk-East cattle bones account for approx. 78% of the overall weight of mammal and bird remains, cattle were by far the most

[399] In the pig/wild boar percentages of Keinsmerbrug in Figure 10.9 the sieved samples are not included because only the number of the remains (and not the weight) is known. If the pig/wild boar remains from the sieved samples are included, the percentage of the number pig/wild boar is 21.5%.

Table 10.22 Bird remains.

Species	NR	%	BW	%
Geese and ducks				
Brent goose (*Branta bernicla*)	1		0.7	
Brent/barnacle goose (*Branta bernicla/B. leucopsis*)	5		1.4	
Goose (*Anser* sp.)	1		4.5	
Mallard (*Anas platyrhynchos*)	53		18.7	
Teal/garganey (*Anas crecca/A. querquedula*)	45		6.2	
Shoveler (*Anas clypeata*)	2		0.9	
Duck (Anatidae)	132		23.4	
Subtotal	**240**	**99.2**	**55.9**	**99.6**
Waders				
Curlew (*Numenius arquata*)	1		0.1	
Common sandpiper (*Calidris alpina*)	1		0.1	
Subtotal	**2**	**0.8**	**0.2**	**0.4**
Total	**242**	**100**	**56.1**	**100**
Birds, indet.	1212		108.5	

NR = number of remains; BW = weight in g. No percentages per species were calculated because of the preponderance of ducks.

Table 10.23 Duck and goose remains: skeletal elements of body parts (numbers) versus species.

Species	Head	Body	Wings			Legs			Totals
			long bones	carpalia phalanges	total	long bones	phalanges	total	
(Greylag) goose	-	-	1	-	1	-	-	-	1
Brent/barnacle goose	-	5	-	1	1	-	-	-	6
Mallard	-	28	20	2	22	3	-	3	53
Teal/garganey	-	22	19	1	20	3	-	3	45
Shoveler	-	1	1	-	1	-	-	-	2
Duck	-	46	56	22	78	8	-	8	132
Total	**-**	**102**	**97**	**26**	**123**	**14**	**-**	**14**	**239**

Table 10.24 Duck remains, three most numerous species: proportions of wing and leg bones (numbers) versus species.

Species	Hu – fe	Ra/ul – tit	Cmc – tmt	Tit – tmt
Mallard	13 – 0	2 – 2	5 – 1	2 – 1
Teal/garganey	12 – 0	3 – 2	2 – 1	2 – 1
Duck	44 – 0	7 – 7	5 – 1	7 – 1

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

Table 10.25 Fish remains.

Species	NR	%
Fresh water (stationary)		
Carp family (Cyprinidae)	9	4.8
Pike (*Esox lucius*)	12	6.3
Perch (*Perca fluviatilis*)	1	0.5
Subtotal	**22**	**11.6**
Anadromous/catadromous		
Atlantic sturgeon (*Acipenser oxyrinchus*)	4	2.1
European sturgeon (*Acipenser sturio*)	5	2.6
Eel (*Anguilla anguilla*)	3	1.6
Flounder (*Pleuronectes flesus*)	7	3.7
Subtotal	**19**	**10.0**
Marine		
Cod (*Gadus morhua*)	2	1.1
Thin-lipped grey mullet (*Liza ramada*)	6	3.2
Grey mullets (Mugilidae)	6	3.2
Plaice/flounder (*Pleuronectes platessa/P. flesus*)	122	64.6
Right-eyed flatfishes (Pleuronectidae)	12	6.3
Subtotal	**148**	**78.4**
Total fish, identified	**189**	**100**
Fish, not identified	51	
Total	**240**	

NR = number of remains

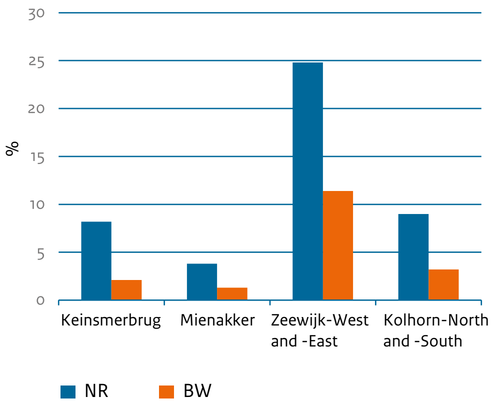


Figure 10.9 Frequency of numbers (NR) and weight (BW, in g) of pig/wild boar at four Late Neolithic sites in Noord-Holland.

important in terms of meat supply. The large numbers of remains make clear that, apart from livestock and birds, fish was an important part of the diet.

The fish spectrum shows that the inhabitants of Zeewijk exploited a number of biotopes in the coastal area. The very low numbers of remains of evident marine species (haddock and to a lesser extent cod) points to the fact that the people mainly exploited freshwater bodies and tidal flats. Flatfish, mainly flounder/plaice, were the most important. The few remains of freshwater fish indicate that these fish (such as cyprinids) were caught incidentally, either in places with very slightly brackish water, where a freshwater creek flowed into a broad estuary, or in freshwater.

The ichthyo-archaeological data from Zeewijk closely resemble those of the Late Neolithic site of Keinsmerbrug and the Early Bronze Age site of Schagen Hoep-North.[400] We assume that the inhabitants of the two mentioned sites fished the same waters as the inhabitants of Zeewijk. At Zeewijk-West only 64 remains of gadids were found among a total of 3998 identified fish remains. No more than two remains of haddock are known to have been found at the site. At Keinsmerbrug 23 remains of gadids were found in a total of 2478 identified fish remains. This site yielded no remains of haddock at all. Nine of the 1389 identified fish remains from Schagen Hoep-North were from gadids. Remains of haddock were absent here too. If we look at the species spectrum of the Mienakker site we see that it deviates a lot from those of the three other sites (Fig. 10.10).[401] Gadids (haddock, cod and whiting) were most important at Mienakker. Haddock is represented there by 1805 remains out of a total of 5293 identified fish remains.

Given these differences, it is quite obvious that fishing for haddock and cod was an important subsistence activity for the inhabitants of Mienakker, but not for the inhabitants of Zeewijk, Keinsmerbrug and Schagen Hoep-North. Since no contemporaneous sites have so far been found with the same subsistence activity, Mienakker occupies a unique position among the Late Neolithic settlements in the coastal region of the province of Noord-Holland.

400 Zeiler, Brinkhuizen & Bekker 2007; Zeiler & Brinkhuizen 2012.
401 Zeiler & Brinkhuizen 2013.

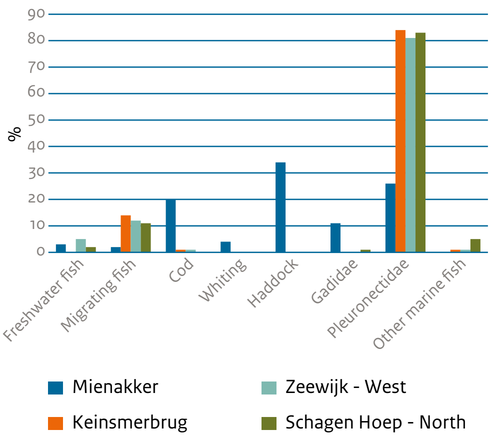


Figure 10.10 Frequency distribution of freshwater fish, migrating fish, cod, whiting, haddock, Gadidae, Pleuronectidae and other marine fish at Mienakker, Keinsmerbrug, Zeewijk-West and Schagen Hoep-North. The percentages are based on the number of identified remains.

In general, information on human activities in specific seasons can be inferred from the presence of certain species of birds and fish.

The bird species are either resident or migratory/winter birds. The first category provides little helpful information on seasonality. As for the latter, brent and barnacle goose are often regarded as typical winter visitors, but in fact have a long residence period: the first from the end of September to the end of May, the second between the end of September and the end of March.[402] As we have said, the guillemot is a bird of the open sea; nowadays, the largest numbers of stranded birds occur between late autumn and early spring (November - March). Another relatively good winter indicator is the swan, even though it is not clear what species is involved here. Of the three species that are found in the Netherlands nowadays, two – whooper and Bewick's swan – are winter visitors, present from October to the end of March. The mute swan has been a breeding bird since around 1950, but before then it was exclusively a winter bird (mid-November - early April).

The ruff used to be a typical summer visitor, but in the course of the last century the Dutch breeding population collapsed and the number of wintering birds increased, although it is still fairly scarce during that season.[403] An important indication of summer activity is the large quantity of duck bones. Ducks were most likely caught during the moulting season, in July and August.

There is also some seasonal evidence from the fish remains. If we assume that the annual cycle of Dutch fish in general, and their migratory behaviour in particular, in prehistoric times was similar to their behaviour in present and historical times, we can draw conclusions about the season in which certain fish species were caught.

The most common species of flatfish along 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, flounders are catadromous. After reproducing at 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 water. This makes flounder a summer indicator.

One heat-loving species, thin-lipped grey mullet, provides clear indications of the catching season. Mullets 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. Towards the winter they migrate 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 the places 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 using wickerwork fish traps when they migrate to the sea to breed in mid-Atlantic.

Nowadays the distribution of haddock in the North Sea differs greatly from that in the past. Over the last century this species gradually became rare in the southern North Sea. At present adult individuals are seldom encountered in Dutch coastal waters.[404] However, at the end of the nineteenth century, the species regularly appeared in winter in large shoals off the Dutch coast, especially in the Terschellinger and Amelander grounds.[405] Houttuyn said that haddock were quite abundant in the North Sea. In winter, large shoals of haddock would often come to the coast and, with wind blowing from the east and freezing temperatures, many of

402 In recent decades, barnacle geese have been breeding in the Netherlands in increasing numbers (250-300 pairs in the late 1990's).
403 Bijlsma, Hustings & Camphuysen 2001.
404 Nijssen & De Groot 1987.
405 Redeke 1935, 1941.

them were caught from the beach.[406] In spring, when the water along the Dutch coast starts to warm up, haddock return to deeper, colder waters. Obviously, therefore, the best season for a successful catch of haddock in the Netherlands is winter.

In view of the presence of large quantities of flounder and a considerable quantity of thin-lipped grey mullet, in contrast to the few haddock remains, we can conclude that the inhabitants of Zeewijk-West and Zeewijk-East mainly fished in summer.

10.6 Conclusions

Based on the research questions, we can draw the following conclusions. Subsistence at Zeewijk was based on stock breeding, fowling and fishing, with cattle, ducks and flatfish as the most important species. The hunting of wild boar played a minor but not insignificant role. Apart from wild boar, beaver and grey seal were hunted locally. The same may apply to the other game species – red deer, roe deer, polecat, stoat, wildcat, brown bear and common seal – but their remains could also have been brought to the site attached to imported skins; roe deer antlers could have been collected.

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. Birds will also have been caught in other ways (and at other times), for instance using nets placed at strategic spots. Fishing occurred in saline and brackish waters, given the preponderance of flatfish and the low numbers of freshwater species. It is likely that several fishing techniques were used, such as fish traps and fish weirs or fences in tidal creeks.

The archaeozoological information on the character of the site points to both summer and winter activities, although indications for the latter are relatively scarce. The presence of thin-lipped grey mullet indicates summer activities, as do the large numbers of mallard and teal/garganey that which were most probably caught during the moulting period. Guillemot and swan are indicative of winter activities.

The faunal spectrum is indicative of an open landscape with a strong marine influence where some freshwater was present. This is demonstrated by the presence of freshwater fish (pike, perch, cyprinids). The salt marshes must have provided good opportunities for pasturing cattle as well as for fowling. Fishing was concentrated in the saline and brackish water of tidal creeks.

406 Houttuyn 1764.

11 Spatial analysis

G.R. Nobles

11.1 Introduction

Zeewijk has been considered to consist of two individual sites, a conclusion based upon the two concentrations of dark humic cultural material.[407] The sites are divided by a gully, but whether they are two distinct settlements or a single settlement complex with a gully running through it requires further investigation.

Zeewijk has been only partially excavated, and as a result any analysis must be interpreted with this in mind. The excavated area is in itself a sample. Due to the large quantities of materials two areas were selected as a further analytical sample for this study. These areas were based primarily upon the 1992 excavations as indicated in Figure 11.1. The actual sample areas chosen differ between find categories and are illustrated later in this chapter, in Figure 11.50.

The Zeewijk-East (central) area as defined in Chapter 3 is not included in the spatial analysis due to the disturbance of the find layers.

11.1.1 The site grids

The 1992 excavation began with the laying out of a grid of two-metre squares over the entire area. The arbitrary grid started in the bottom left corner at square 1. This is located upon the site grid at coordinate 100,400. The squares ran

[407] Hogestijn 1997, 30.

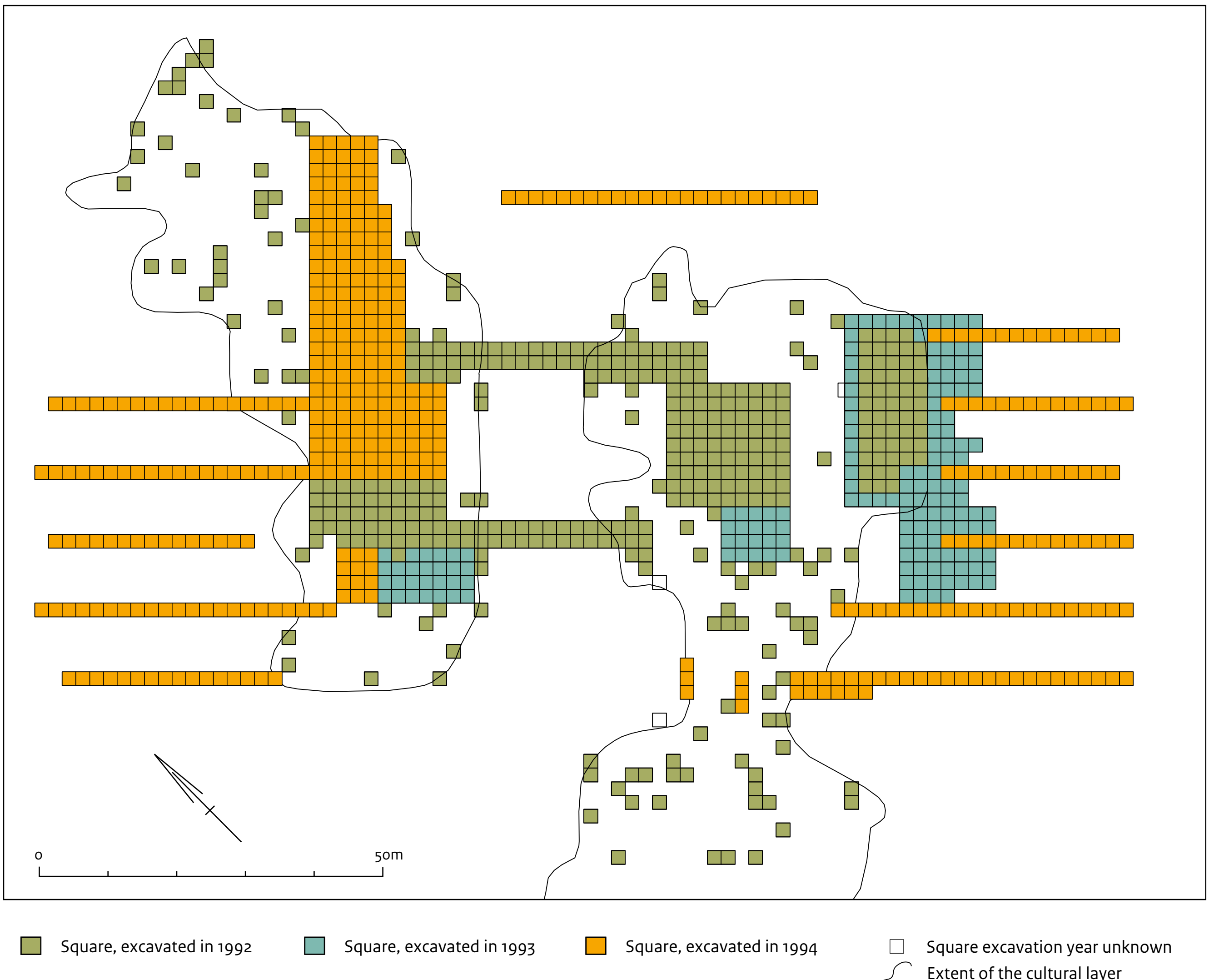


Figure 11.1 Extent of the excavated parts divided per year.

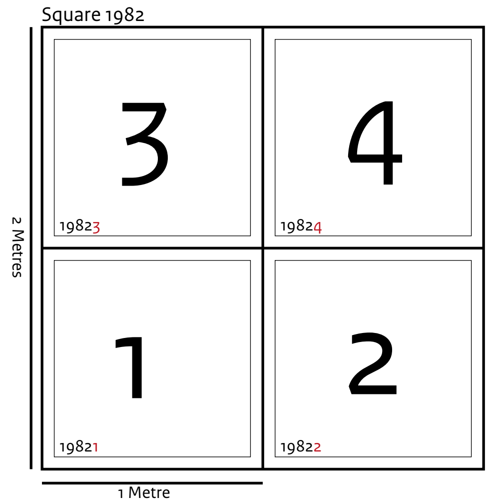


Figure 11.2 The division of the 2m square using square 1982 as an example.

sequentially to the right until square 64. The next row started above this, again from left to right. This pattern was continued over the rest of the site. Figure 11.1 displays only those squares which were excavated within this grid and documented in the archive. They are coloured according to the year of excavation.

Each two-metre square was further subdivided into four one metre square quadrants. These quadrants were numbered: 1 - bottom left, 2 – bottom right, 3- top left, 4 – top right. Square 1 in the 2m square 1982 would therefore be numbered 19821, square 2 would be 19822, the third square 19823 and the fourth 19824, as illustrated in Figure 11.2.

The alignment of the site grid is at approx. 45 degrees east of geographic north. Due to its usage in previous publications the grid north will be used in the remainder of this text. However, geographical north is shown in the figures.

In 1992 the total excavated area measured 550 m² in the west and 816 m² in the east, including several test pits which were distributed around the main excavation areas. The areas in the west and east were expanded in 1993. Due to the previous year's discovery of a large structure the site grid was accordingly expanded to the east (see Chapter 3 Features). To facilitate this extension, unused square numbers were removed from the west of the site grid and used in the east. In the 1994 campaign in the western area the excavation progressed northwards. Trial trenches were dug to try to define the limits of the settlement. In 1994 the grid numbering also changed, most likely due to the limitations of the 64 square wide grid from the previous two years. The original system was applied to the large trenched areas, but the trial trenches were numbered 01-12 with the prefix 94 (e.g. 9401-9412).

11.1.2 Elevation model

Figure 11.3 displays the elevations following interpolation using an unrestricted Inverse Distance Weighted method (IDW12) on the basis of the lowest excavated layers. Over-extrapolation did occur in some places due to the sparseness of the elevation data in certain areas. Places where this extrapolation was deemed to be unreliable were removed, and indicated in grey.

It is evident from the elevation data that there is a depression in the southwest of the excavated area. The slope of the gully can also be identified between the two defined areas.

The combination of the angle of the slope and the direction of the slope is represented in Figure 11.4. The aspect-slope map indicates that, in general, the area was rather flat, especially in the east. However, there are a few areas where the aspect-slope indicates more potential for the movement of materials due to the underlying topography and site formation processes. In the southwest material may move south and westwards. This will be taken into account when discussing the spatial analysis of the various find types. The influence of the gully which divides the site is more apparent in the north of the site between the western and eastern (central) trenches.

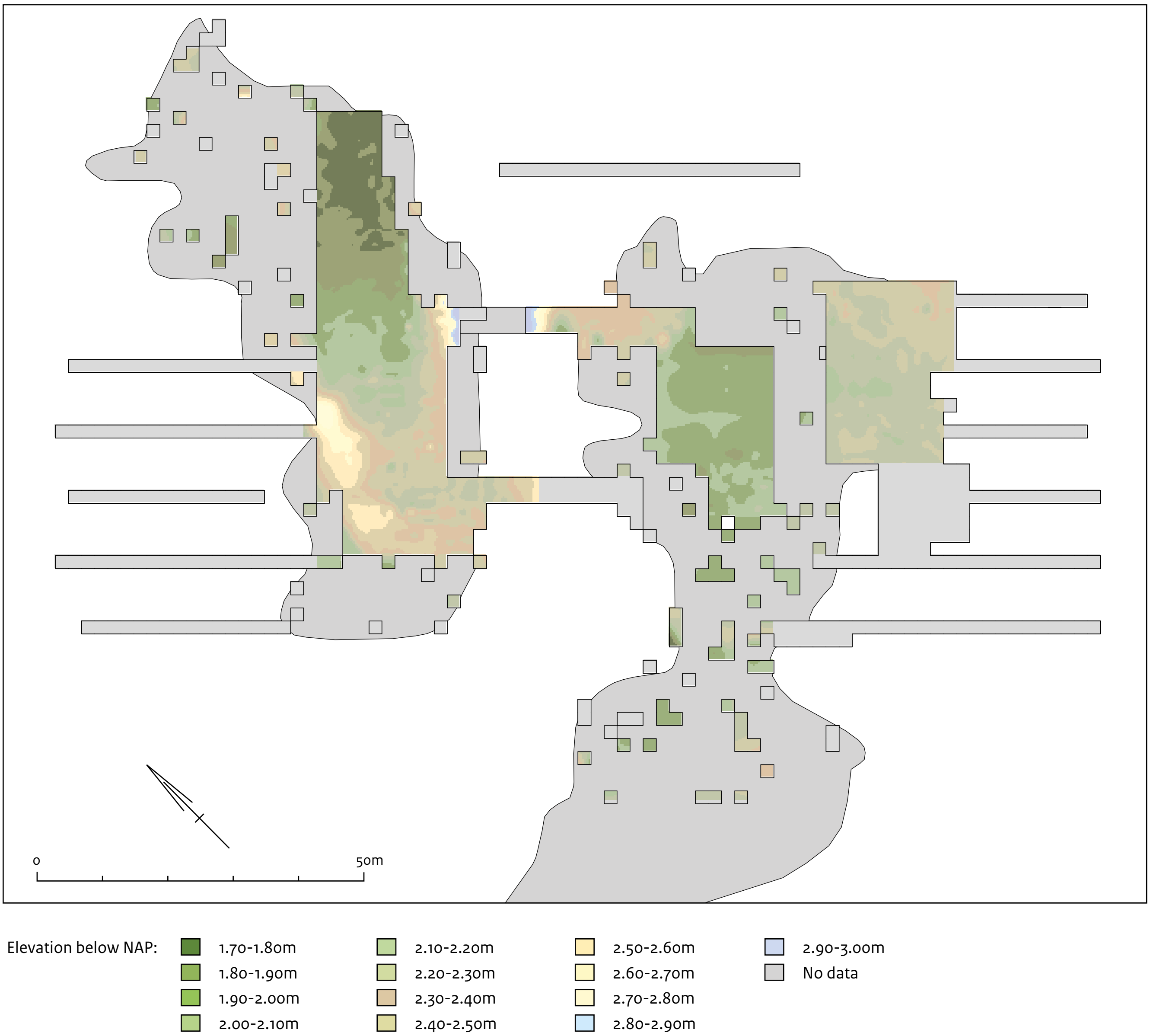


Figure 11.3 The elevation of the lowest excavated layers below NAP (Amsterdam Ordnance Datum).

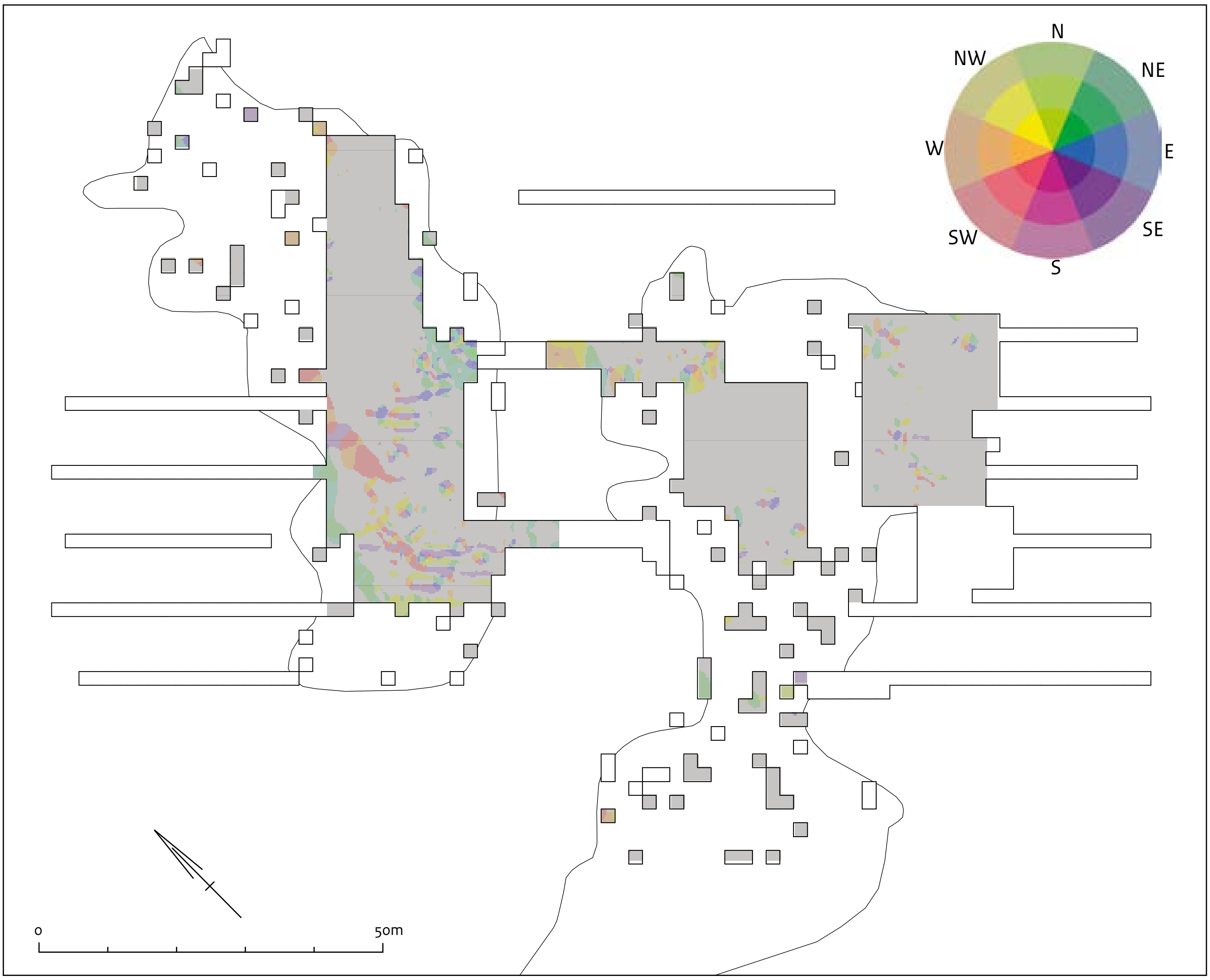


Figure 11.4 Plot indicating the levels of slope relative to their direction.

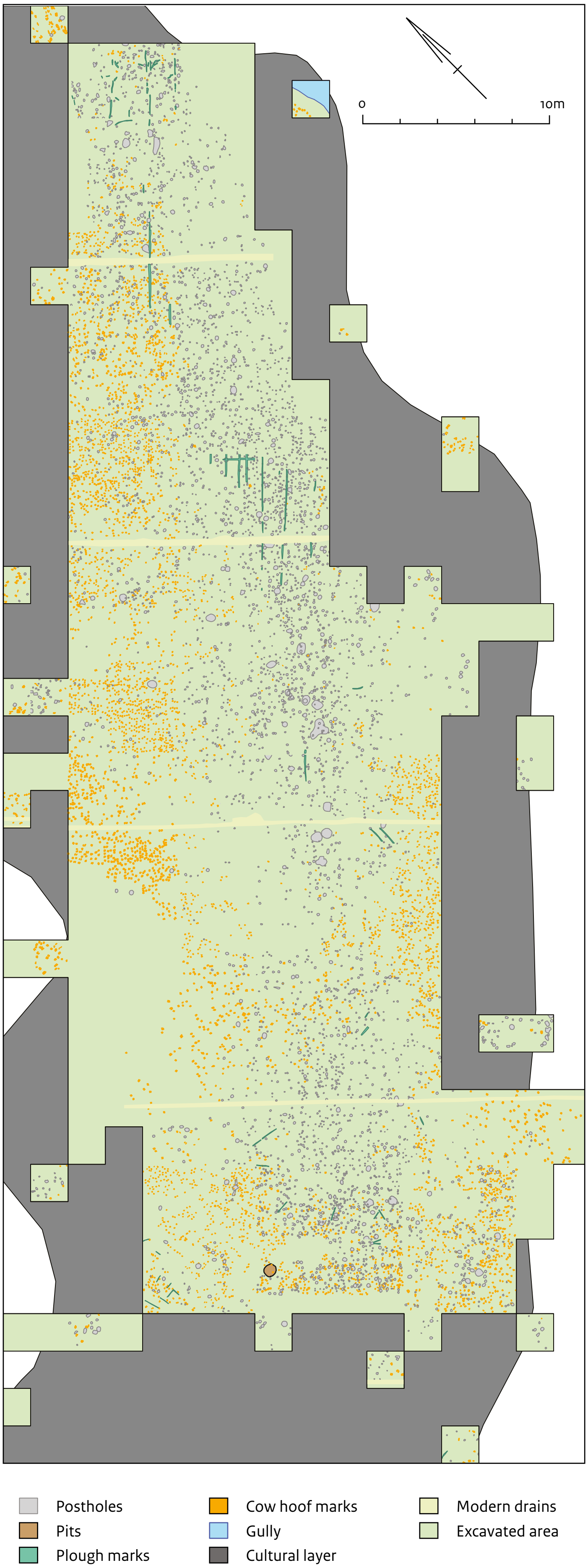


Figure 11.5 Overview of the features of Zeewijk-West.

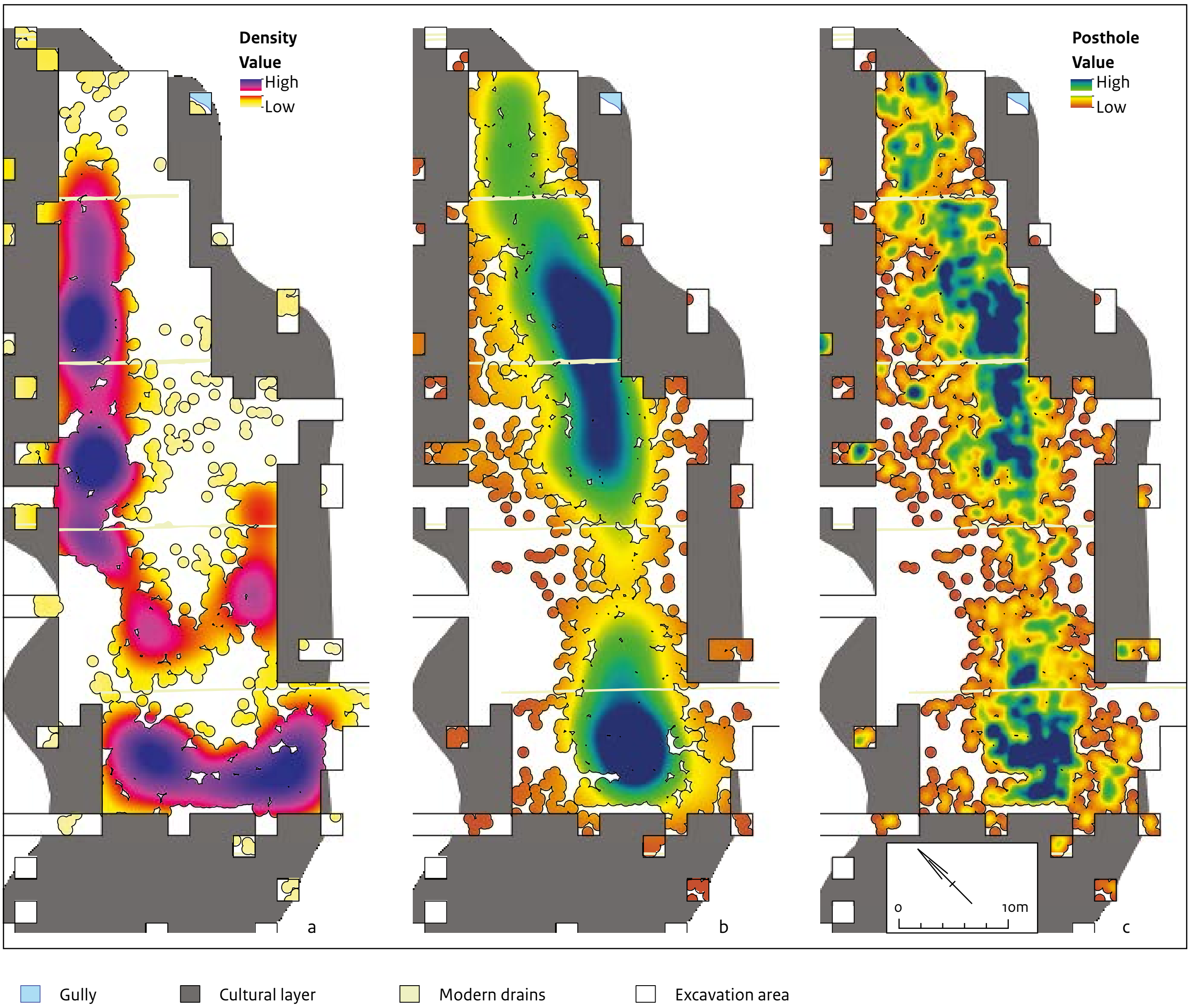


Figure 11.6a density of cow hoof marks using a 5 m search radius; b. density of postholes using a 5 m search radius; c. density of postholes using a 1m search radius. All densities were buffered at a radius of 0.5 m from the centre of the features. The absence of recorded features in the southwest is striking.

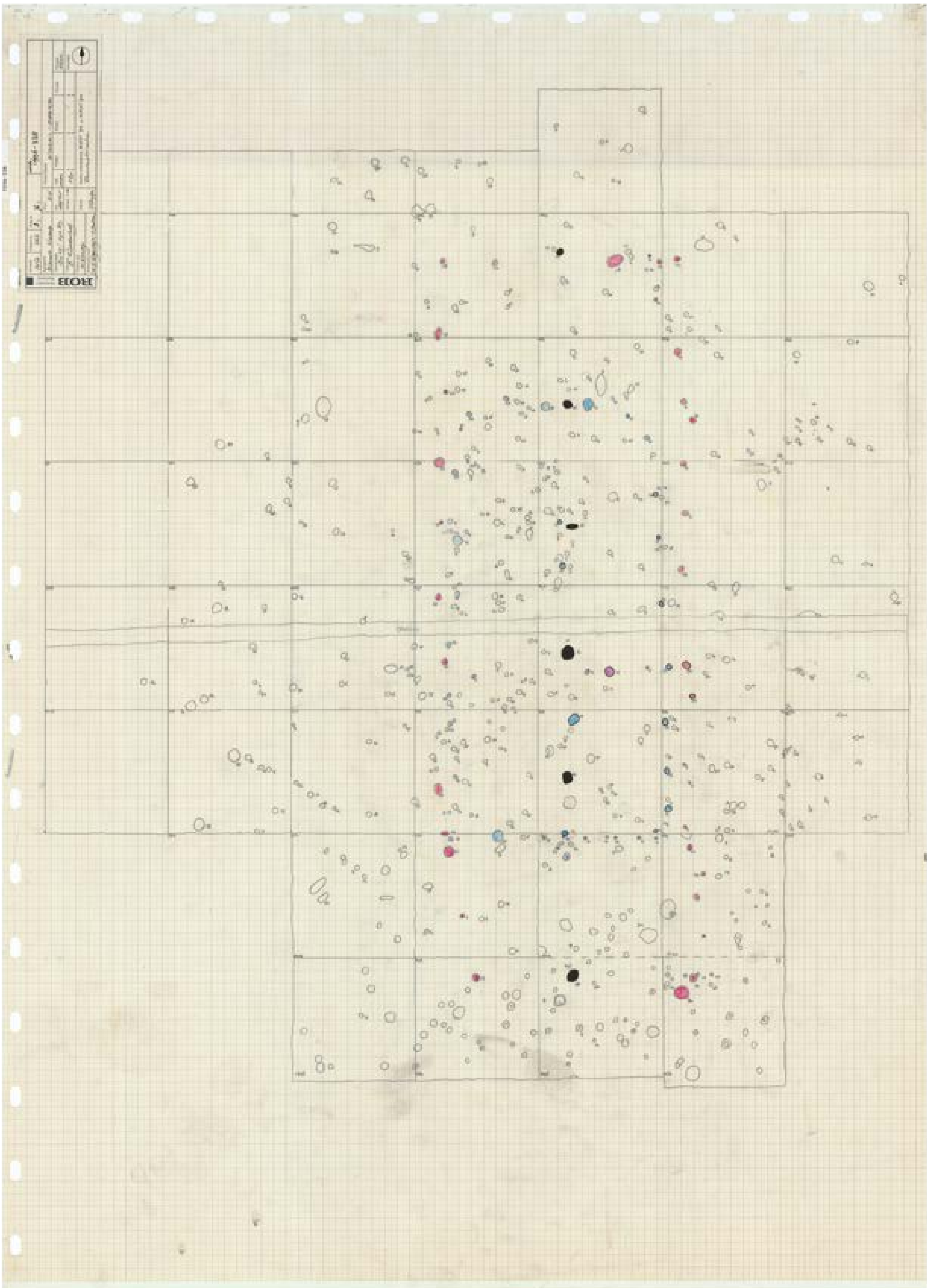


Figure 11.7 The Zeewijk-West structure: the archive image (for the location of this structure see Fig. 11.49).

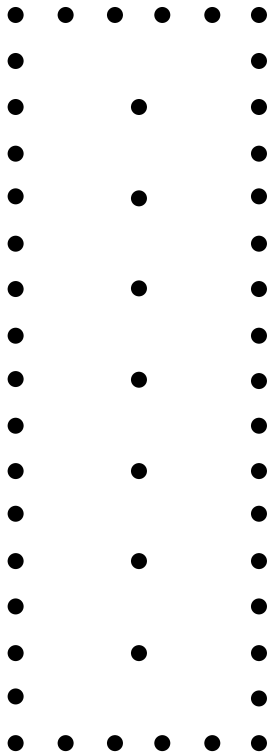


Figure 11.8 The Zeewijk-West structure: the isometric depiction of the same structure after Hogestijn 1997, 112.

11.2 Visual inspection of feature distribution

11.2.1 The west

As illustrated in Figure 11.5, there generally appears to be a clear separation between the cow hoof marks and the postholes. The majority of the posthole distribution seems to curve somewhat, following the general shape of the cultural layer.

There is an area in the south (next to the western edge) which clearly lacks any features. In the archive drawings this area is shaded. No other archive drawings are present for this area. This looks like the result of missing drawings rather than the absence of features. The cow hoof marks surround this 'blank' area, so there is no reason for this to happen. There are no physical boundaries, and they therefore indicate that more features can be expected within the area (Fig. 11.5). Kernel densities of the postholes and cow hoof marks shown in Figure 11.6 indicate that there are some clear patterns in the general distributions and densities of the postholes and the cow hoof marks.

Although it is not possible to relate these densities directly with structures it is apparent that these posts had a bearing on the movement of cattle within the site. It is therefore likely that structures would have stood in the areas which contain high densities of postholes. As cow hoof marks are absent from these areas, the function of any structures within these areas cannot be associated with the housing of cattle. The excavation team has suggested there is at least one structure, possibly more, within the western area (Fig. 11.7). One of these structures has been published as an isometric diagram (Fig. 11.8).[408] Isometric depictions do not sufficiently reflect the nature of these types of structure, however.

Despite some degree of overlap it is clear that the cow hoof marks do not occur in areas with high densities of postholes. There are two areas with high densities of postholes, the larger to the north and a smaller area to the south. The cow hoof prints divide these two areas, albeit with a degree of spatial amalgamation. The linear nature of the posthole distribution does suggest some kind of association between the two areas based upon their axial alignments. Such an association may have occurred over a period of time rather than as a result of any contemporaneous construction.

Within the western area there are a small number of plough marks. Those aligned north to south or east to west are indicated on the archive drawings as modern disturbance. To the south there are plough marks aligned at approximately 45 degrees to the cardinal points; these are ard marks associated with the Neolithic period. An area with more densely positioned ard marks is located in the northwest of the cultural layers within the test pits.

[408] Van Ginkel & Hogestijn 1997, 112.

11.2.2 The east (east)

In the eastern part of the site there are 1264 postholes which were excavated in multiple layers (Fig. 11.9). Some of these are clearly associated with a large structure, identified during the excavation and published widely.[409] The structure spans the 1992 and 1993 excavations, parts of it appearing in different layers depending upon the year of excavation and the trench number. It is not possible to define the features in terms of layers one, two or three etc. The structure can therefore only be fully appreciated with the presence of all of the layers as illustrated in various colours in Figure 11.10. A further potential U-shaped structure is visible. It appears only in the upper layers and potentially continues beyond the extent of the excavation (Fig. 11.10, right) .

In some places the ard marks are cut by the posts from the large structure. However, some posts which are not connected with this larger structure appear to be cut by the ard marks. This indicates a later phasing for the larger structure whilst allowing for activity associated with postholes to both precede and follow the ploughing activity. It does not rule out contemporaneous activities during the creation of these features.

The ard marks are oriented in criss-cross patterns. Two distinct groupings can be identified, the first orientated N-NNW to S-SSE and E-NEE to W-SWW and the second orientated N-NNE to SSW and W-NWW to E-SEE. The second group appears in the lowest excavated layers, with those from group one appearing in the upper layers, indicating the possibility of at least two ploughing events or phases. With the inclusion of the test-pit information the ard marks appear to indicate a large ploughed area which could be 1 hectare or greater. This extent is limited only by the degree of archaeological investigation, as the excavations did not determine the full extent of the ard marks.

The cow hoof marks are represented in most areas of the 1992 and 1993 trenches, albeit more so in the latter. The hoof marks are obscured in some areas of an underlying gully system whereas they are present in other locations. This gully system appears in the lower

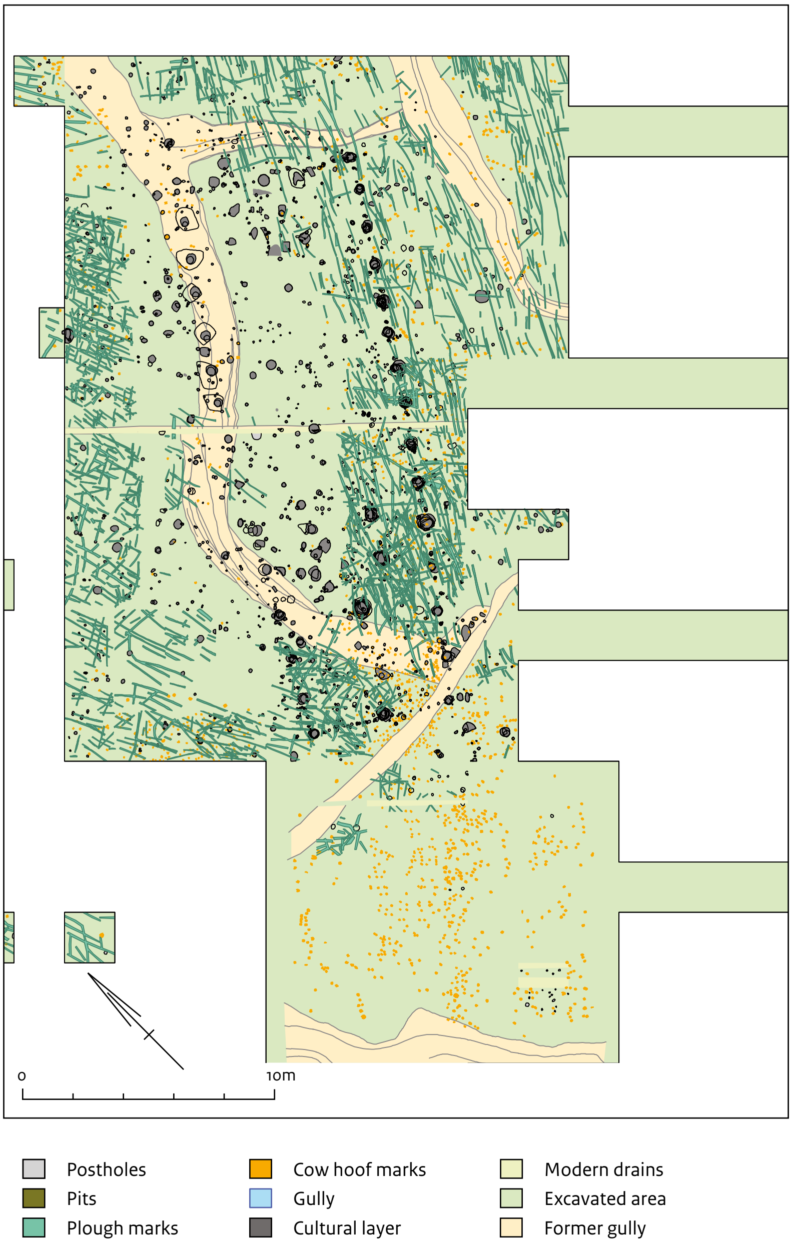


Figure 11.9 Overview of the features of Zeewijk-East.

layers, suggesting an earlier phasing not associated with the large structure and unlikely to have much of an impact upon the creation of the ard marks or the settlement.

409 Hogestijn 1997, 34-42; Hogestijn 1998, 102; Hogestijn 2005, 431; Van Ginkel & Hogestijn 1997, 113; Hogestijn & Drenth 2000, 138; Van Kampen 2013, 50; Whittle 1996, 238; Nobles 2012, 205-206; Nobles 2013a: 236-237.

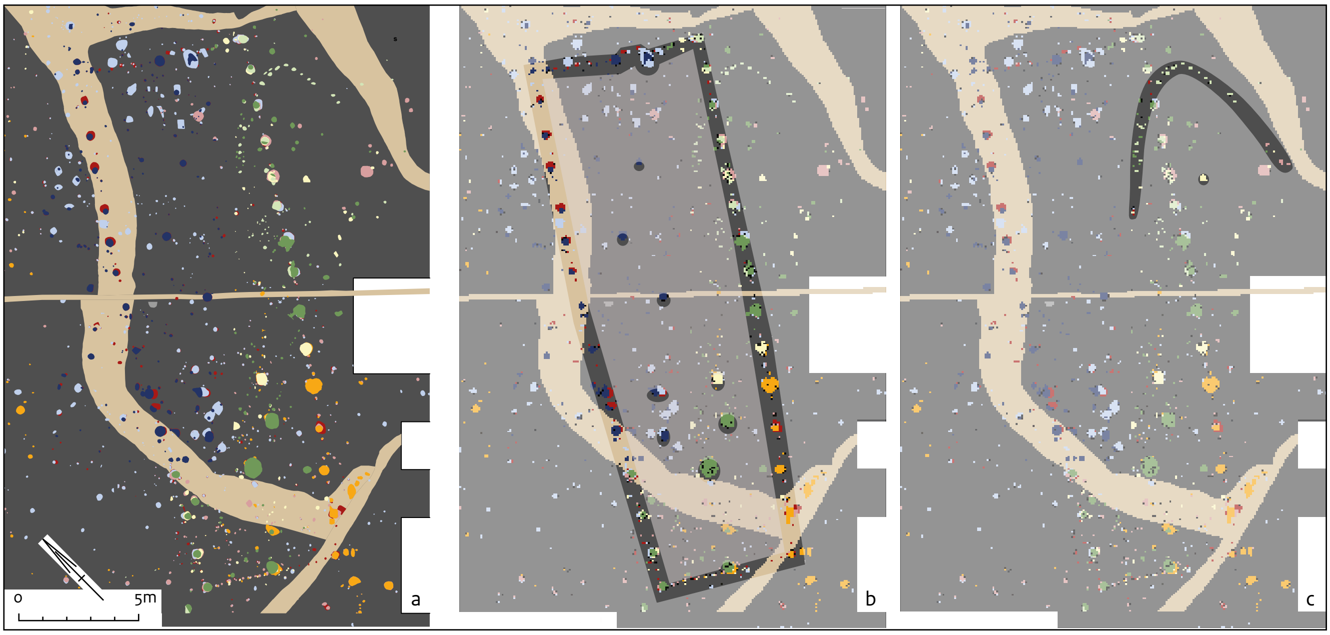


Figure 11.10a. all postholes coloured by layer; b. all postholes coloured by layer with key elements defined; c. the U-shaped structure highlighted.

11.2.3 The eastern structure

Description

The eastern structure is known more commonly as the Zeewijk-East structure (Fig. 11.11). All of the following information, although likely to be a repetition of former publications, is taken from the raw data and excavation plans.

This broadly trapezoidal structure measures 22 m by 5.5-7 m. It bows slightly outwards nearer the wider end to a width of 7.5 m; this bowing was observed previously by Hogestijn.[410] The structure is orientated NE-SW along its axial line. The construction is symmetrical and uniform in many of its components. The central post line consists of five postholes 30-80 cm in diameter, and the terminals form part of the external end walls.

The northeastern terminus forms part of an entrance, the opposing part of which is to the SE, slightly set back into the structure. This creates an asymmetrical effect in the structure. Consequently, the offsetting of the entrance restricts the view of the southwestern partition from the outside. This would allow only glimpses of movement within. This restriction of view could also be enhanced if another posthole which is of comparable dimension to those of the structure is included in the reconstruction. This posthole is situated between the second and third post of the central postline. It is offset from this line to the east by nearly two metres. If this post also reached the roof it would significantly block the view to any part of the interior which stood behind it (Fig. 11.12 and 11.13). In contrast, the area opposite this is much more open to view from the exterior through the entrance. This could lead to hypotheses regarding social restriction/inclusion with the premise of visual access pertaining to physical access.[411] There are also two postholes of 10-20 cm diameter marginally outside the structure, yet within the opening of this entrance. If these are associated with the structure they could have served as a door, a temporary blocking panel, or they could mark a final closing of the structure. This latter option has connotations of monumental constructions such as enclosures and long barrows.[412]

Omitting the framing posts of the entrance, this front façade is constructed of smaller postholes with diameters within a range of 8-15

410 Hogestijn 1997, 39.
411 Gröhn 2004, 301-302; Llobera 2003; Paliou 2013.
412 For enclosures see: Biehl 2011; for barrows see: Piggott 1966; Saville 1990, 77; Britnell & Savory 1984, 64, 150; Thomas 1999, 150.

Figure 11.11 The large structure in Zeewijk-East during the excavation campaign in 1993.

cm. The opposite shorter rear wall is similar to the wider end, albeit without an entrance; the postholes are between 6-16 cm in diameter and form a straight evenly spaced line which is broadly symmetrical.

The external walls on either side display clear oppositions to one another. There are 15 large posts (20-70 cm in diameter) with two or three smaller posts placed between them (15-5 cm in diameter). The spacing of the larger postholes are between one and two metres. The majority, however, are closer to separations of 1.5 m. The repetition of such a pattern is unusual for this period of the Neolithic. Domestic dwellings do not generally feature such clear oppositions in their construction methods. The closest parallels to such a building method would be associated with the Danubian longhouse tradition of the LBK. This indicates clear planning prior to the building of the structure.

Internally, there are numerous small postholes as well as a few larger ones. Four of these form a square arrangement just before the penultimate central post in the narrower end of the structure. Combined with this penultimate central post the configuration forms a U-shape,

Figure 11.12 The visible areas in the Zeewijk-East structure from the perspective of someone standing at the entrance of the structure.

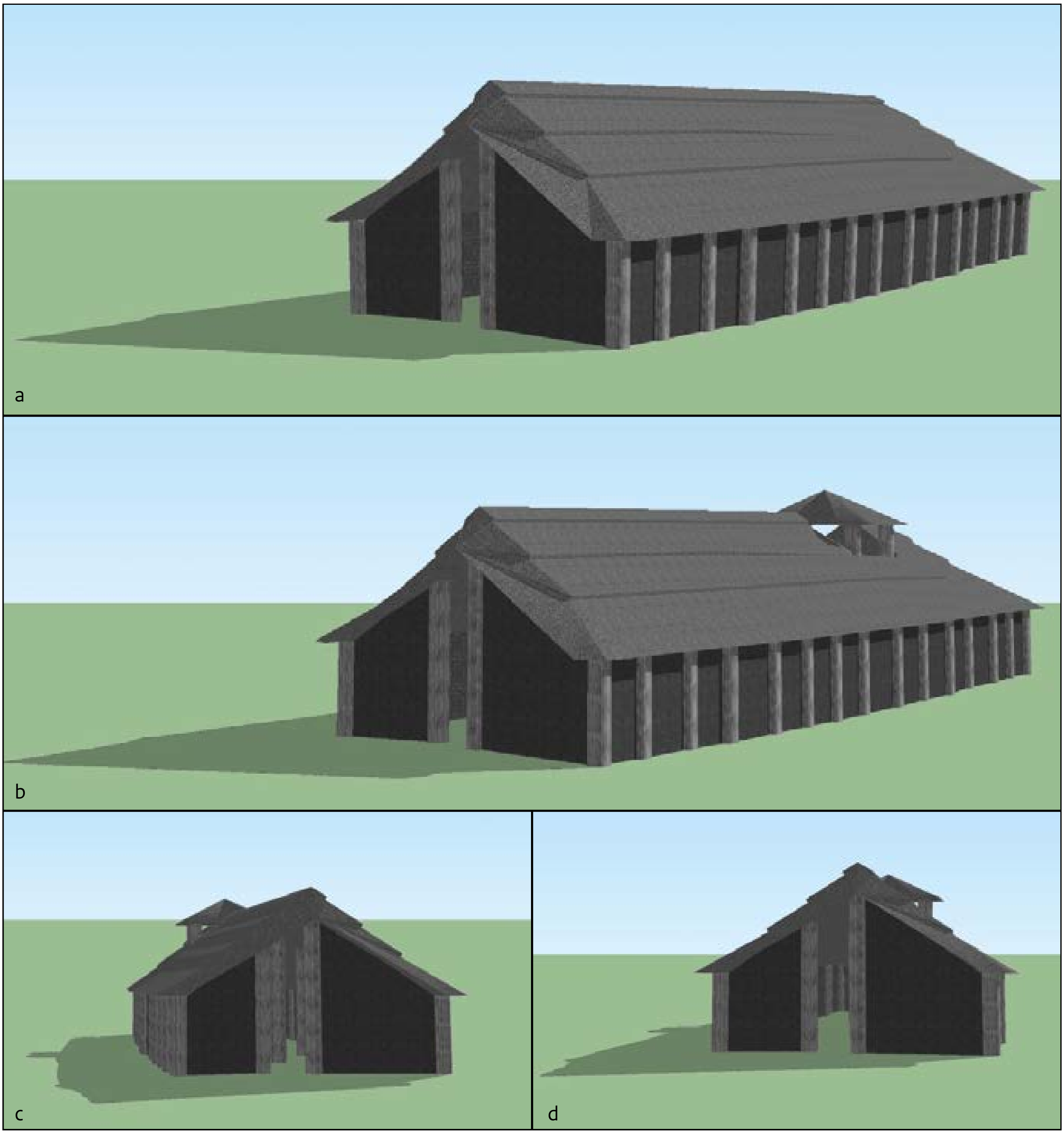


Figure 11.13 The large structure of Zeewijk-East. Two possible reconstructions; a. solid roof; b. 'chimney'; c. entrance looking into the obscured area; d. view into the unobscured area. Even though the posthole arrangements are accurate, the illustrations present only two possibilities.

somewhat similar to a feature of the Mienakker (MKI) structure.[413]

With the exception of the postholes no other archaeological features (e.g. hearths, pits) which one might associate with structures of this period are present.

Reconstructions

Obviously, archaeologists are faced with a two-dimensional view from which the past is reconstructed. Mostly, direct evidence of wall height, roof pitch, exact form of the upstanding posts, position of supporting beams, use of wattle and/or daub is lacking or uncertain. Hence, reconstructions depend on archaeological parallels, ethnographic analogy and inference.

In the case of Zeewijk-East the principle excavators could not agree upon a suitable height for the structure, and suggest heights of 7 m and 5 m (see Chapter 3). The assumption so far has been that this structure was walled and had a roof.[414] The presence of large postholes with two or three smaller postholes between them may be a framework for wattling.

The Zeewijk-East structure has an arrangement of four posts within its rear end, which presumably is not required for its structural stability. If it was incorporated into the roof then it is possible that the appearance of the structure would change. Assuming this was not a later addition the roof in this part of the structure is likely to have risen. This rise may have been very subtle, grossly enhanced or somewhere in between. It may have been part of a functional element, perhaps serving to create a feature within the roof, such as a hole for airflow. As no hearths have been discovered it is difficult to suggest some kind of chimney function as illustrated in Figure 11.13. Another hypothesis would be a function not associated with the roof at all. Perhaps this arrangement was an internal element serving as some kind of focal point within the structure. Furthermore, it is merely an assumption that this structure had a roof, depending upon its interpretation as a domestic or more ritual or ceremonial structure. With the latter interpretation, a roof would not be required in a functional sense although a partial covering could also be possible.

The lower images of the façades illustrate the visual restrictions from outside the structure, clearly showing the restricted view of the interior if the viewer was standing to the left and the more open interior if standing to the right.

Neolithic dwellings are assumed to be designed for living at ground level. This is also the case in these reconstructions, but let us suppose there is a possibility of raised flooring. There are ample archaeological and ethnographical cases for raised dwelling. The possibility of raised floor surfaces therefore warrants serious consideration.

The floor could be simply raised by making use of the abundant reed resources. At Zeewijk the addition of greater quantities of reed may have been able to counteract an excessively high water table which would cause a dampening of the ground surface. Such addition of material is likely to have added a greater quantity of humic material to the cultural layer. As this layer was relatively thin or non-existent such a flooring method is thought unlikely.

The raising of the floor to accommodate occasions when the water table was excessively high and general dampness would allow use of the structure during wetter periods.[415] The spatial distribution of finds within the surface of the floor would not survive clearly, if at all. This has been observed archaeologically at many lake shore sites.[416] Such constructions were similarly formed of two aisles.[417] Their raised floors were easily destroyed unlike those which can be found *in situ* at ground level.[418] Various methods can be used to create raised floors, as illustrated by Suter and Schlichtherle.[419] They include paired posts, log construction, postpads, sleeper beams, log and plank, raised floor on a frame, plank walls, and wattle and daub walls.[420]

Zeewijk-East was constructed using rounded-base oak posts. Between each of the large external wall posts were two smaller posts which could have been used for a wattle construction. It could be argued that the presence of wattle would indicate the absence of a raised floor. However, ethnographic examples exist whereby smaller posts are present at the ground surface for the creation of wattle higher in the structure, for example at Ouedo-Gbadji[421] in Benin, Africa. In this instance the larger posts form the main skeleton of the building with the smaller posts offering further support to the raised floor, walls and roof. The doorway is also situated between two framing posts with an added ladder (Fig. 11.14).

413 Nobles 2013a.
414 Hogestijn 1997, 40.
415 Only one potential 'flooding' event may be represented in the sections (Nobles, this volume chapter 3 Figure 3.15; Smit, this volume). No evidence of regular flooding events of the entire site have been found.
416 Ebersbach 2013, 285.
417 Ebersbach 2013, 285.
418 Ebersbach 2013, 285.
419 Suter & Schlichtherle 2009, 30-134.
420 Ebersbach 2013, 286.
421 Pétrequin 1984 (Plate 2).

Figure 11.14 A house at Ouedo-Gbadji in Benin, Africa (Pétrequin 1984)

The Zeewijk structure may have stood either at ground level, or contained a raised floor. Both interpretations are possible and neither can be ruled out entirely.

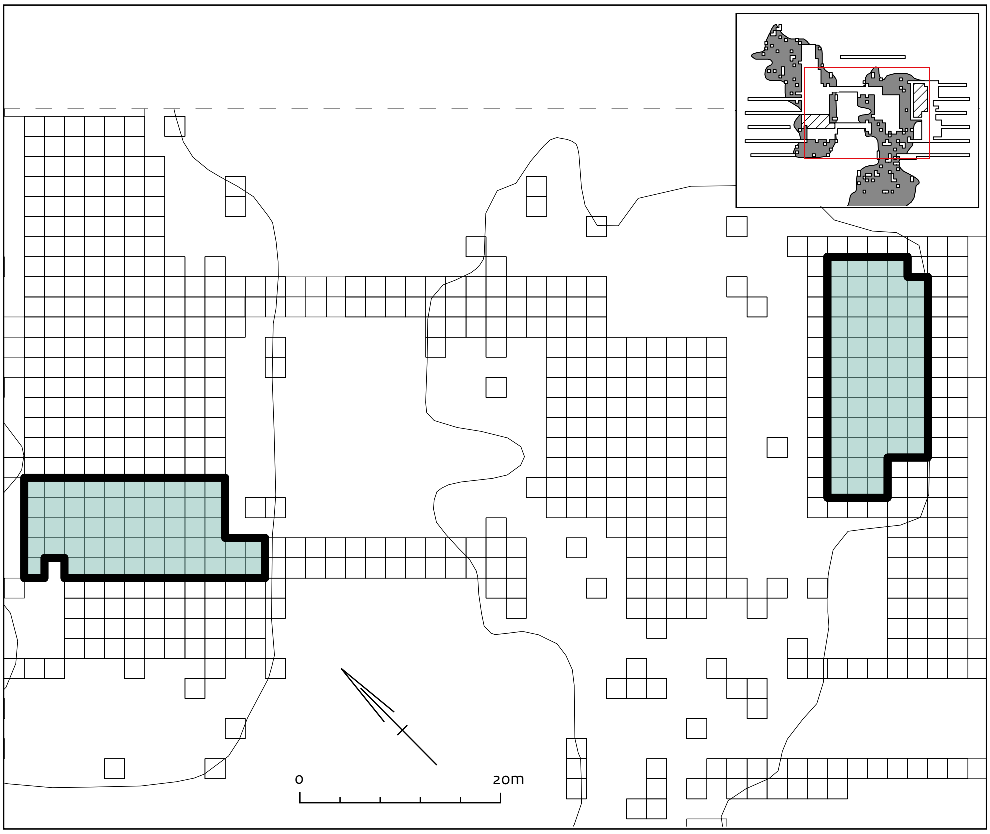
11.3 The artefact distributions: approach and sampling

In view of the vast amount of find material and the relatively limited time available for analysis, it was clear that the totality of the excavated parts of Zeewijk-West and -East had to be sampled. Various sampling strategies were suggested: a straightforward selection of find boxes, a random spatial sample or a regular spatial sample.

A regular sampling method, e.g. every fourth square, would have provided the possibility of analysing a greater area with the use of spatial modelling methods. Such methods would require the use of an interpolation or probability function to model a continuous surface from discontinuous spatial data. As intra-site settlement analysis is focused on the identification of more or less discrete activity areas, discontinuous spatial sampling is not entirely suitable. The identification of behaviourally meaningful clusters is best achieved through neighbourhood methods and continuous data. Clearly, if one seeks to identify the location of built structures and/or activity zones the area must also be large enough relative to the resolution of the excavation units.

Since a sampling method was required it was decided that the areas of interest should be those which yielded (suspected) structures, namely Zeewijk-East and Zeewijk-West. The original plan was to analyse material from the 1992 areas in the east and in the west (Fig. 11.15); if more time was available then material beyond these areas could be incorporated into the dataset.

This created datasets with different extents (see also Section 1.5). In the west the bone material is solely from the 1992 area, whilst the ceramics dataset is more extensive. For unknown reasons the flint material is absent from the 1992 area. As the material to the south was available this can only be an error in the curation of the material rather than an archaeological absence. The analytical area for the flint was therefore restricted to the 1993/94 excavations, south of the 1992 area. Although



Initial analytical areas

Figure 11.15 The site grid displaying the initial analytical areas.

this is not convenient for the comparison of the flint to the other datasets it can still provide useful spatial information.

Other problems presented themselves in the east of the site. It appeared that the 1992 material from all categories was available only from the test pits rather than the entire 1992 area. Flint material from the surrounding 1993 excavation was also examined. The sample area is highlighted at the beginning of the relevant section, as the spatial extent of each specialist dataset varies.

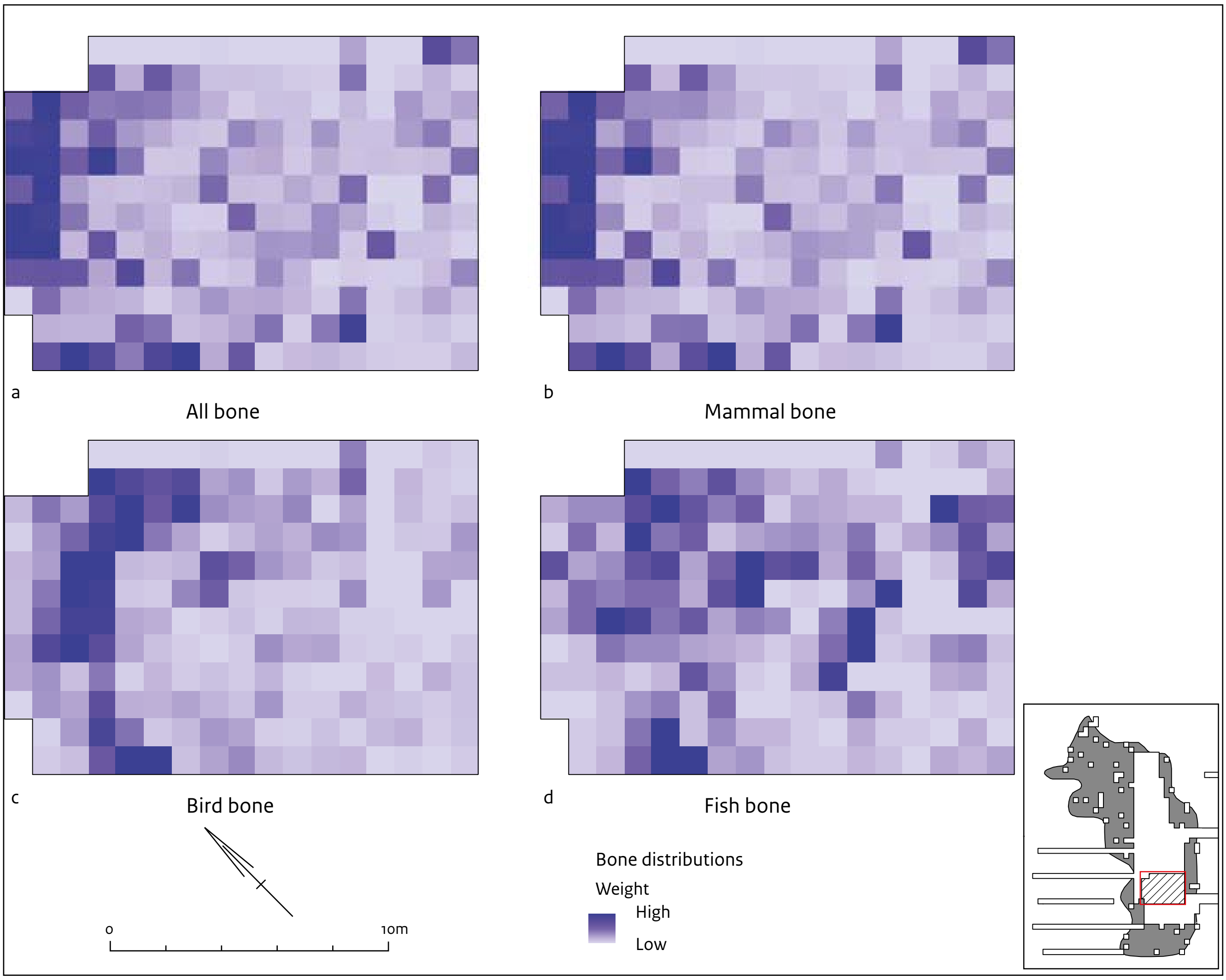


Figure 11.16 Animal bone distributions; a. all bones high=828.8 g, low=0 g; b. mammal bones high=823.3 g, low=0 g; c. bird bones high=38 g, low=0; d. fish bones high=35.05 g, low=0 g.

11.4 Zeewijk-West

The selected area in Zeewijk-West measures 368 m², and was delimited by a poorly identified structure and the available information about the excavation. One clear question relates to the presence of a structure in this area. Did such a structure exist and can the finds can be associated? Or do the spatial characteristics of the artefacts indicate something to the contrary?

11.4.1 Animal remains

The animal remains from this area weigh 17651.4 g.[422] The three main categories are outlined in Table 11.1. In terms of weight the mammal bones account for the greatest proportion. However, since the bird and fish remains are smaller and lighter they are typically represented by lower weight values. This therefore quantifies the assemblage used in the western sample area.

It is clear from the distributions of animal remains that a large quantity was present in the western zone of the sample area (Fig. 11.16). When subdivided into groups there appears to

[422] Omitting Mollusc and unidentified – 17652 grams. To allow for a more direct comparison the weights of the fish bone were estimated. The estimation of the weight of a single fish bone was derived from the average weight of a fish bone from the site of Keinsmerbrug (0.08549g) (Nobles 2012: 158, Table 10.3). This average weight was combined with the total number of fish bones presented by Zeiler and Brinkhuizen (this volume).

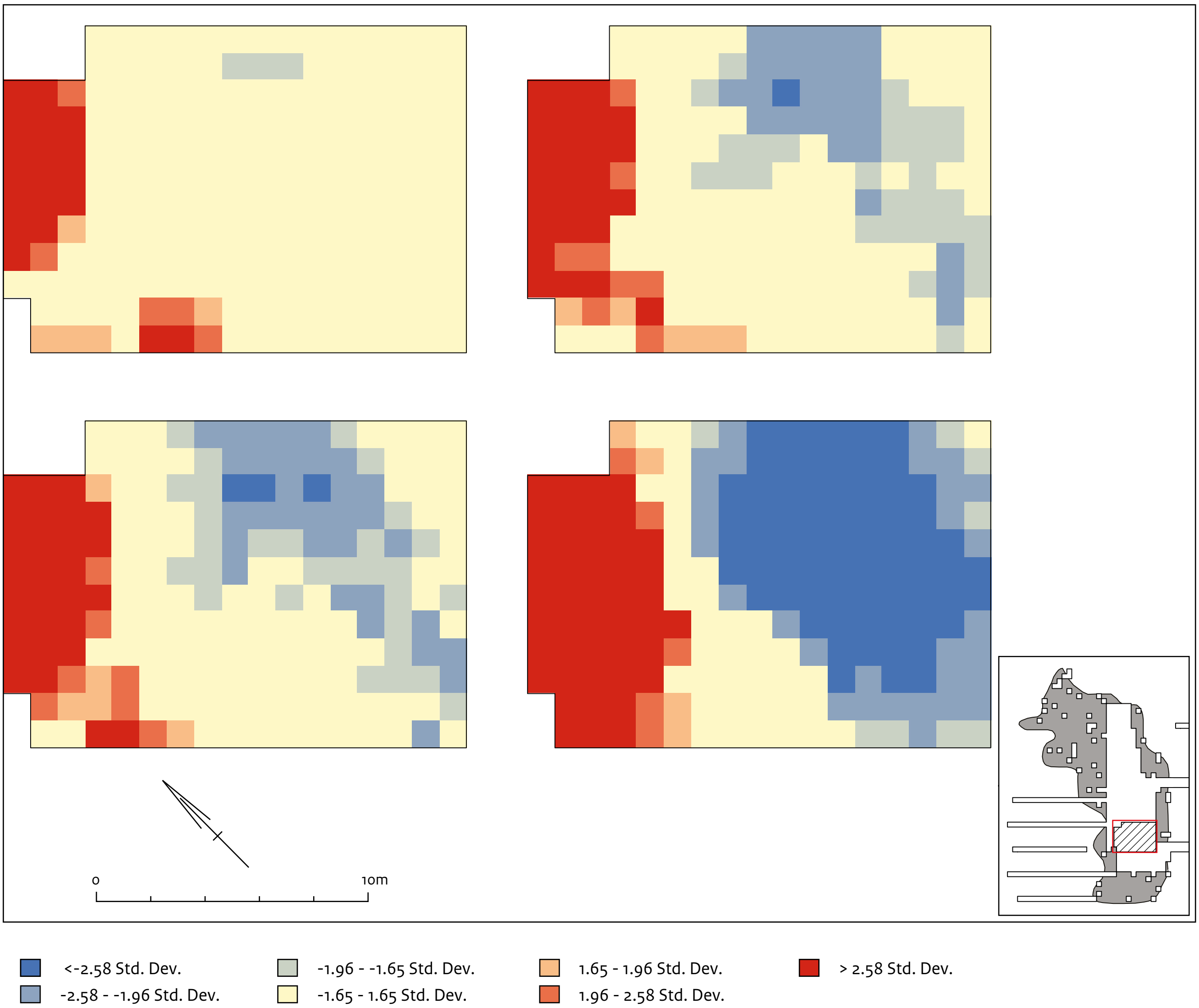


Figure 11.17 The Gi* (hotspot) analysis of the mammal remains with varying bandwidth parameters (metres) 1.75 m; 2 m; 2.9 m; 3 m (top left to bottom right).

be a fairly clear horizontal banding between the mammal, bird and fish bones. The mammal bones appear to be concentrated at the very edge of the sample area, followed by bird bones and then fish bones. The latter occur in several more concentrations across the data extent. The Gi* statistics (Figs. 11.17-11.19) also support this patterning, whilst indicating further clustering of low quantities to the east or northeast at the wider scales. The fish remains, broadly following this banding, show some smaller areas with similar weights. At the wider scales there appears to be a cluster more central to the study area.

Table 11.1 Weights of the animal remains by category.

Category	Weight (g)	%
Bird	658.6	3.7
Mammal	15914.7	90.2
Fish	1078.0	6.1
Total	**17651.4**	**100**

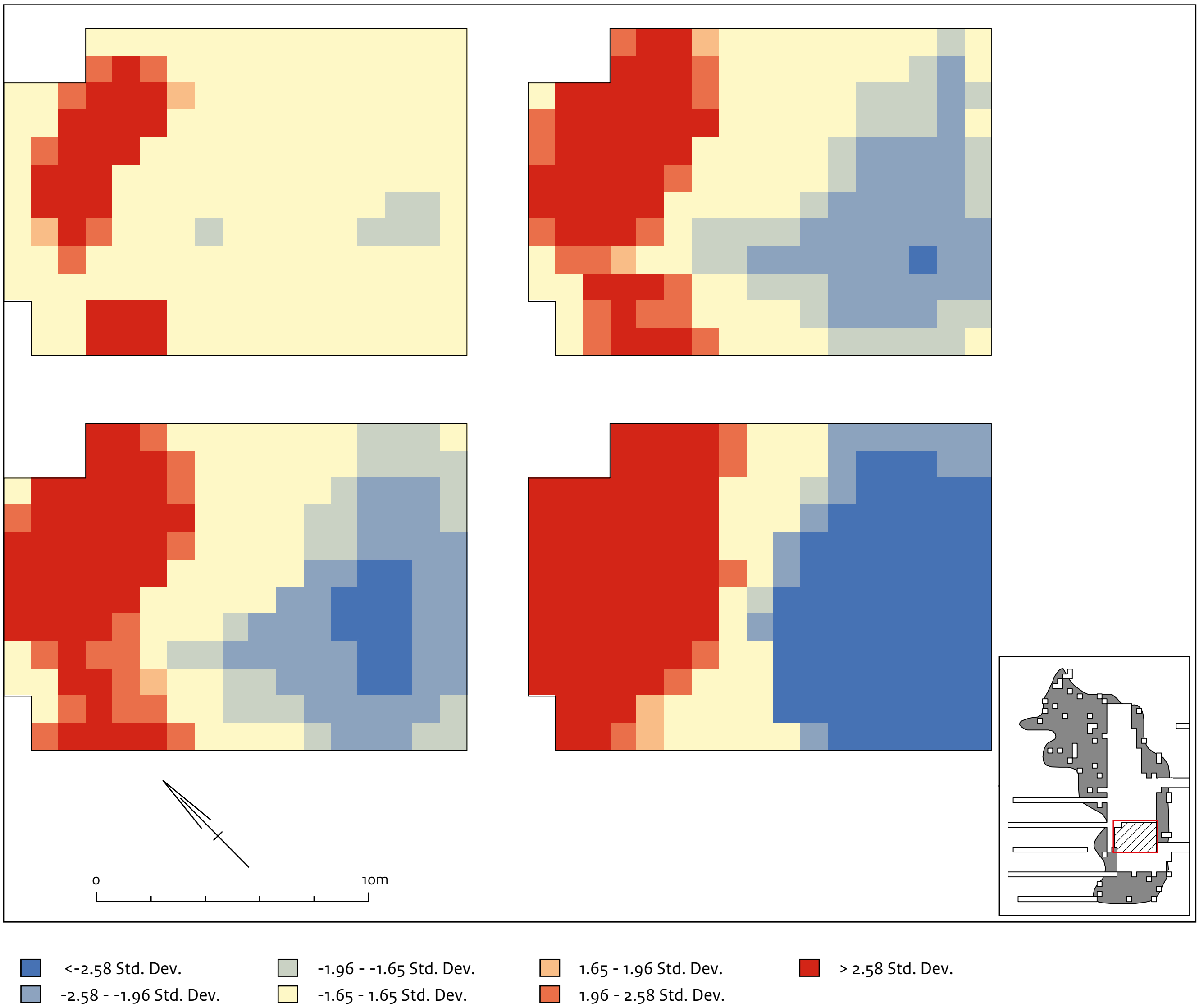
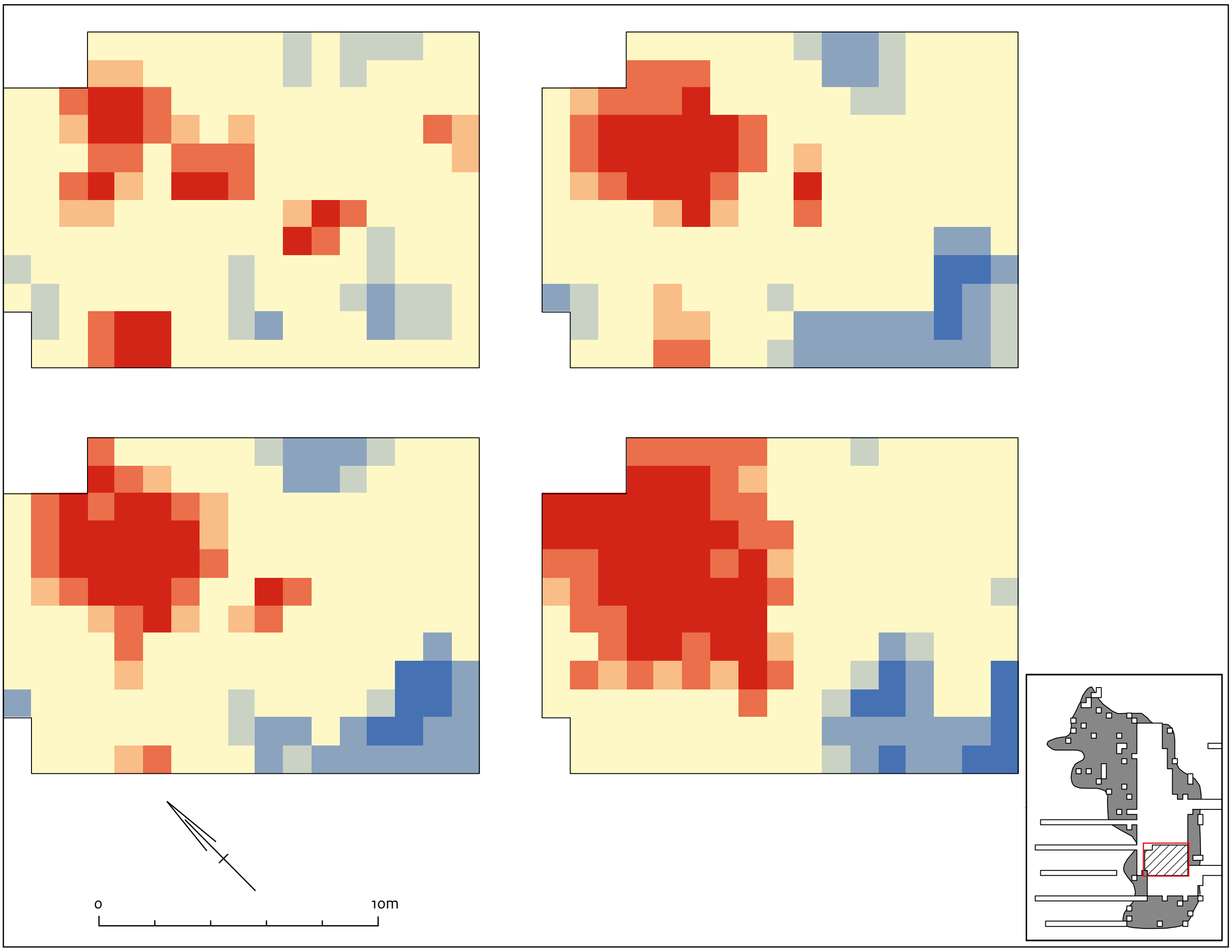


Figure 11.18 The Gi* (hotspot) analysis of the bird remains with varying bandwidth parameters (metres) 1.75 m; 2 m; 2.9 m; 3 m (top left to bottom right).



<-2.58 Std. Dev.
-2.58 - -1.96 Std. Dev.
-1.96 - -1.65 Std. Dev.
-1.65 - 1.65 Std. Dev.
1.65 - 1.96 Std. Dev.
1.96 - 2.58 Std. Dev.
> 2.58 Std. Dev.

Figure 11.19 The Gi* (hotspot) analysis of the fish remains with varying bandwidth parameters (metres) 1.75 m; 2 m; 2.9 m; 3 m (top left to bottom right).

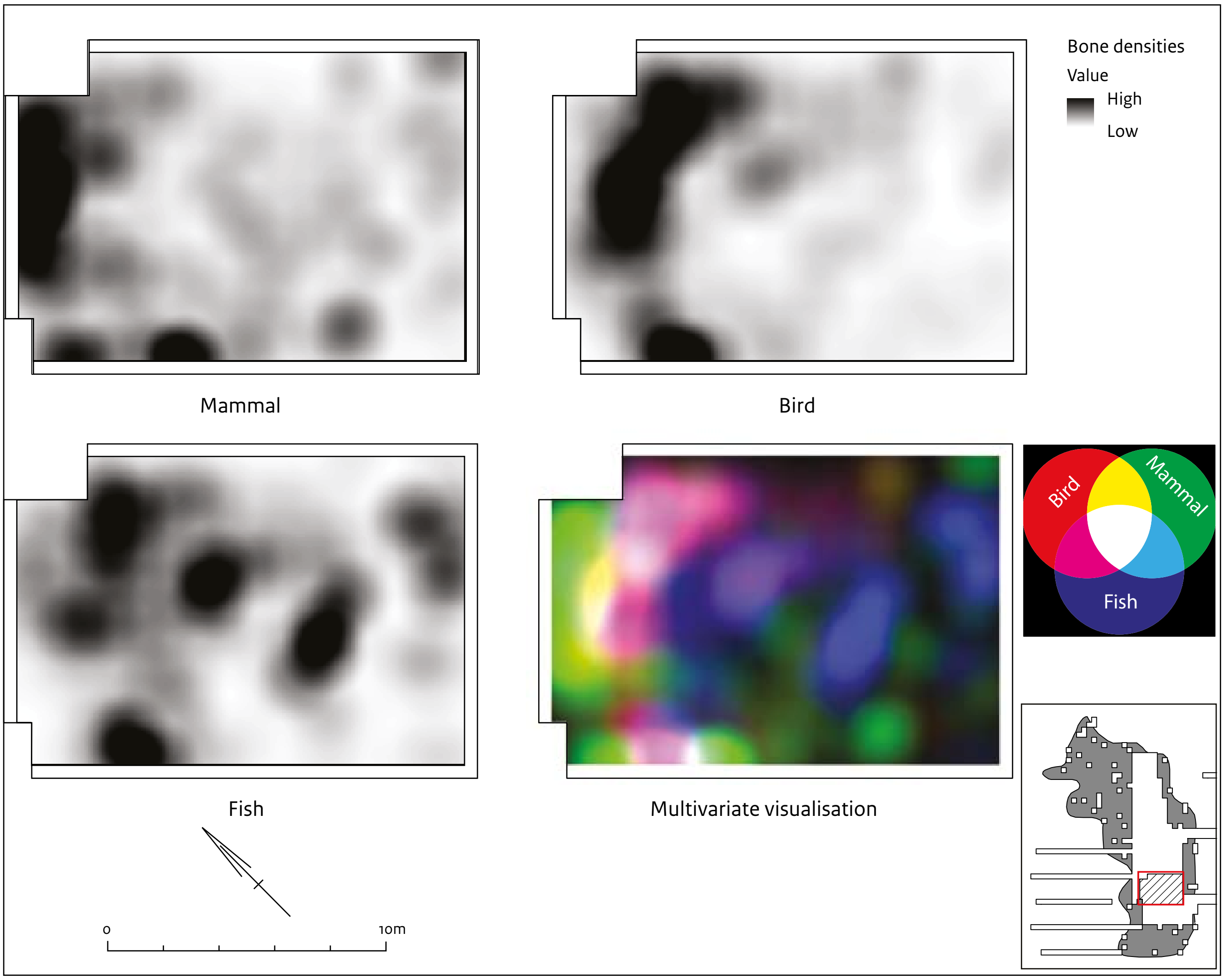


Figure 11.20 Kernel density estimates and multivariate visualisation of the bone data (KDE bandwidth = 1.75 m).

The multivariate visualisation results of the mammal, bird and fish bone densities also reflect this banded pattern (Fig. 11.20). Further attention must be paid to the underlying elevation, slope and aspect plots to understand whether this pattern results from natural or anthropogenic processes. The aspect-slope plot derived from the elevation data (Fig. 11.4, 11.21) confirms that there is indeed a fair degree of slope on the western edge of the extent. When compared with the spatial pattern it would appear that the distributions correlate to the slope and lower-lying area.

The degree of fragmentation in the mammal bones within the depressed area was not compared with the more elevated area. Fragmentation is high throughout the dataset, however.[423]

This can be assessed more generally. No clear patterning can be distinguished when the average weights of bone, as a degree of fragmentation, relative to the elevation displays is investigated. Nor does this support differentiation of the processes involved in the observed zoning of the site; cattle trampling versus habitation zones.

[423] Zeiler & Brinkhuizen, this volume.

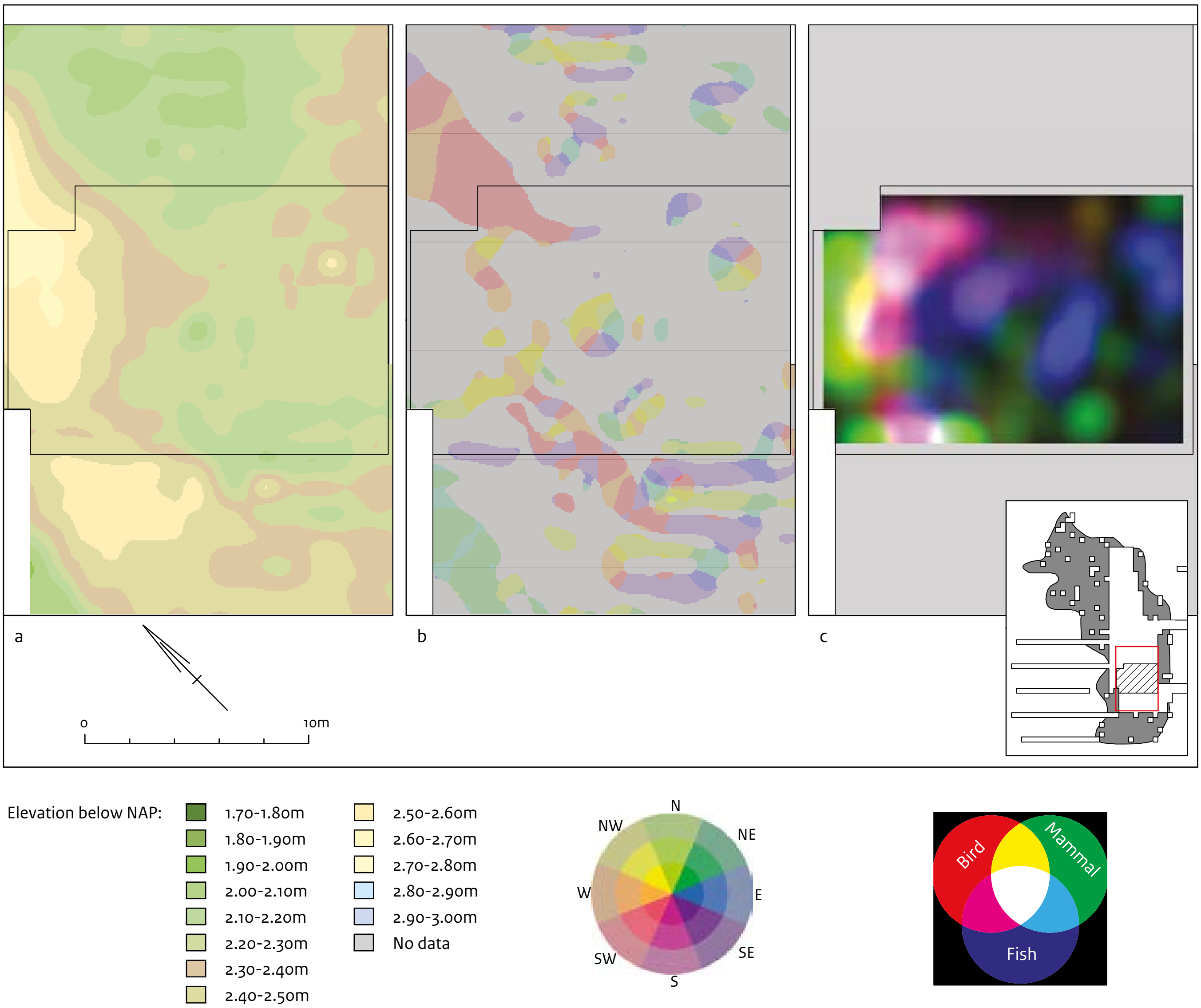


Figure 11.21 The data extent with respect to: a. elevation; b. slope; c. the animal bone multivariate visualisation.

It is always possible that the banding is the result of three different habitation events, each concerned with the processing of one of the categories. Alternatively, the mammal distribution could be the result of other activities occurring to the west directly beyond the sample area. No clear conclusion can be drawn at this point.

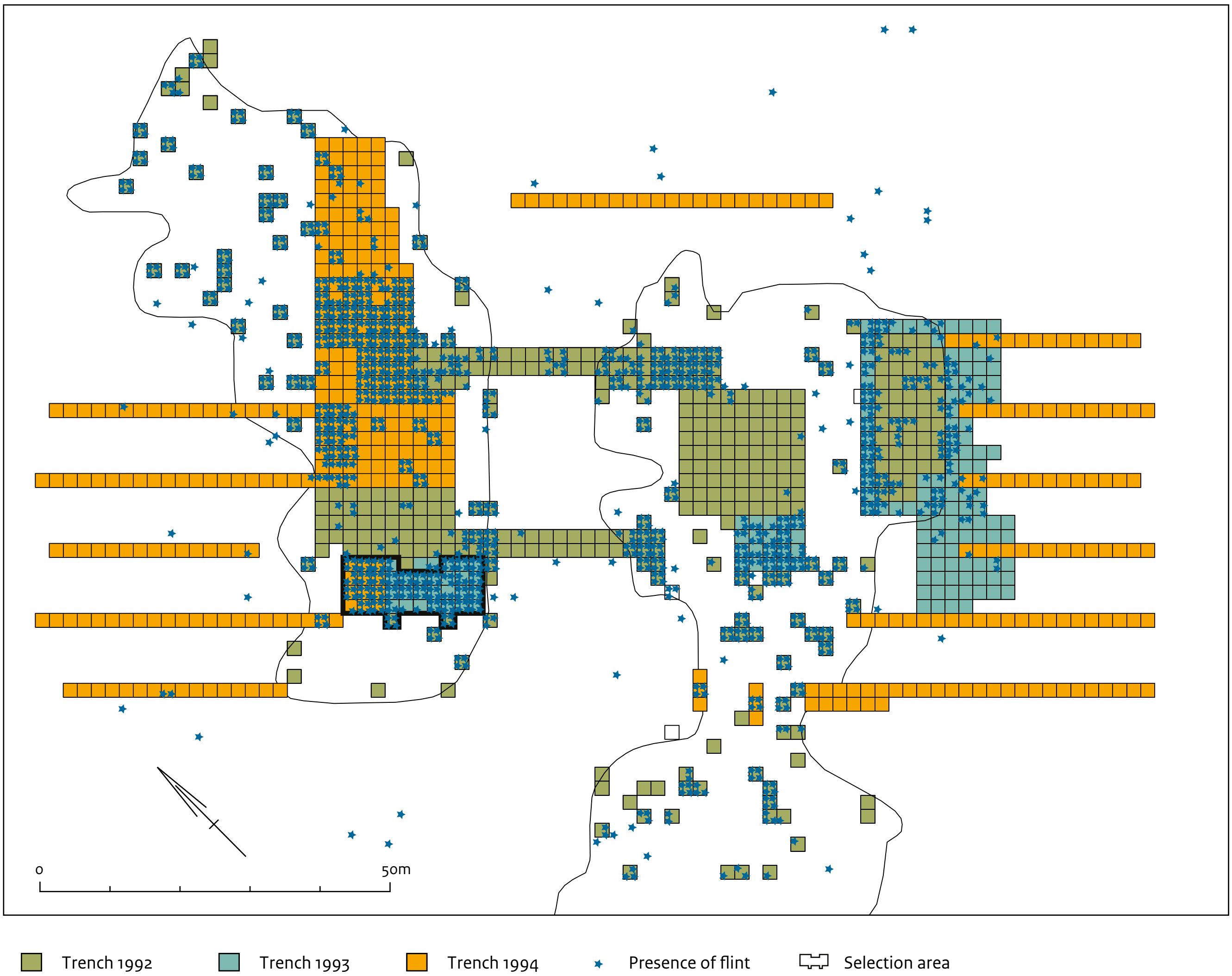


Figure 11.22 The distribution of the flint data (stars) in reference to the excavation year and trench type (squares). Each square represents a 2 m by 2 m area, each x represents the 1 m by 1 m subdivision.

11.4.2 Flint

The majority of the flint data from the 1992 excavations, excluding test pits, appears to be missing, limiting the possibilities for comparative spatial analysis involving the other datasets (Fig. 11.22).[424] However, since other datasets do extend into this area, some broad comparisons can be made (see also Section 11.4.6). The remaining area for analysis of flint distribution patterns is smaller than the rest and this might affect the end results.

As can be seen in the distribution plots (Fig. 11.23) there is some variation but there are no clear patterns. More flint is generally located in the east, most likely due to the distribution of the waste and splinters. The flakes may be higher in number more centrally but this is hard to determine visually.

The Gi* statistics indicate a grouping of high values of flint flakes, waste and splinters in the northeastern corner of the area. The flint flakes and waste also indicate a grouping of high quantities in the south of the plot. At the 5m search radius the focus of the cluster is more central. This is likely to be due to the search radius; it would appear that a radius of 5m is too large for the dataset, a limitation of the analytical method.

Besides significant clustering of high values

[424] García-Díaz, this volume.

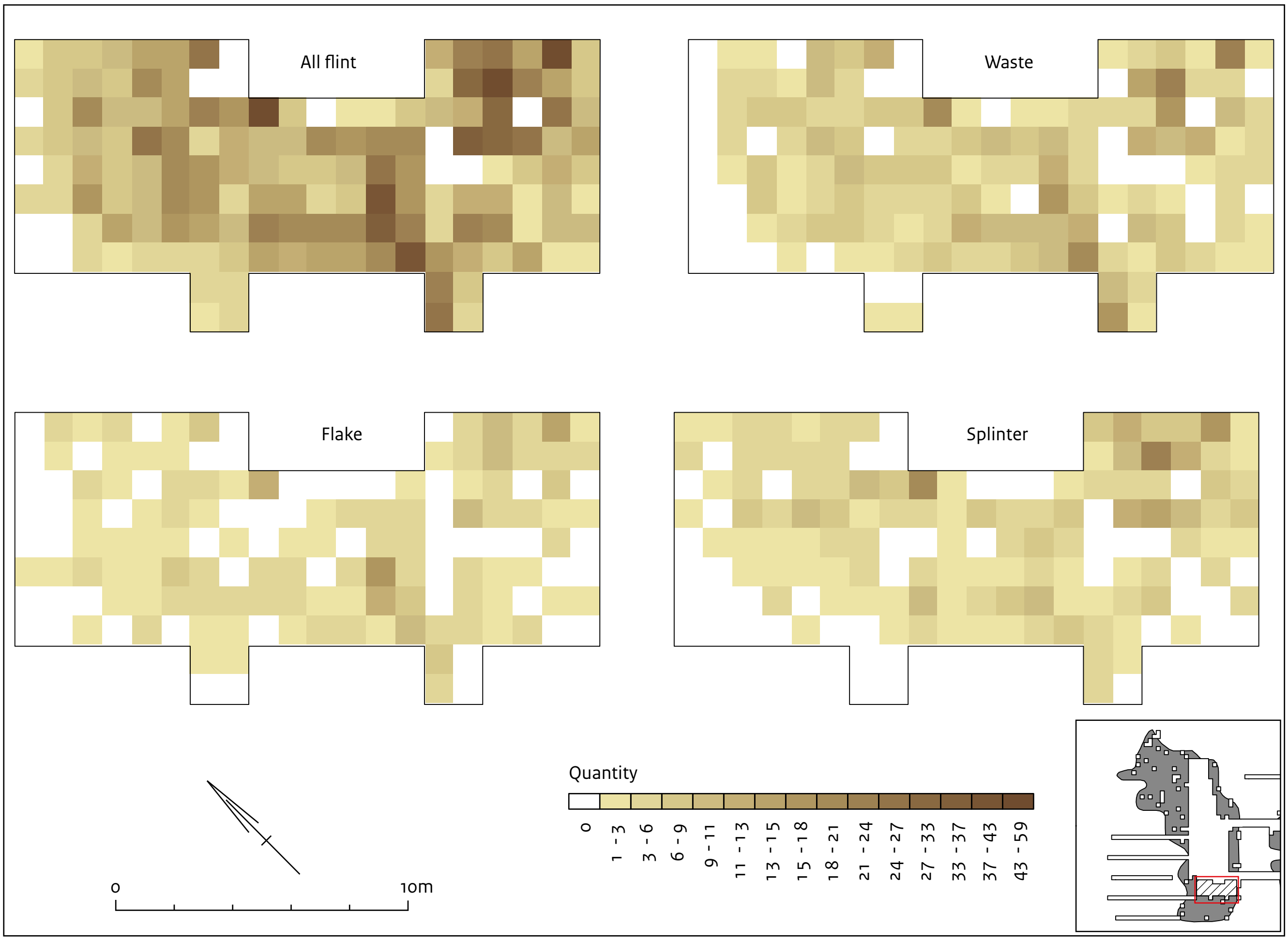


Figure 11.23 Flint distribution in quantities within the studied area.

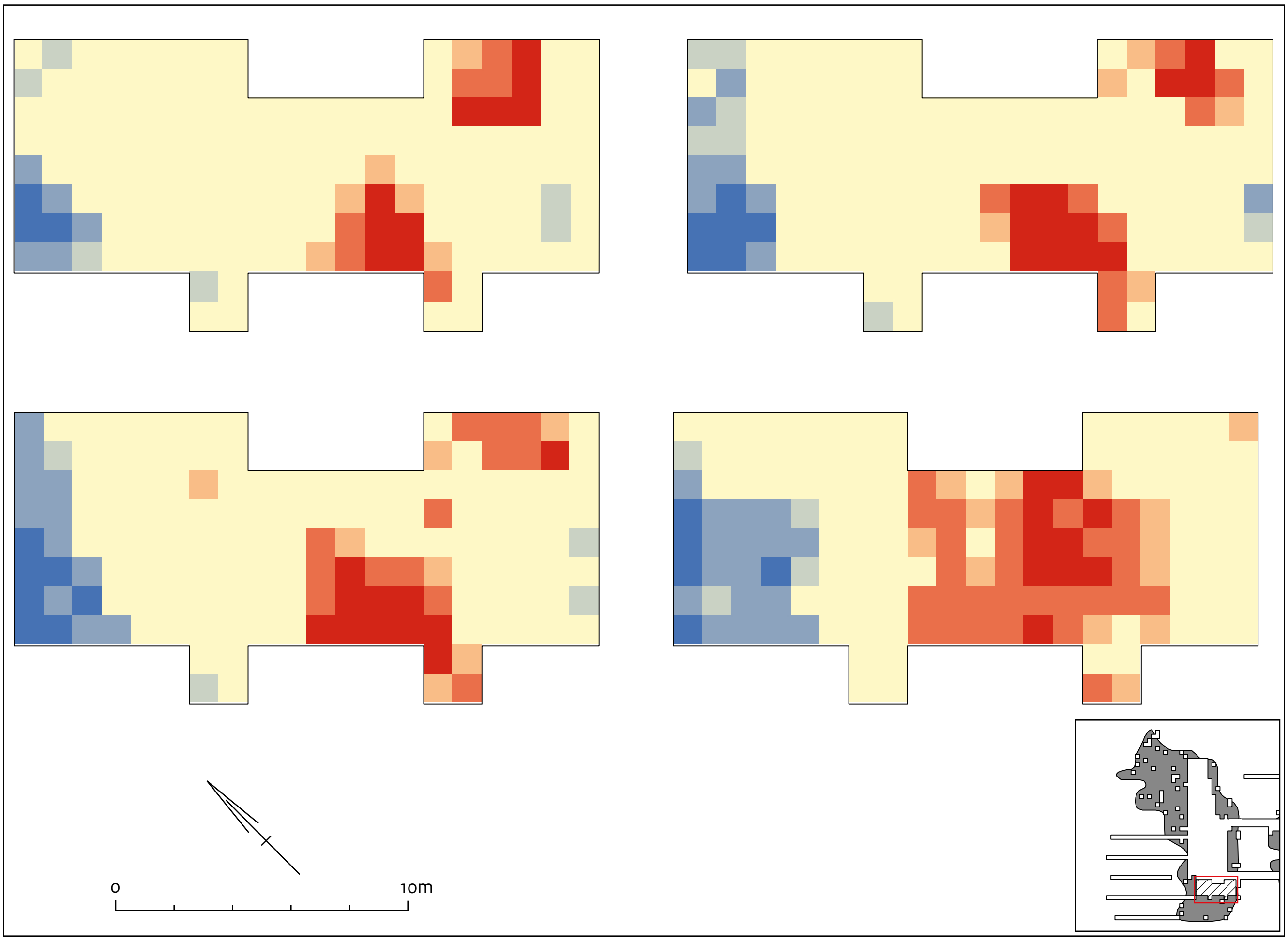
Table 11.2 Quantities of flint by type.

Type	Number	%
Blade	11	0.6
Flake	476	24.4
Splinter	615	31.6
Waste	846	43.4
Total	**1948**	**100**

there is also significant clustering of low values. In all cases this occurs on the western edge and in the southwestern corner. This indicates a clear absence of material in this area.

The KDE (Fig. 11.27) supports the Gi* statistic (Figs. 11.24-11.26) with similar high values. When combined into a multivariate visualisation a banding effect similar to that seen in the animal remains is presented. To the north more magenta, reds and blues are present (waste and splinters), whereas to the south there are more yellows and greens (waste and flakes).

These patterns can be related to the underlying topography, as the majority of this area is situated in what has been defined as a depression. The Gi* clustering of high values in the northeast is located at the very edge of this depression.



<-2.58 Std. Dev.
-2.58 - -1.96 Std. Dev.
-1.96 - -1.65 Std. Dev.
-1.65 - 1.65 Std. Dev.
1.65 - 1.96 Std. Dev.
1.96 - 2.58 Std. Dev.
> 2.58 Std. Dev.

Figure 11.24 The Gi* (hotspot) analysis of the flint waste with varying bandwidth parameters (metres). 1.75 m; 2.9 m; 3 m; 5 m (top left to bottom right).

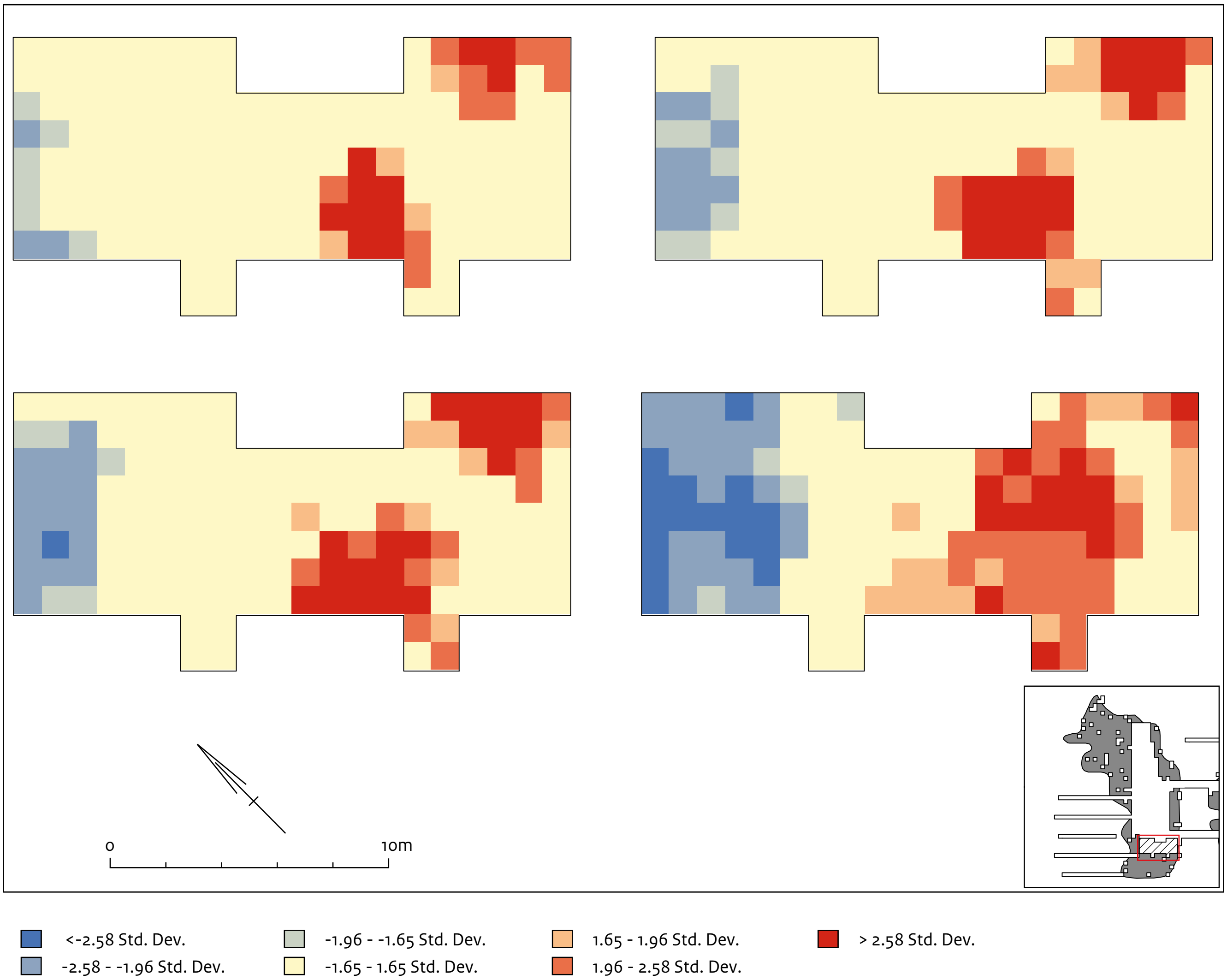
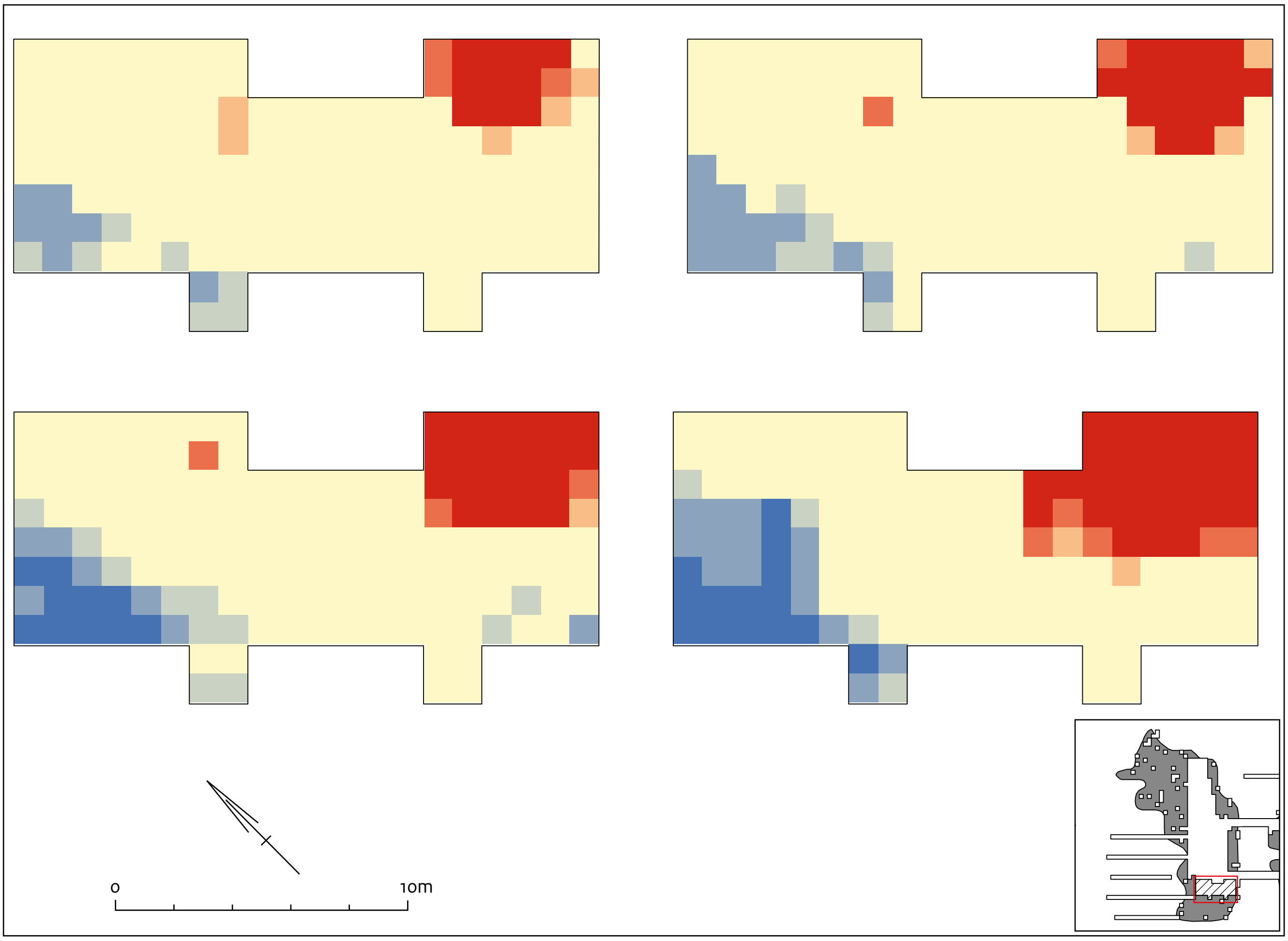


Figure 11.25 The Gi* (hotspot) analysis of the flint flakes with varying bandwidth parameters (metres). 1.75 m; 2.9 m; 3 m; 5 m (top left to bottom right).



<-2.58 Std. Dev.
-2.58 - -1.96 Std. Dev.
-1.96 - -1.65 Std. Dev.
-1.65 - 1.65 Std. Dev.
1.65 - 1.96 Std. Dev.
1.96 - 2.58 Std. Dev.
> 2.58 Std. Dev.

Figure 11.26 The Gi* (hotspot) analysis of the flint splinters with varying bandwidth parameters (metres). 1.75 m; 2.9 m; 3 m; 5 m (top left to bottom right).

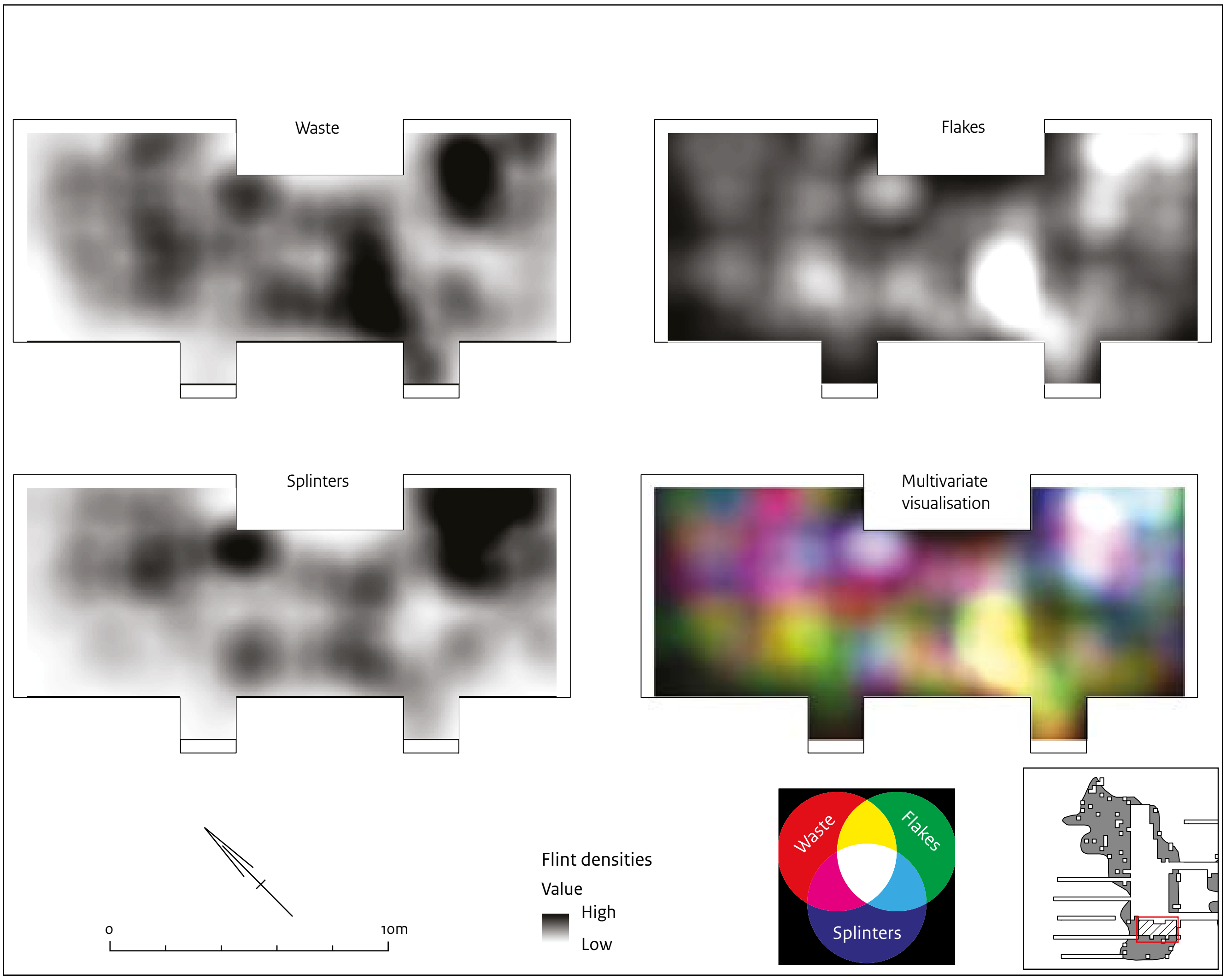


Figure 11.27 Kernel density estimates and multivariate visualisation of the flint data (KDE bandwidth = 1.75 m).

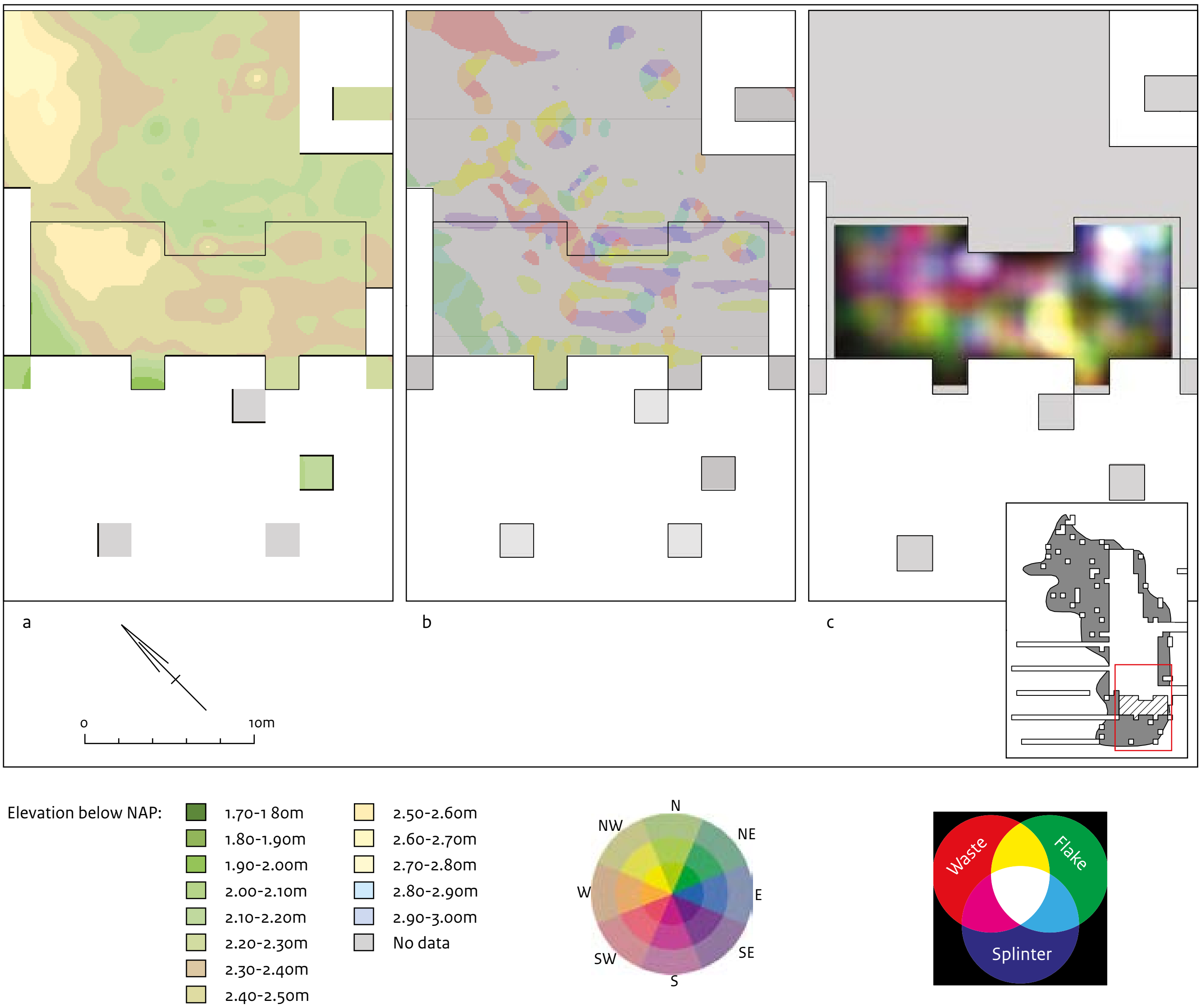


Figure 11.28 The data extent with respect to: a. elevation; b. slope; c. the flint multivariate visualisation.

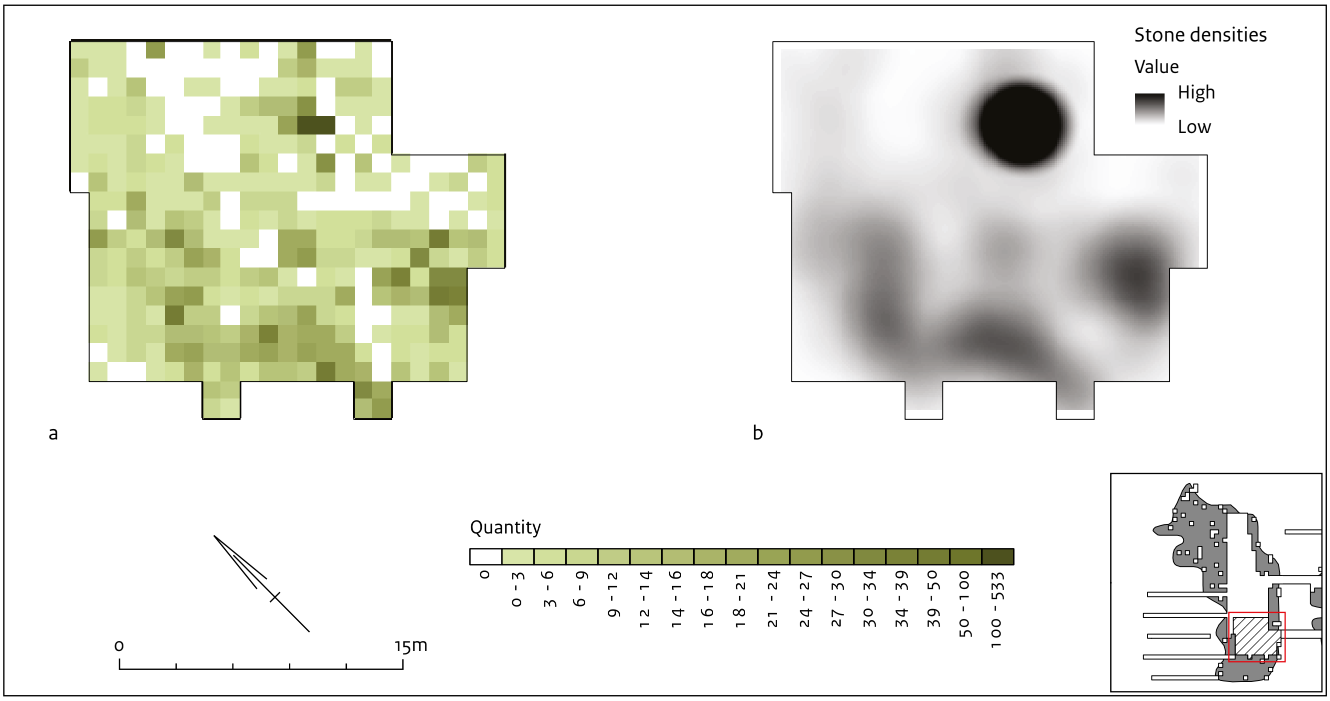


Figure 11.29 The stone data: a. distribution plot; b. stone kernel density.

11.4.3 Stone

The stone from a proportion of the 1992, 1993 and 1994 excavations was analysed. Within the defined sample area 3454 pieces of stone have been counted, weighing a total of 51542.9 g (approx. 50 kg).

Both the distribution and kernel density plots show a large quantity of stone within the 1992 area (Fig. 11.29). Upon further investigation this quantity includes 762 individual unburnt and unmodified stones weighing 843.7 g in total. They are from two neighbouring squares (16914 and 16923). The vast majority is classed as granite.

The Gi* statistics indicate one area of significantly high values (Fig. 11.30). However, comparison with the KDE makes it clear that reliance upon statistically significant patterns may be a too simplistic approach. The KDE further demonstrates that other more discrete areas of stone could exist within the dataset besides this single high-value cluster. These other high-density areas occur in the lower parts of the site as indicated in the aspect-slope plot (Fig. 11.31), within the depression.

Table 11.3 Quantities of stone by type.

Type	Number	Weight (g)
Axe/adze	1	0.6
Hammerstone	12	2009.1
Grinding stones	17	732.7
Quern stones	21	24156.0
Polishing stone	1	17.5
Combi	1	98.9
Stone flakes	12	753.6
Flaked stones	9	28.7
Unmodified	3379	17151.6
Unclassified	1	unknown

The dataset can be subdivided on the basis of the functional designation of the stones (Table 11.3). After exclusion of unmodified stones the quantities in the remaining categories are fairly low, especially when presented spatially. The highest quantity in any one excavation unit totals only four. There are no clear groupings (Fig. 11.32), and patterns appear to be dispersed fairly randomly, although higher quantities do appear within the surrounding depression (Fig. 11.31).

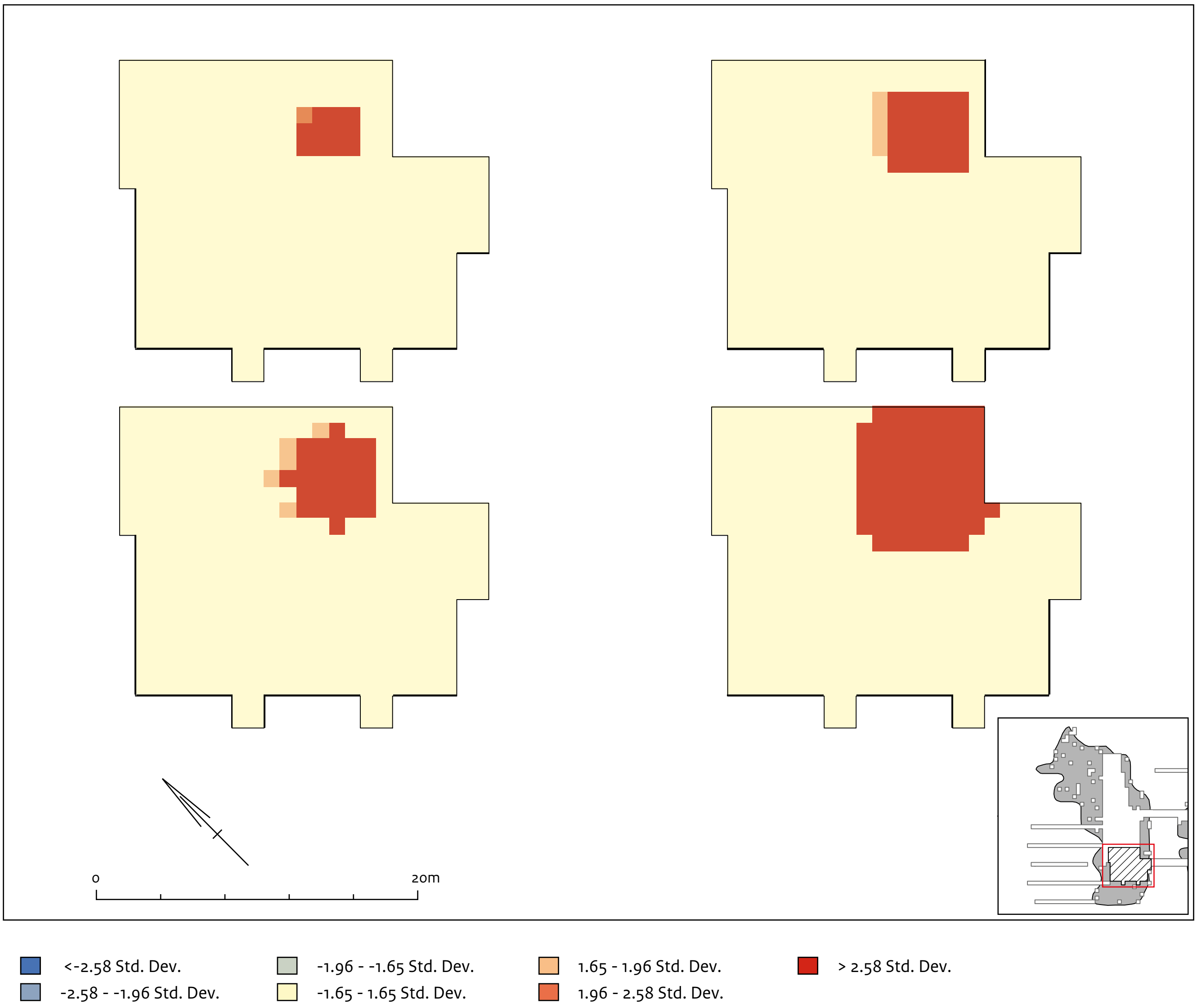


Figure 11.30 The Gi* (hotspot) analysis of the stone material with varying bandwidth parameters (metres). 1.75 m; 2.9 m; 3 m; 5 m (top left to bottom right).

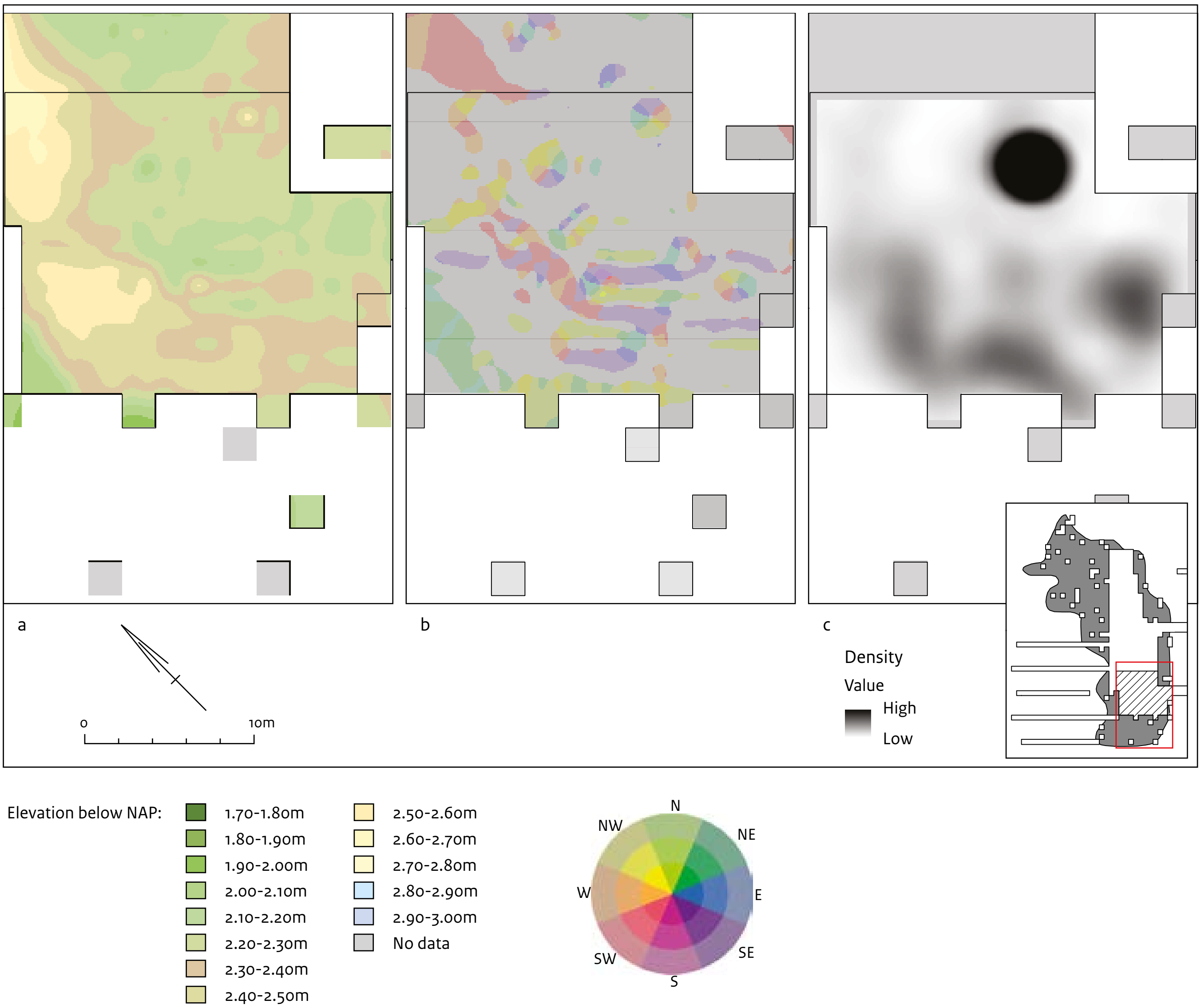


Figure 11.31 The data extent with respect to: a. elevation; b. slope; c. the stone multivariate visualisation.

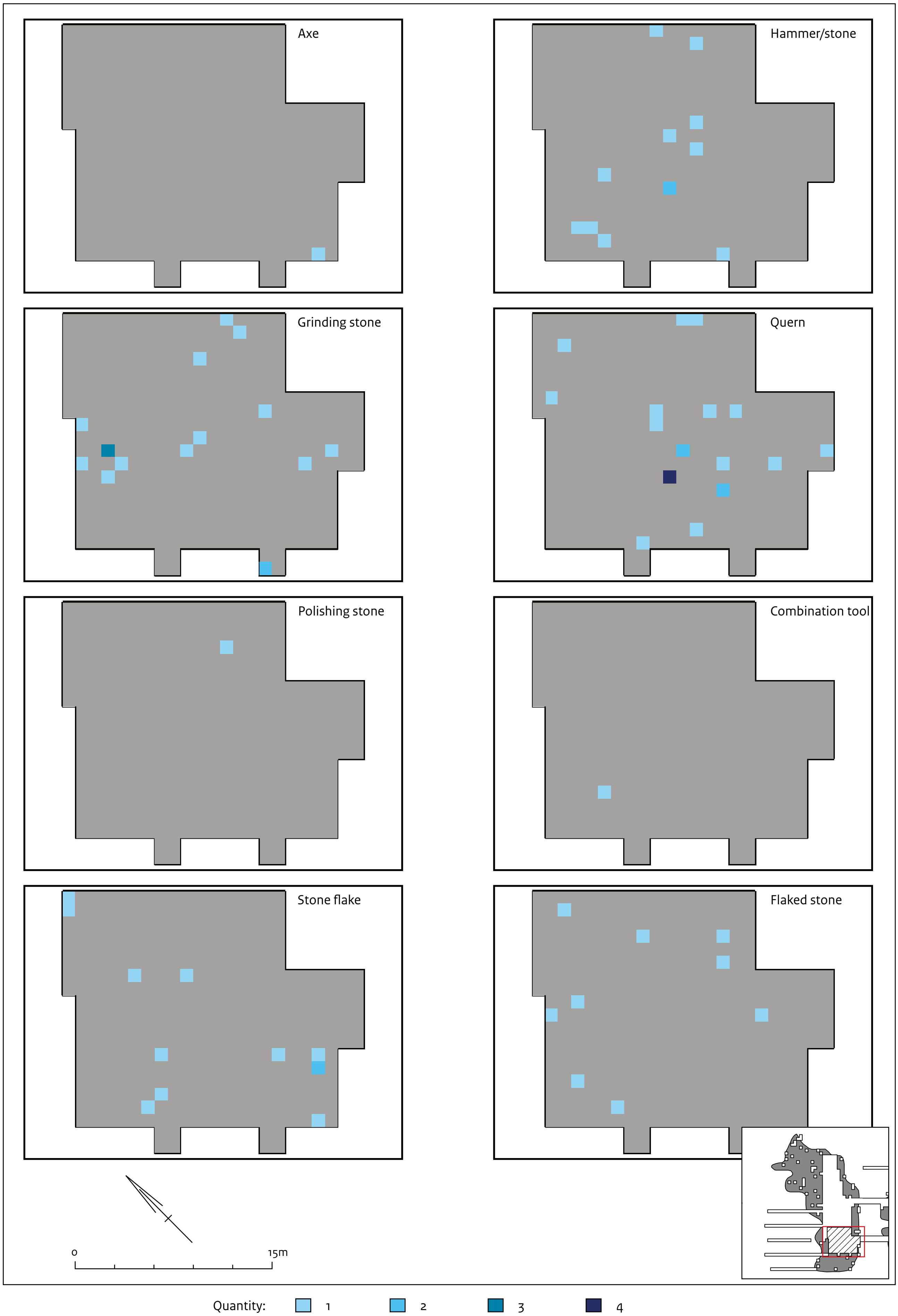


Figure 11.32 Distribution of stone types.

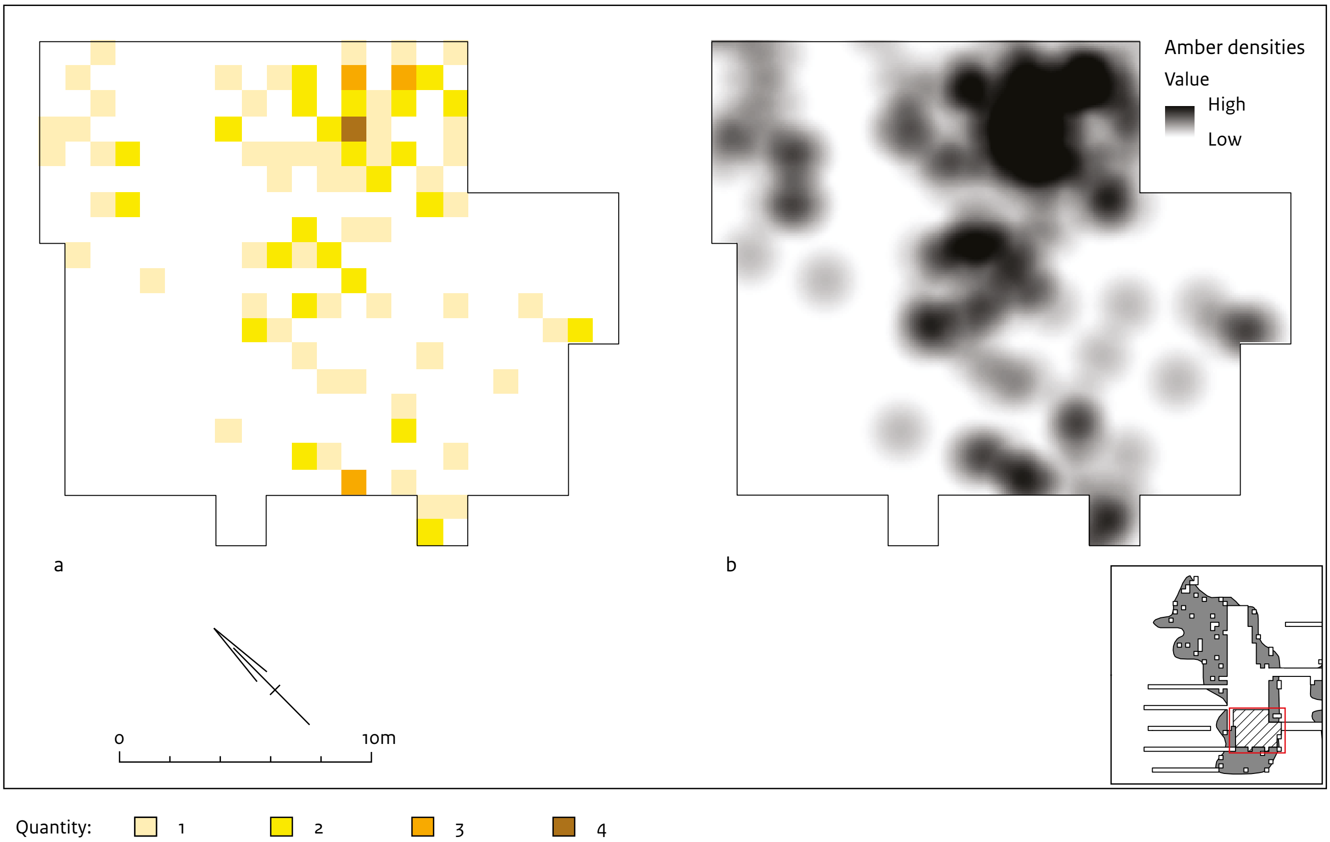


Figure 11.33a. distribution of amber by quantity; b. density of the pieces of amber. Note high densities of amber are represented by only three to five pieces.

11.4.4 Amber

Of the 278 pieces of amber analysed, 115 pieces were from within the chosen sample area (Fig. 11.33).[425] These classifications were grouped accordingly, to provide more meaningful divisions for the spatial analysis (see Table 11.4).

From the distribution plot and kernel density analysis it appears that there is a concentration of amber in the north. Other more vague areas are potentially present.

In this case high densities only reflect the presence of five pieces of amber. Interpretation of any statistical analysis must be approached with a degree of caution as a slight change in these quantities could alter the results.

Based upon the pie chart distribution in Figure 11.34 there appears to be a greater presence of material from the east of the sample area, with amber present more in the north and northeast. The Gi* analysis indicates a grouping of similar high quantities of material in two areas, centrally and to the north (Fig. 11.35). This is indicated at the 1.75 m scale; at increasing scales these two areas merge. At the larger scales there is also a significant clustering of the absence of amber to the southwest and to a

Table 11.4 Amber by type and analytical unit.

Type	Number	%	Grouped %
Complete bead	12	10.4	34.8
Broken bead	16	13.9	
Bead fragment	1	0.9	
Broken bead fragment	2	1.7	
Bead (semi-finished product)	6	5.2	
Broken bead (semi-finished product)	3	2.6	
Block	26	22.6	23.5
Nodule	1	0.9	
Flake	48	41.7	41.7
Total	**115**	**99.9**	**100**

[425] Van Gijn, this volume.

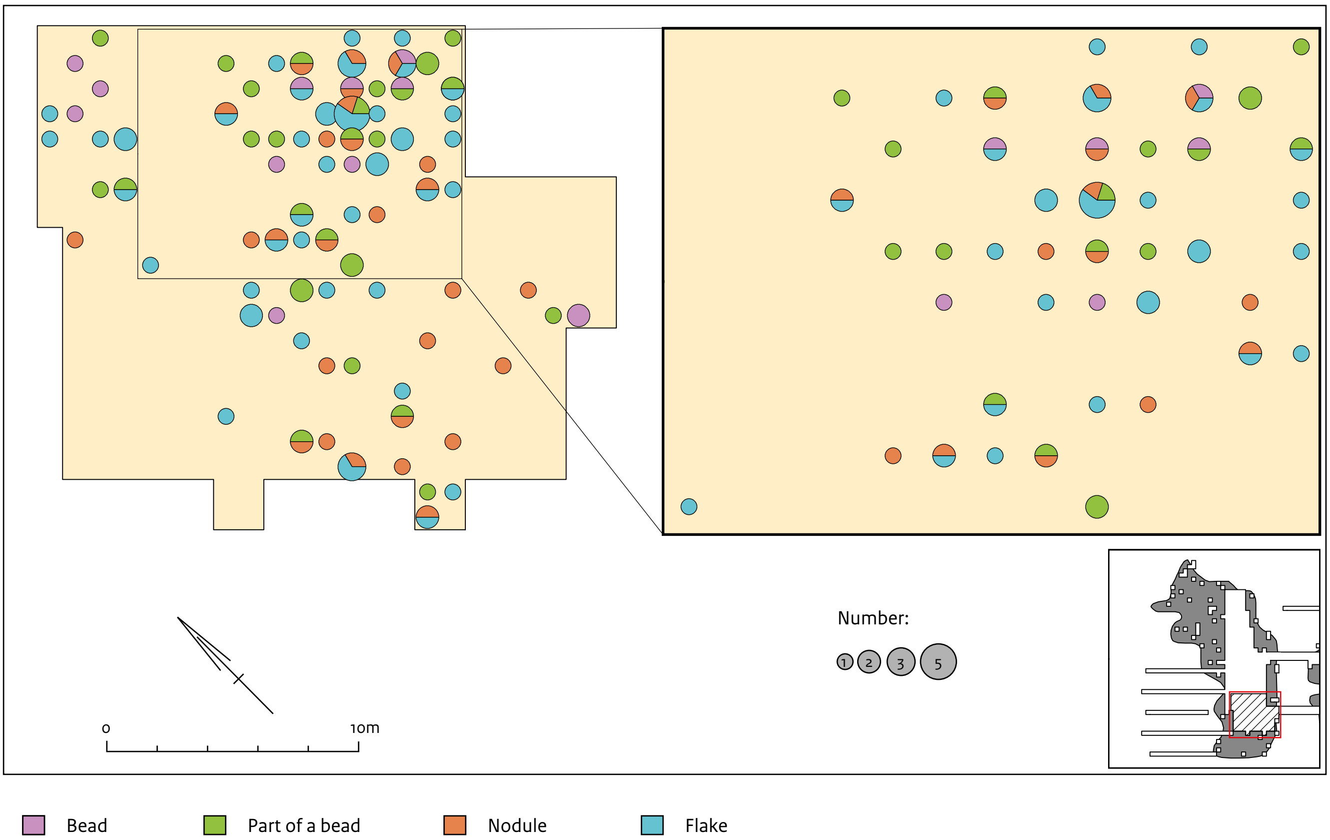


Figure 11.34 Pie chart representation of the amber categories.

lesser degree in the east. The presence of an amber working area could be inferred from these images (Figs. 11.33-11.35). This is a distinct possibility but the range between these high and low values lies between only 0 and 5 whole units. The identified area would have to be combined with the other datasets to see if any correlation occurs between them.

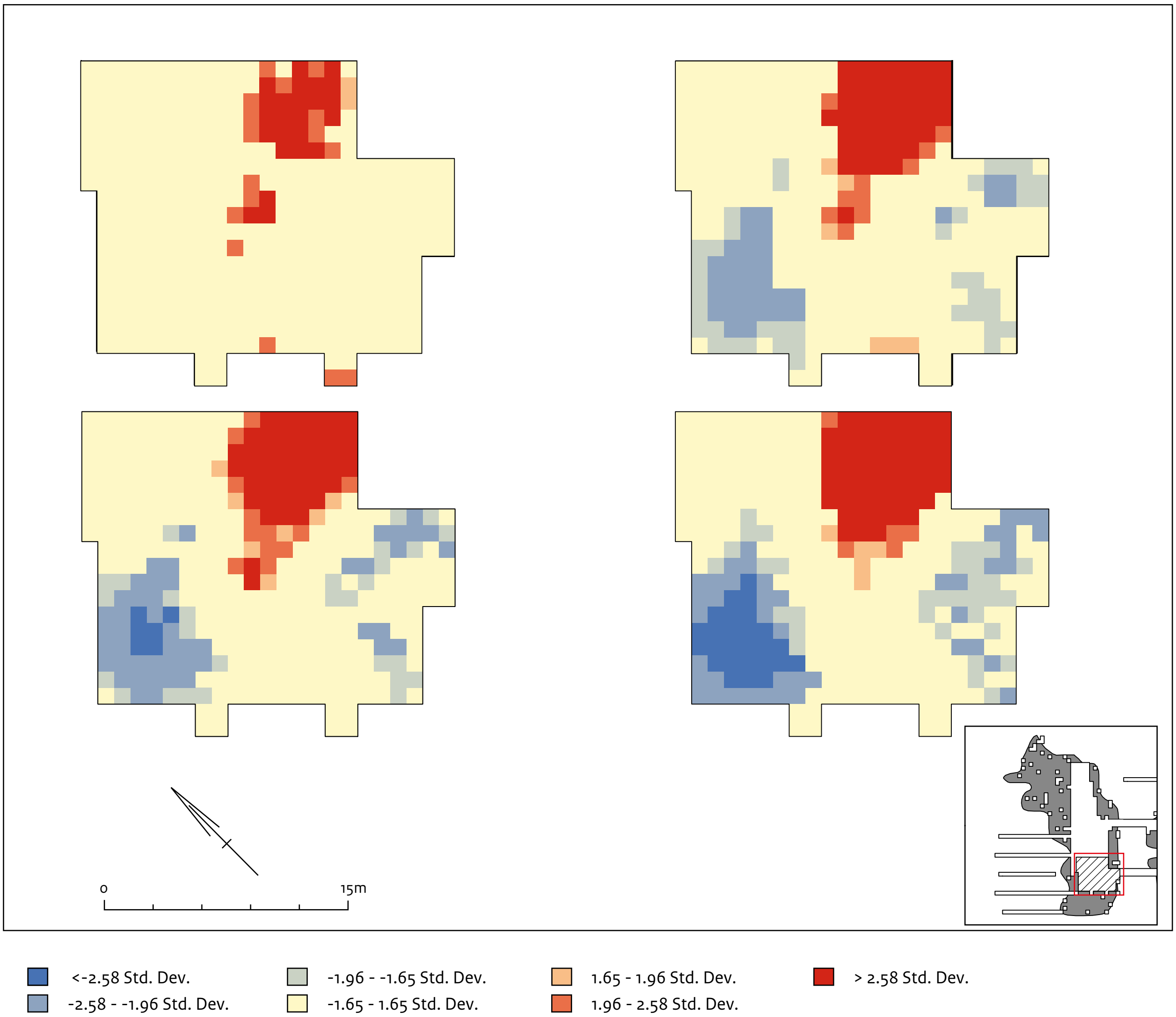
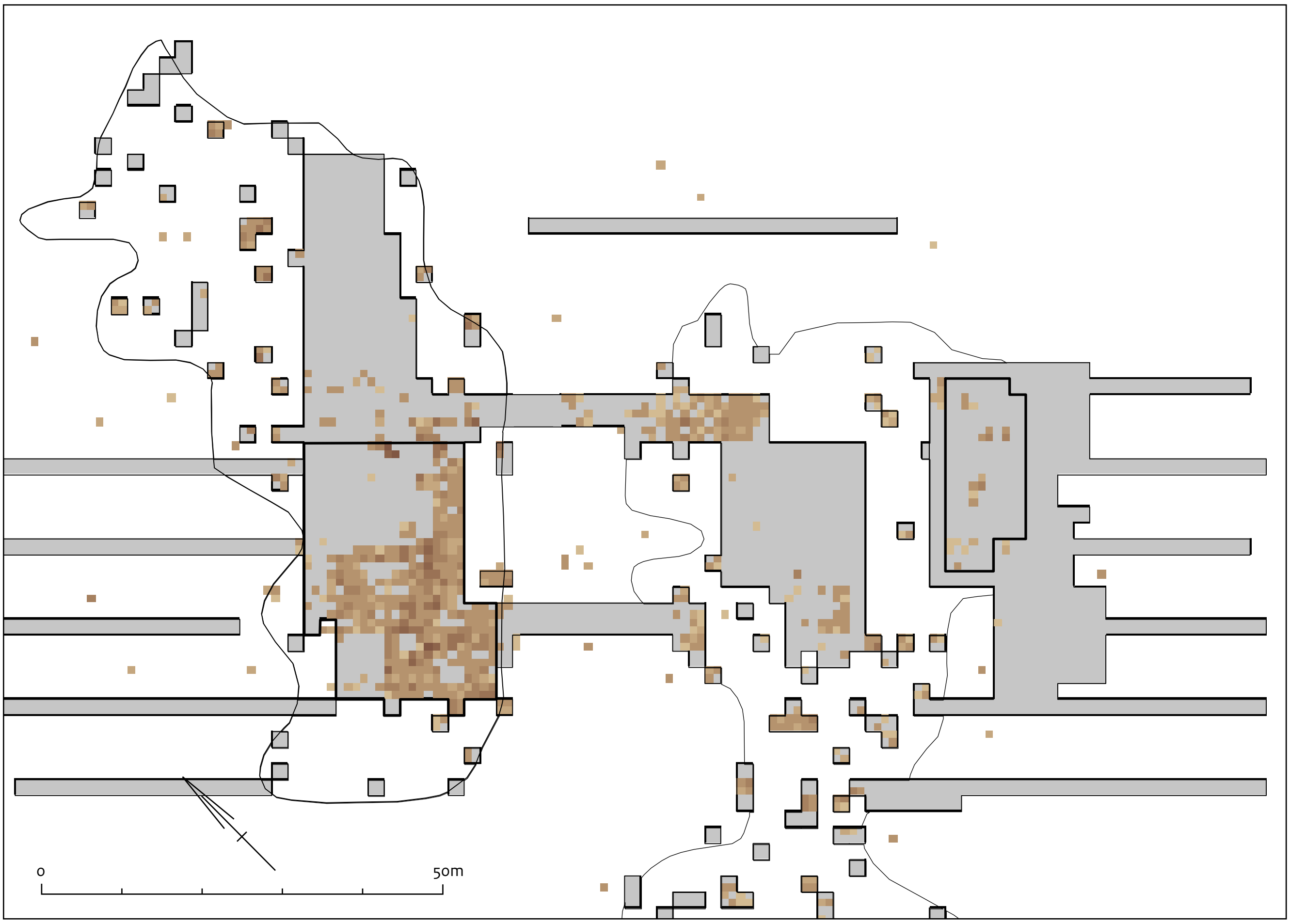


Figure 11.35 The Gi* (hotspot) analysis of the amber with varying bandwidth parameters (metres). 1.75 m; 2.9 m; 3 m; 5 m (top left to bottom right).



Weight (g) ceramic sherds: 0, 0-2, 2-5, 5-10, 10-50, 50-100, 100-200, 200-500, 500-800, Not analysed, Studied area

Figure 11.36 Distribution of the analysed sherds with the original sample areas outlined in black.

11.4.5 Ceramics

All of the ceramics in the southwestern sample area were analysed. These sherds came from the 1992 area as well as an expanded selection into the 1993 and 1994 areas (Fig. 11.36).

No clear spatial patterns are revealed by visualising the overall weight distribution. Ceramic data can be explored on the basis of various associated attributes, such as temper and decoration. In the case of Zeewijk-West, Beckerman[426] suggests that the weight of sherds with a tempering of stone grit (granite, red granite and quartz) could reveal a different phase or function within the settlement. Visual inspection of Figure 11.37 does not show any clear spatial differentiation between the categories of stone and non-stone temper in the south of the area. This could however be the case if the analysed area were extended further north.

In contrast, when the weights of the decorated sherds grouped by type (finger, spatula and cord) are displayed (Fig. 11.37), there appear to be some areas which require further discussion.

The spatula and cord categories show no clear spatial division. However, there appear to be some areas towards the southeast with greater weights of cord decorated material and

[426] Beckerman, this volume.

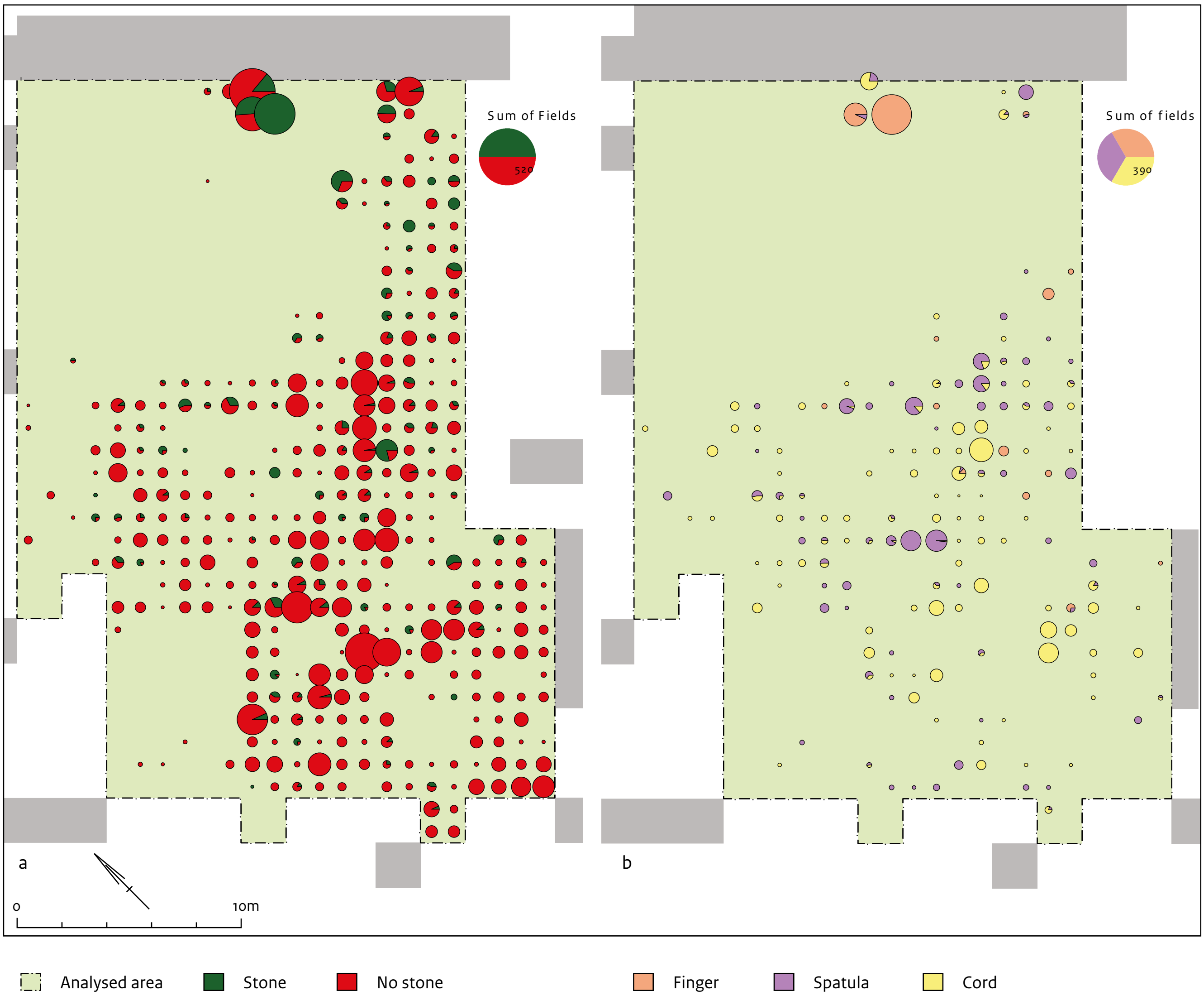


Figure 11.37 Pie chart representation of the weight of sherds per unit in reference to: a. temper type; b. decoration form.

greater weights of spatula decoration towards the north of these distributions. It is not clear how relevant these patterns are as they may be coincidental rather than related to different phases. However, this possibility cannot be completely ruled out.

The total weights of the finger-decorated sherds are relatively low (717 g, 21%) in comparison with cord (1573.9 g, 46%) and spatula (1128.7 g, 33%) decoration. Even though 21% may be viewed as quite high, the majority of these weights are from two test pits at the northern extent of the sample area. There is no reason to suspect the test pits are the source of a quantitative bias compared to the wider areas excavated. As these two areas are on the northern edge of the sample area they may present a trend which continues to the north, as also the distribution pattern of the undecorated sherds show (Fig. 11.38). This would require further investigation for clarification.

Beckerman identified a minimum number of individual (MNI) vessels of 417.[427] The spatial distribution of each vessel has been plotted and visually assessed. Of these, 20 were selected for further spatial analysis on the basis of the expected size of the vessels. These are vessel numbers, 2, 5, 12, 13, 14, 15, 20, 28, 29, 88, 123, 124, 131, III, XV, XVIII, XX, aa, C, and T (Figs. 11.39-11.43). A broadly clustered spatial distribution of the vessel sherds might suggest

[427] Beckerman, this volume.

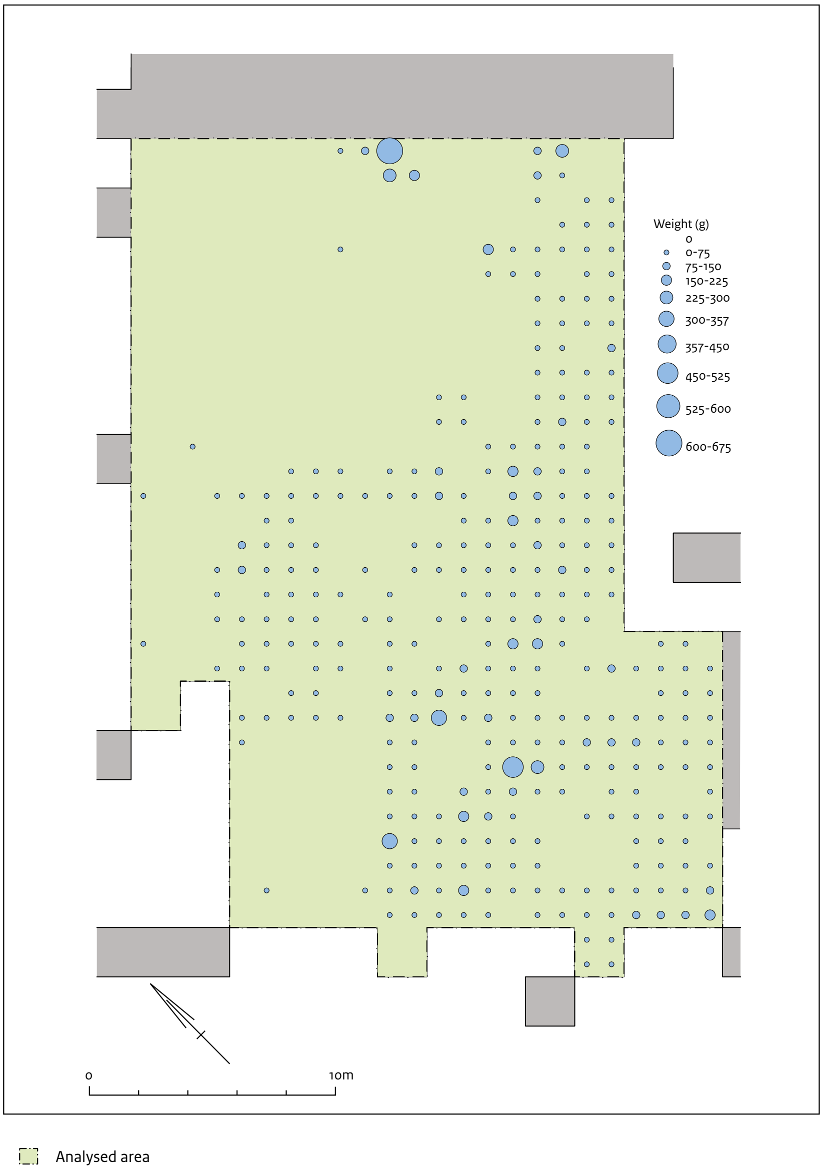


Figure 11.38 Distribution in weights of the undecorated sherds.

a potential for low levels of spatial disruption. The sherds from the vessels that were not selected were spatially dispersed and represented by low overall total weights, especially when assessed per metre square.

The sherds from vessels 12, 28, 29, 124, 131 and C are all clustered within a small area. Of these, some locations have lower weights, but are nonetheless indicative of slight dispersion. Vessel 123 is slightly more dispersed, yet the higher weights can be observed in the east of the distribution, perhaps suggesting some dispersion to the west. Vessel 13 is quite dispersed, whilst the locations do contain fairly high values. The remains of vessel 15 are similar in their pattern although slightly more clustered within the south of the sample area. Sherds from Vessel 14 represent at least 50% of the vessel. The weights of the sherds are relatively small in comparison with the other vessels, but are fairly high compared with the total weight of the entire vessel. Hence, these lower weights may suggest clustering of sherds, but as they are located near to the eastern limit of the sample area the distribution is likely to be 'incomplete'.

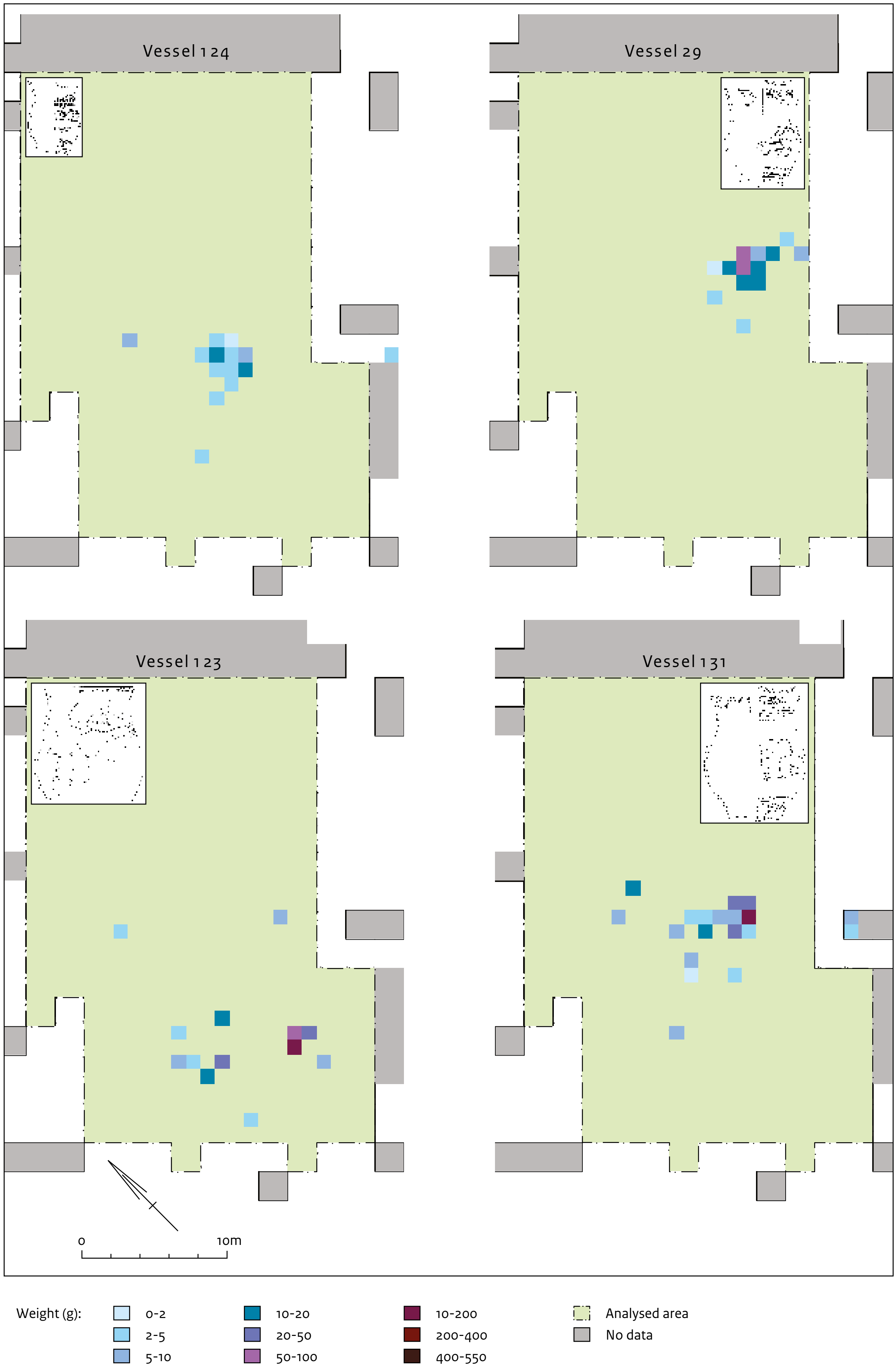


Figure 11.39 Spatial distribution of sherds (by weight) of vessel 124, 29, 123 and 131.

Figure 11.40 Spatial distribution of sherds (by weight) of vessel 12, 13, 15 and 28.

Vessels XV and III are also close to the southern extent of the excavation. Hence there is a high possibility that a large proportion of the vessel remains in the unexcavated area. Vessels aa and XVIII have high values clustered together with low weight values dispersed further from the main concentration. Vessel 2 is located in the southern part of the sample area, and appears to be fairly dispersed.

Vessel XX has an unclear distribution, although there is a single square with a high weight of sherds (square 17561, 133.9 g). The remaining areas are fairly clustered, the combinations of the more southern grouping (squares 15611, 15612, 15622, 16261) can be combined, and are fairly high in weight (77.9 g), although not as high as square 17561, especially not once the surrounding squares are accumulated with this relatively high weight of sherds. It is therefore difficult to interpret without the inclusion of other factors.

Vessels 88 and T consist of low-weight sherds and even though they appear to be concentrated in the centre of the sample area it remains difficult to infer any confident spatial conclusions. Sherds from Vessel 5 occur in four locations. Three of the locations have relatively high weights but it remains difficult to arrive at any clear conclusions for this vessel. Vessel 20 consists of lower-weight sherds and is in the central and southern part of the sample area. No spatial conclusions can be drawn from this vessel distribution.

Unfortunately the layer information was not of a suitable nature to aid in the development of a phasing for the vessels. The inaccuracy of the layer information is such that any interpretation based on the layer data would be biased towards the small quantity of well-recorded sherds.

It has been concluded that the majority of the vessel remains occur centrally or in the west of the sample area. Only relatively low weights of sherds occur in the location of the depression; the higher-weight sherds are located on the relatively higher topography. Accepting that the clustering of relatively high weights from a vessel could indicate an original location, then the original location for the assessed vessels is situated within the area of the higher topography. Those vessels not depicted here were either highly dispersed, comprised low weight values, or a combination of the two. Such an observation may indicate that the more complete and spatially confined sherds from individual vessels could be associated with a later phase in the development of the settlement. It is easy to imagine that vessels from earlier phases of settlement were subjected to a longer period of erosion and dispersal by domestic daily activities. Those vessels which were incorporated into the settlement strata at a later date may have been subject to far fewer destructive and dispersing factors. Although this is a logical statement it is difficult to base any temporal model on the vessels, as local conditions could vary and, with them, the preservation of the vessels in both material and spatial terms.

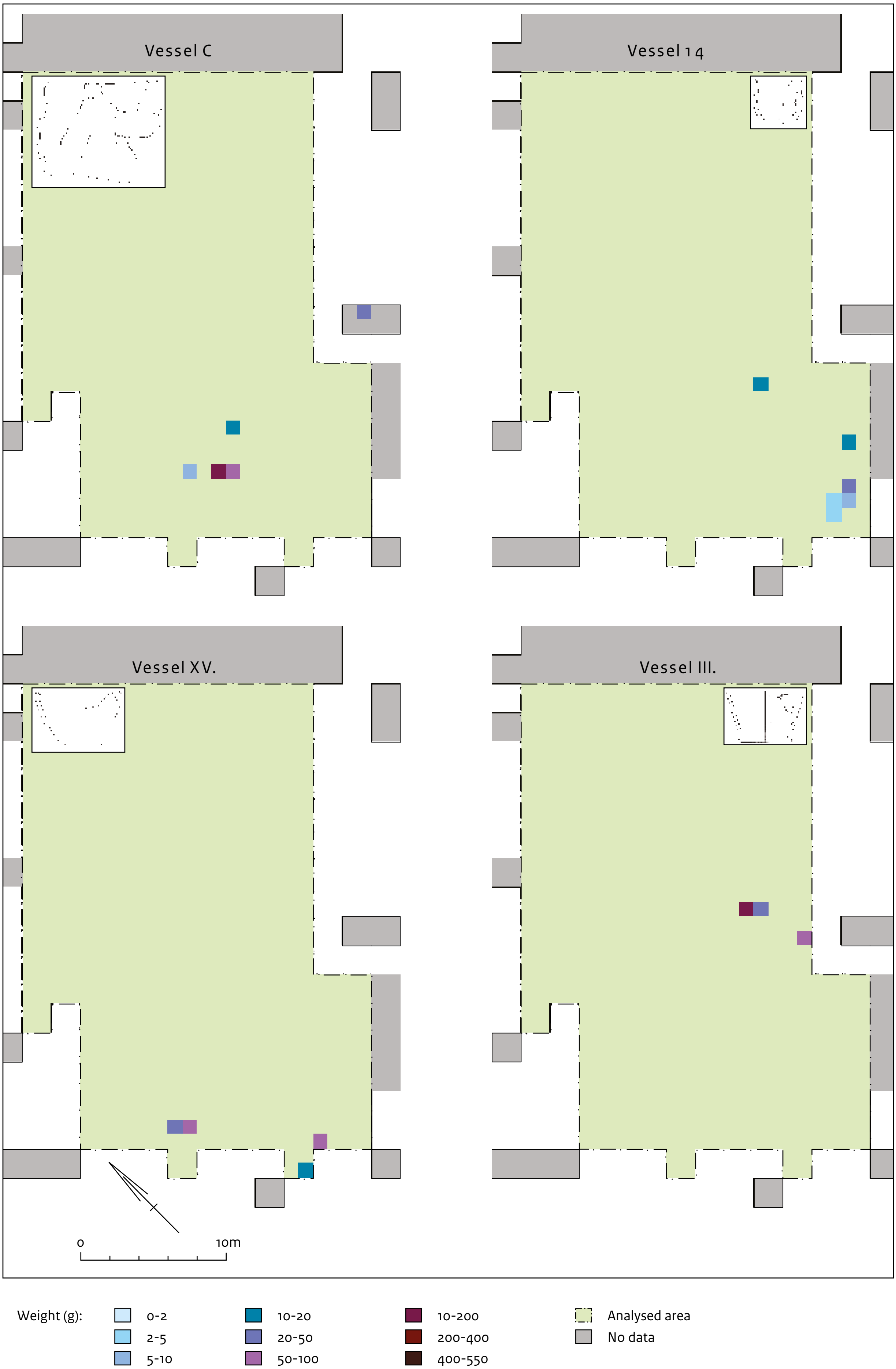


Figure 11.41 Spatial distribution of sherds (by weight) of vessel C, 14, XV and III.

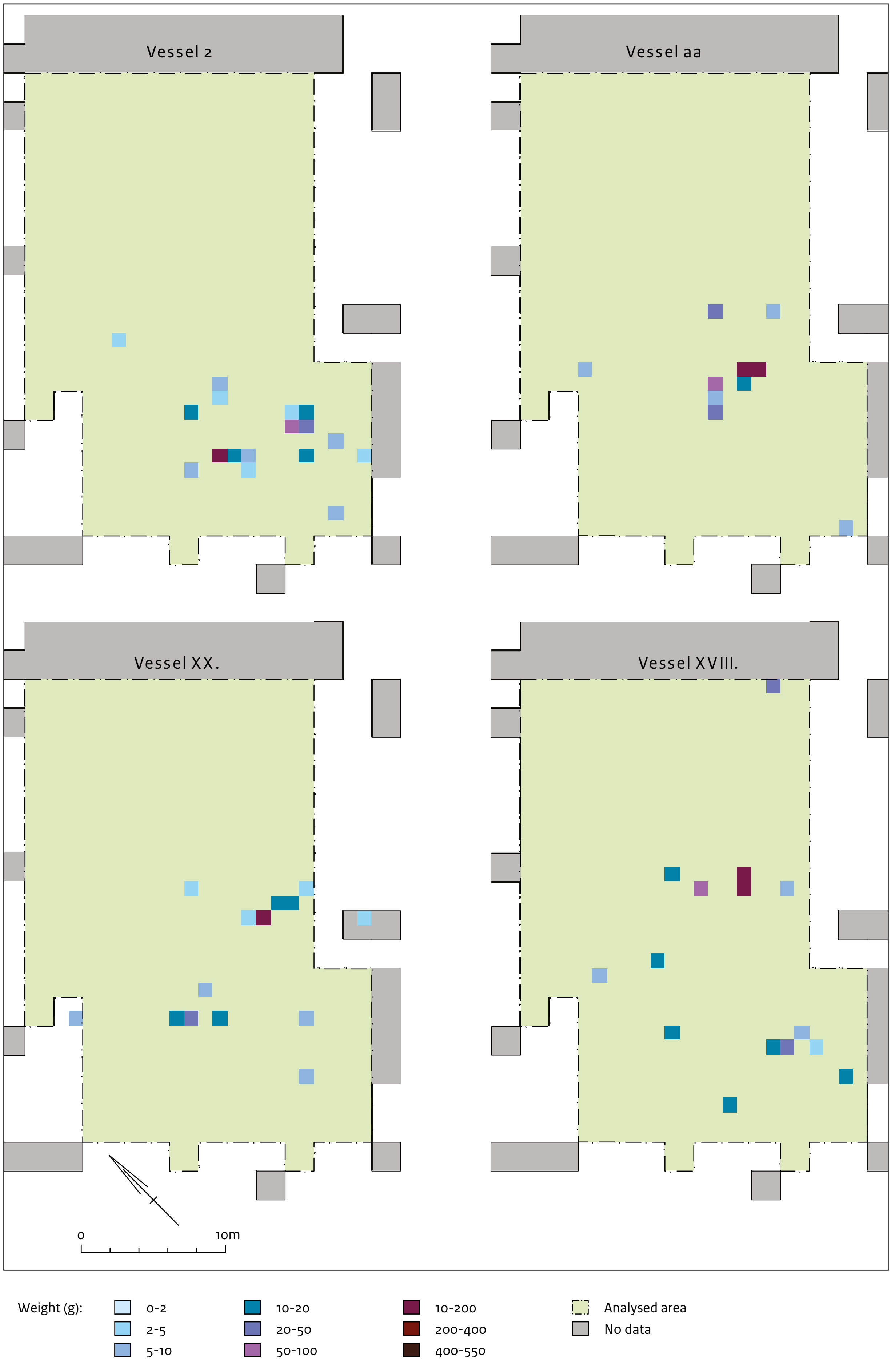
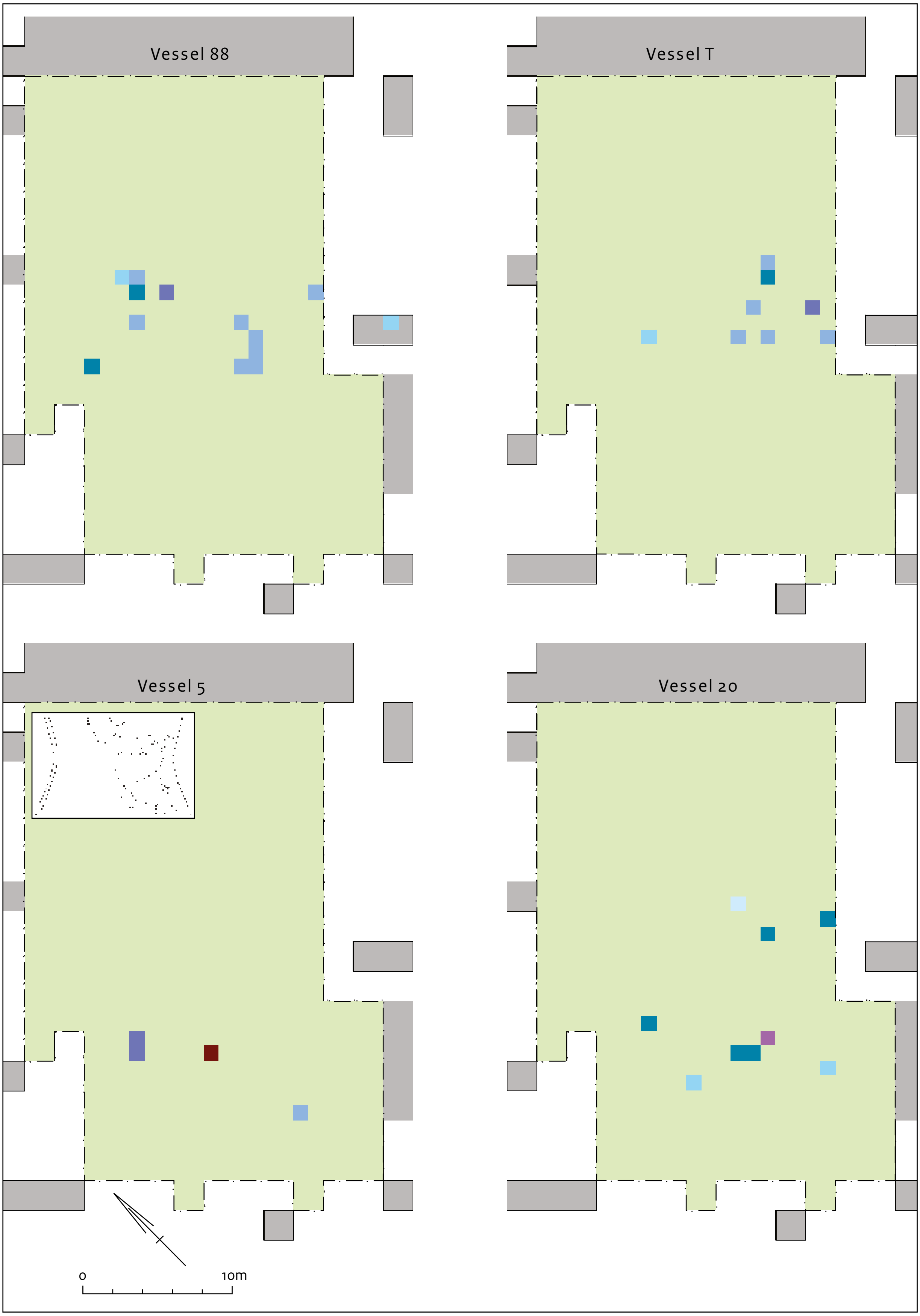


Figure 11.42 Spatial distribution of sherds (by weight) of vessel 2, aa, XX and XVIII.



Weight (g): 0-2, 2-5, 5-10, 10-20, 20-50, 50-100, 10-200, 200-400, 400-550; Analysed area; No data

Figure 11.43 Spatial distribution of sherds (by weight) of vessel 88, T, 5 and 20.

11.4.6 Comparison of spatial configurations

Depression and phasing

The previous sections have dealt with the find categories from Zeewijk-West individually; this section brings all of these data sources together for comparison.

The elevation data in Figure 11.44 indicate a depression which curves around the western and southern edges of the excavated area. Profiles of the elevation data A-B indicate a depth of 20 cm, whereas profile C-B indicates a depression of up to 50 cm in depth. The posthole densities (Fig. 11.45) appear to avoid this depression in the west, although there is overlap to the south. The cow hoof marks, however, seem to be concentrated within this depression in the south. This is likely to extend into the western part of the depression but this area is not recorded on excavation plans. The depression could therefore be a consequence of the movement of cattle, creating a visible feature. This feature would have been carved out of the ground surface by the repetitive movement of predominantly cattle, with the possibility of other livestock. The movement of cattle would be expected to produce a large degree of fragmentation, especially in relation to the animal remains. As has previously been stated, in terms of the assemblage as a whole, the bone remains are highly fragmented. Any differentiation in fragmentation between the material in the depression and that beyond it is therefore unlikely.

The presence of this depression offers four potential scenarios regarding the movements of the cattle:

1. The cows were able to circle a structure or structures which were located within this area, the resulting erosion forming the depression.
2. The cow hoof mark distribution pertains to at least two habitation phases. To the south the cows were able and allowed to move around the southern extent of the site at that time. On another occasion, when the habitation focus was more in the north, the cattle were again able to move around the south of the site, in this case situated slightly further to the north.
3. Hoof marks were present all over the site, but due to differential preservation (e.g. insertion of posts) the cow hoof marks have not survived everywhere.
4. The hoof marks were created by a group or groups of cows wandering randomly around the settlement.

In this instance, scenarios 3 and 4 are unlikely. The general division between the hoof marks and postholes demonstrates a clear opposition between the two. However, there is some overlap, indicating that the insertion of posts before or after the creation of the cow hoof marks had no effect on their preservation and identification. Scenarios 1 and 2 therefore remain as possibilities.

The presence of ard marks (see Chapter 3) within the areas dominated by postholes would indicate that ploughing events occurred in areas either prior to the building of a structure or following the abandonment, destruction or removal of a structure. The absence of large quantities of ard marks within the larger excavated areas is most probably the result of the excavation method.

Ceramics

The spatial distribution of ceramics was not based on whole vessels but on the partial remains consisting of various sherds. Some original locations can be proposed on the basis of the distribution of the sherds from individual vessels. The locations of these vessels are based upon the sherds with the highest weights and those which appear to group in greater concentrations. As illustrated in Figure 11.46, it is clear that all of the selected vessels appear in the higher part of the site, not within the depression. The other sherds are more fragmented and dispersed; these occur in both parts of the sample area.

Animal remains

The majority of the animal remains occur in a lower area defined as a depression. The animal remains distributions are banded within this depression. The majority of the mammal remains occur in the west, followed by the bird remains and the fish remains. The fish remains, although present in the depression, are also largely present in the higher part of the sample area (Fig. 11.47).

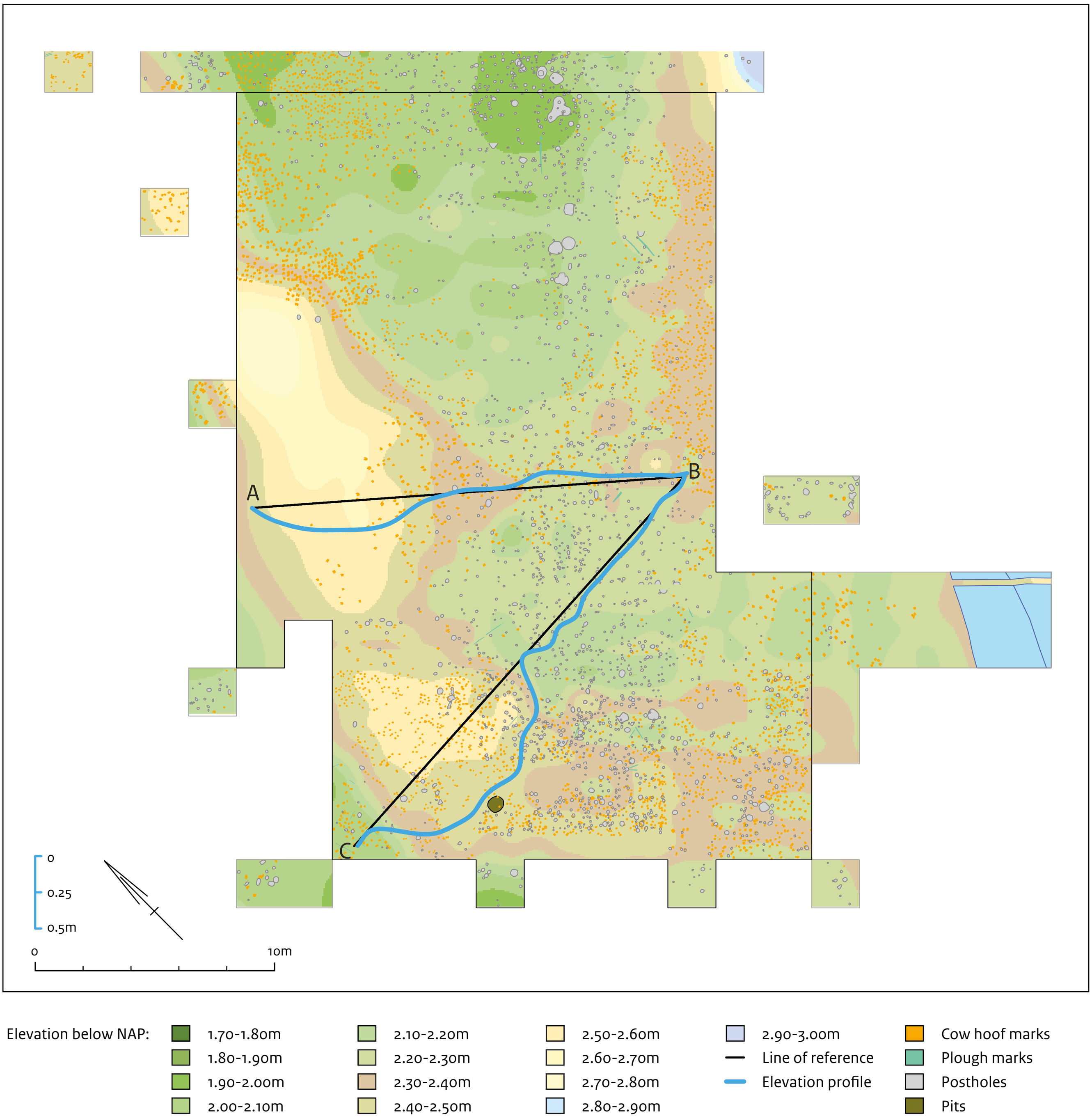


Figure 11.44 The Zeewijk-West area displaying all features and graphical overlays indicating the elevation profiles from points A-B and B-C; vertical scale is provided.

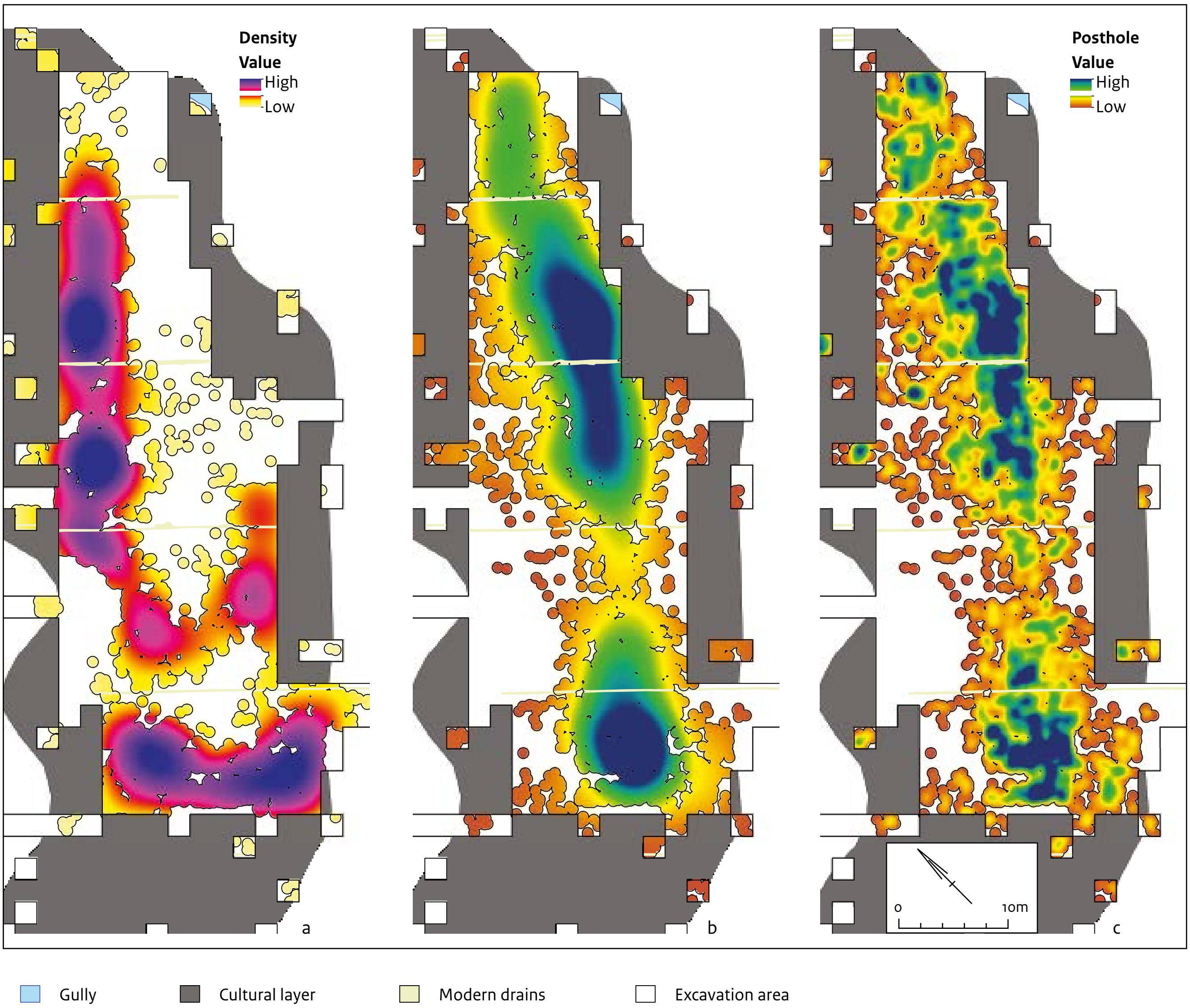


Figure 11.45a. density of cow hoof marks using a 5m search radius; b. density of postholes using a 5m search radius; c. density of postholes using a 1m search radius. All densities were buffered at a radius of 0.5 m from the centre of the features. The absence of recorded features in the southwest is striking.

Flint

Due to the extent of the studied material the flint spatial analysis is restricted to the south of the 1992 excavation. Although clusters have been identified, they are confined to the area of the depression. This makes interpretation of the spatial patterns difficult.

Stone

The stone remains indicate a high density of small pieces of granite in the higher part of the sample area. Moderate densities of stone are present and contained primarily in the depression (Fig. 11.48). This may be comparable with the flint distribution in this area.

The distributions of the individual stone artefacts were also presented (Fig. 11.32). The querns, grinding and hammer stones appear to be more randomly dispersed in this sample area and do not present any clear clustering patterns.

Amber

Amber, although low in terms of relative numbers, shows a greater presence on the higher ground as indicated previously in the Gi* plot (Fig. 11.35). The presence of beads, bead

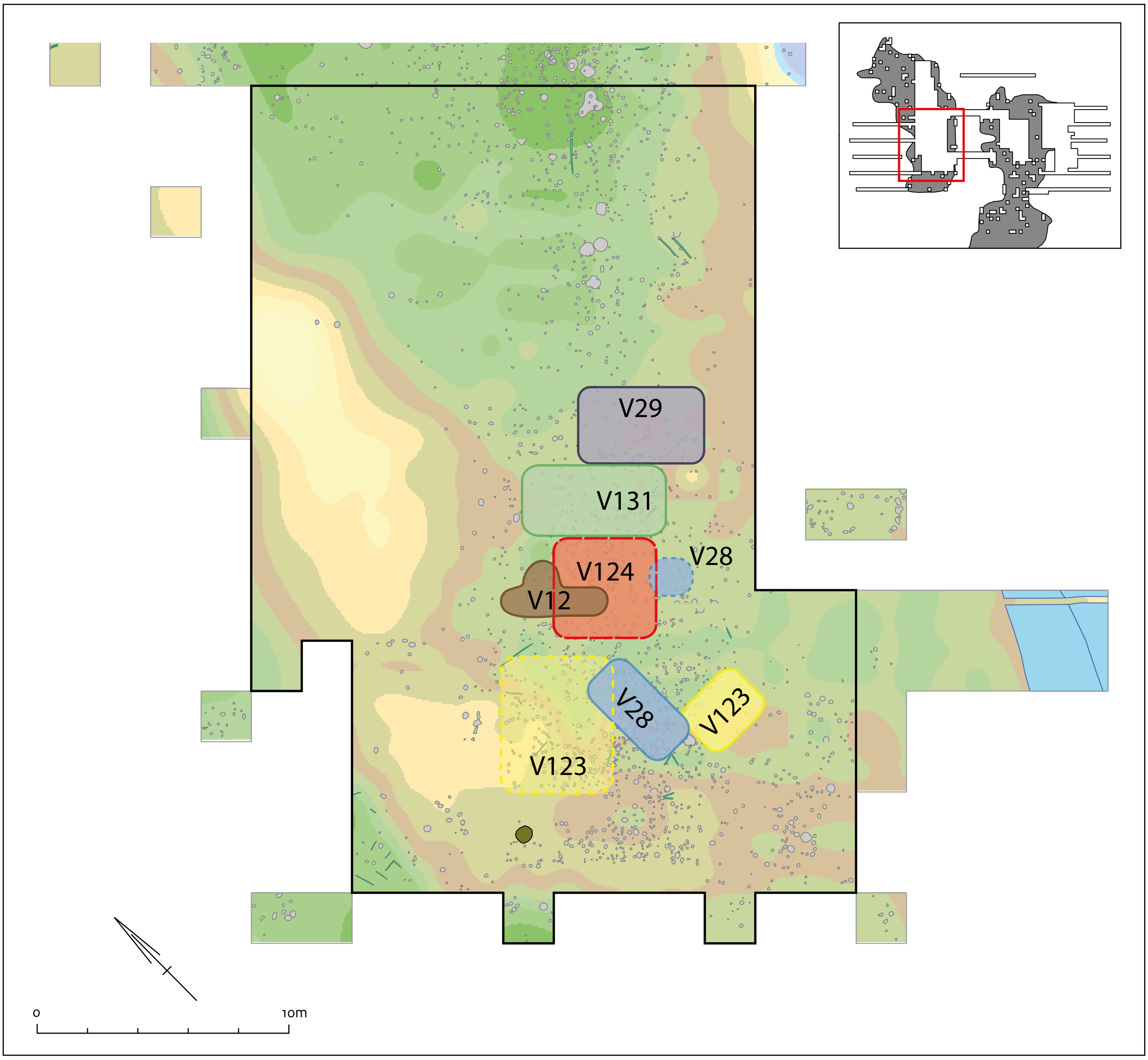


Figure 11.46 Summary of the concentrations of the clustered sherds from the vessels. Vessel 123 and or V28 are depicted in two locations, indicating a second grouping of lighter sherds.

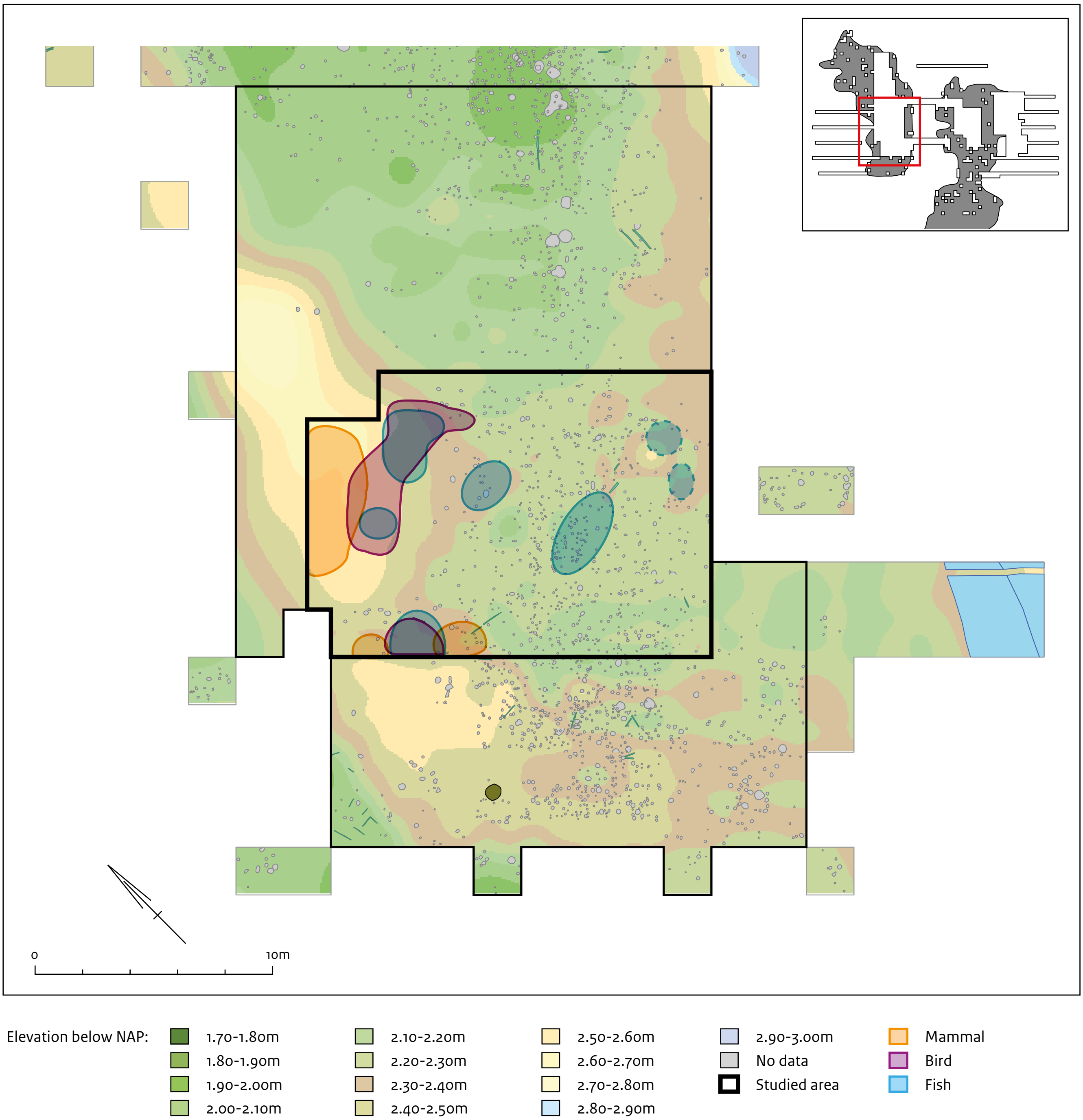


Figure 11.47 Summary of the distribution of the animal remains, banded within the depression: mammals in the west, followed by bird and fish remains.

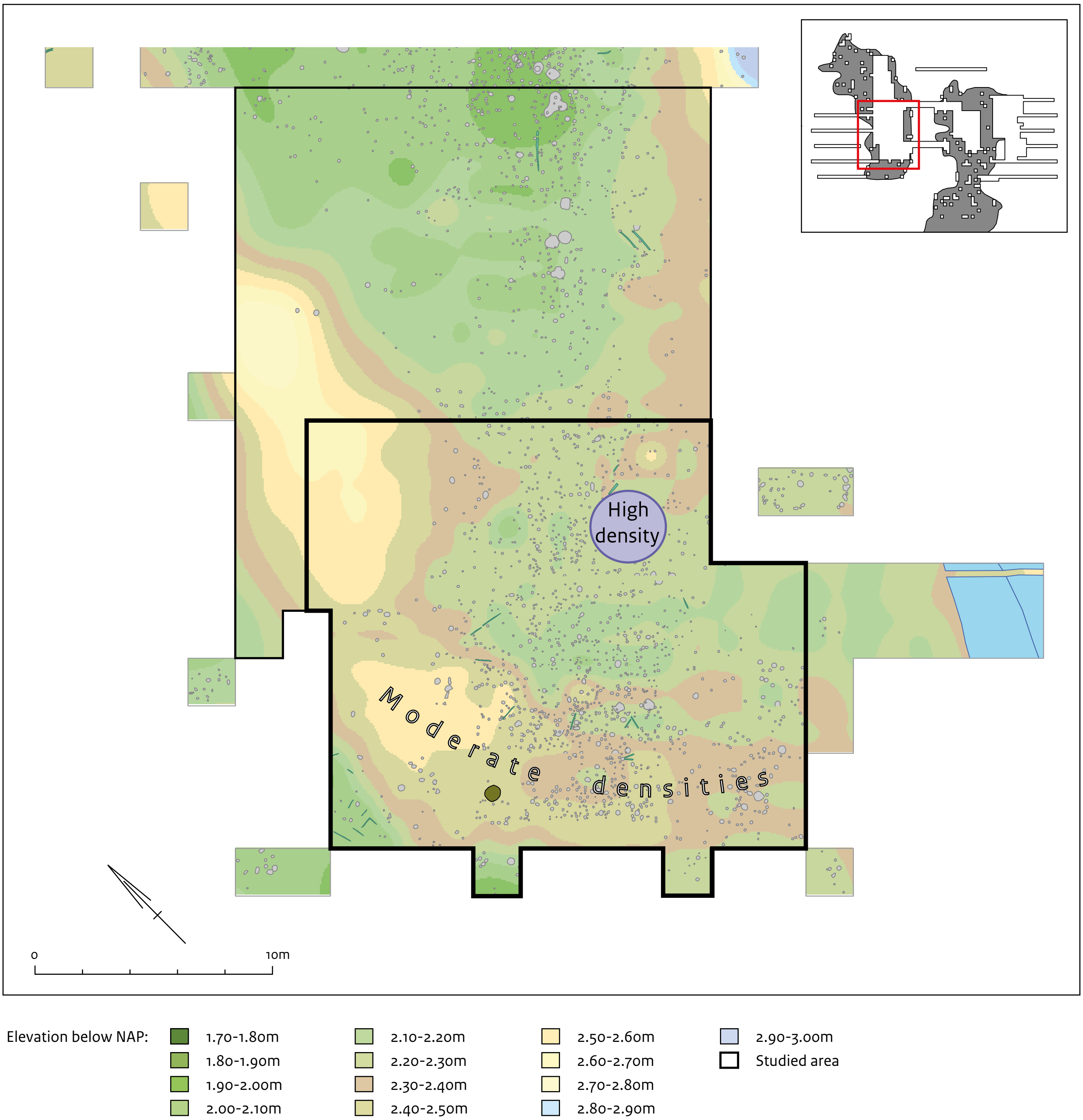


Figure 11.48 Summary of the distribution of the stone remains.

fragments, nodules and flakes may represent amber working within this vicinity.

Structures

So far the features have not been discussed in relation to the find categories. None of the find categories clearly indicates any form of structure based on the postholes. However, one possible structure was previously[428] defined as the Zeewijk-West structure (see also Section 11.2.1). Although it is not possible to adequately distinguish the postholes belonging to this structure, its location is within the area with a high density of postholes. The presence of a

[428] Ginkel & Hogestijn 1997.

Elevation below NAP:				
	1.70-1.80m	2.10-2.20m	2.50-2.60m	2.90-3.00m
	1.80-1.90m	2.20-2.30m	2.60-2.70m	Structure location
	1.90-2.00m	2.30-2.40m	2.70-2.80m	
	2.00-2.10m	2.40-2.50m	2.80-2.90m	

Figure 11.49 General location of the previously identified Zeewijk-West structure (see Fig. 11.7).

single or multiple structures in this area is therefore expected. The structure has merely been outlined in this report. It is contained within the boxed area in Figure 11.49.

Due to the multitude of postholes, many of which appear to form lines and corners, it is very likely that there are several more structures within this area. Due to the lack of clear differentiation between the postholes, especially their uniformity in plan, it is not possible to convincingly define the structures within this area. Furthermore, there are various linear arrangements of postholes which appear to cross over the higher elevation from left to right.

The majority of the posthole lines do appear to run parallel and perpendicular to one another, suggesting some kind of association.

11.4.7 Spatial synthesis

As was seen in the Mienakker study[429] mammal remains can be subject to natural and human processes which can distort their spatial structure. It is therefore possible that the mammal remains have undergone some kind of natural sorting due to gravity, moving them to the lowest parts of the site. Alternatively, anthropogenic factors could also influence the distribution, with the larger elements being tossed away whilst the smaller bird and fish bones were discarded more locally. Fish bones are the smallest and lightest of these categories and they are the only category to have a high concentration of bones in the higher part of the sample area.

Figure 11.50 combines the information from all the available categories. There are clear similarities and differences between the locations of the artefact categories. An area of fish remains coincides with the location of a possible structure or structures. The stone, amber and vessels are partially contained within this area, with the exception of vessel 124 and possibly vessels 131 and 12.

The majority of the material is related spatially to the higher ground. It is possible that material dispersed from this area into that of the lower terrain through natural gravitational forces. A clear exception can be seen in reference to the animal remains. Due to their relative abundance within the depression, particularly the mammal remains, they could signify deliberate deposition of waste material. The case is not as clear when it comes to the fish remains, with sufficient survival of remains on the higher ground and within the area of the proposed structure.

The presence of multiple overlying structures has been suggested. If there was continuous settlement it could result in the need for replacement of settlement structures when required, whereas more sporadic settlement could require the rebuilding of various structures. Both scenarios could be represented by a large quantity of postholes with a defined location as presented at Zeewijk. Dwelling at this part of the site is therefore unlikely to have been a singular (one phase) event. It is not possible to determine the duration of settlement on the basis of the spatial analysis. Whether continuous or sporadic, it is clear that the location of the dwelling was focused upon a limited area.

The described depression marking the lower part of the site contains the majority of the cow hoof marks. This is therefore associated with the movement of cattle. The cow hoof marks are excluded, with only a few exceptions, from the areas dominated by postholes. The absence of hoof marks in this area indicates the cows were unable to access this part of the site. This restriction suggests that there must have been some kind of built environment which restricted cattle movements through this area, diverting their course. Any structures which formed this built environment are therefore contemporaneous with the cow hoof marks and the movement of the cattle through parts of the site.

11.5 Zeewijk-East

The key aim of the spatial analysis in the east was to investigate any spatial structuring of material in association with the large structure identified earlier.[430] Previous reports have suggested that this area yields considerably fewer finds than the neighbouring area in the west.[431] As the two areas are relatively similar in size the quantities of material would be expected to be similar.

11.5.1 Material remains

The artefact remains in this area are few in weight and number; in fact there is a clear problem with the various datasets. The material from the 1992 excavations is derived only from the test pits (Fig. 11.51). The remainder of the recovered material is missing and unavailable for study, creating obvious difficulties for any spatial analysis. Many of the excavation units lack information regarding their contents, a problem which cannot be resolved or worked

[429] Nobles 2013.
[430] Nobles, this volume Chapter 3.
[431] Bulten 2001b.

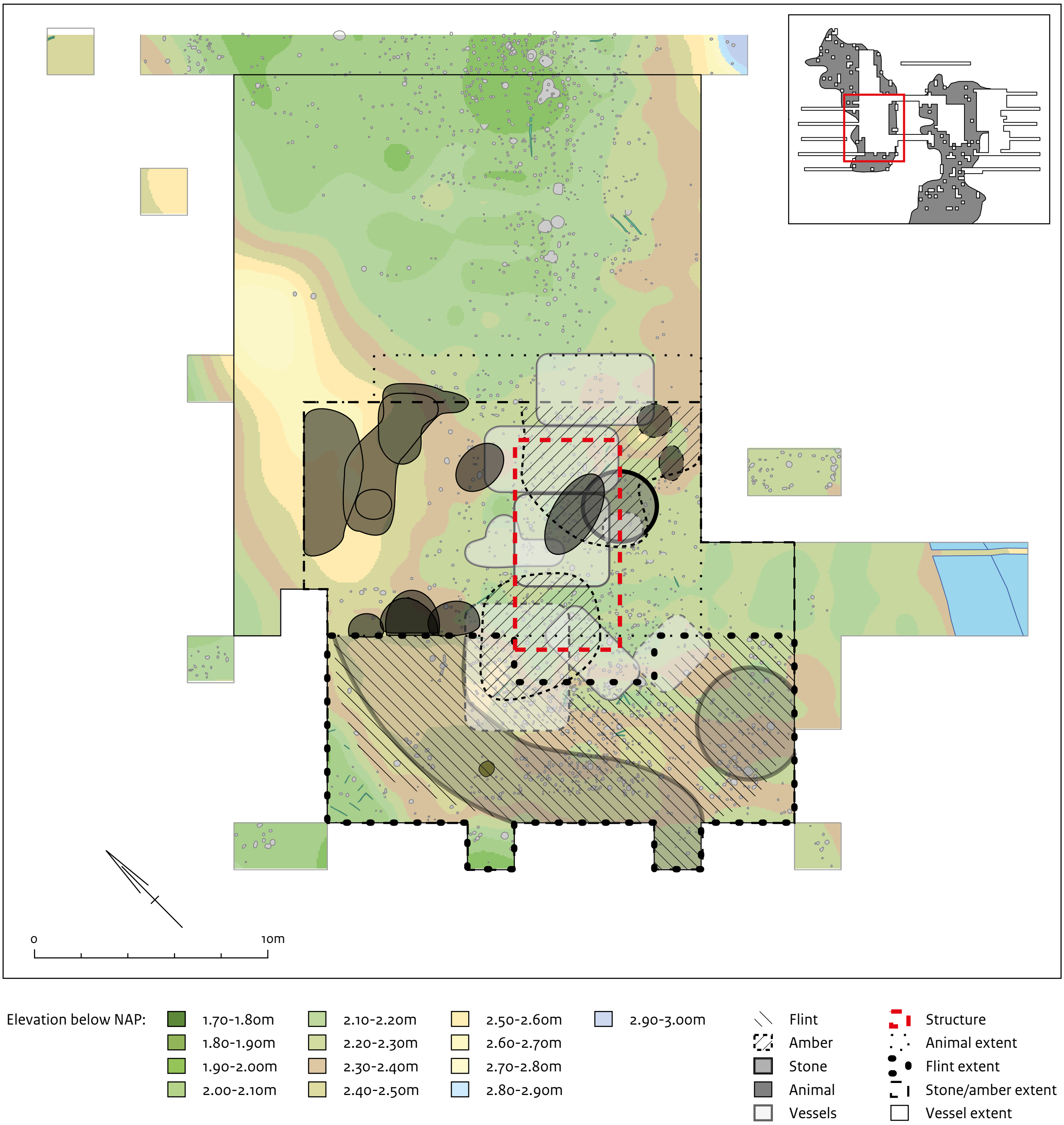


Figure 11.50 Summary of all the datasets and their data extents (for a clearer image of the individual categories see the preceding Figs 11.46-49).

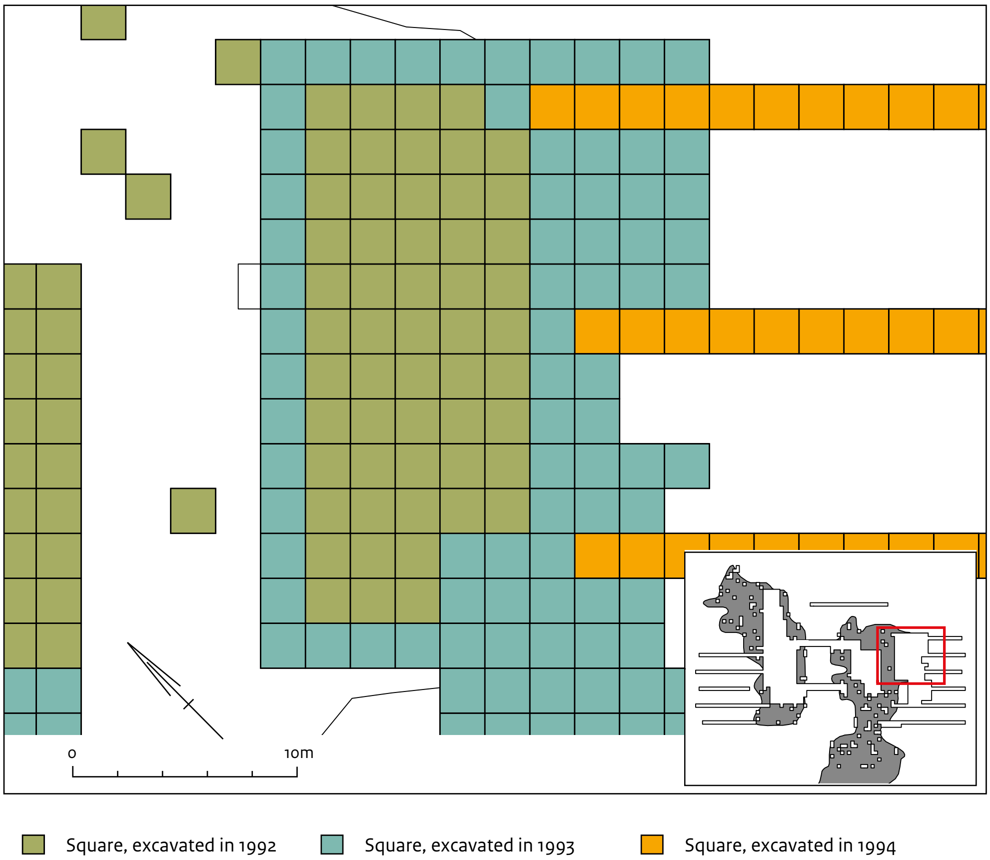


Figure 11.51 Overview of Zeewijk-East (east) excavation by year.

around. However, it is possible to evaluate the available datasets.

Animal remains

All of the animal bone remains are from 14 of the 1992 test pits, totalling just over 3 kg of material. If this is representative of the remaining 41 squares then an average of 200 g would be expected from each square, totalling 11 kg for the entire 1992 excavation area within this part of the site. At Zeewijk-East 54 squares contained approximately 17.5 kg of bone material, which returns an average of just over 300 g per square. This is not so different from Zeewijk-West, but it is important to remember that this is an average and in the west much higher quantities were contained in more discrete areas. Such a comparison may not therefore be so informative.

The spatial distribution of the material appears fairly even between the test pits, although Figure 11.52 does indicate a trend for a slight increase towards the northwest corner of the excavation area. This may not be too significant, based on the low values of the weights.

Flint

Due to extra analysis, flint data are available from the surrounding 1993 excavation. Once overlain with the posthole information these data might suggest that slightly more flint material is located within the Zeewijk-East structure (Fig. 11.53). However, with such a large area without data, it is difficult to attach any significance to such an observation. Yet a relatively high concentration of waste, flakes and splinters is present in a pair of neighbouring test pits towards the northern end of the structure.

Even though a concentration of flint seems to occur within the Zeewijk-East structure, a

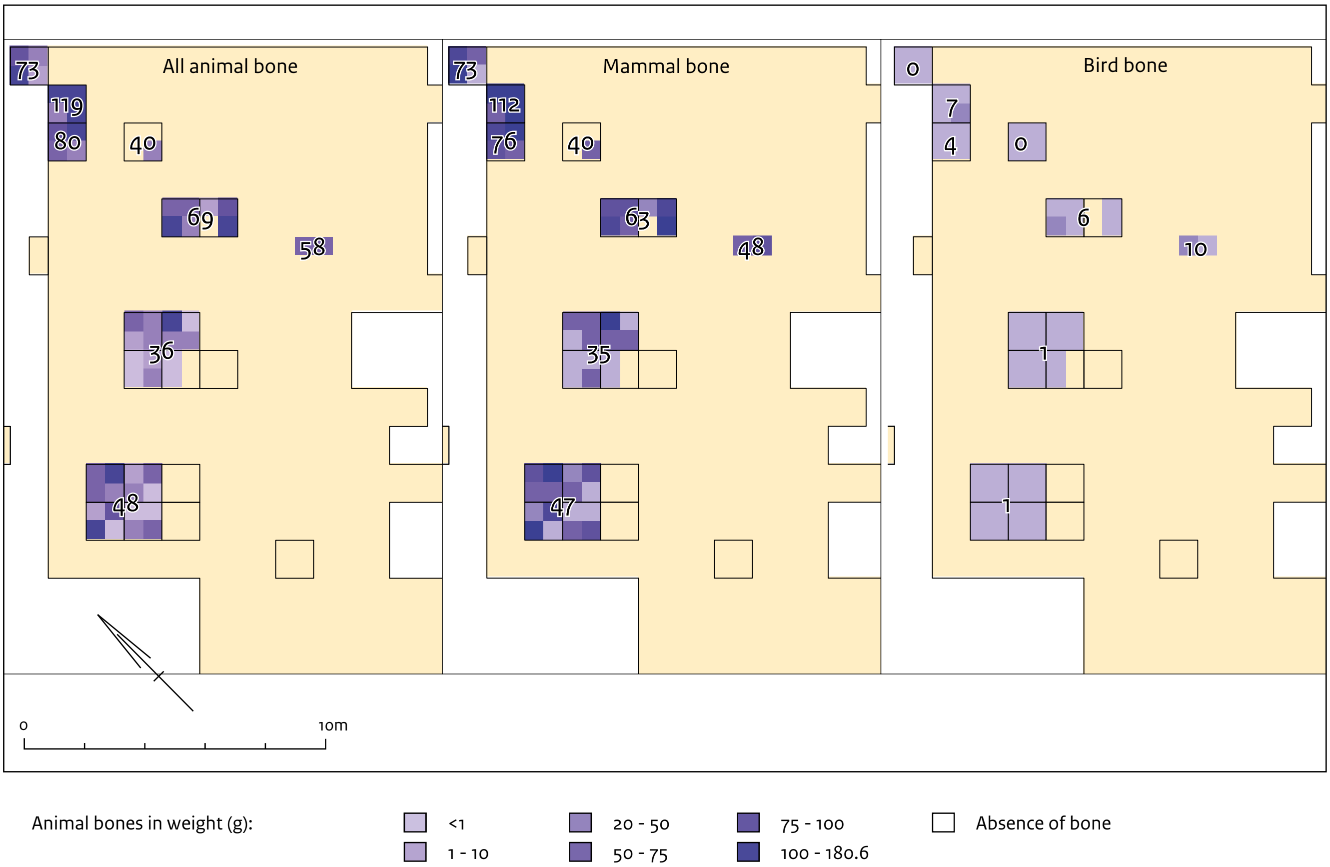


Figure 11.52 Animal remains with the average weight (in g) of material indicated per group of test pits; all quantified weights are rounded to the nearest whole number.

direct association cannot be confirmed. This concentration is quite high relative to the remainder of the flint material, but it only consists of 15 pieces at its peak. Overall, material remains appear to be low in quantity and weight, especially in comparison to Zeewijk-West.

Stone

The stone data are from the 1992 test pits. There are very few pieces, totalling only 28. Due to the low numbers of this material and the sparseness of the test pits no insightful conclusions can be presented from a spatial perspective (Fig. 11.54). Unfortunately, the same conclusion applies to the ceramic dataset.

Ceramics

From the distribution of the pottery sherds (Fig. 11.54) within the eastern sample area it is clear that the ceramics are found only in the test pits of the 1992 campaign. There is a clear absence of data from the 1992 trench and the 1993 continuation. It is highly likely that this is the result of missing data or of the original excavation techniques.

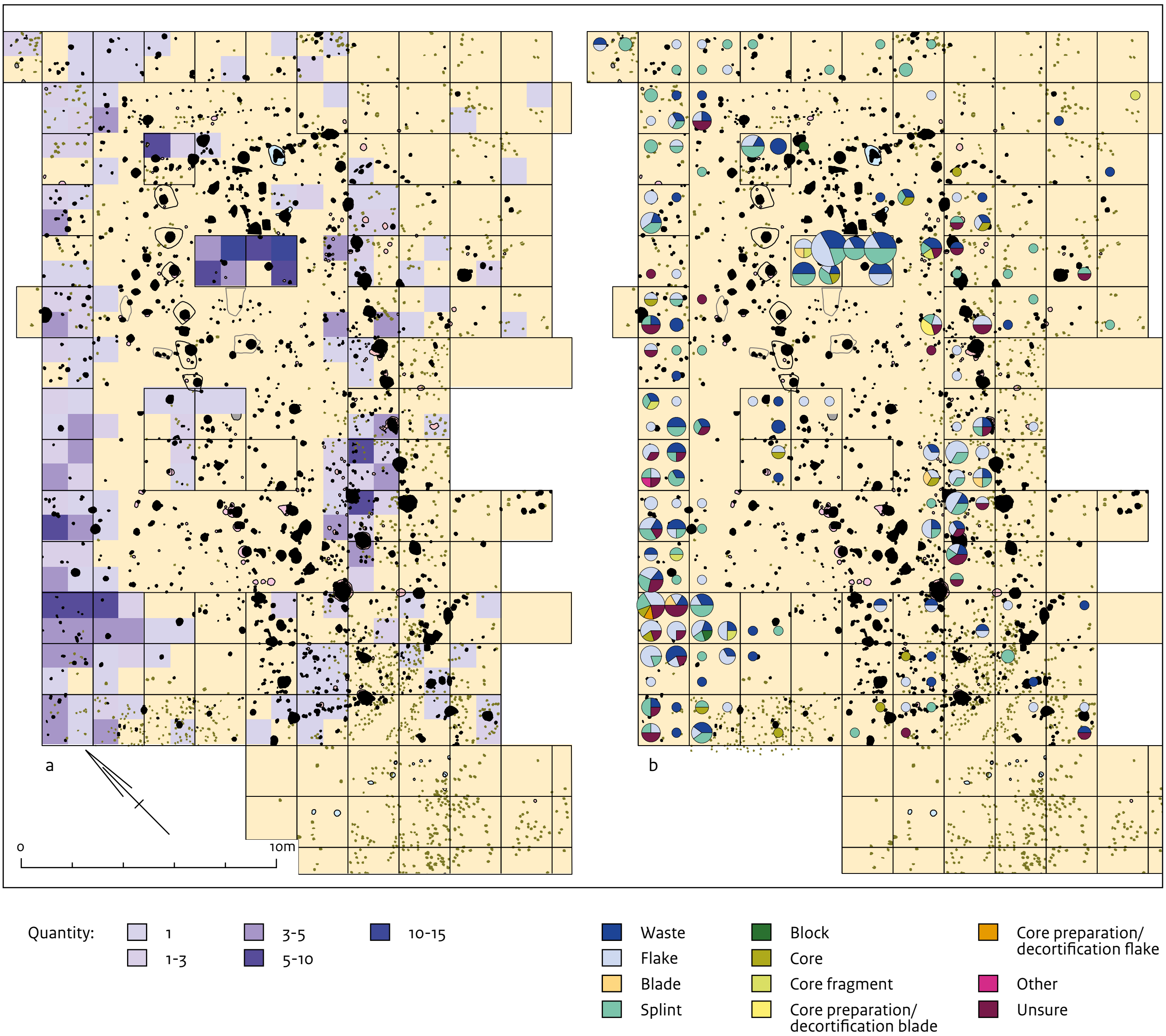


Figure 11.53 Flint remains: a. quantity of flint per square; b. flint type per square.

Figure 11.54a. distributions of stone; b. weights of ceramic sherds.

11.5.2 Concluding remarks

In Zeewijk-East, therefore, we are left with low quantities of material remains and posthole distributions. The presence of the Zeewijk-East structure can be clearly seen, and another possible structure is illustrated in Figure 11.11. Details regarding the possible construction of a raised floor have been put forward. As Zeewijk is located in a wetland environment which was vulnerable to flooding the construction of a raised floor would not be unexpected. This could explain the reason for the relatively lower quantities of materials. However, in this case it is not possible to determine whether the absence of large quantities of material is due to this possibility or is a result of the structure's function.

The function of the Zeewijk-East structure cannot be determined solely on the basis of the artefact distributions. For this to be possible the missing artefacts would have to reappear. No association has been established between domestic debris and the structure. Nor were any burials or quantities of human remains contained within. The question therefore remains: was the Zeewijk-East structure a domestic structure or was it built for another purpose?

As demonstrated in the Mienakker site report, Zeewijk-East has a clear parallel with the Mienakker mortuary structure (MKI), especially with the placement of certain postholes.[432] The use of larger posts might indicate something which has a more monumental design, especially when compared to other Neolithic structures.[433] The wider frontal façade, albeit only a fraction wider, and the slightly bowed middle might suggest ideas associated with many long barrows.[434] The phasing of the structure to the very last phase of the settlement and the dating to the very end of the Single Grave Culture[435] would again indicate that the structure was built upon the former remains of a settlement.

Therefore, taking into account the relatively monumental nature of the architecture and the parallel to the Mienakker structure, the function is more likely to be one of ritual and ceremony than of domestic life.

11.6 Conclusions

Zeewijk is represented by various zones of subsistence. As defined by the excavated areas, ZeewijkWest has two main zones: the dense areas of postholes on the higher ground juxtaposed with the cow hoof marks on the lower ground. Within the posthole zone many indicators are present which suggest habitation. In this area many of the ceramics are more complete. Many of those selected have a limited dispersal range and the majority of the amber is present in this higher zone. A cluster of stone, and some of the fish remains are also present. All of this evidence could be the remains of activity areas created through multiple habitation phases.

Though the lower area is represented by the cow hoof marks, material is also present here. The stone is in relatively moderate concentrations which are dispersed along much of the depression. Much of the animal remains occur here, perhaps a sign of the disposal methods associated with the habitation. The lower area was created by the movement of cattle. Even if this was an already existing natural feature the repetitive use by cows would have enhanced this. The cattle behaviour also signifies the presence of a built environment, a construction which inhibited their movement, causing them to circle around the obstruction. The observed ard marks also indicate the use of the area for the growing of crops.

In the Zeewijk-East part of the site there are the remains of a monumental structure, a structure currently unparalleled in the local environment in terms of the use of large posts. Yet it is familiar in some respects to the Mienakker MKI structure.[436] Regardless of the structure's relative monumentality or parallels, the excavated areas appear to contain less material than those in the west of the site. Postholes associated with this structure are numerous and their distribution appears to continue into the central area of the site. These, in association with a cultural layer, are taken to signify domestic settlement-related activity. The combination with densely-packed ard marks directly indicates the use of the site for crop production. The Zeewijk-East structure, which cuts numerous ard marks, is the last clear phase

432 Nobles 2013.
433 See various sites as summarised in Hogestijn & Drenth 2000.
434 Hodder 1990.
435 Smit, this volume.
436 Nobles 2013.

in the use of this part of the site. A further partial structure has been inferred from the higher excavation levels but it remains unclear how this relates to the site.

Rather than revealing different zones, it has become clear that there was a change in the use of the land. The intermingled relationship of the settlement-related features and the ard marks indicates various changes of focus from settlement to crop. There is the possibility of further settlement prior to return to another phase of agricultural use. Ultimately the creation of the Zeewijk-East structure marks the final phase of activity in this area. With the central posts remaining in the ground, the remains of the structure may have been visible for some time after.

Similarities between the excavations at Zeewijk-West and Zeewijk-East as we have analysed them are clear, yet how exactly these two areas are related remains a mystery. In terms of spatial analysis we can state that habitation occurred at both sites but the developments which took place are quite different. In the west settlement appears to have been in two locations, initially to the north and then later to the south. At some point the area was also used for crop agriculture. The East similarly has indicators for settlement and crop agriculture, the only difference being the creation of a distinctly different form of structure, the ceremonial structure known as the Zeewijk-East structure.

12 Synthesis – A mosaic of habitation at Zeewijk

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12.1 Introduction

The results from the integrated approach applied to the Zeewijk site are presented in this chapter. Zeewijk is an important final building block in the better understanding of Neolithic life in Noord-Holland that we set out to achieve in our project. Looking back at the analysis and publication of the fairly small sites at Keinsmerbrug and Mienakker, the new information added by the much larger site Zeewijk is fascinating. Because Zeewijk is very different in many respects – in terms of the backlog, size, quantity of finds and proportion excavated – its story is a valuable outcome of our Odyssey research project.

Zeewijk so far

Zeewijk was discovered by the landowner K. de Lange in 1983, and reported to the leader of the excavations being performed at the time at Kolhorn. In the years that followed, a test pit was dug and coring campaigns were carried out by the *Biologisch-Archaeologisch Instituut* at the University of Groningen.[437] This research revealed the extent of the cultural layer which appeared to be quite large, over one hectare. Two areas were distinguished, and named Zeewijk-West and Zeewijk-East. Constant erosion of this cultural layer by agricultural activities prompted a decision to excavate. The excavations were carried out by the *Rijksdienst voor het Oudheidkundig Bodemonderzoek* during three campaigns, in 1992, 1993 and 1994.[438] From the beginning the idea was to conduct a partial excavation, covering only 20-25% distributed over the site.

After the excavation, a start was made on the analysis of some find categories excavated in 1992. Studies of the ceramics and the faunal remains were published in 1992 as student theses.[439] In 1997, a first brief outline of Zeewijk based on the preliminary results from the analyses of the 1992 campaign was published by the excavator Hogestijn.[440] This paper focused particularly on the description of the remarkable large structure in Zeewijk-East, and on the comparison of West and East. Hogestijn attributes the Zeewijk site to his group 1 classification, calling the site a permanent residential settlement.[441] He contrasted this group of sites with the temporary extraction camps in group 2, in his dichotomous model of the Single Grave settlement system.[442] He based his interpretation of Zeewijk on the size and layout of the settlement, the presence of five possible house plans in Zeewijk-West, the arable field of at least one hectare at Zeewijk-East, the high proportion of bones of domestic animals, the large diversity in the flint toolset and the diversity in the pottery assemblage.[443] This hypothesis was however not substantiated by a detailed, thorough and integrated analysis of all cultural and ecological resources.

Drenth and others[444] reviewed the evidence for the Single Grave Culture in the Noord-Holland tidal area, and set the information available within a broader Dutch framework. They offered a critical evaluation of the proposed settlement system and site interpretations (group 1 versus group 2), based on the published archaeobotanical and archaeozoological evidence available at the time, looking for instance at the ratio of wild to domestic mammals. It was concluded that the proposed dichotomous model is weakly founded, when looking at the available published information.

Zeewijk, the Odyssey results

Given the wealth of information it yielded, Zeewijk was regarded as a very promising final site for analysis in the Odyssey project, but it was also seen as a tough nut to crack considering the amount of work. First of all, in comparison with Keinsmerbrug and Mienakker, the extent of the backlog at Zeewijk was severe. Furthermore, the area had been only partially excavated, reducing its narrative potential in comparison with Keinsmerbrug and Mienakker, which had been fully excavated. The three-quarters of Zeewijk not excavated still holds unknown information. Besides this, the large size and the very large quantity of finds forced the team to make selections. During this process of sampling selections were enlarged or somewhat altered due to the availability of material, the potential of the samples and the time available. In some cases finds and data were missing, which hampered the spatial analysis, among other things. However, in spite of this, the story of Zeewijk is an intriguing one.

437 Now Groningen Institute of Archaeology at the University of Groningen.
438 State Service for Archaeological Investigations, the forerunner of the Cultural Heritage Agency of the Netherlands.
439 Both student dissertations (regarded as internal reports) were published within the framework of the inventory project in 2001; Sier 2001, De Vries 2001.
440 Hogestijn 1997.
441 Hogestijn 2001.
442 Hogestijn 1992.
443 Hogestijn 1997, 2001, 2005.
444 Drenth, Brinkkemper & Lauwerier 2008.

Research questions

This synthesis aims to combine the new analyses of Zeewijk performed as part of the Odyssey project in order to provide an insight into the Late Neolithic in Noord-Holland. Like the synthesis of Keinsmerbrug[445] and Mienakker[446], the research questions below will serve as a guideline of the integration. These ten questions were formulated at the start of the project. The research questions on the Zeewijk site level (no. 2, 3, 4, 5, 6 and 9) will be addressed in this chapter. Other, more general questions, will be answered in the epilogue (no. 8) and in the future PhD theses (no. 1, 7 and 10) and papers.

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 duration and seasonality of occupation?
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?

12.2 Chronology

Relative chronology

Like most Late Neolithic sites in Noord-Holland Zeewijk can be characterized as a complex anthropogenic entity in, and to some extent influenced by, the tidal environment. Stratigraphical relationships exist between dark humic cultural layers, natural sandy clay deposits and several shell layers of consumed mussels. At Zeewijk, the distribution of these phenomena is widespread, covering a hectare, on both sides of a former active gully.

At the base of the anthropogenic entity, a 'contact layer' is present, representing the original surface on which the first settlers of Zeewijk set foot. In the first phase of habitation in particular, trampling by people and animals resulted in a mixture of surface and cultural debris. Over the course of time, deposition of settlement waste, shells, burnt reed and other anthropogenic material continued which resulted in the formation of a midden. A few scattered clay layers are embedded in these numerous deposition events, evidence of flooding episodes, especially in areas near the gully at times of high water levels. The nature, intensity and spatial extent of these episodes is difficult to establish. At Zeewijk-West, periods of high groundwater levels led to the growth of peat in areas used by Neolithic people.

The numerous postholes and ard marks occurring outside the distribution of the cultural layer suggest that the Zeewijk site comprises a large settlement area with farmland divided by a residential gully. During habitation cultural debris and waste were dumped or (re)deposited in this watery area. The question whether this zone could be crossed easily by humans and animals, by foot, or not – did they experienced it as a linear barrier? – remains unanswered. Large deposits of mussel shells might suggest the creation of a ford-like zone, but this is only speculative.

We assume that all human activities, such as habitation, arable farming, cattle rearing, etc. were strongly interlinked, occurring successively while shifting spatially, resulting in multiple habitation phases. The recurrence marks Zeewijk as a palimpsest site.[447] Unravelling these activities in episodes is a great challenge, if not impossible, considering the palimpsest character, the selective excavation in the 1990s and the selections sampled for analysis within our project. Our research results give some clues for a possible differentiation into habitation phases at Zeewijk-West. The posthole distribution, two separate clusters of features, and differences in the ceramic assemblage may point to different episodes of occupation. We have been able to produce a chronological sequence based on comparisons of the pottery groups in three areas of Zeewijk, Keinsmerbrug

445 Smit *et al.* 2012.
446 Kleijne *et al.* 2013.
447 Bailey 2007.

Figure 12.1 Although dates on charred food crusts are problematic (due to the reservoir effect), it is one of the very few possibilities to get a grip on the absolute chronology of the site. A sample of a food crust on this vessel (no 30) was taken for ^{14}C analysis (GrA-56013), resulting in 4030 ± BP, which corresponds to Furholt phase D.

and Mienakker. On typochronological grounds, the habitation at Zeewijk-East and in the northern part of Zeewijk-West can be seen as the earliest – possibly contemporaneous – phase, whereas the south part of Zeewijk-West is the latest. In this sequence, the construction of the large structure at Zeewijk-East, cutting through numerous ard marks and the tearing down of the exterior posts of this building and reuse of the wood from these wall posts might have been the final acts on the eastern side of the gully. Habitation in the south part of Zeewijk-West continued, while the area of Zeewijk-East was used for other activities or may have been abandoned. The central posts of the large structure remained in the ground, still visible for some time after.

After the dwelling phase at Zeewijk-West south, the settlers moved away. The levees were abandoned and overgrown with peat. In the course of the first centuries AD peat rivers developed at the northern fringe, and with that the draining of the peat started. The stronger influence of the sea was halted in the 13th century by human interference, when a dike, the *Westfriese Omringdijk*, was built. The Zeewijk site, situated outside this protective enclosure, was inundated by Zuyder Zee water, until 1843 when this former seabed was reclaimed to become the Groetpolder.

Absolute chronology

Besides identifying stratigraphical relationships between features and cultural layers, several samples were taken for ^{14}C analysis prior to, during and after the excavations, in order to gain an understanding of the chronology of the site. The resulting eleven dates give a rough chronological outline of the formation of the tidal landscape and the use of the higher parts of the site by Neolithic people. Between 3650 and 3000 BC, a tidal marsh landscape, with gullies, levees and back swamps was formed. Habitation on the high sandy levees started somewhere 3000 and 2500 BC (Fig. 12.1). The last habitation phase covered by ^{14}C dates is an episode between 2500 and 2200 BC. One date is derived from one of the wooden posts of the large structure at Zeewijk-East.[448] This was built when the arable field was abandoned.

448 3910 ± 50 BP (GrN-18488).

12.3 Environment

The site at Zeewijk is situated on two sandy levees on both sides of an active gully. In the open tidal landscape these levees are somewhat elevated and covered with herbaceous plants and shrubs and a mosaic of different trees including willow, alder, ash, bird cherry and field maple. Ivy and honeysuckle climbed and flourished in these trees.

The site, nestling on levees, is surrounded by different biotopes, ranging from marine to freshwater. The nearby tidal creeks, filled with saline and brackish water, offered great possibilities for fowling and fishing, and mussels could be gathered on the more saline tidal planes. In the high salt marshes marshmallow, common/spear-leaved orache and sea purslane were abundantly present, as well as sea aster, common sea-lavender, various grasses and sedges. Given the great diversity of grasses and other herbaceous plants in the marshes they were probably chosen by the Neolithic farmers for their excellent grazing properties. The extensive reedbeds and patches of woody vegetation on the somewhat higher sandy levees were ideal for sheltering groups of wild boar.

In the lower parts of the salt marshes members of the goosefoot family dominated. Glasswort and sea-blite occurred frequently. Although this landscape is dominated by marine influences, with salt and brackish wetlands, there are also places at or near the settlement where fresh water accumulates. This kind of freshwater environment would have been ideal for beavers.

Oak trees, transformed into worked wood for use as building material, and also used as firewood, along with other species, might have grown on levees outside the reach of saline or brackish water or, most likely, on the Pleistocene boulder clay outcrops at a distance of 10-12 km to the north of Zeewijk.

12.4 Exploitation of animal resources

The exploitation of animal resources at Zeewijk was based on stock breeding, fowling and fishing, with cattle, duck and flatfish as the most important species. The hunting of wild boar played a minor but significant role.

Cattle were by far the most important food source in terms of meat supply. Age data suggest mostly adult and subadult animals were slaughtered. There is no evidence of any bovine 'secondary products': in terms of milk for human consumption and cheese production and manure for the cultivation of the plots. The abundance of cattle hoof prints, which barely overlap with the dense pattern of postholes in Zeewijk-West, shows the importance of keeping cattle close by. Pig/wild boar and sheep/goat were of minor importance when it came to the meat supply. Occasionally dogs might have been eaten.

The presence of deer (red deer and roe deer) and wild boar in this kind of open tidal landscape is not strange; they both are lovers of marshy environments as long as dry spots are present. The question is whether these deer animals are hunted. The deer remains at Zeewijk – antlers and phalanges – are specific elements. Antlers could have been shed and collected, while the phalanges might have been attached to imported hides. The same line of argument applies to the fur animals stoat, brown bear and wildcat, and the hide of the common seal. Their furs could have come into the possession of the Zeewijk inhabitants as exchanged goods. The beaver bones most probably come from locally hunted animals, as does the grey seal. The furs from these animals or the imported hides could be processed into clothing or (in the case of the seal hides) into watertight buckets or skin-lined canoes, as has been suggested at Mienakker.[449]

The fowling catch consisted mainly of ducks, especially mallard and teal or garganey. The quantity of ducks and geese consumed was high. As at Mienakker and Keinsmerbrug, traces of slaughtering are absent. Apart from ducks and geese, waders were also caught for consumption. Small numbers of other species were also found. The cut marks on a swan humerus might indicate that swan was eaten. The find of great crested grebe is remarkable, as it is rare in a Dutch archaeological context, and the presence of guillemot and falcon is also quite special.

Fishing, mainly for flatfish (flounder/plaice), occurred largely in saline and brackish waters of the tidal creeks. It is likely that the people of Zeewijk used fish traps, fish weirs or fences and may have caught the flatfish by treading

[449] Nobles 2013b.

(‘flounder treading’ or *bottrappen* in Dutch). In this environment mussels were collected, mostly likely in trusses, and transported to the site. The importance of shellfish gathering for subsistence was probably limited, as shellfish are low in calories. Marine resources like the haddock at Mienakker were exploited far less. Also, fish from fresh water, such as cyprinids were caught only incidentally. The fact that the inhabitants of Zeewijk caught both small fish (small cyprinids and flatfish) and also large fish like cod and large mullet indicates that they were experienced in different fishing techniques.

Animal bones were used for the production of common utilitarian objects. Several ‘ripples’, made of cattle ribs were found. Some of these tools were too fragmented for use-wear analysis. Others had been consolidated using a chemical preservative that covered the traces on the surface, so no functional information could be obtained. Bone material from medium-sized mammals, including sheep/goat, was worked to produce needles, an awl and two toggles.

12.5 Crop cultivation and the use of wild plant resources

Besides the cultivation of the common Late Neolithic cereals naked barley and emmer wheat, flax was also important for the settlers of Zeewijk. This crop was probably cultivated both for its oil-rich seeds and for its fibres. The intertwined flax fibres were probably made into cords. These cords were probably used for the production of textiles and possibly also used for the decoration of pottery. Flax is very elastic, soft, and easy to twist into cords.[450] These cords can be used for impressions in the soft clay of freshly made vessels.

It seems that the higher-lying sandy levees were the most stable elements in the coastal landscape for settling down and for establishing small arable fields next or near the houses. The nature of the agriculture that was practiced at Zeewijk (but also in Mienakker) may have resembled one of the models proposed for Neolithic farming in Europe referred to as intensive or garden cultivation, with small cultivated plots located close to the settlement.[451]

The people of Zeewijk worked their fields, perhaps in an initial phase with a hoe, and later with an ard. They ploughed these plots, sowed, grew, possibly controlled the weeds and harvested the crops nearby. Both barley and emmer wheat were brought to the site as ears of grain, and possibly as complete plants. Cereals were processed and cooked.

Various wild plant foods were gathered to supplement the cereal-based diet. Crab apples, acorns and hazelnuts were available from the boulder clay outcrops at Wieringen, while sea club-rush tubers, knotgrass rhizomes and orache seeds could have been found nearby. Wood was mainly brought in from levees within the reach of fresh water, but also from the drier soils that will have been found at Wieringen (at a distance of approx. 10-12 km).

Various, locally available grasses, rushes and sedges would have served many purposes as raw material. The stems and leaves of reed, great sedge and sea club-rush may all have been used for thatching roofs and making the walls of shelters and/or houses. The stems of grey club-rush may have been used to make sitting and sleeping mats, floor coverings and to insulate the walls of the houses. Dried stands of reed, rushes, sedges, and even glasswort and sea aster may have been collected for fuel. It would have been poor-quality fuel for domestic fires, but nonetheless a welcome addition to firewood.

12.6 Food preparation and consumption

Food processing at Zeewijk shows an interesting variety, reflecting a broad choice and certain preferences. Meat from mammals, birds and fish was probably roasted in hearths. These hearths were recognised not as features in the spatial distribution but as charcoal and ash layers in the sections of the cultural layer. These layers of hot ashes probably were also the place where crab apples were dried and acorns were roasted to enhance their palatability. Use-wear traces on flint tools show that fish were cut and their skin scraped.

It seems that cereals were ground and/or pounded prior to cooking. Use-wear analysis of the querns and grinding stones show that, with one exception, these tools were used to process plant materials, especially cereals. At least two different types of cereal products were

450 Grömer & Kern 2010.
451 Bogaard 2005; Jones 2005.

identified in the isolated lumps of processed cereal food: a porridge-like food, made of coarsely crushed or ground cereal grains and a compact, mushy food made of finely ground grain. In the cooking process also stone pebbles could be used to boil water.

The remains of food encrusted on ceramic vessels gave more insight into the methods of food preparation and kind of foods that were cooked at Zeewijk. Combined botanical and chemical analysis suggest that emmer grain was often cooked with various other components, such as fat (or meat) of animal or fish sources. The consumption of acorns as an important, starch-rich food source is very distinct in the botanical evidence. Various methods would have been used at Zeewijk to prepare acorns for consumption. Prior to cooking, however, the acorns' shells would have been cracked using hammer stones. The shells were peeled off and the de-husked acorns would have been roasted, then pulverised and cooked in ceramic vessels to a mush or soup.

The remarkably mushy nature of many food residues encrusted on ceramic vessels from Zeewijk (and on some from Mienakker) suggests that food prepared in these vessels was well processed prior to cooking, possibly crushed, pounded or even pulverized and subsequently cooked, possible with addition of water, into a mush or a thick paste. All the mushy residues from Zeewijk share the well-defined chemical signals for the presence of proteins and polysaccharides, often with the addition of lipids. This suggests that both plant and animal components were used in the cooking of these mushy meals. A few plant resources can be proposed as the starchy components of these organic residues: cereals, acorns, tubers of sea club-rush and seeds of various orache species. Orache seeds and other closely related chenopods are also rich in protein. Interestingly, the absence of lipids from some of Zeewijk mushy residues suggests a plant origin for the proteins traced back in these residues, suggesting that orache seeds may have been indeed the source of plant protein for the people of the Single Grave Culture.

Even though at Zeewijk only the thinner ceramic vessels were used for cooking, their use demonstrates a broad range of cooking practices. Thin-walled decorated beakers were used to cook the cereals and acorns into a thick porridge or mush. Besides cooking in this kind of thin-walled ware, ceramic plates were also used for food preparation. Charred residue on one ceramic plate fragment indicate that it was heated and used as a kind of griddle. The mixed residue points to the heating of mixed food, consisting of proteins, polysaccharides and lipids of both animal and plant origin. Zeewijk is the first Dutch prehistoric site where the use of ceramic plates for baking has been demonstrated.

12.7 Production and use of ceramics

The probably locally produced pottery of Zeewijk is characterised by the many different tempering materials added to the clay. Pieces of quartz, granite, shells and pottery were crushed using stone implements to create tempering material.

About half of the ceramics at Zeewijk are thin-walled ware, decorated with spatula and cord. The clay of these beakers is always tempered with grog and sand. The medium thick-walled and thick-walled ware is decorated with fingertip imprints, and has stone grit temper. Spindle whorls, baking plates and a ceramic disc used as a lid or loom weight were also found at Zeewijk. The question is whether sheep's wool was used for yarn production, as the presence of spindle whorls and one possible loom weight might suggest. Another suggestion is that these ceramic artefacts were used for processing flax into linen.

The beakers are related to many different types in the classification devised by Van der Waals and Glasbergen: 1b, 1c, 1d, 1e, zigzag, type 2IIb and the half-decorated type 1a and 2IId.[452] Smaller undecorated beakers and medium-large and large undecorated vessels have also been found. The percentages of undecorated sherds vary from 74% (Zeewijk-West south) to 82% (Zeewijk-West north) and 90% (Zeewijk-East).

Different vessels were used for cooking and maybe storage. The residue analysis of the food crusts showed that thin-walled and medium thick-walled vessels, including the majority of the cord-decorated beakers, were most frequently used for the preparation of meals. This preference for beakers for cooking purposes is remarkable, as beakers are generally seen as

[452] Van der Waals & Glasbergen 1955.

drinking vessels.[453] These meals consisted of cereals and/or acorns cooked into a thick porridge or soup or, more generally, to a fine mush. The ceramic plates were used to heat mixed food as on a griddle. The ceramic artefacts, spindle whorls and ceramic disc that probably served as a loom weight were used for spinning and weaving.

12.8 Production and use of flint, hard stone, amber and jet

The variety of raw materials used at Zeewijk is not as great as at Mienakker, but notwithstanding this uniformity a few pieces of southern flint are present (specifically Valkenburg, Light Grey Belgian and Rullen flint). This suggests the existence of long-distance exchange networks. Most flint has a northern origin and like stone and amber was gathered locally, on the beach and at the Pleistocene glacial outcrops, some 10-12 km away. These local materials were important for the production of implements and beads. The northern flint and hard stone implements were produced locally. The few pieces of southern flint may have been brought to the site as finished products.

Flint knapping was focused on flake production, using an ad hoc technique. The settlers of Zeewijk used a combination of bipolar technology with other types of approaches, as uni- and bidirectional flaking. Flakes were retouched on the spot and used as 'ad hoc' tools in the execution of domestic activities. Stone types were chosen selectively: volcanic and sedimentary rocks as grinding and quern stones and sandstone pebbles for use as hammerstones. They could be used for cracking acorns and hazelnuts, making tempering material, and crushing tuber roots. The majority of the stones were not modified, but used in a way that took advantage of their natural shape. Some querns and grinding tools were flaked and reshaped before use. Use wear indicates that the querns and grinding stones were used to process plant materials, especially cereals, but one *mano* was used for woodworking. Also, animal hide was cleaned or worked with stone implements.

Unmodified flakes are the most frequent tool type. Retouched flint artefacts are low in number. Retouched flakes, blades, scrapers and borers constitute the majority of the implements. The scraping of hides is the most frequently represented activity, mostly performed with scrapers and retouched implements. Tools used for scraping scales and fish skin were also identified. Fishing was one of the main subsistence activities of SGC groups, but use-wear traces on flint was never found, until now. Zeewijk is the first Dutch SGC site to yield use-wear traces related to fish processing.

Amber was most likely gathered from the relatively nearby coastal area, as natural pieces are transported along the North Sea.[454] Jet is far less common. The provenance area is situated in the Pas de Calais region. Jet may have been gathered on the beach as fragments transported north by the tidal effect of the Channel and the North Sea.[455] Another, more plausible, option is that the settlers of Zeewijk obtained the jet by exchange.

The production of amber ornaments occurred locally, at the settlement (as at Mienakker). This conclusion is based on the abundant evidence of production waste and the use wear on one flint borer. The beads and pendants were well crafted, in comparison with beads known from other sites.

12.9 Spatial distribution of finds and features

Identification of activity areas

Due to the sampling strategy during the excavation campaigns, the selection process during our project and some missing find categories, the spatial analysis of the finds was very limited. In Zeewijk-West the studied area comprises 368 m². In this area many features were recorded. Although no clear structures were identified, the presence of one or more structures can be expected. In general, the majority of the finds was found on the higher ground. The distribution of the animal remains showed a concentration in the western zone of this area, in a banded pattern. This may be the result of habitation events or related to natural slope processes. No clear pattern can be seen in the flint distribution, but stone showed a large concentration of small pieces of granite. The modified stone artefacts have a more dispersed

453 Sheratt 1987.
454 Waterbolk & Waterbolk 1991.
455 Van Gijn 2006a, 2008.

pattern. In the amber distribution a significant clustering was visible in the northeastern part of the site. This could indicate an amber working area. The ceramics, generally speaking, showed no clear patterns, but at the level of individual vessels, clustering is apparent in the case of six of the twenty selected vessels, possibly pointing to a later phase of habitation.

In Zeewijk-East, the missing data hampered the spatial analysis. There is no clear association between these remains and the large structure.

Features and dwellings

The features at Zeewijk consist of many postholes, a few pits, a large number of cattle hoof marks and ploughmarks, a couple of small and one large former gullies separating West and East. Following the initial interpretations no new or different structures could be reconstructed on the basis of the finds and features. In Zeewijk-West, two main areas are distinct: the dense area of postholes on the higher ground, juxtaposed with the cow hoof marks on lower ground. This cattle behaviour signifies the presence of a built environment. At least one and probably more structures (buildings/house plans) are hidden in the concentration of postholes. The large number of postholes prompted the possibility that the people of Zeewijk may have built dwellings with elevated floors. This idea, inspired by present-day West-African houses and Neolithic lake settlements on the shores of Lake Constance[456], is also attractive in terms of a better understanding of deposition processes and the formation processes of middens. Many questions remain about the formation of the cultural layer, containing a lot of domestic refuse, mussel shells and huge amounts of charred reed.

The large structure in Zeewijk-East, already described in detail and published widely, is impressive and enigmatic.[457] Its monumentality, the absence of domestic refuse and associated hearths or pits points to a ceremonial or ritual function.

No direct evidence of human presence as a feature, like the burial at Mienakker, was found in the area studied, but human footprints, size 42-45 (EU), were recognised. In the central area of Zeewijk-East six of these prints reveal movement of people. Other indirect evidence includes some stray teeth, including a canine from a ten-year-old.[458]

Ploughmarks, orientated in criss-cross patterns, are ubiquitous, especially in Zeewijk-East, which indicate repeated ploughing activities covering an area of a hectare or more.

12.10 Seasonality and duration of habitation

Evidence from the archaeozoological and archaeobotanical studies point to human activities in specific seasons. The large numbers of ducks were probably caught in the moulting period, in late summer (July-August), when they are unable to fly. Some birds, such as brent and barnacle geese, guillemot and swan, can be seen as indicators of winter time, as can fishing for haddock. The presence of thin-lipped mullet and the preponderance of flatfish are indicative of summer and autumn activities.

With regards to consumed plants as evidence for seasonality at Zeewijk, it is clear that different activities were carried out in different seasons of the year and in varied places in the wider landscape. Crops like cereals and flax were most likely sown in spring and harvested in late summer. The small cultivated fields were probably watched and weeded through the growing season. It is remarkable that there is no evidence of storage in pits at Zeewijk. Pits are very rare in general, numbering only four in total. No large grain concentrations like those at Mienakker, indicating the storage of crop yields, have been found at Zeewijk. In addition to crop plants, crab apples, oraches seeds, hazelnuts, acorns, and possible tubers of sea club-rush were collected for food. The best season to collect crab apples and orache seeds would have been early through late summer. Soon after that, in early through late autumn, hazelnuts and acorns would have been available. Although many roots and tubers (also tubers of sea club-rush) are available throughout most of the year, their highest concentration of starch content coincides with the period between autumn and early spring. Combining season-specific information (Fig. 12.2) we would conclude that Zeewijk was inhabited throughout the year. Indications of the duration of habitation are limited. The ^{14}C dates give only a rough outline: a first phase somewhere between 3000 and 2500 BC and a

456 Suter & Schlichtherle 2009; Pétrequin 1984.
457 Hogestijn 1997, 34-42; Hogestijn 1998, 102; Hogestijn 2005, 431; Van Ginkel & Hogestijn 1997, 113; Hogestijn & Drenth 2000, 138, Hogestijn & Drenth 2000/2001, 62.
458 De Vries 2001, 300.

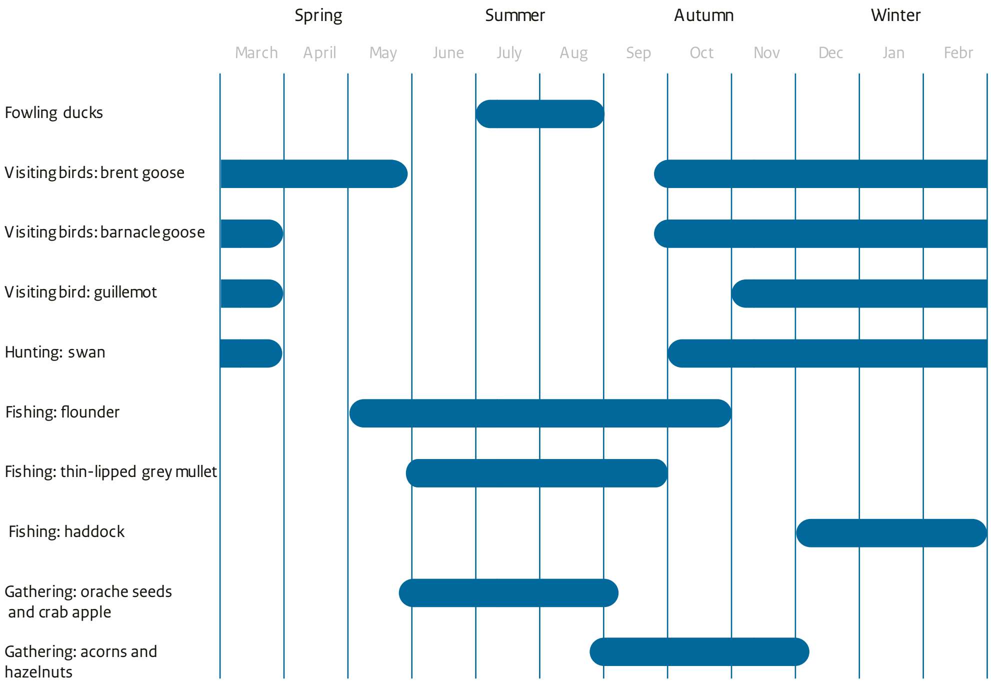

Figure 12.2 Overview of the season-specific information at Zeewijk.

final phase between c. 2500 and 2200 BC. These dates leave us with a very long timespan with multiple habitation phases spanning eight centuries. The analysis of the ceramics points to at least three phases. It is impossible to discern these as successive or with long/short intervals. The phasing and use of the settlement can only be assessed in relative terms.

All human activities seem to be arranged in a kind of mosaic: habitation, growing crops on small arable fields, collecting wild plant foods, raising cattle occurred simultaneously and successively, and shifted spatially. Charcoal evidence points to long-lasting habitation. The large variety of taxa in the wood spectrum of Zeewijk is one reason, the other is the greater degree of fragmentation in the charcoal, caused by frequent trampling by animals and humans.

12.11 Concluding Zeewijk

Even though our conclusions are based on a relatively small sample of the site, it is possible to characterise Zeewijk. We can conclude that Zeewijk was a large domestic settlement, occupied all year round. In our view Zeewijk must be seen as a location where recurrent habitation took place, intensively, alternated with subsistence activities. It is a permanent mosaic of different assemblages: relocated dwellings, cultivated plots and the building and partial demolition of a remarkable ritual structure. This variety in life history was restricted to the higher parts of the levees and may have been divided by the large gully, or perhaps connected by a crossing. The levees were the stable landforms in the dynamic tidal landscape, an environment well known to the settlers of Zeewijk.

The habitants of Zeewijk carried out a broad spectrum of activities related to subsistence: mixed intensive farming (including small-scale crop cultivation, crop processing and consumption, and animal herding and consumption), foraging, fishing, fowling and hunting all took place there. Their meals were rich and varied, containing cereals, cattle, wild boar/pig, sheep/goat, birds, fish, wild mammals and diversity of wild plants. From all the evidence presented in Zeewijk study, it is clear that the subsistence economy and diet at Zeewijk is comparable with Mienakker. At Zeewijk, however, the focus on mammals is much greater, while much less fish was consumed here than in Mienakker. The preference for decorated beakers as cooking vessels at Zeewijk can be regarded as an eye-opener. The demonstrated use of the baking plate is another new result.

There is ample evidence of craftsmanship. Labour-intensive activities were performed at the site. Flint implements were made and used for scraping hides and processing fish. Wood was worked by flint and stone and large oak posts were lopped with a stone axe. The production of amber and bone beads, spinning and weaving were all local crafts practised at the settlement.

This variety of local crafts, the construction and use of the large ceremonial building in Zeewijk-East and the large variation in ceramics are seen as indications that different groups of Corded Ware people settled at Zeewijk. These groups were probably household groups, a community of several families, related by kinship both genetic and affinal. The question of how many household social units lived at Zeewijk simultaneously or – in the longer term – in subsequent generations is essential, but remains unanswered. In many ways, Zeewijk still holds a lot of questions for future archaeologists to explore.

Epilogue

E.M. Theunissen, B.I. Smit, O. Brinkkemper, I.M.M. van der Jagt, R.C.G.M. Lauwerier & J.H.M. Peeters

Introduction

From a broad perspective, this monograph will not be the last publication to recount the Late Neolithic treasure chest story. Three PhD theses are forthcoming, as well as several papers on various subjects.[459] However, as far as the Cultural Heritage Agency is concerned, this publication completes the project. Our growing awareness of this fact while recording the results from the Zeewijk analysis prompted an urge to look back and reflect upon the project's goals. In addition to our reflections about the outcome of our project, we also wanted to evaluate the process and organisation. This kind of information, which is also very valuable, is not often recorded in scientific publications.

Our project aimed to unlock and integrate cultural/ecological information and research data in order to provide a sound basis for cultural modelling, explaining what the Single Grave people actually did in the tidal environment, and for the development of heritage management strategies. This would give us a better understanding of site variability in relation to landscape use, subsistence strategies and the material world of the inhabitants in the tidal environment of the province of Noord-Holland in the Netherlands 4500 years ago.

This retrospective chapter brings closure to the work performed by the project team over the past five years. The focus will be on various issues, though generally speaking two main questions will be addressed.

- (1) What is the scientific outcome of our Odyssey project in general terms? What new knowledge has been provided about the Single Grave Culture in Noord-Holland?
- (2) What can we learn from working with old excavations? What are the challenges of tackling a serious backlog problem?

The project organisation in a nutshell

The 'Unlocking Noord-Holland's Late Neolithic treasure chest: Single Grave Culture behavioural variability in a tidal environment' project was initiated by the Cultural Heritage Agency and received a € 500,000 grant, representing four years of funding under the Odyssey programme. This programme was funded by the Netherlands Organisation for Scientific Research (*Nederlandse Organisatie voor Wetenschappelijk Onderzoek*, NWO) and the Ministry of Education, Culture and Science. The Single Grave project was designed and organised by the Cultural Heritage Agency in close collaboration with the universities of Groningen and Leiden and archaeological agencies BIAX Consult, ArchaeoBone and Kenaz Consult, with additional funding from the University of Groningen, Noord-Holland provincial authority and *Stichting Nederlands Museum voor Anthropologie en Praehistorie*.

The project started on 1 September 2009 and was carried out under the direction of the Cultural Heritage Agency, represented by project manager Hans Peeters. After two weeks, he accepted a new job at Groningen Institute of Archaeology and he left the Agency. The guidance of the project was successively transferred to Liesbeth Theunissen, Bjørn Smit, Jos Kleijne and then back to Liesbeth Theunissen.

In the final quarter of 2009, three PhD students were appointed. At Leiden University Virginia García-Díaz started to analyse the lithics, stone and bone tools and ornaments. She is being supervised by Annelou van Gijn. The other two PhD students are Gary Nobles, who performed the spatial analysis of the three sites, and Sandra Beckerman, who studied the ceramics. Both are PhD students at the University of Groningen, supervised by Daan Raemaekers, Hans Peeters (Gary) and Stijn Arnoldussen (Sandra). Gary Nobles and Virginia García-Diáz were funded by the Netherlands Organisation for Scientific Research, Sandra Beckerman by the University of Groningen. These three young researchers were added to the project team, which consisted of a group of specialists, as stated in the introductory chapters of the three publications. The project team consisted of 16 to 18 people, studying different subjects. Two young undergraduates from Leiden University joined the team on a more occasional basis. Esther Plomp performed a thorough study of the human skeleton from Mienakker and Marit van den Hof studied the charcoal fragments from Mienakker and Zeewijk as part of an internship at the Cultural Heritage Agency.

459 Beckerman in prep., García-Díaz in prep., Nobles in prep.

The approach to the project highlighted three research themes and ten specific research questions. Ten expert meetings were organised to foster the integration of the results obtained by the specialists from the three old excavations at Keinsmerbrug, Mienakker and Zeewijk. These meetings were crucial moments in the process. During these sessions there was a lot of discussion about the reconstruction of Neolithic life. The results from the spatial analysis carried out by Gary Nobles were related to the outcome of the research performed by the various specialists, such as the botanical and faunal remains, the flint and stone artefacts (including micro-wear analysis), the amber and the ceramics (including organic residues analysis). In close collaboration, and in a friendly atmosphere the ten research questions (see Section 1.2, this volume) – the basis of our research approach – were discussed and conclusions drawn. Although most of the team members are not native speakers of English, the fact that the meetings were conducted in English proved no impediment to the lively discussions and exchange of ideas. On several occasions, one of the former excavators who had worked at Mienakker and Zeewijk, Everhard Bulten,[460] joined these meetings, adding very useful information based on his own field observations. His knowledge of the methods employed in the field and the way data was recorded was also very valuable.

During the first two years the team focused on unlocking the old find material and data and integrating the results. After those two years, the dissemination of the new knowledge became a crucial additional aspect of their work. The information was targeted at several groups. First, the academic world of Late Neolithic researchers, with the publication of three monographs in English,[461] papers in journals[462] and lectures at international conferences (in Barcelona, Krakow, Oslo, Thessaloniki and Kiel).[463] Second, Dutch archaeologists were informed in lectures at national meetings (in Rotterdam, Leiden and Amersfoort) and papers in journals and books.[464] Third, we also informed the public in Noord-Holland, especially those living in West Friesland. The civil servants in the project team – provincial archaeologist Rob van Eerden, working closely with Liesbeth Theunissen of the Cultural Heritage Agency – took the lead on the communication strategy for this last group. This collaboration led to the creation of a lifelike reconstruction of a Neolithic man, *Cees, de steentijdman van Mienakker*, and a Stone Age calendar (see also Outreach to the wider public).[465] Several lectures were also given for local audiences (in Keinsmerbrug, Hoorn and Alkmaar), articles appeared in local magazines[466] and two brochures were published.[467]

A better understanding of human behaviour in a tidal landscape

Refining the general picture of the tidal environment

Before the start of our project, a general picture of the landscape of the West Frisian part of Noord-Holland during the Single Grave Culture already existed, especially from a physical-geographical point of view. Our project did not specifically aim to produce a new detailed reconstruction of the former landscape. The focus was on answering the question: what ecozones are represented in the archaeozoological and archaeobotanical assemblages?[468] In retrospect, we are forced to conclude that this approach was too lightweight, given the scope of our project. A specialist on the tidal landscape should have been added to the team, providing a solid basis for understanding human behaviour in this kind of landscape. Nevertheless, the present results do allow the general view to be refined.

The sites were situated in a salt marsh landscape, where the tidal influence of the sea was experienced through a system of gullies. Bones of marine and terrestrial mammals, birds and fish and plant macro-remains and pollen of salt marsh plants were found at the three sites of Keinsmerbrug, Mienakker and Zeewijk. The SGC people inhabited the slightly higher sandy levees near active or residential gullies, in an environment of tidal flats and salt marshes.

There were few sources available for palynological research, but one watering pit at Keinsmerbrug provides a picture of a very open landscape, with barely any trees in the immediate surroundings of the site and with alder woodland typical of wet freshwater environments at some distance. The charcoal evidence is in good agreement with these observations, with salt-tolerant aspen

460 Now working as senior archaeologist at The Hague city council.
461 Smit *et al.* 2012, Kleijne *et al.* 2013; this volume.
462 Beckerman 2012, Kubiak-Martens, Brinkkemper & Oudemans 2014.
463 Beckerman *et al.* in press; Kleijne *et al.* in press.
464 Theunissen & Smit 2013a; Drenth *et al.* 2014.
465 Theunissen & Van Eerden 2014.
466 Theunissen & Smit 2013b.
467 Theunissen 2013, 2014.
468 This question is the eighth of the ten research questions forming the framework of our project, see Section 1.2, this volume.

dominating at the most westerly site of Keinsmerbrug, and alder and willow, probably growing along the gullies in the freshwater range, prevailing at Mienakker and Zeewijk, which are both further inland in the tidal system. Although the environment was predominantly saline and brackish, there are places at or near the three sites where fresh water accumulated, as – among other things – the presence of the beaver indicates. Wild boar and deer suggest an environment with patches of woody vegetation, the animals probably using the higher sandy levees as sheltering places.

The nearby sea and shore are represented at all three sites by seals, large quantities of mussels, amber and various plants characteristic of salt marches (including glasswort, shore orache, sea purlane, sea beet and others). The presence of many mature haddock remains at Mienakker also points to sea exploration, or fishing in skin-lined boats at deep primary tidal creeks nearby. Some of the wood used for fires, such as oak and yew, will not have been available in the immediate vicinity of the sites, except as driftwood. The Pleistocene outcrops of the boulder clay area of Wieringen at a distance of approx. 10-15 km is the most likely source of this wood. Oak was also used for the construction of the large structure of Zeewijk-East, as is evidenced by the remaining posts. These stumps, together with the poorly-preserved branches from Mienakker, are the only waterlogged botanical remains found at any Single Grave Culture site studied in Noord-Holland.

New insights into settlement practices and subsistence activities

Unlocking the three sites has yielded new insights into settlement practices and subsistence activities. In this short presentation attention will be devoted first to the most conspicuous similarities between the sites, followed by a review of the differences (Table 1 and Fig. 1).

Similarities

One important characteristic common to most Late Neolithic sites in Noord-Holland is the dark humic cultural layer. This anthropogenic layer, or midden, is the result of the deposition or dumping of waste, shells, bones, charred reed and other anthropogenic materials. The thickness of the layer varies, as does the depth below the present surface. At the sites of Keinsmerbrug, Mienakker and Zeewijk, the Neolithic cultural layer was covered with peat and finally with clay sediments which date to the Middle Ages. The distinct black colour and the presence of mussel shells are important features, facilitating identification in corings (Mienakker) and small test pits (Keinsmerbrug). Zeewijk was discovered when the topsoil was moved to fill up a ditch. A blackish earth containing pottery decorated with cord impressions, flint artefacts and bone material was uncovered. The average thickness of the cultural layer at Zeewijk is approx. 50 cm, which is fairly thick compared to Keinsmerbrug and Mienakker. At Zeewijk clay, charcoal and ash layers intertwined with cultural debris, hearths and waste were recognised, indicating (local) flooding episodes and multiple habitation phases.

The use of local flint and stone is common in the material culture of Keinsmerbrug, Mienakker and Zeewijk. Artefacts were made of small flint nodules that were collected on the nearby beaches or at the higher boulder clay outcrops at Wieringen. Reduction was performed on an *ad hoc* basis, and mainly for flake production. The ceramics show that both fine and coarse ware were used for cooking. There is no evidence of functional differences between these types of ware. The use of nicely decorated beakers for cooking purposes is a remarkable result from our Odyssey project, as beakers are generally seen as drinking vessels.

Two cereals, nakely barley and emmer, have been confirmed as the principle crops of all three sites. Flax was also important for the settlers of Mienakker and Zeewijk. It was used for its oil-rich seeds and, in Zeewijk at least, for its fibres.

Breeding cattle was one of the activities in which the communities at Keinsmerbrug, Mienakker and Zeewijk engaged. Sheep (or goats) and pigs were of minor importance. At all three sites dogs were present. A cut mark on a dog bone of Zeewijk indicated that this animal, considered man's best friend, was sometimes eaten.

Differences

At Keinsmerbrug, a small site, three to five structures were recognised. They were interpreted as light dwellings. The charcoal evidence suggests a surface less trampled than at Mienakker and Zeewijk.

The picture to emerge from the material

Table 1: Settlement practices and subsistence activities.

	Keinsmerbrug	Mienakker	Zeewijk
Site extent	small, 300 m²	small, 840 m²	large, over 10,000 m²
Structures (house plans and 'ritual' buildings)	three to five light dwellings	one house plan and one mortuary structure	several house plans and one ceremonial structure
Relative phasing recognised	two	two	multiple
Charcoal evidence	large variation in species and high average weight (less trampling)	restricted variation in species and low average weight (more trampling or hearths used for a longer period)	large variation in species and low average weight (more trampling or hearths used for a longer period)
Ceramics	very large variation	very uniform	large variation
Food prepared in vessels	one type of food	large variation in food	very large variation in food
Imported flint	no imported flint	few pieces of southern flint (Grand Pressigny)	few pieces of southern flint (Valkenburg, Light Grey Belgian and Rullen)
Flint use	limited variation in use	variation in use	large variation in use
Stone use	very little evidence	limited variation	large variation
Amber	one bead fragment	clear evidence of bead production	clear evidence of bead production
Gathering	no nuts or fruits	nuts and fruits	nuts and fruits
Cereals	not local (imported)	local production (small-scale) and storage	local production (intensive cultivation) and no evidence of storage
Ard marks	no	minor evidence	abundant evidence
Animal resources	focus on birds (duck)	focus on fish (flatfish, haddock and cod)	focus on mammals (cattle)
Cow hoofprints	yes	yes	yes
Game species	some variation	some variation	large variation
Bone artefacts	none	several (many ripples)	several (ripples, beads, needles/awl)
Seasonality	several episodes of short-term use, from spring to autumn	all year round	all year round
SGC people	gathering of different household groups for specific activities	a few household groups	several household groups

culture is striking. At Keinsmerbrug there are low numbers of flint and ceramics, but there is great variation in thickness, tempering and decoration, suggesting origins in different local SGC traditions. The food crusts on the ceramics, on the other hand, point to the preparation of one specific type of food; emmer porridge with fat.

There is no evidence of agricultural production at Keinsmerbrug; ard marks are absent. And also threshing remains from the early stage of cereal processing barley chaff are absent, and there is no evidence of cereal storage. Cereals were brought to the site. Interestingly, only seeds of various orache species were gathered – the overwhelming presence of charred seeds is striking – but no other wild plant resources such as hazelnuts, wild apples, acorns, roots or tubers were found.

Subsistence was based on a combination of cattle breeding, fishing and fowling, with a strong emphasis on catching ducks. Ducks were caught in large quantities, probably during the moulting season. The numbers and even the weight of bird bones exceed those for mammals, indicating that this was the main activity of the settlers at Keinsmerbrug.

Keinsmerbrug is regarded as a non-permanent settlement. People of different household groups gathered at this settlement for special reasons, maybe feasting. Hunting ducks, eating specific food and sharing information were important activities. The same place was used repeatedly over a period of time. This short-term, occasional use was most probably seasonal, occurring mainly from spring to autumn, with late summer for frequent duck hunting.

Mienakker, a slightly larger site than Keinsmerbrug, reveals a completely different

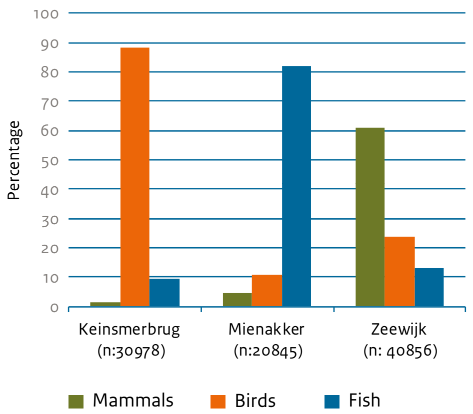

Figure 1 Frequencies of different categories of mammal, bird and fish bones at Keinsmerbrug, Mienakker and Zeewijk. In this figure 'n' indicates the total number of remains. Numbers for small rodents have not been included in the mammal bones.

picture of SGC settlement structure. One house plan and one mortuary structure were recognised, partially overlapping each other. The oldest phase is related to domestic activities, while the youngest phase of Mienakker is related to the burial of an adult male. The size of the charcoal particles is ten times smaller than at Keinsmerbrug. This implies that either there was much more trampling at Mienakker, and/or that the hearths were used for a much longer period.

The uniformity of the pottery is striking. The analysis of the food crusts showed a much larger variety of meals, including fish. Amber beads were made locally at Mienakker, as were flint and stone tools. Besides local flint some pieces of southern flint were also found, possibly the recycled remains of a Grand Pressigny dagger.

There is clear evidence of the cultivation of naked barley and emmer and for the storage of both cereals. Cereal remains and potential arable weeds are indicative of small-scale local production. Some ard marks were identified in the eastern part of the site itself. In addition to crop plants, hazelnuts, acorns, crab apples and various orache seeds were gathered.

One important element of subsistence was the intensive exploitation of the abundant aquatic environment. The inhabitants of Mienakker caught and ate a lot of fish, mainly marine species, including cod, flatfish and haddock. The high numbers of mature haddock indicate that they fished during the winter period in deep tidal channels or even on the open sea. They probably used skin-lined boats coated with seal skin as suggested by two clusters of straight and bent wooden branches in combination with a relatively high number of seal bones, some with cut marks. Ducks were caught too, but not in such large numbers as at Keinsmerbrug, although again they exceed the number but not the weight of mammal remains.

Mienakker has been interpreted as a site that was inhabited year-round, where a wide range of very diverse (domestic) activities were performed. Notwithstanding its small size, Mienakker was an intensively used site that can be regarded as a permanent settlement. The question of how many household groups inhabited the place and returned to it is difficult to answer. The scarce evidence – one house plan, uniform pottery – suggests one or maybe a few household groups. The site was abandoned, but after some time people returned and built a trapezoidal structure. The incomplete body of an adult male was buried next to one of the central posts. This final phase of Mienakker has a more 'ritual' character. It became a place where people said goodbye to someone who had passed away.

In appearance Zeewijk is a much larger site. Due to its vast size and the very high number of finds, even though the site was only partially excavated, a sampling strategy had to be applied. This affects discussion of the results in some respects, as some conclusions are only indicative. The distribution of the cultural layer is large, covering a hectare, on both sides of a former active gully. The presence of numerous postholes, cow hoofprints and ard marks suggests a large settlement area with farmland.

It was not possible to identify any house plans in the large abundance of postholes, especially in Zeewijk-West, but clearly some must have been present. In Zeewijk-East, a large ceremonial structure was present, already recognised during the excavations.

The ceramics show a large variation in technology and decoration and the food prepared in these vessels was also very diverse. As at Mienakker, there is clear evidence of local production of amber beads. Some southern flint and some arrowheads (with traces of hafting) are present in the flint material and the use wear on other implements shows traces of scraping fish scales and hides.

The local crop cultivation can be

characterized as small-scaled intensive cultivation on levees, with small cultivated plots located near or next to the settlement. As at Mienakker, wild plant foods were gathered to supplement the cereal-based diet. Crab apples, acorns, hazelnuts, orache seeds and possible various roots and tubers were consumed.

Exploitation of mammals, especially cattle, was important, although ducks and marine fish were also found. Much less fish was consumed, but the marine fish at Zeewijk included more flatfish and no haddock. Just as at Keinsmerbrug and Mienakker, cattle is the dominant mammal species accompanied by some sheep (or goat) and pigs. Wild boar is found together with other game species that are more diverse in the bone record of Zeewijk, with species such as red deer, roe deer, beaver, brown bear, and wildcat in addition to the species found at Keinsmerbrug and Mienakker (wolf, horse, wild boar, stoat, polecat and marten).

Although the average weight of the charcoal from Zeewijk and Mienakker is similar, the variation in species is much larger at Zeewijk. This implies that Zeewijk was also intensively used, but probably in various phases that were individually comparable to Mienakker.

Zeewijk is regarded as a location where recurrent habitation took place. The habitation was intensive, alternating with subsistence activities, in a year-round cycle. Mixed intensive farming, foraging, fishing, fowling and hunting all point to an extended broad-spectrum subsistence economy and diet. This, combined with the local crafts (spinning and weaving) and the construction and use of the large ceremonial building in East suggests that several household groups lived permanently at Zeewijk.

A quick test of the SGC settlement model

The analysis of Keinsmerbrug, Mienakker and Zeewijk allowed us to put the settlement model proposed by Hogestijn in the 1990s to the test.[469] In this model the SGC settlements of Noord-Holland are divided into two groups. Group 1 consists of large, permanent settlements (> 3000 m²) that were inhabited by relatively large groups of people. Group 2 consists of small settlements (< 500 m²) that were inhabited by small groups of people for short periods (during a particular season) and for specific activities. The products from these seasonal logistical camps were taken to the large residential settlements.[470] According to this model, Keinsmerbrug and Mienakker would have been seasonal camps and Zeewijk a residential settlement.

The results from our Odyssey project show that Keinsmerbrug can be labelled as a Group 2 settlement, a small non-permanent gathering site, and Zeewijk as a Group 1 settlement, a large site inhabited all year round. Mienakker, however, was also inhabited all year round, despite its small size, and thus belongs to Group 1.

In our view, the similarities between Mienakker and Zeewijk are more striking than the differences. We would suggest that it is likely that large sites such as Zeewijk are an accumulation of several smaller sites, such as Mienakker. The main difference may be based more upon the temporality in habitation phases than on the number of household groups. In this way Mienakker can be seen as a representation of a much shorter habitation episode, whereas Zeewijk is an example of multiple, recurrently inhabited settlements.

Other results from our project also contradict the proposed model.[471] There is no dichotomy in the percentages of wild and domesticated animal species between residential and seasonal settlements. Special activities such as fishing, catching birds, hunting game and collecting amber were not only performed at the seasonal settlements but also at residential settlements. Amber, and the production of beads, is even predominantly found at permanently inhabited settlements. To conclude, although the model was tested by means of only a quick scan manner, we can say that the Odyssey project yielded conclusive arguments against the proposed dichotomous model of SGC settlements. An in-depth evaluation of this model will be presented as a major element of the three PhD theses.

The challenges of working with old excavations

We also felt a need in this retrospective chapter to reflect upon the main feature of unlocking former excavations: working with old find materials and data. The three monographs show that this kind of information, mostly hidden in archives and repositories, is highly valuable.

469 Hogestijn 1992, 2005.
470 Hogestijn 1997.
471 Hogestijn 1992, 1997, 2005.

New questions can be defined, new methodologies or techniques applied and new knowledge created. On the other hand, we also dealt with several problematic issues during the five years of working with old data, more than we had expected at the outset. This section describes some of our Odyssey experiences.

In the late autumn of 2008, in the run-up to submitting our project proposal to the Netherlands Organisation for Scientific Research (NWO), we made an assessment of the quality and availability of materials and excavation data. This quick scan at the provincial repository in Wormer showed that materials had been sorted and stored according to find category. A sample of some excavations was tested: the original find numbers and administration appeared to be present and in perfect order.

The selection of the sites addressed in our proposal was also made according to specified criteria, whereby accessibility of excavation documentation and availability and quality of find materials were vital. Representativeness of the excavated area and settlement size/type variability completed the four criteria which formed the touchstone of the selection process.

During the project we found that the availability of the data was not as good as expected, however. We were repeatedly confronted with gaps in the data, both finds as well as documentation. The site of Kolhorn was selected at first, as representative of a large, double site. Unfortunately, several attempts to unlock Kolhorn proved very problematic. The main problem was that the renumbering of finds in the 1980s before they were entered in a database had caused the loss of crucial context information. The loss of context data precluded spatial analysis of the different find categories, one of the key aspects of our project. Hopefully, in the future, the lists of codes of old and new find numbers will turn up, and reinvestigation of Kolhorn will be possible. Due to this problem, we had to turn our attention to another large double site: Zeewijk. It goes without saying that this change in our project was unavoidable, but also time-consuming. A lot of effort was put into finding and unlocking Kolhorn, all in vain.

Besides missing data, we also found that quite a number of finds were missing. For instance, a lot of the fine finds from Mienakker are gone: almost all flint artefacts, the bone awls and the majority of the amber pieces. Also, most

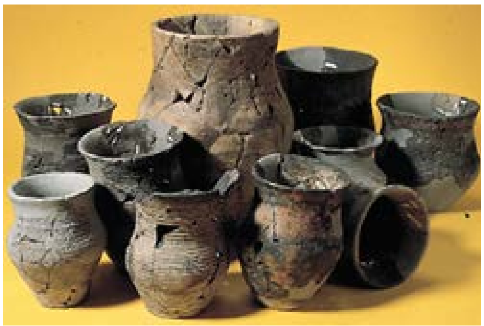

Figure 2 Wanted: seven of these vessels from Mienakker are missing.

of the restored vessels from Mienakker have been lost or mislaid. Only a group photo of these pots, published in 1997, is still available (Fig. 2).[472] We assume that these appealing objects have been stored together, maybe after a photo shoot. It seems to be a rule in archaeology that, the more beautiful an object, the greater the chance it will disappear. The same rule applies to a portion of the flint and amber of Zeewijk, which appears to be gone. Another example is the ribs and the left hand of the human skeleton from Mienakker. These bones could not be traced, and were probably mislaid after the study by Pasveer and Uytterschaut in 1992.

It is probably impossible to completely avoid this kind of problem with old excavations as it is inextricably bound up with the acts of recording, saving and storing performed by different people over decades. Mistakes are easily made. Nowadays, many of the provincial repositories are in the process of digitizing all their objects. The objects are described, pictures are taken, and everything is stored in large databases and made accessible as a web application. It is likely that finds assumed lost will be retrieved during this process.

To reduce the problems associated with old excavations, we would recommend reserving ample time to explore all the analogue documentation, finds and other things, preferably in collaboration with the original excavators. This exploration phase should be the first step, the first phase of the many activities of a project team setting about unlocking an old excavation.

472 Van Ginkel & Hogestijn 1997.

Outreach to the wider public

In close cooperation with staff of Noord-Holland province, various initiatives were undertaken to bring the Single Grave Culture into the world of today's general public. The initiatives were an attempt to foster greater appreciation of these prehistoric societies and their vulnerable archaeological remains. This is vital because the Neolithic past is largely invisible, and so the past of 4500 years ago is a very abstract concept for the present-day inhabitants of the region. It is not common knowledge that the meadow parcels around Hoogwoud and Aartswoud and the large arable fields in the Groetpolder were part of a broad tidal landscape in which inventive late Neolithic people once lived. Most people are surprised to hear that habitation was possible 45 centuries ago and that the potential for farming, fishing and gathering was excellent.

The most conspicuous of these initiatives was the reconstruction of a lifelike Neolithic man (Fig. 3), named *Cees, de steentijdman van Mienakker*.[473] The facial reconstruction, based on a 3D print of his skull, was performed by Maja d'Hollosy (Skullpting) and financed from project funds. Replica clothing was created by Marije de Mol and financed by the provincial authority. The choice of garments was based on the find material from the SGC sites (hides of roe deer, beaver, cow and fabrics made of linen). Cees the Stone Age man was unveiled on 8 November 2013 at the West Frisian Museum in Hoorn. This event, followed by a Meet & Greet weekend at the museum, attracted a lot of attention from local residents (drawing over 800 visitors) and the national media.[474] Cees featured in several national and regional TV news items and was invited on the popular national daily talkshow *De wereld draait door*. Over a million viewers saw the Stone Age man on their television screens. Cees was subsequently exhibited for one week at the West Frisian Museum and for one day (1 December 2013) at the cattle museum *Aat Grootes* in Aartswoud, close to his place of burial. From 15 April to 14 September 2014 the Stone Age Man was on show at the National Museum of Antiquities in Leiden, as part of an exhibition entitled *Bij Nader Inzien* (On Further Reflection), featuring all the projects in the Odyssey programme.[475] From 2015 onwards, Noord-Holland archaeology centre, *Huis van Hilde*, in Castricum will become his permanent home. The Stone Age man Cees will be the representative of prehistory, the first in a series of several reconstructed individuals from key periods in the long history of Noord-Holland.

Figure 3 Cees the Stone Age man.

Figure 4 The Stone Age birthday calendar.

Another initiative targeted at a wider audience was the making of a Stone Age birthday calendar (Fig. 4).[476] The basic principle was to create a product that reflects life 4500 years ago, lavishly illustrated with images that can be understood only through careful observation. A very accessible item, made specially for the people of the region where the excavations took place

473 Cees, the Stone Age man, was named after C.J. (Cees) van Berkel, the owner of the land when the excavation of Mienakker took place in 1990.
474 During the week before the unveiling Cees posted tweets about his Neolithic life. He hunted, ate cereal soap and set off on a journey to the boulder clay outcrop at Wieringen with his son Abe and dog Neo.
475 Amkreutz & Van Ginkel 2014.
476 The Stone Age calendar project was realised by Weleer (www.weleer.com), in close co-operation with the Cultural Heritage Agency.

some quarter of a century ago. Each month is illustrated with photos of objects and landscapes and drawings of characteristic seasonal activities of SGC settlers, featuring Cees. The images are based on the finds from and analysis of Keinsmerbrug, Mienakker and Zeewijk. These Stone Age reconstructions alternate with images of the present-day landscape and local people with an interest in archaeology.

Cees the Stone Age man and the Stone Age birthday calendar are two products from our Odyssey project that bring the prehistoric past closer and enhance appreciation of our rich late Neolithic past, showing the beauty and giving us valuable new knowledge to pass on to future generations.

Relevance for archaeological heritage management

We hope that the results from our project will help improve archaeological heritage management. Better protection of the remains of Single Grave Culture sites in Noord-Holland is something that the national, provincial and local authorities have long desired. Translating this into practical measures is a long and bumpy road. Most sites are situated on farmland in private ownership. The remains, the cultural layer and the underlying feature level lie at the surface or at shallow depths immediately below the cultivated soil. They are therefore very vulnerable, even to normal agricultural practices like ploughing. The former tidal landscape, with its differences in relief, produces height variations in the present surface. From an agricultural viewpoint this is not desirable, and leads to measures to level the terrain and lower groundwater levels. Such major interventions have a devastating effect on buried archaeological features and finds.

The shallow position of the archaeological remains in the subsoil also implies that they are situated above the water table. This results in biological decay of botanical remains. The three analysed sites yielded hardly any waterlogged (uncharred) plant remains, showing that this decay is an ongoing process. Only the wooden posts of the large structure at Zeewijk-East and the poorly preserved branches of Mienakker survived in the 1990s.

The conservation of the animal bones is somewhat better because of the ubiquitous mussel shell remains in the cultural layer, which result in a high pH that helps preserve (unburnt) animal bones. The preservation of the bone is however poor and the remains are very fragmented and weathered, especially those from Mienakker. Earlier research has shown that animal bone from the Late Neolithic site of Aartswoud is suffering microbial attack due to the desiccation of the *in situ* context.[477]

Secure protection of any of the sites still *in situ* will therefore only be feasible if the area concerned is withdrawn from agricultural use, or much more restricted agricultural practices are at any rate imposed, with financial compensation for the landowner. The provincial archaeological monument of Maantjesland is the only SGC site that has a successful history of improved protection. In 2007 the water level at this site was raised by 30 cm, no tillage of the soil is allowed and the growth of reeds is limited by strict nature management.

Last year, a new programme was initiated by the Cultural Heritage Agency, focusing on 'top sites': scheduled archaeological monuments that are threatened by everyday land use. One of the main objectives is to explore the extent and dimension of the process of degradation and to find pragmatic solutions to stop it. One of the top sites selected is the Late Neolithic site of Aartswoud. This site is considered one of the most important prehistoric sites in the Netherlands. Now, with Zeewijk published, it will be interesting to evaluate this site, in light of the results from our Odyssey project. Aartswoud is impressive in terms of its size (over 6 ha), the thickness of the cultural layer (average 80 to 100 cm) and number of finds (over 200,000, from 341 m² excavated in the 1970s). Since little has been published on the Aartswoud excavations, unlocking this site would be an important step towards understanding it. The cultural layer was excavated in a detailed way, so stratigraphical information is available. Hopefully, in future, the owner and the local and provincial authorities will be able to take effective action to curb the degradation of Aartswoud. A tailor-made approach is needed, and in the long run, a long-lasting policy to protect this national monument of inestimable value, including adequate financial support.

477 Jans *et al.* 2004.

Rounding off

Rounding off this retrospective is a pleasant task. On the one hand, it marks the end of some exceptionally good team work over five years of discussing Neolithic life. The outcome of the Late Neolithic treasure chest is a collective interpretation of the past, in joint authorship. The different team members brought not only their own expertise, they also contributed to the work of others. Such an interdisciplinary approach leads to a whole that is greater than the sum of its parts. Working together, in good spirit and close harmony, is inspiring and stimulates new thoughts and ideas.

From the viewpoint of our project, the future looks very promising. Three PhD theses, presenting in-depth stories about human behaviour 4500 years ago, are forthcoming. And with that, a part of the treasure chest has been opened. A lot remains to be done and there is much to unlock. New insights and challenges await us, the future delights concealed in the treasure chest of Noord-Holland.

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Appendices

Appendix I: Studied characteristics of ceramics

~1st phase: sherds
Type sherd
1: Rim
2: Neck
3: Shoulder
4: Wall
5: Base
6: Grit
7: indet/younger
EB: empty bag

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; location i=inside, o=outside
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 ceramics of Zeewijk-East

Decorated

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
O.1	rim till neck	fingertip imprints	sand	8	dark	rough	-	-	-	-	-
O.2	rim till shoulder	spatula, herring-bone	grog and sand	5.5	dark	lightly smoothe-ned	-	-	-	-	-
O.5	rim till shoulder	spatula, oblique row one direction	grog and sand	5.5	dark	rough	-	10	-	-	-
O.17	rim till neck	fingertip imprints	grog and sand	10.5	dark	rough	-	13	-	-	-
O.18	rim till neck	fingertip imprints	grog and sand	9	dark	rough	-	-	-	-	-
O.20	rim till shoulder	spatula, zig zag	granite, grog and sand	7	dark	rough	-	10	-	-	-
O.21	rim till neck	spatula, oblique row one direction	grog and sand	8.5	light	rough	-	-	-	-	-
O.26	rim till neck	spatula, oblique row one direction	grog and sand	7	dark	rough	-	-	-	-	-
O.27	rim till neck	spatula, oblique row one direction	grog and sand	6.5	dark	lightly smoothe-ned	-	16	-	-	-
O.28	rim till neck	spatula, zig zag	quartz, grog and sand	5	light	-	-	-	-	-	-
O.33	rim till neck	spatula, oblique row one direction	grog and sand	6	dark	rough	-	-	-	-	-
O.58	rim till shoulder	fingertip imprints	granite, grog and sand	10	dark	rough	-	-	-	-	-
O.59	rim till shoulder	fingertip imprints	grog and sand	12	dark	rough	-	-	-	-	-
O.60	rim till neck	fingertip imprints	grog and sand	-	dark	rough	-	-	-	-	-
O.61	rim till neck	cord im-prints	granite, grog and sand	6	light	rough	-	-	-	-	-
O.62	rim till belly	spatula, zig zag	grog and sand	5.5	dark	rough	-	13	-	-	-

Undecorated

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
O.3	rim till shoulder	grog and sand	6.5	dark	lightly smoothened	yes: 1	16	-	-	-
O.4	rim till neck	grog and sand	11.5-12.5	dark	rough	-	18	-	-	-
O.7	rim till shoulder	grog and sand	9	dark	rough	-	-	-	-	-
O.8	rim till shoulder	granite	7	dark	rough	-	17	-	-	-
O.9	rim till neck	grog and sand	8.5	dark	lightly smoothened	-	-	-	-	-
O.10	rim till neck	grog and sand	6	dark	rough	-	-	-	-	-
O.11	rim till shoulder	grog and sand	6	dark	lightly smoothened	-	11	-	-	-
O.12	rim till neck	granite, grog and sand	8	dark	rough	-	-	-	-	-
O.13	rim till shoulder	grog and sand	8	dark	rough	-	-	-	-	-
O.14	rim till neck	grog and sand	6	dark	rough	-	-	-	-	-
O.15	rim till neck	grog and sand	10	dark	rough	-	-	-	-	-
O.16	rim till neck	grog and sand	8.5	light	rough	-	-	-	-	-
O.19	rim till neck?	granite, grog and sand	-	dark	rough	-	-	-	-	-
O.22	rim till shoulder	grog and sand	5.5	dark	smoothened	-	22	-	-	-
O.23	rim till neck	quartz, grog and sand	8	dark	lightly smoothened	-	-	-	-	-
O.24	rim till neck	grog and sand	9	light	rough	-	-	-	-	-
O.25	rim till neck	granite, grog and sand	6.5	dark	lightly smoothened	-	-	-	-	-
O.29	rim till shoulder	grog and sand	8	dark	rough	-	-	-	-	-
O.30	rim till shoulder	grog and sand	7-7.5	dark	rough	-	-	-	-	-
O.31	rim till shoulder	grog and sand	7,5	dark	rough	-	-	-	-	-
O.32	rim till shoulder	granite, grog and sand	7	dark	rough	-	-	-	-	-
O.34	rim till neck	grog and sand	6.5	dark	lightly smoothened	yes; 1 half and 2 attempts	-	-	-	-
O.35	rim till shoulder	grog and sand	6.5	light	rough	-	-	-	-	-
O.36	rim till neck	grog and sand	7.5	light	rough	-	-	-	-	-
O.37	rim till shoulder	granite, grog and sand	8.5	dark	rough	-	-	-	-	-
O.38	rim till shoulder	grog and sand	7.5	light	lightly smoothened	-	-	-	-	-
O.39	rim till neck	grog and sand	-	dark	rough	-	-	-	-	-
O.40	rim till shoulder	grog and sand	5,5	dark	smoothened	-	-	-	-	-
O.41	rim till neck	grog and sand	5	light	smoothened	-	14	-	-	-
O.42	rim till neck	grog and sand	10	light	lightly smoothened	-	-	-	-	-
O.43	rim till shoulder	grog and sand	5	light	smoothened	-	-	-	-	-
O.44	rim till neck	granite red, grog and sand	9.5	dark	smoothened	-	-	-	-	-

Undecorated

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
O.45	rim till neck	granite, grog and sand	-	dark	rough	-	-	-	-	-
O.46	rim till shoulder	grog and sand	7	dark	lightly smoothened	-	-	-	-	-
O.47	rim till shoulder	grog and sand	10.5	dark	rough	-	-	-	-	-
O.48	rim till shoulder	grog and sand	7	dark	rough	-	-	-	-	-
O.49	rim till shoulder	grog and sand	6	dark	rough	-	10	-	-	-
O.50	rim till shoulder	granite red, grog and sand	7	dark	rough	-	-	-	-	-
O.51	rim till neck	granite red, grog and sand	7.5	light	rough	-	-	-	-	-
O.52	rim till shoulder	grog and sand	5.5	dark	lightly smoothened	-	11	-	-	-
O.53	rim till shoulder	grog and sand	7.5	dark	rough	-	-	-	-	-
O.54	rim till shoulder	grog and sand	12	dark	rough	-	11	-	-	-
O.55	rim till shoulder	granite, grog and sand	6,5	light	smoothened	-	-	-	-	-
O.56	rim till shoulder	grog and sand	6	light	lightly smoothened	-	-	-	-	-
O.57	rim till shoulder	grog and sand	8.5	light	lightly smoothened	-	-	-	-	-

Other special sherds

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations
O.A	wall	spatula, herringbone	grog and sand	4.5	dark	lightly smoothened	yes; 1 half
O.A2	wall	spatula	grog and sand	4	dark	lightly smoothened	-
O.B	wall	cord	grog and sand	6	dark	-	yes; 1
O.B2	wall	x	grog and sand	5.5	dark	rough	yes; 1 half
O.C	wall	cord	grog and sand	5.5	dark	-	-
O.C2	wall	fingertip imprints	grog and sand	6.5	dark	rough	-
O.D	wall	spatula, oblique row one direction and cord?	quartz, grog and sand	7	dark	lightly smoothened	-
O.D2	wall	fingertip imprints	grog and sand	9	light	lightly smoothened	-
O.E	wall	spatula	grog and sand	9.5	light	rough	-
O.E2	wall	spatula, oblique row one direction	grog and sand	7.5	dark	-	-
O.E2	wall	spatula, oblique row one direction	grog and sand	-	-	-	-
O.F	wall	fingertip imprints	grog and sand	8	dark	rough	-
O.F2	wall	spatula, oblique row one direction	grog and sand	5	dark	rough	-
O.G	wall	fingertip imprints	grog and sand	8.5	dark	rough	-
O.G2	wall	fingertip imprints	grog and sand	11	dark	rough	-
O.H	wall	cord	grog and sand	-	-	-	-
O.H2	wall	fingertip imprints	grog and sand	7	dark	-	-
O.J	wall	cord	grog and sand	5	dark	-	-
O.J	wall	cord	grog and sand	5.5	dark	-	-
O.J2	wall	spatula, zig zag	grog and sand	6.5	dark	rough	-
O.K2	wall	spatula, oblique row one direction and groove line	grog and sand	6	dark	rough	-
O.L	wall	fingertip imprints	grog and sand	8.5	dark	rough	-
O.L2	wall	spatula, oblique row one direction	grog and sand	6.5	dark	rough	-
O.M	wall	fingertip imprints	grog and sand	8.5	dark	rough	-
O.M2	wall	spatula, herringbone	grog and sand	6	dark	-	-
O.N	wall	spatula, oblique row one direction	grog and sand	5	dark	lightly smoothened	-
O.N2	wall	fingertip imprints	grog and sand	7	dark	rough	-
O.O	wall	spatula	granite, grog and sand	5.5	dark	rough	-
O.O2	wall	fingertip imprints	grog and sand	9.5	dark	rough	-
O.P	wall	spatula, herringbone?	grog and sand	5.5	dark	-	-
O.Q	wall	spatula, oblique row one direction and cord	grog and sand	5	light	rough	-
O.R	wall	spatula, oblique row one direction	grog and sand	4	dark	lightly smoothened	-
O.S	wall	spatula, oblique row one direction?	grog and sand	8	dark	rough	-
O.T	wall	spatula, herringbone and grooved lines	grog and sand	5.5	dark	-	-

Other special sherds

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations
O.U	wall	spatula, oblique row one direction and groove line	grog and sand	5	dark	-	-
O.W	wall	spatula, zig zag	grog and sand	5	dark	-	-
O.X	wall	spatula, oblique row one direction	grog and sand	5.5	dark	-	-
O.Y	wall	spatula, oblique row one direction	grog and sand	6	dark	-	-
O.Z	wall	spatula, zig zag	grog and sand	3.5	light	lightly smoothened	-
O.aa	neck till belly	-	granite, grog and sand	6.5	dark	rough	-

Base

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Diameter of the foot (cm)	Remarks
O.I.	belly and base	grog and sand	-	dark	rough	7	
O.II	belly and base	grog and sand	6.5	dark	rough	-	
O.III	belly and base	grog and sand	3.5	dark	rough	7	
O.IV	base	grog and sand	-	dark	rough	9	
O.V	belly and base	grog and sand	-	dark	rough	6	
O.VI	belly and base?	grog and sand	5.5	dark	smoothened	-	
O.VII	belly and base	grog and sand	9.5-11	dark	smoothened	-	spatula, oblique row one direction
O.VIII	belly and base	grog and sand	10	dark	smoothened	6	
O.IX	belly and base	grog and sand	6	dark	smoothened	-	
O.X	belly and base	grog and sand	5.5	dark	smoothened	-	
O.XI	belly and base	granite, grog and sand	10	dark	lightly smoothened	-	
O.XII	belly and base	grog and sand	13.5	dark	rough	-	
O.XIII	belly and base	quartz, grog and sand	7.5	dark	rough	10	
O.XV	belly and base	grog and sand	-	dark	rough	-	
O.XVI	belly and base	grog and sand	-	dark	rough	-	
O.XVII	base	grog and sand	23	dark	rough	-	
O.XVIII	base	granite, grog and sand	-	dark	rough	-	

Rim diameters

	Diameter of the rim (cm)												
	10	11	12	13	14	15	16	17	18	19	20	21	22
Decorated (n)	2	-	-	2	-	-	1	-	-	-	-	-	-
Undecorated (n)	1	3	-	-	1	-	1	1	1	-	-	-	1

Appendix III: Characteristics of the ceramics of Zeewijk-West south

Decorated

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
8	rim till neck	spatula, herringbone	grog and sand	5.5	dark	-	-	-	-	-	-
10	rim till neck	fingertip imprints	grog and sand	9	dark	-	-	-	-	-	-
11	rim till neck	spatula, herringbone	grog and sand	7	dark	-	-	-	-	-	-
12	rim till shoulder, belly till base	spatula, oblique row one direction	grog and sand	5	light and dark	rough	yes	13	14.5?	6	15.5?
13	rim till belly	spatula, herringbone	grog and sand	6-7	dark	-	-	13	-	-	-
15	rim till shoudler and belly	spatula, zig zag	grog and sand	6-6.5	dark	rough	yes	15.5	-	-	-
16	rim till shoulder	cord imprints	grog and sand	6.5	dark	lightly smoothened	-	-	-	-	-
17	rim till belly	cord imprints	grog and sand	6.5	dark	lightly smoothened	-	-	-	-	-
20	rim till shoulder and belly	cord imprints	grog and sand	5.5-7.5	dark	-	-	-	-	-	-
21	rim till shoulder	spatula, zig zag	grog and sand	4.5	dark	lightly smoothened	-	-	-	-	-
22	rim till shoudler and belly	spatula, zig zag	grog and sand	6	dark	rough	yes	10	-	-	-
24	rim till neck, neck till shoulder	cord imprints	grog and sand	5.5	light	lightly smoothened	-	-	-	-	-
26	rim till shoulder	cord imprints	grog and sand	6	dark	-	-	-	-	-	-
27	rim till neck and belly	spatula, oblique row one direction	grog and sand	7.5-8	dark	rough	-	16	-	-	-
39	rim till shoulder and belly	spatula, herringbone	grog and sand	4.5-7	dark	lightly smoothened	-	9	-	-	-
54	rim till neck and belly	cord imprints	grog and sand	4.5-6	light	-	-	-	-	-	-
55	rim till neck	cord imprints	grog and sand	5	dark	-	-	-	-	-	-
56	rim till neck	cord imprints	grog and sand	5.5	dark	-	-	-	-	-	-
57	rim till neck	cord imprints	grog and sand	5.5	dark	-	-	9	-	-	-
60	rim till neck	spatula, oblique row one direction	grog and sand	9	dark	-	-	-	-	-	-
62	rim till neck	spatula, oblique row one direction?	grog and sand	6.5	dark	-	-	-	-	-	-
63	rim till neck	spatula, oblique row one direction?	grog and sand	6.5	light	rough	-	-	-	-	-
64	rim till neck and belly	cord imprints	grog and sand	4-5	dark	-	-	-	-	-	-
66	rim till neck	fingertip imprints	grog and sand	7.5	dark	-	-	-	-	-	-
84	rim till shoulder	cord imprints	grog and sand	4	dark	rough	-	10	-	-	-

Decorated

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
123	rim till belly	cord imprints, half	sand	4-5	dark	lightly smoothened	-	14	17	-	-
124	rim till belly, belly till base	cord imprints, all over	grog and sand	3.5-4.5	light and dark	-	-	11.5	-	4	11.5
131	rim till belly, belly till base	cord and spatula imprints	grog and sand	4-7.5	light and dark	-	yes	13.5	16	8	20

Undecorated

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
1	rim till neck	mica and grog	9	dark	rough	yes	19	-	-	-
2	rim till neck, belly till base	grog and sand	5-9	dark	rough	yes	14	-	-	-
3	rim till shoulder	grog and sand	7	dark	rough	-	11	-	-	-
4	rim til shoulder and belly	grog and sand	7-8	light	rough	-	-	-	-	-
5	rim till neck and belly	grog and sand	6-8	dark	lightly smoothened	-	21	-	-	-
6	rim till neck and belly	grog and sand	5-7.5	light	lightly smoothened	-	10	-	-	-
7	rim till neck	grog and sand	6.5-7	dark	lightly smoothened	-	16	-	-	-
9	rim till neck	grog and sand	7.5	dark	-	-	-	-	-	-
14	rim till neck, shoulder till bel-ly, belly till base	grog and sand	4-9	light	lightly smoothened	-	7	8	4.5	7.5
19	rim till neck	grog and sand	6	dark	lightly smoothened	-	-	-	-	-
28	rim till shoulder, belly till base	grog and sand	5-8	dark	rough	yes	19	22.5	8	23.5?
30	rim till neck, neck to belly, belly to base	grog and sand	4-9.5	dark	polished	-	12.5	14.5	5	12
52	rim til shoulder and belly	grog and sand	5.5-8	light and dark	smoothened	-	-	-	-	-
53	rim till neck and belly	grog, sand and plant	6-9	light	rough	yes	16	-	-	-
65	rim till neck	grog and sand	6	dark	smoothened	-	-	-	-	-
69	rim till shoulder	granite and sand	7.5	dark	rough	-	-	-	-	-
71	rim til shoulder and belly	grog and sand	5.5-8.5	dark	lightly smoothened	-	-	-	-	-
72	rim till neck	grog and sand	9	dark	rough	-	-	-	-	-
85	rim til shoulder and belly	grog and sand	6-6.5	dark	rough	-	10	-	-	-
86	rim till belly	grog and sand	5-5.5	dark	smoothened	yes	12	-	-	-
87	rim till neck, belly till base	granite and sand	5.5-9	light and dark	rough	yes	-	-	9	-
88	rim till shoulder, belly till base	granite and sand	4.5-7	light and dark	smoothened	yes	15	-	-	-
89	rim till belly	grog and sand	8-11	dark	lightly smoothened	-	-	-	-	-
90	rim till shoulder, belly till base	grog and sand	10-19	dark	rough	-	12	-	7	-
91	rim till belly	grog and sand	7.5	dark	rough	-	18	-	-	-
92	rim till shoulder	grog and sand	7-8	dark	rough	-	11	-	-	-
93	rim till shoulder	grog and sand	7.5	dark	rough	-	-	-	-	-
94	rim till shoulder	grog and sand	8	dark	rough	yes	-	-	-	-
95	rim till shoulder	grog and sand	7.5	dark	rough	yes	12	-	-	-

Undecorated

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
96	rim till shoulder	grog and sand	5.5	dark	smoothened	-	10	-	-	-
97	rim till shoulder	grog and sand	6	dark	lightly smoothened	yes	10	-	-	-
98	rim till neck	grog and sand	8.5	light	rough	-	-	-	-	-
99	rim till shoulder	grog and sand	3.5	light	polished	-	-	-	-	-
100	rim till shoulder	grog and sand	5.5	dark	rough	-	-	-	-	-
101	rim till neck	grog and sand	9	dark	rough	-	-	-	-	-
102	rim till neck	grog and sand	7.5	dark	rough	-	-	-	-	-
103	rim till shoulder	grog and sand	6	dark	rough	-	-	-	-	-
104	rim till neck	grog and sand	5.5	dark	rough	-	-	-	-	-
105	rim till shoulder	grog and sand	4-5	dark	smoothened	yes	11	-	-	-
106	rim till shoulder	granite, grog, sand and shell	6	light	lightly smoothened	-	13	-	-	-
107	rim till neck	grog and sand	4,5	dark	rough	-	-	-	-	-
108	rim till shoulder	granite, grog and sand	6	dark	rough	-	-	-	-	-
109	rim till shoulder	grog and sand	6	dark	rough	-	-	-	-	-
110	rim till neck	grog and sand	6	dark	lightly smoothened	-	-	-	-	-
111	rim till neck	grog and sand	6.5	light	lightly smoothened	-	-	-	-	-
112	rim till neck and belly	grog and sand	8.5-10	light	smoothened	-	-	-	-	-
113	rim till neck and belly	grog and sand	6-7.5	dark	smoothened	-	-	-	-	-
114	rim till neck	granite, grog and sand	6.5	dark	smoothened	-	-	-	-	-
115	rim till shoulder	granite, grog and sand	7-8.5	dark	rough	-	-	-	-	-
116	rim til shoulder and belly	grog and sand	4-5.5	dark	smoothened	-	-	-	-	-
117	rim till shoulder	grog and sand	8-8.5	dark	lightly smoothened	-	-	-	-	-
118	rim till neck and belly	grog and sand	7.5-8.5	light	rough	-	-	-	-	-
119	rim til shoulder and belly	grog and sand	4.5-5.5	dark	smoothened	-	9	-	-	-
120	rim till neck	grog and sand	8	dark	lightly smoothened	-	-	-	-	-
121	rim till neck and belly	grog and sand	4.5	light	lightly smoothened	-	-	-	-	-
122	rim till neck and belly	grog and sand	7.5-8	light	rough	-	-	-	-	-
155	rim till neck and belly	grog and sand	7.5-8.5	dark	rough	-	-	-	-	-

Other special sherds

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations
A2	wall	cord imprints	grog and sand	5.5-6	dark	lightly smoothened and rough	-
B	wall	-	grog and sand	5.5	dark	rough	yes; 1 half
B2	wall	cord imprints	grog and sand	5	light	rough	-
B3	wall	spatula, oblique row one direction	grog and sand	5.5	dark	rough	-
C	wall	-	grog and sand	7-9	dark	smoothened	yes; 3
C2	wall	cord imprints	grog and sand	3.5	dark	rough	-
C5	wall	cord imprints	grog and sand	6	dark	-	-
D	wall	cord imprints	grog and sand	3.5	dark	-	-
D2	wall	cord imprints	grog and sand	4.5-5	light	rough	-
D3	wall	spatula, zigzag	grog and sand	4.5	light	rough	-
E	wall	cord imprints	grog and sand	5-5.5	light	-	-
E2	wall	spatula, oblique row one direction	grog and sand	5-6	dark	rough	-
E3	wall	fingertip imprints	grog and sand	8	dark	rough	-
F	wall	fingertip imprints	grog and sand	7.5	dark	rough	-
F3	wall	fingertip imprints	grog and sand	7	dark	rough	-
G	wall	spatula, oblique row one direction	grog and sand	5.5	dark	smoothened	-
G3	wall	fingertip imprints	grog and sand	9	dark	rough	-
H	wall	spatula, herringbone	grog and sand	5.5	dark	lightly smoothened	-
I	wall	?	grog and sand	7	dark	-	-
I3	wall	fingertip imprints	grog and sand	7	dark	rough	-
J	wall	spatula, oblique row one direction	grog and sand	5.5	dark	lightly smoothened	-
J2	wall	cord imprints	grog and sand	5.5-7	dark	-	-
K	wall	cord imprints	grog and sand	5-6	dark	-	-
K2	wall	-	grog and sand	7.5	dark	-	yes; 1 half
K3	wall	?	grog and sand	6.5	dark	rough	-
L	wall	spatula, zigzag	grog and sand	5.5	dark	lightly smoothened	-
L2	wall	?	grog and sand	7	dark	-	-
L3	shoulder till belly	?	grog and sand	8	light	rough	-
N	wall	cord imprints	grog and sand	5.5	dark	-	-
N3	wall	cord imprints	grog and sand	6.5	light	-	-
O	wall	cord imprints	grog and sand	6	dark	-	-
P	wall	cord imprints	grog and sand	6	dark	lightly smoothened	-
P3	wall	cord imprints	grog and sand	5	light	rough	-
Q	wall	spatula, herringbone	grog and sand	5.5-7	dark	lightly smoothened	-
Q3	wall	cord imprints	grog and sand	6	dark	rough	-
R	wall	spatula, herringbone	grog and sand	5.5-6.5	light	rough	-
R2	wall	spatula, oblique row one direction	grog and sand	6	dark	rough	-

Other special sherds

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations
S	neck till belly	cord imprints	grog and sand	5.5-6	dark	-	-
S2	wall	cord imprints	grog and sand	4.5	light	-	-
S3	wall	spatula, zigzag	grog and sand	5	dark	rough	-
T	wall	cord imprints	grog and sand	5-5.5	light and dark	-	yes; 1
T2	wall	cord imprints	grog and sand	4.5-5.5	light	-	-
U	shoulder till belly	spatula, herringbone	grog and sand	7.5	dark	rough	-
U2	wall	cord imprints	grog and sand	5.5	dark	-	-
U3	wall	-	grog and sand	7,5	light	lightly smoothened	yes; 1 and 1 half
V	wall	cord imprints	grog and sand	5	dark	-	-
V2	wall	cord imprints	grog and sand	6.5	light	-	-
V3	wall	-	grog and sand	7.5	dark	lightly smoothened	yes; 1 and 1 half
W	wall	cord imprints	grog and sand	4.5	dark	-	-
W2	wall	cord imprints	grog and sand	6	dark	-	-
W3	wall	-	grog and sand	8	dark	rough	yes; 1 and 1 half
W4	wall	-	grog and sand	7.5	light	lightly smoothened	yes; 1half
X	wall	cord imprints	grog and sand	4.5	dark	-	-
X2	wall	spatula, zigzag	grog and sand	4.5-5.5	dark	lightly smoothened	-
X3	wall	-	grog and sand	9.5	dark	rough	yes; 2
X4	wall	spatula, oblique row one direction	grog and sand	7	dark	rough	-
Y	wall	cord imprints	grog and sand	5	dark	-	-
Y2	wall	spatula, oblique row one direction	grog and sand	4.5	dark	-	-
Y3	wall	-	grog and sand	-	-	-	yes; 1 half
Y4	wall	spatula, oblique row one direction	grog and sand	4.5	dark	rough	-
Z	wall	cord imprints	grog and sand	6	dark	-	-
Z2	wall	spatula, oblique row one direction	grog and sand	6	dark	lightly smoothened	-
Z4	wall	cord imprints	grog and sand	4	light	-	-
aa	shoulder till belly	-	grog and sand	6.5-7	dark	rough	-
bb	wall	-	grog and sand	9.5-11	dark	rough	-
cc	wall	-	grog and sand	4-4.5	dark	lightly smoothened to polished	yes; 1

Base

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Diameter of the base (cm)	Remarks
I.	belly till base	grog and sand	6	dark	smoothened	-	
II	belly till base	grog and sand	7	dark	-	8	cord imprints, all over
III	belly till base	grog and sand	5.5	dark	rough	8	
III	belly till base	grog and sand	8	dark	lightly smoothened	-	
IX	belly till base	grog and sand	7.5	dark	-	5	cord imprints, all over
VI	belly till base	grog and sand	7.5-8.5	dark	smoothened	-	
VII	belly till base	granite, grog and sand	13	dark	smoothened	8	
VIII	belly till base	grog and sand	6	dark	lightly smoothened	7	
XII	belly till base	grog and sand	-	-	lightly smoothened	-	
XIII	belly till base	grog and sand	8.5	dark	rough	-	
XIV	belly till base	grog and sand	9.5-10	dark	lightly smoothened	-	
XIX	belly till base	grog and sand	7-9	dark	rough	9	
XV	belly till base	grog and sand	7-9	light and dark	rough	6	
XVI	base	grog and sand	13	dark	rough	11	
XVII	belly till base	grog and sand	9.5	dark	rough	-	
XX	belly till base	red granite, grog and sand	6-8.5	dark	lightly smoothened	6	
XXI	belly till base	grog and sand	7-9	light	rough	-	
XXII	belly till base	grog and sand	11	dark	rough	-	
XXIII	belly till base	grog and sand	9.5-11	dark	rough	7?	
XXV	belly till base	grog and sand	-	-	rough	6	
XXVI	belly till base	grog and sand	-	-	rough	-	
XXVII	belly till base	grog and sand	6.5-8	-	rough	6	
XXVIII	belly till base	grog and sand	6.5-8	dark	rough	-	
XXXIV	belly till base	grog and sand	9	dark	rough	7	cord imprints, all over

Rim diameters

	Diameter of the rim (cm)																			
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Decorated (n)	-	-	2	2	-	1	2	2		2	-	-	-	-	-	-	-	-	-	-
Undecorated (n)	1	-	1	4	3	3	2	1	1	2	-	1	2	-	1	-	-	-	-	-

Appendix IV: Characteristics of the ceramics of Zeewijk-West north

Decorated

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circum-ference (cm)	Diameter of the base (cm)	Height (cm)
25	rim till shoulder, shoulder till belly	fingertip imprints	grog and sand	8.5-12	dark	rough	-	26	-	-	-
36	rim till shoulder	spatula, oblique row one direction	grog and sand	6	dark	smoothened	-	-	-	-	-
38	rim till shoulder	cord imprints	granite, grog and sand	6	dark	lightly smoothened	-	-	-	-	-
44	rim till neck and belly	spatula, oblique row one direction	grog and sand	4-5.5	light	lightly smoothened	-	-	-	-	-
46	rim till neck	fingertip imprints	quartz, grog and sand	11	-	rough	-	-	-	-	-
50	rim till shoulder and belly	cord imprints	grog and sand	4.5-6	light	rough	-	8	-	-	-
51	rim till neck	spatula, oblique row one direction	grog and sand	5.5	dark	-	-	-	-	-	-
58	rim till shoulder and belly	spatula, oblique row one direction	grog and sand	5.5-6	dark	lightly smoothened	-	19	-	-	-
59	rim till neck	spatula, oblique row one direction	grog and sand	8	dark	-	-	-	-	-	-
82	rim till shoulder	fingertip imprints	granite and sand	6-6.5	dark	rough	-	-	-	-	-
83	rim till shoulder	spatula, zig zag	granite, grog and sand	10	dark	rough	-	11	-	-	-
128	rim till neck	spatula, oblique row one direction?	sand	7.5	dark	smoothened	-	-	-	-	-
129	rim till neck	spatula, herringbone	sand	8	dark	smoothened	-	-	-	-	-
139	rim till shoulder	spatula, zig zag	grog and sand	6	dark	rough	-	-	-	-	-
140	rim till shoulder	spatula, zig zag	grog and sand	7	dark	rough	-	-	-	-	-
142	rim till neck	fingertip imprints	granite and sand	8	light	rough	-	-	-	-	-
143	rim till neck	fingertip imprints	grog and sand	14	dark	rough	-	-	-	-	-
147	rim till shoulder and belly	fingertip imprints	granite and sand	7-8	dark	rough	-	-	-	-	-
151	rim till neck	spatula, zig zag?	grog and sand	6	dark	rough	-	-	-	-	-
153	rim till neck	fingertip imprints	grog and sand	9.5	dark	rough	-	-	-	-	-
154	rim till neck	cord imprints	x	4.5	dark	polished	-	12	-	-	-
156	rim till shoulder and belly	cord imprints	grog and sand	4.5-6	dark	rough	-	16	-	-	-
157	rim till shoulder	spatula, oblique row one direction	grog and sand	8	light	rough	yes	23	-	-	-
160	rim till shoulder	spatula, zig zag	grog and sand	7	dark	rough	-	-	-	-	-
161	rim till neck	fingertip imprints	grog and sand	7	dark	rough	-	-	-	-	-
162	rim till neck	spatula, oblique row one direction	grog and sand	6	dark	rough	-	-	-	-	-

Undecorated

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
32	rim till shoulder	granite	7.5	dark	lightly smoothened	-	-	-	-	-
33	rim till neck	grog and sand	7.5	dark	smoothened	-	-	-	-	-
34	rim till neck and belly	grog and sand	7-8	light and dark	lightly smoothened	yes	-	-	-	-
35	rim till shoulder	granite	8	dark	smoothened	yes	-	-	-	-
37	rim till shoulder	grog and sand	5	dark	lightly smoothened	-	10	-	-	-
40	rim till neck, neck till belly	grog and sand	11	dark	rough	yes	17	-	-	-
41	rim till neck and belly	quartz, grog and sand	7.5-11	light	rough	-	-	-	-	-
42	rim till shoulder and belly	grog and sand	6.5-8	dark	rough	-	-	-	-	-
43	rim till shoulder	grog and sand	5	dark	rough	yes	-	-	-	-
45	rim till neck	grog and sand	7.5	dark	rough	-	-	-	-	-
47	rim till shoulder	grog and sand	6.5	light	lightly smoothened	-	-	-	-	-
48	rim till neck	quartz, grog and sand	6.5	light	rough	-	-	-	-	-
49	rim till shoulder and belly	grog and sand	3.5-5	dark	lightly smoothened	-	9	-	-	-
67	rim till shoulder and belly	granite and sand	6-9	dark	rough	-	-	-	-	-
68	rim till neck	granite and sand	8.5	dark	rough	-	-	-	-	-
70	rim till neck	granite, grog and sand	8	dark	lightly smoothened	-	14	-	-	-
73	rim till neck	grog and sand	6	dark	rough	yes?	15	-	-	-
74	rim till shoulder and belly	granite, grog and sand	5-8	dark	rough	-	-	-	-	-
75	rim till shoulder	grog and sand	6	dark	lightly smoothened	-	-	-	-	-
76	rim till shoulder	grog and sand	6.5	light	rough	-	-	-	-	-
77	rim till shoulder	grog and sand	5	dark	rough	-	-	-	-	-
78	rim till shoulder	grog and sand	6	dark	smoothened	-	12	-	-	-
79	rim till neck	grog and sand	6.5	light	rough	-	-	-	-	-
80	rim till shoulder and belly	grog, sand and plant	8-11	dark	rough	-	-	-	-	-
81	rim till neck, neck till belly	grog and sand	5.5-7.5	dark	lightly smoothened	-	-	-	-	-
125	rim till shoulder	grog and sand	8	dark	rough	-	15	-	-	-
126	rim till shoulder	granite and sand	7.5	light	lightly smoothened	-	-	-	-	-
127	rim till neck	granite and sand	8	dark	rough	-	-	-	-	-
130	rim till neck, belly till base	grog and sand	8-9	dark	rough	-	14	-	7	-
132	rim till shoulder	grog and sand	6.5	dark	rough	-	-	-	-	-

Undecorated

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
133	rim till shoulder	grog and sand	5.5	dark	smoothened	-	9	-	-	-
134	rim till shoulder	grog and sand	6	light	smoothened	-	19	-	-	-
135	rim till shoulder	grog and sand	5.5	light	rough	-	8	-	-	-
136	rim till shoulder	grog and sand	7	dark	lightly smoothened	-	-	-	-	-
137	rim till neck	grog and sand	8	light	rough	-	-	-	-	-
138	rim till neck and belly	grog and sand	7.5-9	dark	lightly smoothened	-	-	-	-	-
141	rim till neck	granite, grog and sand	11	dark	rough	-	-	-	-	-
144	rim till shoulder	grog and sand	7.5	dark	rough	-	-	-	-	-
145	rim till shoulder	grog and sand	9.5	dark	rough	-	-	-	-	-
146	rim till shoulder and belly	grog and sand	5.5-6	dark	smoothened	-	11	-	-	-
148	rim till shoulder	grog and sand	7	light	rough	-	-	-	-	-
149	rim till shoulder	grog and sand	7.5	dark	rough	-	-	-	-	-
150	rim	grog and sand	14	dark	rough	-	-	-	-	-
152	rim till shoulder and belly	granite, grog and sand	7-9	dark	lightly smoothened	-	-	-	-	-
158	rim till shoulder	grog and sand	8.5	dark	rough	-	-	-	-	-
159	rim till neck	grog and sand	7.5	dark	rough	-	-	-	-	-
163	rim till neck	grog and sand	6	light	-	-	-	-	-	-
164	rim till neck	grog and sand	7.5	light	rough	-	-	-	-	-

Other special sherds

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations
A	wall	-	grog and sand	5.5	dark	rough	yes; 1 half
A3	wall	spatula, oblique row one direction	grog and sand	7	dark	rough	-
A4	wall	spatula, herringbone	grog and sand	5.5	dark	-	-
A5	wall	spatula, oblique row one direction	grog and sand	6.5	dark	-	-
B4	wall	spatula, oblique row one direction	grog and sand	6.5	dark	rough	-
B5	wall	spatula, oblique row one direction	grog and sand	6.5	dark	rough	-
C3	wall	spatula, herringbone	grog and sand	6.5	dark	rough	-
C4	wall	cord imprints	grog and sand	6	dark	-	-
D4	wall	cord imprints	sand	5.5	dark	-	-
D5	wall	fingertip imprints	grog and sand	10	-	rough	-
E4	wall	cord imprints	sand	4	dark	lightly smoothened	-
F2	wall	spatula, oblique row one direction	grog and sand	6.5	dark	rough	yes; 1 half
F4	wall	cord imprints	sand	5.5-6	dark	lightly smoothened	-
G4	wall	lines, pattern?	grog and sand	5	dark	smoothened	-
H2	wall	spatula, zig zag	grog and sand	5.5	dark	smoothened	-
H4	wall	-	grog and sand		dark	lightly smoothened	yes; 1 half
I2	wall	fingertip imprints	grog and sand	9.5	light	lightly smoothened	-
I4	wall	-	grog and sand	5.5	dark	lightly smoothened	yes; 1
J4	wall	cord imprints	sand	4.5	dark	-	-
K4	wall	cord imprints	grog and sand	5.5	light	-	-
L4	wall	cord imprints	grog and sand	5	light	rough	-
M	wall	cord imprints	grog and sand	4	dark	-	-
M2	wall	-	quartz, grog and sand	7	dark	rough	yes; 1 half
M3	wall	fingertip imprints	grog and sand	10	dark	rough	-
M4	wall	-	grog and sand	6-6.5	dark	rough	-
N2	wall	-	grog and sand	7	dark	rough	yes; 2 half
N4	wall	spatula, herringbone	grog and sand	5	dark	-	-
O2	wall	fingertip imprints	grog and sand	8	dark	-	-
O3	wall	fingertip imprints	grog and sand	8	dark	rough	-
O4	wall	fingertip imprints	granite and sand	9.5	dark	rough	-
P2	wall	spatula, herringbone	grog and sand	8	dark	rough	-
P4	wall	fingertip imprints	grog and sand	11	dark	rough	-
Q2	wall	cord and spatula	grog and sand	4.5	light	-	-
Q4	wall	-	grog and sand	8	dark	rough	yes; 1 half
R3	wall	cord imprints	grog and sand	6	dark	rough	-
R4	wall	-	grog and sand	6.5	dark	rough	yes; 1 half
S4	wall	fingertip imprints	granite and sand	7.5-8	dark	rough	-
T	wall	?	grog and sand	5	dark	-	-

Other special sherds

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations
T3	wall	spatula	grog and sand	6	dark	rough	-
T4	wall	cord imprints	grog and sand	5-6	dark	rough	-
U4	wall	fingertip imprints	grog and sand	7	light	lightly smoothened	-
V4	wall	cord imprints	grog and sand	5.5	light	-	-
Z3	wall	spatula, herringbone	granite and sand	6-6.5	dark	-	-
gg	wall	-	quartz, grog and sand	9.5-11	dark	lightly smoothened	-

Base

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Diameter of the base (cm)
IV	belly till base	grog and sand	9	dark	rough	6
V	base	grog and sand	9	dark	rough	6
X	base	grog and sand	5.5	light	rough	x
XI	belly till base	grog and sand	8.5	dark	rough	10
XXIX	belly till base	grog, sand and plant	14	light	rough	5
XXX	belly till base	grog and sand	19	dark	rough	6
XXXI	belly till base	grog and sand	4.5	dark	rough	6
XXXII	belly till base	grog, sand and shell	10	dark	lightly smoothened	x
XXXIII	belly till base	grog and sand	13-14	light	rough	10

Rim diameters

	Diameter of the rim (cm)																			
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Decorated (n)	-	1	-	-	1	1	-	-	-	1	-	-	1	-	-	-	-	-	-	1
Undecorated (n)	-	1	2	1	1	1	-	2	2	-	1	-	1	-	-	-	-	-	-	-

Appendix V: Characteristics of the ceramics of Zeewijk-West location unknown

Decorated

Vessel number	Vessel part	Decoration	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
Both areas											
29	rim till neck, belly till base	spatula, oblique row one direction and grooved lines all over	grog and sand	4-11	light and dark	rough	yes	12	-	6	15.5?
Location unknown											
18	rim till shoulder	cord imprints	grog and sand	5	dark	lightly smoothened	-	-	-	-	-
61	rim till neck	spatula, oblique row one direction	grog and sand	6	dark	lightly smoothened	-	9	-	-	-

Undecorated

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Perforations	Diameter of the rim (cm)	Diameter of the greatest belly circumference (cm)	Diameter of the base (cm)	Height (cm)
165	rim till belly	grog and sand	7.5-?	dark	rough	yes	15.5	-	-	-

Base

Vessel number	Vessel part	Tempering	Thickness (mm)	Outside colour	Surface treatment outside	Diameter of the base (cm)
XVIII	4-5	grog and sand	7.5-9	dark	lightly smoothened	11
XXIV	4-5	grog and sand	5-6.5	dark	lightly smoothened	7

Appendix VI: ^{14}C dates for the ceramics from the different sites and areas

Undecorated

Group	Furholt plateau *	Date	$\Delta^{13}C$	Calibrated 1σ	Calibrated 2σ	Reference no	Site	Dated material
2	D	4130 ± 60	Unknown	2866-2620	2884-2500	GrA-48396	Keinsmerbrug	mixed botanical
1	D	4150 ± 30	-24.97	2868-2670	2876-2626	GrA-113	Zeewijk-West (south lowest layers)	charred reed
2	D	4140 ± 40	-24.49	2866-2632	2876-2584	GrA-114	Zeewijk-West (north top layers)	charred twigs
1	D	4130 ± 40	-25.36	2862-2624	2872-2580	GrA-108	Mienakker	charred reed
1	D	4100 ± 40	-26.04	2850-2578	2871-2498	GrA-56014	Zeewijk-West (south)	charred residue
1	D	4120 ± 30	-22.73	2856-2623	2866-2578	GrA-110	Mienakker	charred reed
1	D	4100 ± 30	-23.08	2840-2578	2863-2502	GrA-109	Mienakker	charred reed
1	D/E/F	4010 ± 50	-18.35	2578-2471	2840-2348	GrA-15698	Mienakker	bone, rib
1	D/E	4030 ± 40	-26.15	2580-2481	2836-2467	GrA-56013	Zeewijk-West (south)	charred residue
2	D/E	4025 ± 40	-25.31	2578-2482	2834-2466	GrA-47383	Keinsmerbrug	grain
2	D/E	4000 ± 40	-23.90	2569-2474	2831-2356	GrA-47380	Keinsmerbrug	mixed botanical
2	E	3995 ± 40	-26.17	2569-2472	2624-2351	GrA-47381	Keinsmerbrug	grain
1	E	4030 ± 30	-23.36	2578-2490	2623-2472	GrA-112	Zeewijk-West (south top layers)	charred reed
1	E	3975 ± 40	-23.32	2568-2464	2580-2346	GrA-56044	Mienakker	grain
2	E	3970 ± 40	-24.63	2570-2461	2579-2345	GrA-47377	Keinsmerbrug	mixed botanical
2	E/F	3965 ± 40	-28.56	2570-2410	2577-2344	GrA-47382	Keinsmerbrug	grain
2	E/F	3910 ± 50	-27.09	2470-2309	2565-2208	GrN-18488	Zeewijk-East	wooden post, outermost 4-6 rings
	E/F	3925 ± 40	-20.85	2474-2346	2564-2290	GrN-15565	Zeewijk-West	bone

* Furholt plateau (1σ): D: 2880-2580 BC; E: 26202480 BC; F: 2460-2200 BC (Furholt 2003).

Group	Location	Related ceramics	Problems
2	Feature 1003, possible well	none	no ceramics
1	Square 14333, layer 7	in this square different vessels are found, Vessel 15 (ZZ, kayer 1 and 5), vessel 87, (undecorated, layer 6 and 7), vessel 123 (1a, layer 4), vessel C (perforated, layer 5), vessel VIII (undecorated foot, layer 6). Relation with dated reed?	association
2	Square 23982, creek filling, highest layer	Vessel 157 (1e, layer 1), vessel S4 (Golfband like, layer 1, 2) vessel T4 (1a/2IIb, layer 2) in lower layers other vessels and types are found	association
1	Square 1632, feature 35	in square only grit	association
1	sherds of this vessel have been found in squares 1557, 1757, 1816, 1821, 1824	Vessel 13 herringbone decoration	
1	Square 1632, feature 110	in square only grit	association
1	Square 1632, feature 110	in square only grit	association
1	burial, feauture 54	none	no ceramics
1	Sherds of this vessel have been found in squares 1305, 1309, 1311, 1369, 1374, 1474, 1629, 1753, 1882	Vessel 30, early Veluwe shape?	
2	Square 416, far north, area possible associated with cereal threshing	one sherd, thick walled tempered with red granite and grog	
2	Square 127, hearth area	one im sherd, vessel 11, undecorated quartz and grog tempered	
2	Square 178, possible domestic activities, related to plant processing	no ceramics found in this square	association
1	Square 14333, layer 3	in this square different vessels are found, Vessel 15 (ZZ, layer 1 and 5), vessel 87, (undecorated, layer 6 and 7), vessel 123 (1a, layer 4), vessel C (perforated, layer 5), vessel VIII (undecorated foot, layer 6). Relation with dated reed?	association
1	Feature 120, concentration of grain	no ceramics found in this square	association
2	Square 82, trample zone, northern structure	no ceramics found in this square	association
2	Square 287, area 6, southern structure	no ceramics found in this square	association
2	large structure	no direct association	association
	location unknown	unknown	association

Appendix VII: Botanical macro-remains

Botanical macro-remains

Trench/square number		22032	18782	18782	22034	22704	18782	20113	22704	21984	23931	22034
Serial number		4	9	6	2	?	5	7	?	7	102	3
Feature		7	31	5	3	69	5	24	55	18	?	16
Context/location		WIIIB	W3D	W3D	WIIIB	W	W3D	WIIIB	W	W30	WIV	WIIIB
Taxon (all remains are charred unless marked as uncharred or mineralized)												
Cereals and other crop/used plants												
Hordeum vulgare var. nudum	grain	12	65	59	53	43	38	4	12	6	16	8
	rachis internodes	-	89	38	44	20	23	2	7	4	9	16
	basal rachis segments	-	-	-	-	-	-	-	-	-	-	1
Triticum dicoccon	grain	19	26	45	25	57	25	-	2	12	8	11
	glume base	86	167	270	260	250	68	23	38	79	19	92
	spiklet forks	45	126	120	104	193	65	7	12	32	11	28
	basal rachis segments	-	-	-	-	5	-	-	-	4	1	6
Triticum dicoccon	processed emmer food	-	-	-	-	-	-	-	-	-	-	-
Cerealia (cf), straw	culm frg	++	++	++	++	++	+	-	++	-	+	+
Corylus avellana	nut-shell	2frg	3frg	2frg	8frg	-	1frg	-	-	-	-	-
Linum usitatissimum		2	-	7	-	-	1	-	-	-	8	-
Linum usitatissimum (m)		-	-	-	-	-	-	-	-	-	24	-
Linum	fibres (cordage/string)	-	-	-	-	-	-	-	1frg	-	-	-
Quercus	acorn	-	-	-	-	-	1frg	-	1frg	-	-	-
Malus sylvestris	fruit parenchyma	-	-	-	-	-	-	-	-	-	-	-
Salt marsh												
Agrostis/Poa		-	-	-	-	-	-	-	-	-	-	-
Althaea officinalis		78	4	5	1	-	-	1	-	2	-	-
Althaea officinalis (m)		-	-	-	-	-	-	-	-	-	78	-
Aster tripolium		-	-	-	3	-	-	-	-	-	-	-
Atriplex littoralis type		c.175	35	1	4	-	12	2	-	4	-	2
Atriplex portulacoides		65	-	14	1	2	-	-	-	1	-	1
Beta vulgaris (subsp. maritima)	perianth	-	-	-	-	-	-	1	-	-	-	-
Bolboschoenus maritimus		6	9	15	3	-	5	-	-	-	-	-
Bolboschoenus maritimus	tuber	2frg	-	-	-	-	-	4frg	-	-	-	-
Carex distans		-	1	-	-	1	-	-	-	-	-	-
Carex distans (un-ch)		-	-	-	-	-	-	-	-	-	-	-
Festuca/Lolium		2	1	2	-	-	-	-	-	-	-	-
Hordeum marinum		-	2	3	-	-	-	-	-	-	-	-
Puccinellia distans		-	-	-	-	-	-	-	-	-	-	-
Salicornia europaea		-	-	-	-	-	-	-	1	-	1	-
Suaeda maritima		1	-	1	-	-	-	-	-	-	-	1

(+): 2-10; +: 11-50; ++: 51-100; +++: >100

Trench/square number		25223	2327	18782	22034	24573	24574	22704	20503	22993
Serial number		**103**	**?**	**6**	**5**	**3**	**3**	**?**	**13**	**6**
Feature		**103**	**?**	**5**	**7**	**16**	**16**	**41**	**129**	**237**
Context/location		**filling of the pit (north-east part)**	**fill north-east quadrant of pit**	**WIIID**	**WIIIB**	**WIV**	**WIV**	**W**	**EII**	**EII**
Taxon (all remains are charred unless marked as uncharred or mineralized)										
Cereals and other crop/used plants										
Hordeum vulgare var. nudum	grain	12	28	120	35	-	8	8	-	3
	rachis internodes	-	8	175	15	-	2	9	-	4
	basal rachis segments	-	-	5	-	-	-	-	-	-
Triticum dicoccon	grain	12	64	75	45	56	92	12	1	9
	glume base	82	230	c.400	362	225	62	52	-	59
	spiklet forks	34	175	105	50	48	54	21	-	24
	basal rachis segments	-	2	3	4	1	-	-	-	-
Triticum dicoccon	processed emmer food	-	-	-	1 lump	-	-	-	-	-
Cerealia (cf), straw	culm frg	++	+	++	+	-	-	'-	+	+
Corylus avellana	nut-shell	-	-	-	-	-	-	-	-	-
Linum usitatissimum		-	1	18	-	-	-	-	-	-
Linum usitatissimum (m)		-	-	-	-	-	-	-	-	-
Linum	fibres (cordage/string)	-	-	-	-	-	-	-	-	-
Quercus	acorn	-	-	-	-	-	-	2frg	-	-
Malus sylvestris	fruit parenchyma	-	-	-	-	-	-	1frg	-	-
Salt marsh										
Agrostis/Poa		-	-	-	3	-	-	-	-	-
Althaea officinalis		4	4	-	16	3	-	-	1	-
Althaea officinalis (m)		-	-	-	-	-	-	-	-	-
Aster tripolium		-	-	-	-	-	-	-	-	-
Atriplex littoralis type		32	34	-	4	8	3	3	-	4
Atriplex portulacoides		2	2	-	-	-	-	-	-	-
Beta vulgaris (subsp. maritima)	perianth	-	-	-	-	-	-	-	-	-
Bolboschoenus maritimus		-	-	24	-	2	1	1	1	-
Bolboschoenus maritimus	tuber	-	-	-	-	-	8frg	-	-	2frg
Carex distans		1	-	-	-	-	-	-	-	-
Carex distans (un-ch)		-	-	1	-	-	-	-	-	-
Festuca/Lolium		1	-	-	-	-	-	1	-	1
Hordeum marinum		2	-	6	-	-	-	-	-	-
Puccinellia distans		-	-	-	-	1	-	-	-	-
Salicornia europaea		-	-	-	-	1	-	2	-	-
Suaeda maritima		-	-	1	-	-	-	-	-	-

Botanical macro-remains

Trench/square number		**22032**	**18782**	**18782**	**22034**	**22704**	**18782**	**20113**	**22704**	**21984**	**23931**	**22034**
Serial number		**4**	**9**	**6**	**2**	**?**	**5**	**7**	**?**	**7**	**102**	**3**
Feature		**7**	**31**	**5**	**3**	**69**	**5**	**24**	**55**	**18**	**?**	**16**
Context/location		**WIIIB**	**W3D**	**W3D**	**WIIIB**	**W**	**W3D**	**WIIIB**	**W**	**W30**	**WIV**	**WIIIB**
Fresh water marshes/backswamps												
Carex otrubae		-	-	-	-	-	-	-	-	-	-	-
Cladium mariscus		-	-	-	-	-	-	-	-	-	-	-
Phragmites, culm frg	culm frg	+	++	+	-	+	-	-	+	-	+	-
Ranunculus lingua		-	-	-	-	-	-	-	-	-	-	1
Schoenoplectus tabernaemontani		-	1	-	5	-	-	-	-	-	-	-
Weeds/waste places												
Atriplex patula/prostrata		>250	c.150	c.75	26	30	25	8	-	32	-	-
Atriplex patula/prostrata (un-ch)		-	-	-	-	-	-	-	-	-	-	-
Carduus/Cirsium		1	-	-	7	-	-	-	-	-	-	1
Chenopodium album		-	-	-	-	1	1	-	-	-	-	-
Chenopodium album (un-ch)		-	12	46	4	-	-	-	-	-	-	-
Persicaria lapathifolia		-	-	-	1	-	-	-	-	-	-	-
Polygonum aviculare		-	-	-	-	-	1	-	-	-	-	-
Rumex crispus type		-	-	-	2	-	-	-	-	-	-	-
Solanum nigrum		-	-	-	3	-	-	-	-	-	-	-
Solanum nigrum (un-ch)		-	-	-	-	-	-	-	-	-	-	-
Open, moist and enriched soils												
Chenopodium ficifolium (un-ch)		-	9	-	7	-	-	-	-	-	-	-
Chenopodium ficifolium		-	-	-	-	-	-	-	-	-	-	-
Open, dry and enriched soils												
Hyoscyamus niger (un-ch)		-	-	-	-	-	-	-	-	-	-	-
Moist, nutrient rich grasslands												
Ranunculus acris/repens, cf.		-	1	-	-	-	-	-	-	-	-	-
Water plants												
Potamogeton natans		-	-	-	1	-	-	-	-	-	-	-
Sparganium erectum		-	-	-	2	-	-	-	-	-	-	-

(+): 2-10; +: 11-50; ++: 51-100; +++: >100

Trench/square number		25223	2327	18782	22034	24573	24574	22704	20503	22993
Serial number		103	?	6	5	3	3	?	13	6
Feature		103	?	5	7	16	16	41	129	237
Context/location		filling of the pit (north-east part)	fill north-east quadrant of pit	WIIID	WIIIB	WIV	WIV	W	EII	EII
Fresh water marshes/backswamps										
Carex otrubae		1	-	-	-	-	-	-	-	-
Cladium mariscus		-	-	-	2	-	-	-	-	-
Phragmites, culm frg	culm frg	-	+	++	++	+	-	-	+	+
Ranunculus lingua		-	-	-	-	-	-	-	-	-
Schoenoplectus tabernaemontani		-	-	-	-	1	-	-	-	-
Weeds/waste places										
Atriplex patula/prostrata		91	25	c.90	c.200	-	6	25	-	9
Atriplex patula/prostrata (un-ch)		-	-	-	-	-	-	-	-	+
Carduus/Cirsium		-	-	-	-	-	-	-	-	-
Chenopodium album		-	-	-	1	-	-	-	-	-
Chenopodium album (un-ch)		-	-	++	-	-	-	-	-	+
Persicaria lapathifolia		-	-	2	-	1	-	-	-	-
Polygonum aviculare		2	-	1	-	-	-	-	-	-
Rumex crispus type		-	-	-	-	-	-	-	1	-
Solanum nigrum		-	-	-	-	-	-	-	1	-
Solanum nigrum (un-ch)		-	-	2	-	-	-	-	-	-
Open, moist and enriched soils										
Chenopodium ficifolium (un-ch)		-	-	++	-	-	-	-	-	+
Chenopodium ficifolium		-	-	-	-	-	-	-	2	-
Open, dry and enriched soils										
Hyoscyamus niger (un-ch)		-	-	1	-	-	-	-	-	-
Moist, nutrient rich grasslands										
Ranunculus acris/repens, cf.		-	-	-	-	-	-	-	-	-
Water plants										
Potamogeton natans		1	-	-	-	-	-	-	-	-
Sparganium erectum		-	-	-	-	-	-	-	-	-

Botanical macro-remains

Trench/square number		22032	18782	18782	22034	22704	18782	20113	22704	21984	23931	22034
Serial number		4	9	6	2	?	5	7	?	7	102	3
Feature		7	31	5	3	69	5	24	55	18	?	16
Context/location		WIIIB	W3D	W3D	WIIIB	W	W3D	WIIIB	W	W30	WIV	WIIIB
Ecologically indeterminate												
Carex		-	-	-	1	-	-	-	-	-	-	-
Poaceae		-	-	-	-	-	-	-	-	-	-	-
Bromus		-	-	-	-	-	-	1frg	-	-	3	-
Diverse												
Charcoal		+	+	++	+	+	+	+	(+)	+	+	+
Root/tuber parenchyma indet.		-	-	-	-	-	-	-	2frg	-	-	-
Pottery with crust		-	+	-	+	-	-	-	-	-	-	-
Shells		++	+++	-	-	++	-	+	-	-	-	-

(+): 2-10; +: 11-50; ++: 51-100; +++: >100

Trench/square number		**25223**	**2327**	**18782**	**22034**	**24573**	**24574**	**22704**	**20503**	**22993**
Serial number		**103**	**?**	**6**	**5**	**3**	**3**	**?**	**13**	**6**
Feature		**103**	**?**	**5**	**7**	**16**	**16**	**41**	**129**	**237**
Context/location		**filling of the pit (north-east part)**	**fill north-east quadrant of pit**	**WIIID**	**WIIIB**	**WIV**	**WIV**	**W**	**EII**	**EII**
Ecologically indeterminate										
Carex		-	-	-	-	-	-	-	-	-
Poaceae		-	-	1	-	-	-	-	-	-
Bromus		-	-	-	-	-	-	-	-	-
Diverse										
Charcoal		+	+	++	+	+	(+)	(+)	(+)	+
Root/tuber parenchyma indet.		-	1frg	1frg	-	-	-	-	-	-
Pottery with crust		-	-	-	-	-	-	-	-	-
Shells		+++	+++	-	-	-	-	-	-	+

Appendix VIII: Remains of charred processed plant food and charred parenchyma

Remains of charred processed plant food and charred parenchyma

Trench/ square number	Processed cereal food (charred)	Vegetative and none-vegetative parenchyma (charred)	Dried residue/ botanical sample
1491	processed emmer grain (possible porridge like food). Fig. 7.7.	-	dried residue
1498	processed cereal food-outlines of fragmented cereal grains are visible within the lump; possible orache seed embedded in the matrix. Fig. 7.8 (SEM micrographs)	-	dried residue
2327	-	root or tuber parenchyma 1frg (no further identification)	botanical sample
13052	-	Bolboschoenus maritimus-tuber 4frg, Quercus-acorn 4frg	dried residue
13053	-	Malus sylvestris-fruit parenchyma fragment with partially preserved calyx. Fig. 7.14a	dried residue
13054	-	Bolboschoenus maritimus-tuber 3x; parenchyma 1frg (no further identification)	dried residue
13062	-	Bolboschoenus maritimus-tuber 2x	dried residue
13071	-	Bolboschoenus maritimus-tuber 1x	dried residue
13074	processed cereal food with barley grain embedded in the matrix 1frg	-	dried residue
13103	-	Quercus (oak)-acorn 1 frg (half cotyledon). Fig. 7.15a	dried residue
13721	-	Bolboschoenus maritimus -1x almost intact, flattened tuber (possible crushed before charring). Fig. 7.10a	dried residue
13753	processed plant food 1frg (no further identification)	Bolboschoenus maritimus-tuber, Quercus-acorn frg++	dried residue
14332	processed plant food+ (no further identification)	Bolboschoenus maritimus-tuber+; parenchyma 1frg; Quercus-acorn frg+, parenchyma 1frg (no further identification)	dried residue
14353	-	Bolboschoenus maritimus-tuber 1x	dried residue
14371	processed plant food 3frg (no further identification)	fruit parenchyma 1frg (no further identification)	dried residue
14392	-	Quercus-acorn 3frg	dried residue
14973	-	Bolboschoenus maritimus-tuber 1x	dried residue
15031	-	Bolboschoenus maritimus-tuber 1x	dried residue
15263	processed plant food 1frg (no further identification)	-	dried residue
18782	-	root or tuber parenchyma 1frg (no further identification)	botanical sample
18823	processed plant food 1frg (no further identification)	-	dried residue
18824	processed cereal food 4x lumps	-	dried residue
19451	-	Quercus-acorn 1frg	dried residue
19471	processed cereal food 5frg	-	dried residue
19473	processed plant food 1frg (no further identification)	Bolboschoenus maritimus-tuber 2x	dried residue
19484	processed plant food+ (incl. fragments with Atriplex/ Chenopodium seeds)	Polygonum (knotgrass)-rhizome 1frg. Fig. 7.12 a&b and Fig. 7.13 a&b (SEM micrographs), Bolboschoenus maritimus-intact/ fragmented tubers+ (incl. 1x almost complete, flattened tuber, possible crushed before charring), Quercus-acorn frg+	dried residue
20093	processed plant food 1frg (no further identification)	-	dried residue
20104	processed emmer food (possible porridge like food) 1frg	-	dried residue
20113	-	Bolboschoenus maritimus-tuber 4frg	botanical sample
20734	-	Quercus-acorn frg+; root/fruit parenchyma 4frg (no further identification)	dried residue
20752	-	Quercus-acorn parenchyma 1frg. Fig. 7.15b (SEM micrograph)	dried residue
20753	-	Bolboschoenus maritimus-tuber 1x	dried residue
21374	processed cereal food 5frg (possible porridge like food, incl 1x bigger lump)	-	dried residue

+: few/some; ++: numerous

Remains of charred processed plant food and charred parenchyma

Trench/ square number	Processed cereal food (charred)	Vegetative and none-vegetative parenchyma (charred)	Dried residue/ botanical sample
21383	-	Bolboschoenus maritimus-tuber 1x	dried residue
22021	-	Bolboschoenus maritimus-tuber 1x	dried residue
22032	-	Bolboschoenus maritimus-tuber 1x	dried residue
22032	-	Bolboschoenus maritimus-tuber 3frg	botanical sample
22034	processed cereal food (probably emmer) with emmer glume base embedded in the matrix. Fig. 7.9	-	botanical sample
22674	-	Bolboschoenus maritimus-tuber 1x	dried residue
22674	-	Bolboschoenus maritimus - 1xtuber. Fig. 7.10b and tuber parenchyma Fig. 7.11 a&b	dried residue
22704	-	root or tuber parenchyma 2frg (no further identification)	botanical sample
22993	-	Bolboschoenus maritimus-tuber 2frg	botanical sample
23811	-	Bolboschoenus maritimus-tuber 1x	dried residue
24561	-	Bolboschoenus maritimus-tuber 2x, Quercus-acorn 1frg	dried residue
24574	-	Bolboschoenus maritimus-tuber 3x	dried residue
24574	-	Bolboschoenus maritimus-tuber 8frg	botanical sample
25161	-	Bolboschoenus maritimus-tuber 4x, Quercus-acorn 2frg	dried residue
25163	-	Bolboschoenus maritimus-tuber 2x	dried residue
25182	-	Bolboschoenus maritimus-tuber 3frg	dried residue
25803	-	fruit parenchyma 1frg (no further identification)	dried residue
26452	-	Quercus-acorn 3frg	dried residue
29182	-	Quercus-acorn 2x cotyledon	dried residue
35163	-	Bolboschoenus maritimus-tuber 1x	dried residue

+: few/some; ++: numerous

Appendix IX: Charcoal and other findings

Charcoal and other findings

Square/unit	1878/2		1878/2		1878/2		1878/2		2011/3		2050/3		2198/4		2203/2		2203/4	
Find number	5		6		6		9		7		13		7		4		2	
Feature number	5		5		5		31		24		129		18		7		3	
	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)
Acer campestre-type trunk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus trunk	27	499.4	15	234.9	3	35.5	9	291.4	1	38.0	-	-	-	-	37	1320.1	21	500.6
Alnus branch	7	57.3	11	97.7	7	164.7	13	141.5	2	4.9	-	-	2	12.9	1	15.2	2	8.2
Alnus trunk explosion holes	-	-	-	-	-	-	2	1238.5	-	-	-	-	-	-	-	-	-	-
Betula branch	1	9.9	1	21.1	-	-	8	148.1	1	1.6	-	-	-	-	-	-	-	-
Betula trunk	5	56.6	-	-	3	152.4	3	139.5	-	-	-	-	-	-	-	-	-	-
Betula trunk/branch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cornus branch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corylus trunk	-	-	1	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corylus trunk/branch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedera branch	-	-	-	-	-	-	-	-	1	1.8	-	-	-	-	19	203.7	-	-
Fraxinus trunk	-	-	-	-	-	-	3	127.1	-	-	-	-	-	-	-	-	1	73.4
Lonicera branch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Prunus padus-type trunk	2	53.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus trunk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus trunk	25	758.8	34	580.0	8	479.2	7	116.8	-	-	-	-	-	-	2	25.6	21	655.9
Quercus branch	-	-	-	-	1	51.3	-	-	-	-	-	-	-	-	-	-	-	-
Quercus trunk/branch	-	-	-	-	-	-	-	-	1	2.6	-	-	-	-	1	15.3	-	-
Salix branch	6	106.8	29	383.3	6	110.9	5	45.7	1	11.4	-	-	-	-	1	6.8	-	-
Salix trunk	9	123.3	8	192.6	5	412.3	4	88.3	-	-	-	-	-	-	-	-	13	161.2
Taxus trunk	1	52.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet. diffuse porous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet. bark	4	171.6	4	86.0	3	86.4	10	496.2	9	69.2	1	17.3	1	13.9	4	232.8	6	184.4
Indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet. root	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet. node	-	-	1	79.3	1	19.7	-	-	-	-	-	-	-	-	-	-	-	-
cf. Phragmites stem	46	210.0	20	85.5	4	46.5	11	103.9	11	45.5	51	266.2	12	47.5	131	877.8	14	46.1
cf. parenchym indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Althaea officinalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
Corylus avellana nutshell	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cerealia indet fragm.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hordeum vulgare var. nudum	5	-	2	-	-	-	3	-	-	-	-	-	1	-	1	-	-	-
Triticum dicoccon	-	-	-	-	-	-	1	-	1	-	1	-	1	-	2	-	4	-
Triticum dicoccon spikelet fork	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Rest		1518.0		1620.7		-		989.6		-		-		-		-		-

n: number; w: weight (mg)

2203/4		2203/4		2270/4		2270/4		2270/4		2299/3		2327/-		2393/1		2457/3		2457/4		2522/3	
3		5		2 of 2		1/2 2/2		1 of 2/2 of 2		1				102		3		3		103	
16		7		41		69		55		237						16		16			
n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)	n	w (mg)
-	-	6	39.2	2	46.8	-	-	-	-	-	-	-	-	-	-	1	24.5	-	-	-	-
3	23.0	26	304.4	21	923.7	3	18.5	31	615.4	14	133.2	4	357.8	8	201.4	16	158.5	5	24.2	-	-
4	35.6	21	83.1	5	54.2	-	-	18	108.6	-	-	23	579.5	17	197.6	11	102.3	-	-	16	51.6
-	-	-	-	-	-	-	-	2	7.2	-	-	-	-	-	-	-	-	-	-	-	-
-	-	1	11.8	3	37.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	24.8
-	-	-	-	5	100.7	-	-	-	-	-	-	-	-	1	23.7	4	83.0	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	2	12.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	18	61.8	-	-	-	-	3	17.2	-	-	-	-	-	-	19	65.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	13.0	-	-	-	-
-	-	1	27.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	1	4.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	11.9	-	-	14	161.2	1	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	1	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	5.8	9	89.8	8	33.2	-	-	-	-	7	58.8	4	28.7	3	33.3	3	66.9	-	-	6	25.6
-	-	6	682.0	9	173.6	3	11.6	2	23.5	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	1	11.2	-	-	2	5.9	-	-	-	-
2	11.7	38	274.5	9	122.9	61	146.8	2	19.5	5	46.7	26	129.6	5	102.2	3	31.4	34	218.1	17	41.5
2	6.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	12.5	-	-	-	-
1	28.0	53	330.4	67	346.7	222	635.1	c. 500	2332.9	14	57.3	109	386.4	c. 50	236.5	35	199.7	17	45.1	115	462.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	1	-	-	-	3	-	-	-	1	-	1	-	1	-	8	-	-	-	4	-
1	-	2	-	-	-	8	-	1	-	7	-	4	-	-	-	1	-	1	-	-	-
-	-	-	-	-	-	3	-	-	-	-	-	2	-	-	-	1	-	1	-	-	-
	-		-		636.9		-		-		-		-		94.2		-		-		-

Appendix X: Measurements zoological remains

Measurements zoological remains

Species/skeletal element	Measurement	Value (mm)	Withers height (cm)
Cattle			
Scapula	SLC	56.9	-
	GLP	74.8	-
	LG	61.5	-
	BG	52.5	-
Humerus	BD	87.6	-
	BT	76.1	-
Radius	BP	84.9	-
Metacarpus	BP	56.9; 59.6; 60.4; 60.5; -	-
	SD	-; - ; 34.2; -; -	-
	BD	-; -; 61.1; -; 61.0	-
	GL	-; -; 215.6; -; -	133.5
Metatarsus	BP	49.9; 52.1	-
Phalanx I	BP	28.9	-
	SD	25.1	-
	BD	27.5	-
	GL	66.8	-
Tibia	BD	59.2; 65.8	-
	SD	-; 39.1	-
Astragalus	GLL	64.3; 71.1	-
	GLM	60.4; 64.2	-
	BD	39.7; -	-
Sheep			
Tibia	BD	28.0	-
Dog			
Mandibula	M1L	19.7	-
Maxilla	P4L	18.0	-
Pig			
Mandibula	M2L	23.4	-
	M2WA	12.8	-
	M2WB	13.5	-

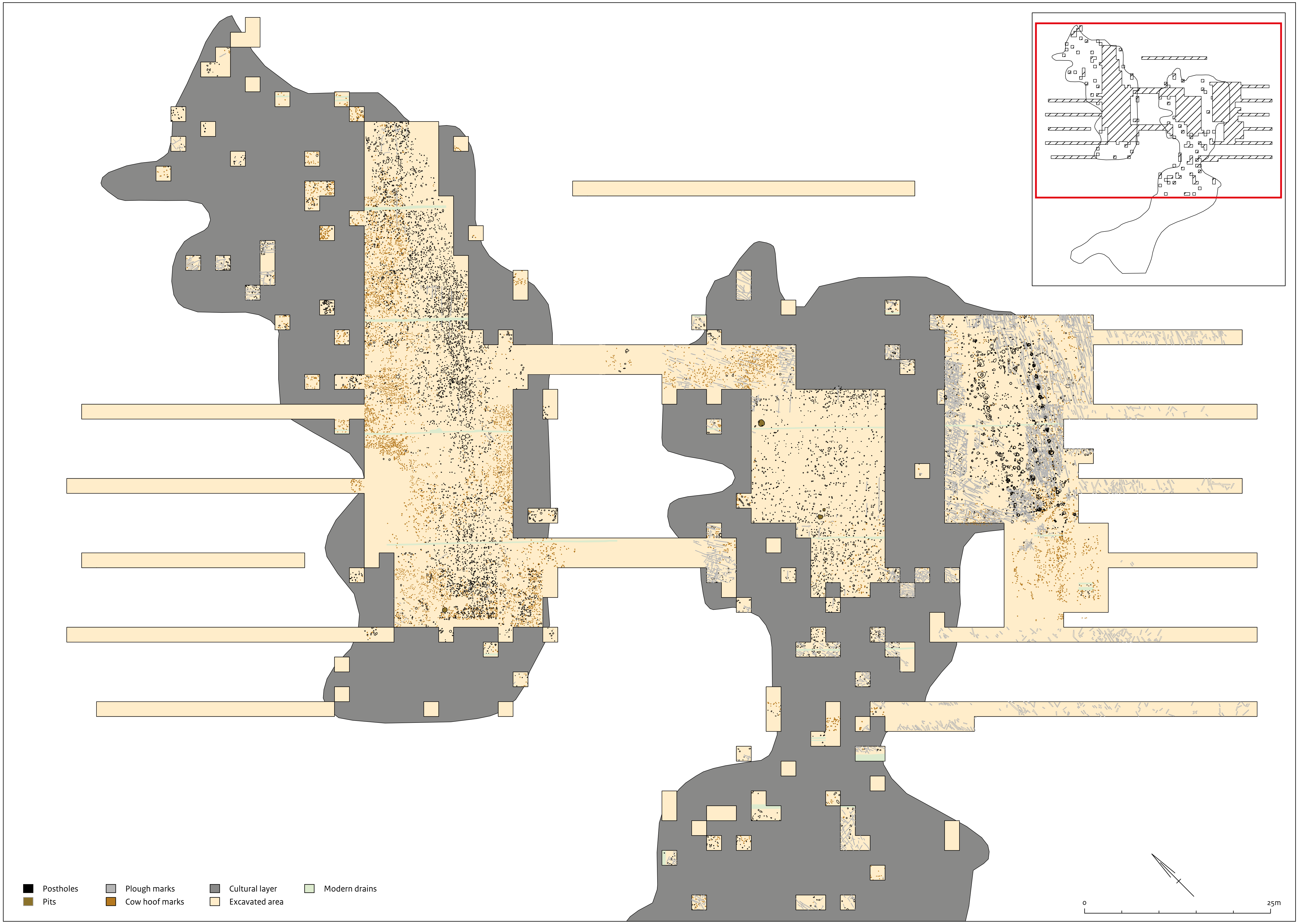
Measurements zoological remains

Species/skeletal element	Measurement	Value (mm)	Withers height (cm)
Pig/wild boar			
Humerus	BT	33.0	-
Mandibula	M2L	24.0	-
	M2WA	14.8	-
	M2WP	15.2	-
	M3L	36.0	-
	M3WA	13.1	-
	M3WP	14.2	-
Wild boar			-
Humerus	BT	34.3	-
Mandibula	M3L	42.0	-
	M3WA	14.5	-
	M3WP	18.1	-

Legend

BD = greatest width of the distal end
BG = width of the glenoid cavity (scapula)
BP = greatest width of the proximal end
BT = greatest width of the trochlea (humerus)
GL = greatest length
GLL = greatest length of the lateral half
GLM = greatest length of the medial half
LG = length of the glenoid cavity (scapula)
MxL = length of molar x
MxWA = width of molar x, anterior
MxWP = width of molar x, posterior
P4L = length of the fourth premolar
SD = smallest width of the diaphysis
SLC = smallest length of the collum scapulae

Appendix XI: Site overview (scale 1:500)



This scientific report is the third and final monograph to emerge from the Odyssey project ‘Unlocking Noord-Holland’s Late Neolithic Treasure Chest: Single Grave Culture behavioural variability in a tidal environment’. It focuses on the analysis of the Zeewijk site, excavated in 1992, 1993 and 1994. In one of the trenches of Zeewijk-East the remains of a large, unusual structure were revealed. This discovery made the Dutch site well known among archaeologists abroad. Due to its large size, it was only partially excavated, yielding a very high quantity of finds. This forced the Odyssey project team to make selections.
Looking back at the analysis and publication of the fairly small sites at Keinsmerbrug and Mienakker, the new information added by the much larger Zeewijk site is fascinating. The new results and interpretations are presented in this volume.
The analyses show that Zeewijk was a location where recurrent habitation took place, year-round and intensive, alternating with subsistence activities. It is a permanent mosaic of different assemblages: relocated dwellings, cultivated plots, a large variety of local crafts and the building and partial demolition of a remarkable ritual structure in Zeewijk-East. This points to a community of several families, with ties of kinship both genetic and affinal.

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.