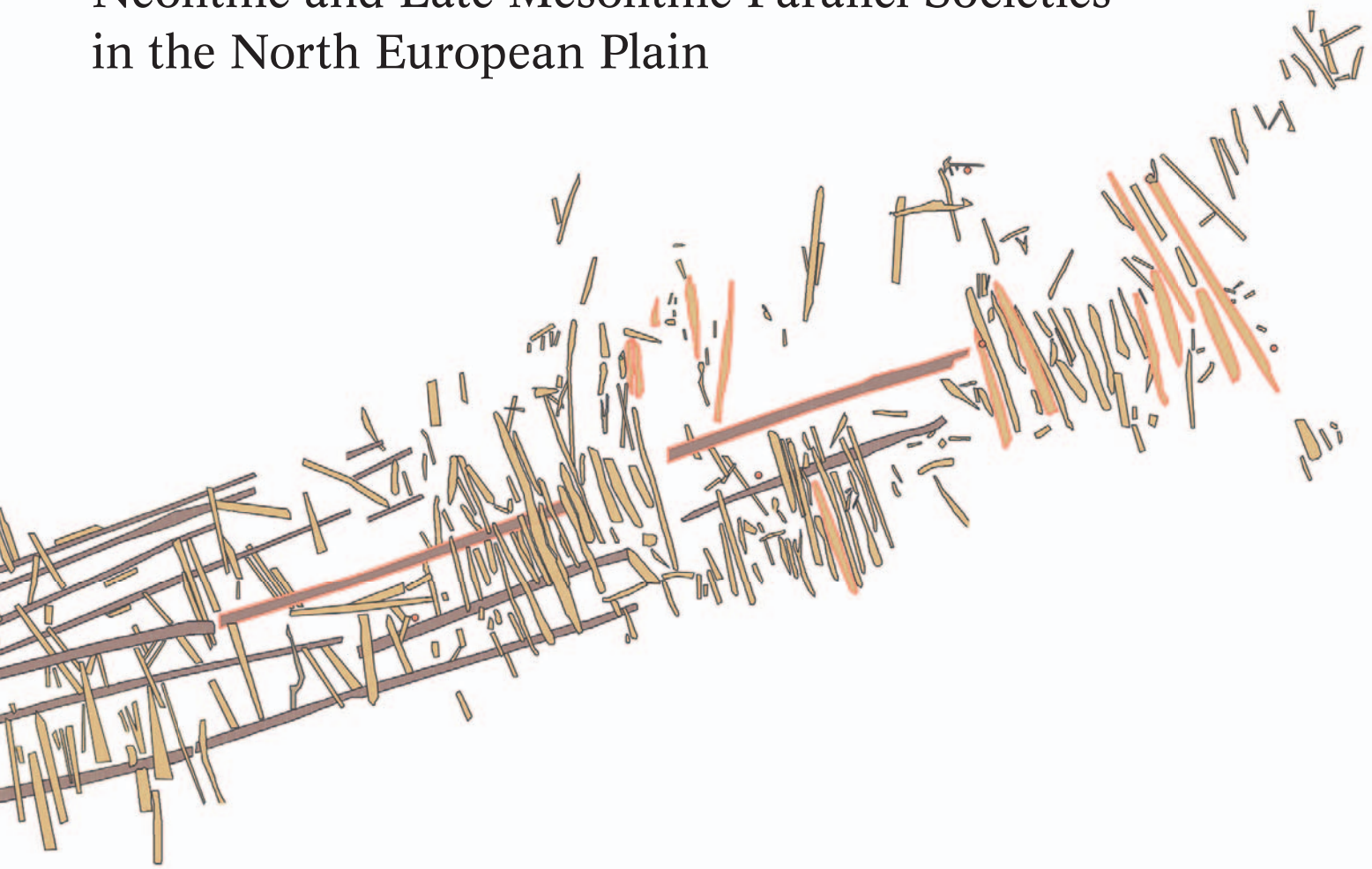
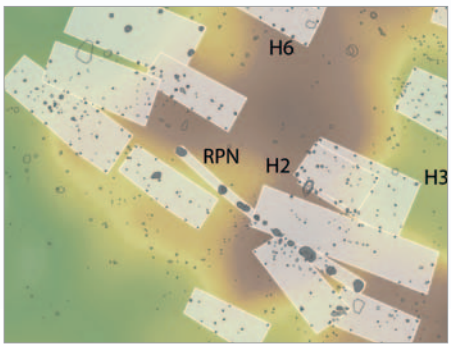
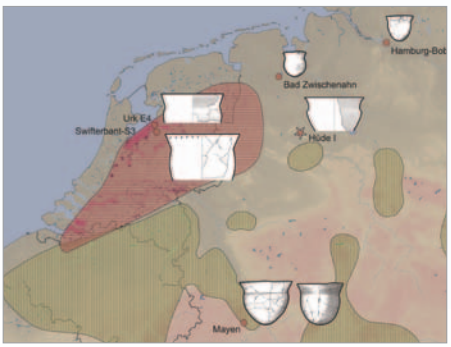
MATERIALHEFTE ZUR UR- UND FRÜHGESCHICHTE NIEDERSACHSENS | BAND 60

Florian Klimscha, Marion Heumüller, Daan C. M. Raemaekers,
Hans Peeters and Thomas Terberger

Stone Age Borderland Experience: Neolithic and Late Mesolithic Parallel Societies in the North European Plain







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Florian Klimscha, Marion Heumüller,
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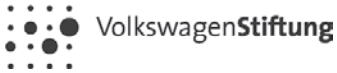

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Stone Age parallel societies?

When we started the preparations for new research on the Mesolithic-Neolithic transition in the North European Plain, the great differences between both modes of life specified by previous research had just been enhanced by exciting results of palaeogenetic analysis: The publication of isotope studies and palaeogenetic data from the Blatter Cave (Blätterhöhle) in Westfalia suggested seperated communities for as long as 2,000 years.[1] While the spread of agriculture certainly stops at the loess border, contacts between the Linear Pottery culture and its successors and Late Mesolithic groups in the north were nevertheless present.

A key site to comprehend how this communication might be understood in terms of intensity and interactivity is the wetland settlement Hüde I at Lake Dümmer in Lower Saxony, where the existence of Late Mesolithic as well as Early Neolithic strata suggested the unique possibility to examine the changes which finally led to the neolithisation of the North Europan Plain and the formation of the Funnelbeaker culture. Key aspects of the excavations there have never been fully published and, furthermore, at the time of the excavation in the 1960s findings were understood under a paradigm which saw Mesolithic pottery in northwest Germany as a subgroup of Ertebølle culture ware.

This perspective has been dramatically changed by groundbreaking new research making clear that the Hüde I-site needs to be included in the Swifterbant culture.[2] This new interpretation opens up a whole new perspective on the neolithisation of the north, as new research has made it evident that regular contacts between Swifterbant groups and Danubian farmers indeed led to an early northern experimentation with animal husbandry and agriculture. While we certainly see differences in both ways of life, the situation is much more complex than suggested before; this new research has already made clear that important impulses for the early Funnelbeaker pottery are visible within the Swifterbant ceramic tradition.

The spread of this pottery seems to correlate with an initial adoption of elements of the Neolithic economy in the north.

This volume sums up the contributions of an international conference hosted in Hanover, May 20th – 22nd, 2019 in the State Museum of Lower Saxony. The papers follow several lines of thought and can be divided into two groups.

A first part, *Grenzgängers, traders and the last hunter-gatherers of the North European Plain*, scrutinises the interactions between Mesolithic and Neolithic communities. New evidence from Hüde I and the Swifterbant culture is presented and contrasted with the broader picture in the North European Plain. Papers about the archaeological context of the Hüde I site include those by Marion Heumüller, Mirjam Briel, Florian Klimscha, Andreas Kotula, Hanns Hubert Leuschner, Reinhold Schoon and Tanja Zerl who introduce new excavation data from the Dümmer basin, as well as the one by Andreas Bauerochse and Hanns Hubert Leuschner who examine the same area from a palaeo-botanical point of view with a special reference to road building. Özge Demirci, Alexandre Lucquin, Florian Klimscha, Oliver E. Craig and Daan C. M. Raemaekers present the first results from lipid residue analysis on some of the Hüde I pottery, while Helle M. Molthof and Steffen Baetsen show the first results from an exciting new discovery at Nieuwegein-Het Klooster in the Netherlands, where well-preserved Swifterbant graves were excavated in a settlement context. Theo J. ten Anscher and Sebastiaan Knippenberg review another Swifterbant settlement and can, for the first time, document houseplans resembling those from contemporary Danubian villages in the Rhineland. Whereas Bernhard Stapel sums up unexpected evidence for Swifterbant sites in Westphalia, Svea Mahlstedt, Martina Karle and Jan F. Kegler scrutinise the Late Mesolithic evidence for the coastal areas of Lower Saxony. Finally Laura Thielen sums up new data on Hamburg-Boberg, another key site for understanding the Late Mesolithic.

On a larger scale, Erwin Cziesla examines the distribution of specific microlithic flint types to reconstruct Mesolithic territories and the origin of pottery in hunter-gatherer societies, while Klaus Gerken, Andreas Kotula, Clemens Ludwig, Hildegard

1 Cf. the paper by Daniela Hoffmann, Hans Peeters and Ann-Kathrin Meyer for a more elaborate discussion.

2 Cf. the papers by Bernhard Stapel, Daan Raemaekers and Theo ten Anscher and Sebastiaan Knippenberg.

Nelson and Alexandra Philippi present excavation data from the first settlement of the Linear Pottery culture discovered north of the loess border in northwestern Germany. Michael Müller and Michael Schirren analyse the evidence from hoards along the boundaries of Mesolithic and Neolithic groups. A later Danubian expedition into the north is dealt with in the paper by Christian Hülsebusch and Albrecht Jockenhövel on the Middle Neolithic settlement of Nottuln-Uphoven. Three other papers study contemporary Late Mesolithic evidence in the Baltic Sea area. Sönke Hartz sums up the evidence from Schleswig-Holstein, while Andreas Kotula as well as Jacek Kabaciński and Agnieszka Czekaj-Zastawny study northern Poland. Daniela Hofmann, Hans Peeters and Ann-Katrin Meyer then discuss the evidence and sketch a detailed and complex interaction pattern between foragers and farmers.

In the second part of the book, *Changing Worlds: The Spread of the Neolithic Way of Life in the North*, more general aspects of the neolithisation are collected, starting with Daan C. M. Raemaekers, who argues against agonistic narratives charged with conflict and presents an alternative reading of the imports in the Swifterbant culture. Luc Amkreutz combines a long-term narrative on the neolithisation with a strictly local perspective focussing on the Rhine-Meuse delta. Technical innovations are the focus of the papers by Anne Birgitte Gebauer and Lasse Sørensen (metallurgy) and Florian Klimscha and Daniel Neumann (arsenic bronze, traction). New data on specific regions or archaeological phenomena, respectively, are discussed in three papers by Alexandra Philippi (Schöningen group), Benedikt Knoche (causewayed enclosures) and Anja Behrens, Moritz Mennenga, Steffen Wolters and Martina Karle (Cuxhaven region), while recapitulary papers by Walter Dörfler, Johannes Müller and Wibke Kirleis present up to date interpretations on the causes, mechanisms and consequences of the neolithisation in northern Europe.

This volume would not have been possible without the help of many people. First and foremost we want to express our thanks to the Volkswagen Foundation, who generously funded the project and its publication with a grant in the *Forschung in Museen* initiative. Michaela Finsel and Linda Delkeskamp were always helpful and gave valuable advice how to finish the project successfully during the Corona pandemic.

We also want to thank Prof. Dr. Katja Lembke (Director of the Lower Saxony State Museum) for hosting the conference and assisting its performance.

Dr. Henning Hassmann (Director of the Lower Saxony State Office for Cultural Heritage) greatly helped us by funding the printing of the volume. We are much obliged to him.

Members of the Lower Saxony State Society for Prehistory (Niedersächsischer Landesverein für Urgeschichte) took over the organisation of the conference, the conference office and the catering. Without those honorary helpers it would not have been possible to host more than 80 international participants in Hanover.

The publication was made possible by helping hands and funding from both the Lower Saxony State Museum and the Lower Saxony State Service for Cultural Heritage. Special thanks are also due to the District Administrator (*Landrat*) of Diepholz district Cord Bockhop. We would also like to thank Vijay Diaz (Lower Saxony State Service for Cultural Heritage) for the graphic editing, and our colleague Dr. Ulrike Weller (Collection Manager of the Lower Saxony State Museum's archaeological finds) who presented original finds to the participants.

Finally we would like to thank all those who also presented research results at the conference but unfortunately could not contribute to this volume: Ulrich Schmölcke (Kiel), Canan Çakirlar, Safoora Kamjan (Groningen), Johannes Krause (Jena), Erik Drenth (Amersfoort), Martha Zur-Schaepers (Cologne), Harald Lübke (Schleswig), Kenneth Ritchie (Schleswig), Marcello Mannino (Århus), Harry Robson (York), Sebastian Lorenz (Greifswald), Lisbeth Messiaen, Dimitri Teetaert, Eva Halbrucker and Philippe Crombé (Gent).

Last but not least, we want to point out that the outcomes of this conference did not only result in the publication of this book, but were also essential for a special exhibition in the Lower Saxony State Museum, 'Invention of Gods. Stone Age in the North', which will be presented in Hanover from April 1st – August 28th, 2022, and we thank all contributors to this volume for having made this possible.

Hanover and Groningen, February 24th 2022
Florian Klimscha, Marion Heumüller,
Daan C. M. Raemaekers, Hans Peeters and
Thomas Terberger

Grenzgänger, traders and the last hunter-gatherers of the North European Plain

Some remarks on the origin of Mesolithic pottery in northwestern Europe

Erwin Cziesla

Abstract This contribution points out different topics. Firstly: 'neolithisation' and 'ceramicisation' are to be separated from each other. Secondly: it can be shown that the occurrence of Limburg and La Hoguette pottery types is linked with that of dorsoventral base retouched arrowheads. Since 9,000 calBC this arrowhead type is distributed in a limited area in the river-systems of Seine, Sâone and Rhine, called the 'Se-Sa-Rhe-Traditions-Region'. This area remains stable up to 5,000 calBC. During Late-Mesolithic times these arrowheads' distribution did extend to the west, reaching the Atlantic coast, similarly to the pottery of La Hoguette type, as shown by a newly discovered vessel from Guibrelow I near Machecoul. Thirdly: the pottery types of Limbourg and La Hoguette might be 'hunter/gatherers ceramics', having been developed in the area between Seine, Sâone and Rhine. The neolithisation process was unaffected by this.

Keywords Neolithisation, ceramicisation, origin of northwest European pottery, hunter-gatherer ceramics, dorsoventral base retouched arrowheads

Zusammenfassung *In diesem Beitrag werden zunächst der Neolithisierungs-Prozess und die „Keramikisierung" voneinander entkoppelt. Anschließend werden die Keramikarten Limburg und La Hoguette mit dem Auftreten dorsoventral-basisretuschierter Pfeilspitzen verknüpft. Dieser spezielle Pfeilspitzen-Typ hat seit ca. 9000 v. Chr. eine begrenzte Verbreitung im sogenannten „Se-Sa-Rhe-Traditionsraum", also an Seine, Sâone und Rhein. Dieser Raum bleibt stabil bis mindestens 5000 v. Chr. Während des Spätmesolithikums erreichten dorsoventral-basisretuschierte Pfeilspitzen erstmals die Atlantikküste, ebenso auch La Hoguette- Gefäße, wie jüngst in Guibrelow I bei Machecoul nachgewiesen. Offenbar haben wir es bei der La Hoguette und Limburger Ware mit einer Jäger-Sammler-Keramik zu tun, die an Seine, Sâone und Rhein entwickelt wurde. Der Neolithisierungs-Prozess bleibt davon unbeeinflusst.*

Introduction

Let us start here with the compelling, immense term 'Neolithic Revolution', coined already in the 1930's by Vere Gordon Childe (*1892, †1957), as well as with the successful excavations in the 'Fertile Crescent' which provided a geographical connection along the lines of the biblical traditions for an 'archaeological Garden of Eden' in Mesopotamia[1] and in the Levant region as the starting points for the following processes of 'neolithisation'. Later, towards the end of the 1980's, these processes – by then generally accepted – were shown on maps, usually with the help of arrow symbols that all pointed to the western European region and marked the end of the distribution there. A map (Fig. 1), published by the archaeo-zoologist Hans-Peter Uerpmann with the title 'Entstehungsgebiete der bäuerlichen Wirtschaftsform und ihre Ausbreitung nach Europa' ('Formation regions of the farming economic system and its spread to Europe'; Uerpmann 1983, fig. 243), can serve as an example of this kind of comparative depiction. Taking a closer look at the map, one can see two spatially divided events: on the one side there is a spread inland, characterised by large houses, technical facilities, such as ovens and wells, and domestic cattle. This is a rather slow process of gradual land gain ('neolithisation slow and heavy') (Cziesla 2015b, 230). In addition, one also sees a spread along the coast, likely using small boats without the possibilities for larger transportation. This distribution, known under the French term 'cabotage', ends in the Golf du Lion area and continues inland to the north and northeast along the river Rhône ('neolithisation

1 Genesis 2: 'Now a river flowed out of Eden to water the garden. And from there it divided and became four rivers … The name of the third river is Tigris. It flows east of Assyria. And the fourth river is the Euphrates'.

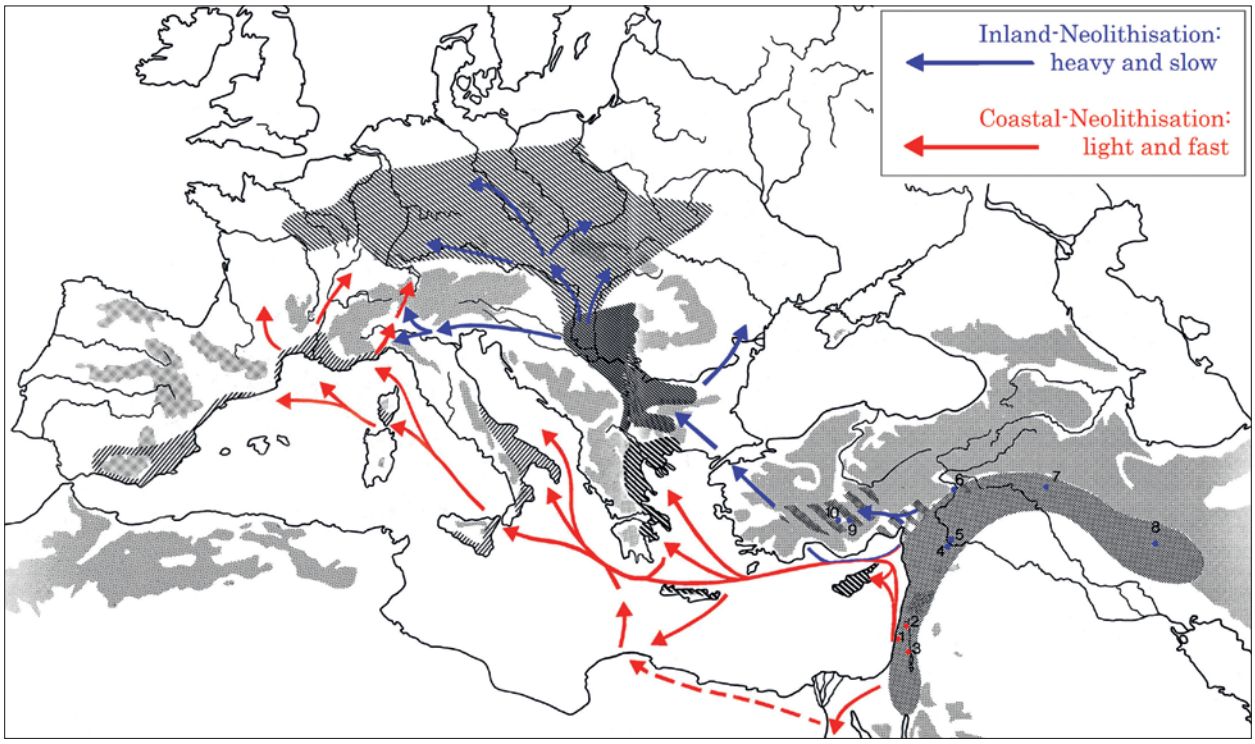

Fig. 1 Map of the region of origin and spread of the farming economy and its distribution to Europe (after Uerpmann 1983, fig. 243; text added).

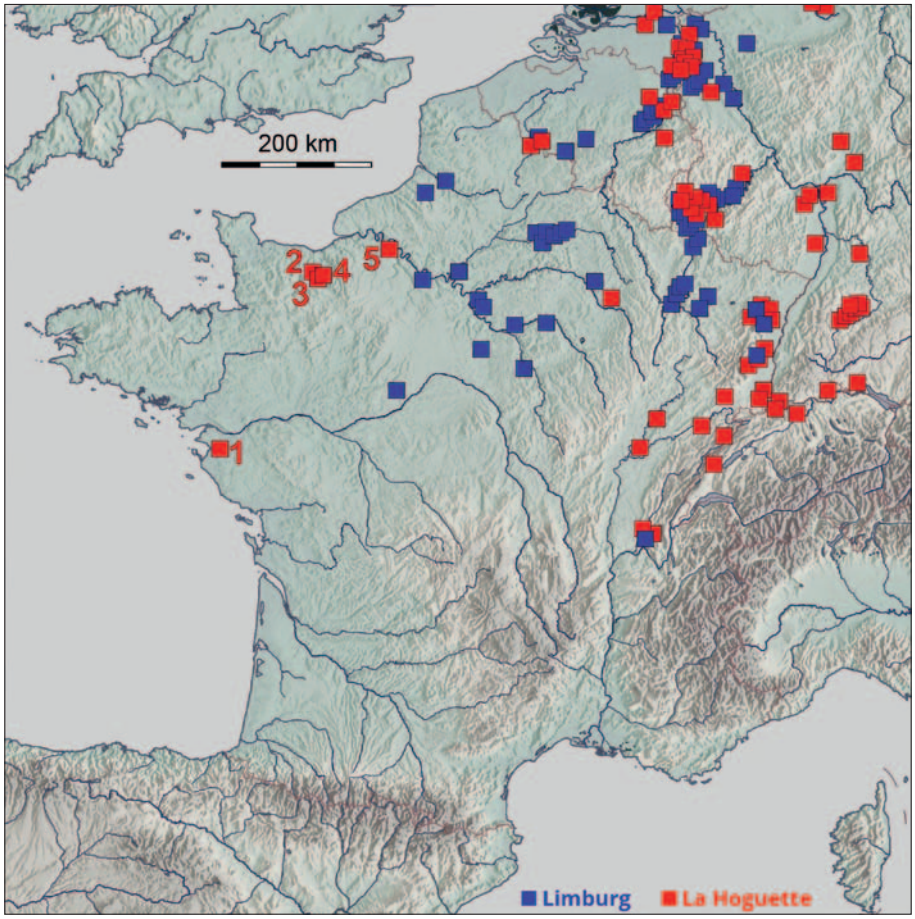

Fig. 2 Distribution of the sherd finds of types Limbourg and La Hoguette. The western sites, towards the Atlantic coast, of La Hoguette finds include: 1 Guibrelou I near Machecoul; 2 Fontenay-le-Marmion 'La Hoguette'; 3 Fontenay-le-Marmion 'La Grande Piéce'; 4 Fontenay-le-Marmion 'Grand Champ'; 5 Alizay-Igoville, Eure (map compiled after Cziesla 2015b, 209 ff.; Rousseau et al. 2015, fig. 15; Schauer in press).

fast and light') (Cziesla 2015b, 230). On the one hand the 'neolithisation' took place in the island and coastal regions of the Mediterranean, and on the other hand across the European mainland. Both areas represent topographically favourable regions for settlement, and in both cases the pottery sherds, as cultural witness, 'paved the way'.

This model, however, of distribution, diffusion and expansion out of the Levant and the Anatolian mountains into western Europe assumes for three unspoken factors: that on the one hand the indigenous Mesolithic population hardly played a role in these processes, that furthermore the coastal region of the Atlantic was of no importance, and, finally and most important, that the process of neolithisation was identical with the distribution of ceramics.

Once this model of distribution had been worked out, it became the almost sole purpose of research, over the last 50 years, to reconstruct and date the individual sections of the distribution.

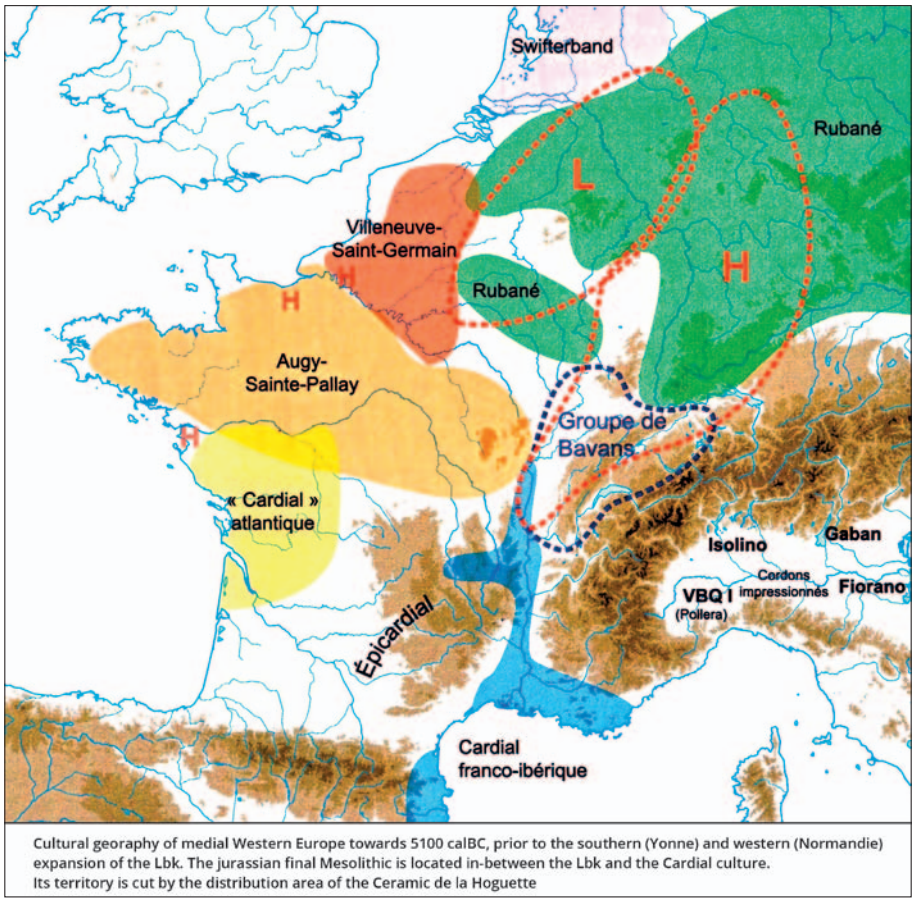

Fig. 3 Map after Jeunesse et al. 2019, fig. 32, showing western Europe at about 5,100 BC. The 'Group de Bavans' only has a distribution in the eastern French and Swiss region (in contrast to Fig. 9), contradicting mappings by Jaccottey et al. 2000; Cziesla 2015b, fig. 99 and Cziesla 2018b, fig. 8. The distribution of the Limbourg and La Hoguette groups is shown as two separate regions, with the La Hoguette sherds only as isolated singular findspots on the Atlantic coast.

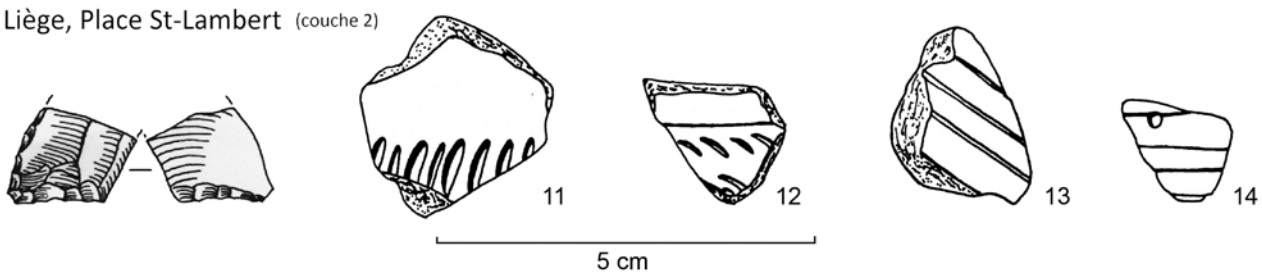

Fig. 4 Dorsoventral base retouched arrowhead and Limbourg ceramic from 'Place St.Lambert', Liège, Layer 2 (after Otte 1984, fig. 11; Rousselle 1984, fig. 7).

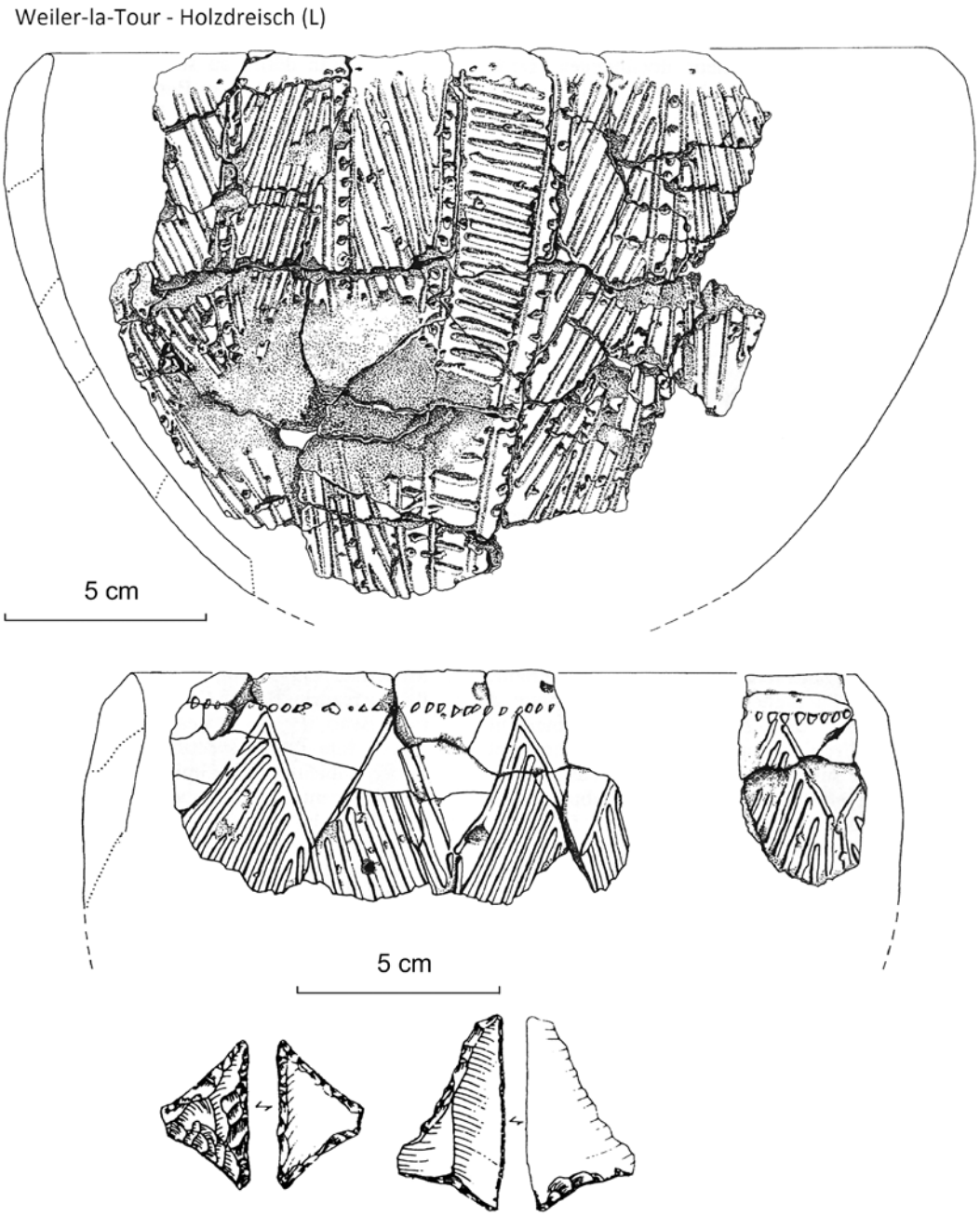

Fig. 5 Dorsoventral base retouched arrowheads and Limbourg ceramic from the site Weiler-la-Tour in Luxembourg (after Jadin 1996, figs. 3; 5; Jadin/Cauwe 1991).

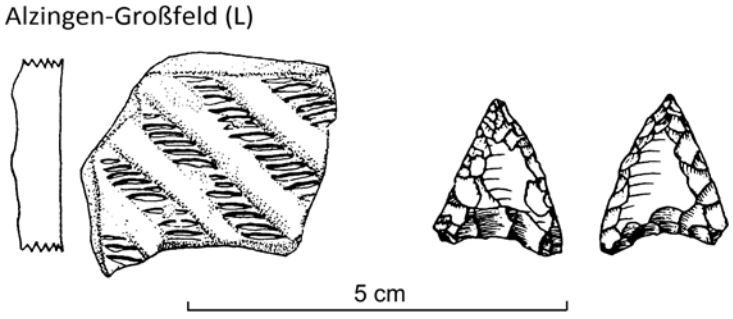

Fig. 6 Dorsoventral base retouched arrowhead and La Hoguette ceramic from the site Alzingen-Großfeld in Luxembourg (after Jadin 1996, figs. 8; 12).

In 1967, Günter Smolla, former professor of prehistory at Frankfurt/Main University, wrote that the pots and sherds play a large, often even central role in the research of the Neolithic, as the neolithisation is inextricably linked with the development of the ceramics (Smolla 1967, 92). This colleague would not believe his eyes when viewing todays' analytic results, where – due to the decoration on the vessel bodies – even marriage rules and relationship patterns can be discerned (Gronenborn / Strien 2014, 36f).

Early studies concerned with the complete European neolithisation process left no space for doubt as to the validity of previous interpretations. But Christian Jeunesse and Jean Sainty, however, were able to recover sherds from a building site in Bischoffsheim in Alsace that were comparable to other ceramics, published by Robert Caillaud and Edouard Lagnel (Caillaud / Lagnel 1972), found under the megalithic tomb at La Hoguette near Fontenay-le-Marmion in the Département Calvados. At a conference in Caen ('X^{é} colloque interregional sur le Néolithique') in 1983, Christian Jeunesse was able to connect four sites on the Upper Rhine and from the Doubs valley with this site in Calvados (Jeunesse 1986; Fig. 3). Thus, for the first time, sherds from a Bandkeramik settlement area were linked to a region in which the Bandkeramik – as a culture – was not documented, which raised questions regarding the origin of these obviously non-Bandkeramik ceramics. In the following year, however, Christian Jeunesse pointed out (Jeunesse 1987) significant similarities with the pottery from the site of Leucate-Corrège in southern France, so that the ceramics could be connected with the Mediterranean Cardial culture. Thus, the popular image of the neolithisation processes (see Fig. 1) was neither damaged nor questioned by the La Hoguette and Limbourg ceramics (see Modderman 1970) as well. On the contrary: apparently ceramics from the southern French Cardial reached central Europe along the river Rhône, which were then heaped up in (early) Bandkeramik pits. This was an ideal combination of both distribution ways, with the La Hoguette site in Calvados remaining isolated, far away from the important Neolithic development routes. Additionally, Jens Lüning and colleagues rushed to help by mapping the increasingly growing finds material (55 Limbourg and 30 La Hoguette sites). Their article was called 'Westliche Nachbarn der bandkeramischen Kultur' (western neighbours of the Bandkeramik culture), with cultural references, dating results and connections already clearly outlined in the title (Lüning et al. 1989). The presentation of the beloved neolithisation processes and the associated spread of the ceramics took no damage, everything was confirmed anew.

Once this had been presented in the scientific journal 'Germania', further sites with sherds could be quickly added to the scheme, with, for example, Claire Manen and Karoline Mazurié de Keroualin providing 72 Limbourg and 51 La Hoguette sites with sherds (Manen / Mazurié de Keroualin 2003, figs. 2– 3). Recently, I was able to increase this inventory to 93 Limbourg and 83 La Hoguette sites (Fig. 2; Cziesla 2015b, fig. 178). In the meantime, further old and new finds have been presented (e. g. Van Wijk et al. 2014).

It needs to be highlighted that my own following considerations are in clear contrast to the depictions that have been presented and interpreted by Christian Jeunesse, who has recently reiterated his view together with colleagues (see Fig. 3; Jeunesse et al. 2019, fig. 32). The current comparison of the distribution of Limbourg and La Hoguette (Fig. 2, cf. Fig. 3) already shows that Christian Jeunesse, Rose-Marie Arbogast, Michel Mauvilly and Anthony Denaire still assume two separate distribution areas, with the La Hoguette sherds in western France being rated as isolated outliers only. In addition, they see interactions of finds materials between the Cardial culture in the south and the Bandkeramik in the north, whilst the space between is exactly filled by the 'Group of Bavans'. I will come back to this aspect later.

It occurred to me, whilst examining the non-Bandkeramik ceramics, that they could be occasionally linked to stone arrowheads. Thus, there were so called 'Danubian-arrowheads' (in detail: Cziesla 2015b, 133–146) from the Place St. Lambert in Liège (Fig. 4) and the Luxembourg site Weiler-la-Tour (Fig. 5) together with Limbourg sherds, as well as arrowheads together with La Hoguette sherds (Fig. 6) at the site Alzingen-Großfeld, also in Luxembourg. Bavans-arrowheads were found with La Hoguette sherds in Layer 5 of the Bavans-caves (Fig. 7) on the upper reaches of the river Doubs (Aimé 1981) – which, by the way, were also published in the Caen conference volume (Aimé / Jeunesse 1986, figs. 2–3). Luc Jaccottey pointed out that the connection between sherds and stone artefacts could play an important role in evaluation when he wrote 'the shelter of Bavans shows the association between a mesolithic industry and ceramic' (Jaccottey 1997, 313). This is a revolutionary idea, in which Mesolithic arrowheads are associated with ceramics, and it contradicts, for the first time, parts of the general scheme of the neolithisation processes outlined above. Most

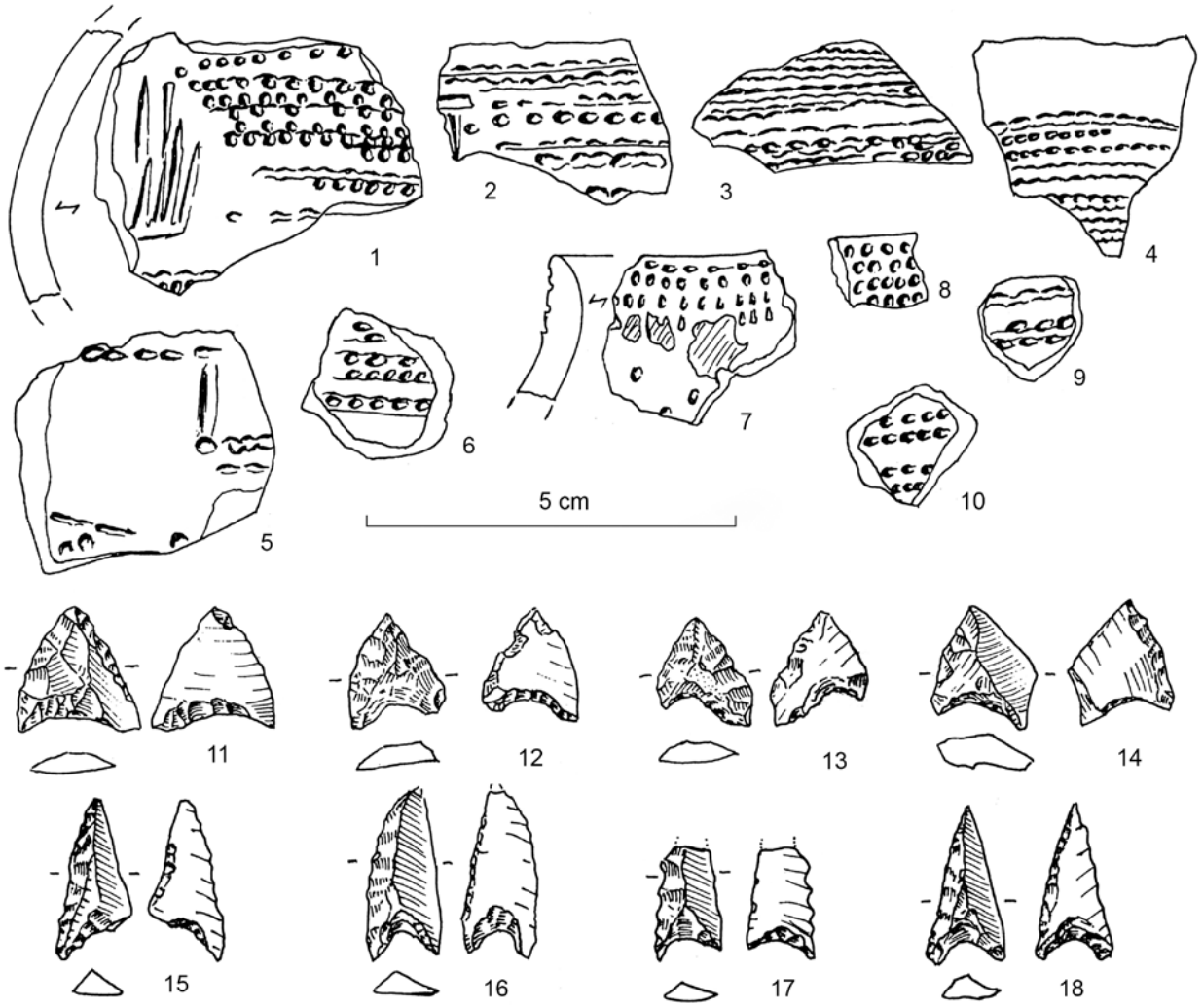

Fig. 7 Dorsoventral base retouched arrowheads (type Bavans; 11–18) and La Hoguette sherds (1–10) from Layer 5 of the Bavans Caves (after Aimé 1987, figs. 3–4).

of these arrowheads have a base retouched from both the ventral and the dorsal sides (dorsoventral retouched base) in common.

The dorsoventral base retouching of arrowheads

In order to understand the importance of these dorsoventral retouched bases, we have to, on the one hand, consider stone arrowheads and, on the other hand, the Mesolithic. The dorsoventral base reduction, i. e. the retouching of the ventral and dorsal sides, is an innovation from the early part of the Mesolithic. Currently, it is indicated that arrowheads with this special base appeared at the latest c. 9,000 calBC in central Europe (Cziesla 1992, 284; 2015a; 2015b, 31 f.; 2016, fig. 2; 2018a, fig. 2). When sites with such projectiles from the Early and Middle Mesolithic (c. 9,000 to 6,500/6,000 calBC) are mapped, this results in a clearly defined concentration (Fig. 8), whereas these arrowheads are not present in the adjoining regions and do not reach the Atlantic. I have, therefore, labelled this region on the rivers Seine, Saône and Rhine, with its boundaries that appear to have been stable over several millennia, as the 'Se-Sa-Rhe-Traditions-Region'.

Although this tradition and region also remain visible in the Late Mesolithic, there are, however, within this area at least three arrowhead types distinguishable that continue to have a dorsoventral base retouching: the arrowheads of the types Bavans/Fléchettes asymétriques, Danubian arrowheads and arrowheads of the 'Rhein-Maas-Schelde' culture. Their geographical distribution is shown again in a map (Fig. 9). It is interesting to note that, in principle, major spatial areas of distribution are formed: the Bavans/Fléchettes arrowheads tend to appear in the south with a main focus in Luxembourg as well as Rhineland-Palatinate, Danubian arrowheads are rath-

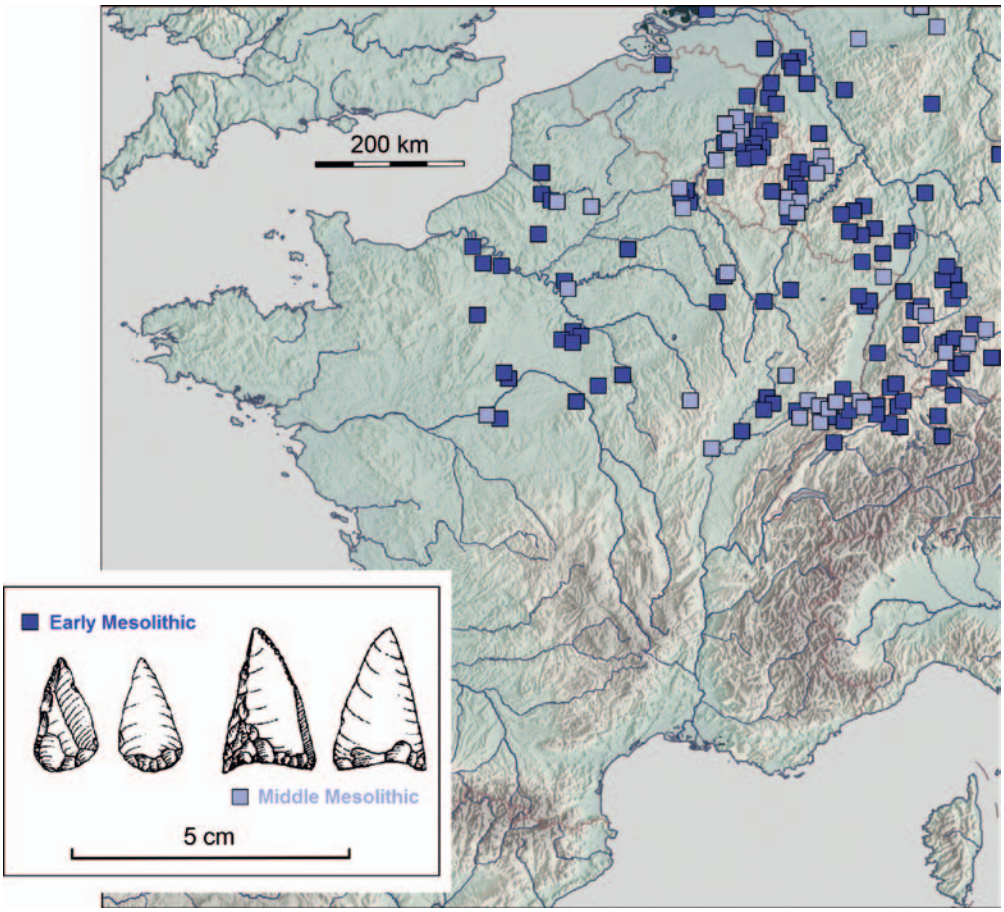

Fig. 8 Distribution of the arrowheads with dorsoventral retouched base in the Early and Middle Mesolithic (c. 9,000–6,500 calBC; data after Cziesla 2015b, figs.14; 22; 46). The sites show the distribution of the 'Se-Sa-Rhe-Traditions-Region'.

er distributed in the centre and in the east, while the arrowheads of the 'Rhein-Maas-Schelde' culture tend to appear more to the northwest to the English Channel. The exchange within the 'Se-Sa-Rhe-Traditions-Region' was apparently intense. It is important to note, that in the west, during the Late Mesolithic, other arrowhead types with dorsoventral base reduction appeared that eventually even reached the Atlantic coast. These include 'Pointes de Sonchamps', 'Pointes de Falaise', and, finally, 'Armatures à éperon' of the 'Retzien-Culture' (Thévenin 1991, fig. 44; Cziesla 2015b, fig. 203; Schauer in press; see Fig. 10). Such Late Mesolithic arrowheads have been dated to 5,600 to 5,200 calBC (Marchand 2014; Séara / Lajoux 2019, fig. 6). As the tradition of base formation of arrowheads in the 'Se-Sa-Rhe-Traditions-Region' has its origins around 9,000 calBC (or several centuries earlier) in central Europe, it is beyond doubt that this arrowhead tradition extends in a western direction to the Atlantic (Cziesla 2015b, fig. 245). This direction of distribution is important for the evaluation of the ceramic types of Limbourg and La Hoguette.

New finds of the ceramic type La Hoguette

I have discerned in an extensive study that the dorsoventral retouched bases of arrowheads arose in central Europe and spread to the Atlantic during the Late Mesolithic and, subsequently, continued along the coast to the south (Cziesla 2015b, 162 fig. 109; Fig. 11). The dorsoventral base retouched arrowheads can be linked with the ceramic types Limbourg and La Hoguette (Figs. 5–7) and have an identical distribution area (compare Figs. 2; 10). Now a newly discovered find verifies this theory. In 1999, 2007 and 2009 (published in 2015: Rousseau et al. 2015) the remains of a vessel were found in Guibrelow I, near Machecoul, only a few kilometers distant from the Loire estuary (Fig. 2). The similarity of this pot – ovoid, roughly 56 cm high, with a body circumference of 45 cm – with a vessel from Alzey-Dautenheim is so striking that researchers think it possible that, even with a geographical distance of c. 800 km, the same potter could have been responsible (Rousseau

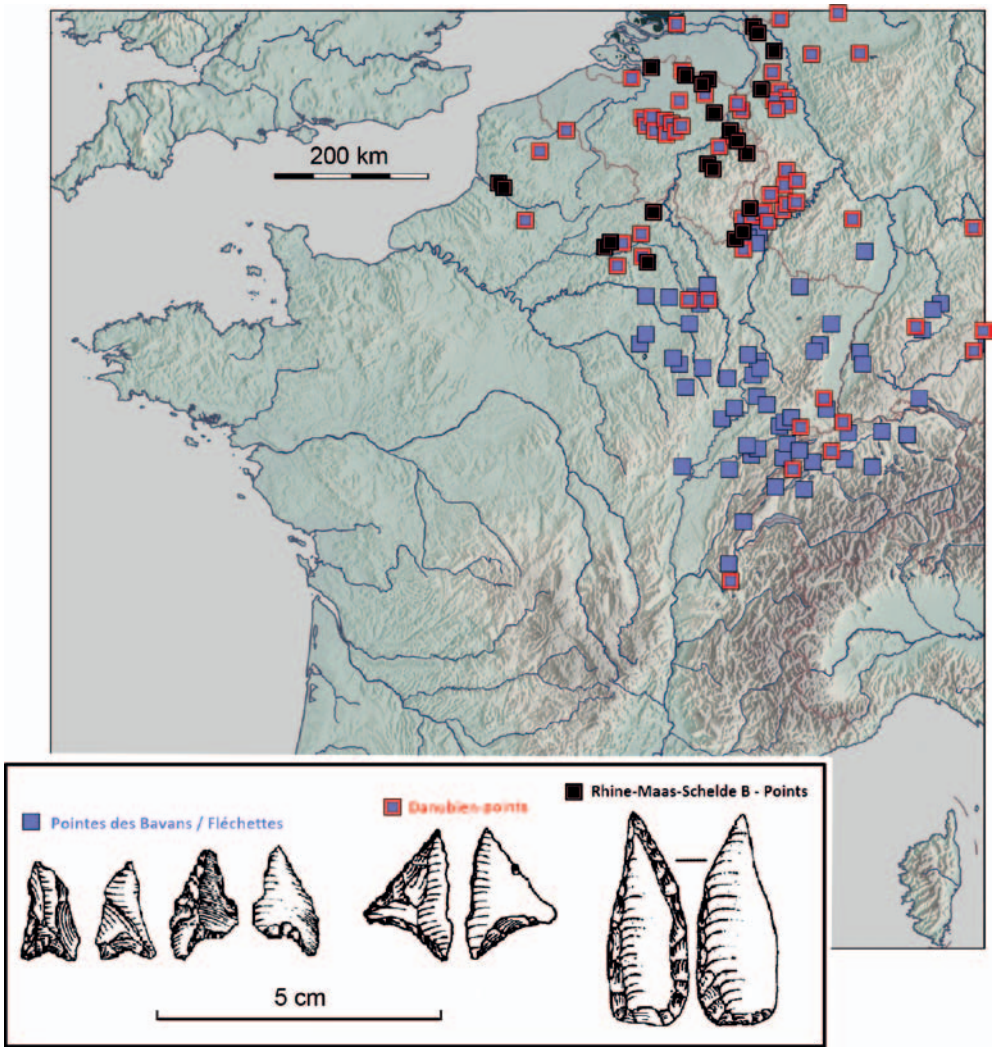

Fig. 9 Distribution of the arrowheads with dorsoventral retouched bases of the Late Mesolithic: Bavans-points, Danubian arrowheads, arrowheads of the Rhine-Maas-Schelde culture (after Czieśla 2015b, fig. 101).

et al. 2015, 27).[2] As numbers of finds have increased in northwestern France in recent years (Fig. 2), with further finds in the surroundings of 'La Hoguette' in Fontenay-le-Marmion also joining them, one should not view the ceramics of the La Hoguette type in this region as isolated finds (cf. Fig. 3), but instead assume that their distribution once covered this entire region in northwestern France. The distribution can meaningfully be explained in combination with the dorsoventral base retouched arrowheads.

While the direction of expansion for dorsoventral base retouched arrowheads from central Europe towards the Atlantic coast is certain, the direction of expansion for the ceramics remains, for the time being, open. It is possible that the ceramics were transported out of the 'Retzien' to the east, in the opposite direction of distribution of the dorsoventral base retouched arrowheads. As I could prove (Czieśla 2015b, fig. 109), a distribution towards the south apparently took place along the Atlantic coast (see also Schauer in press), until finally the dorsoventral retouched bases also appeared in southeastern France (Fig. 11), along with (although not yet associated) sherds of the La Hoguette type.

It should be noted that the west-east-exchange appears initially only as an exchange of ceramics and arrowheads. Whether other elements were subject to this exchange and whether this also had to do with the neolithisation processes has to remain open at the moment. The 'neolithisation' and the 'ceramicisation'

2 According to Google Maps it is a distance of even 885 km, needing 182 hours to cover by foot. An experienced traveller, therefore, would definitely need 2–3 weeks to negotiate the route from Guibrelou on the Atlantic to Alzey on the Rhine, provided that the groups present in these regions would have allowed it to happen. If we see the 'Se-Sa-Rhe-Traditions-Region' also as a uniform cultural and linguistic region, then the present Mesolithic groups could have allowed that, perhaps even welcoming or helping the traveller. Whether he was on the move from Alzey to the coast or in the opposite direction remains open in this consideration.

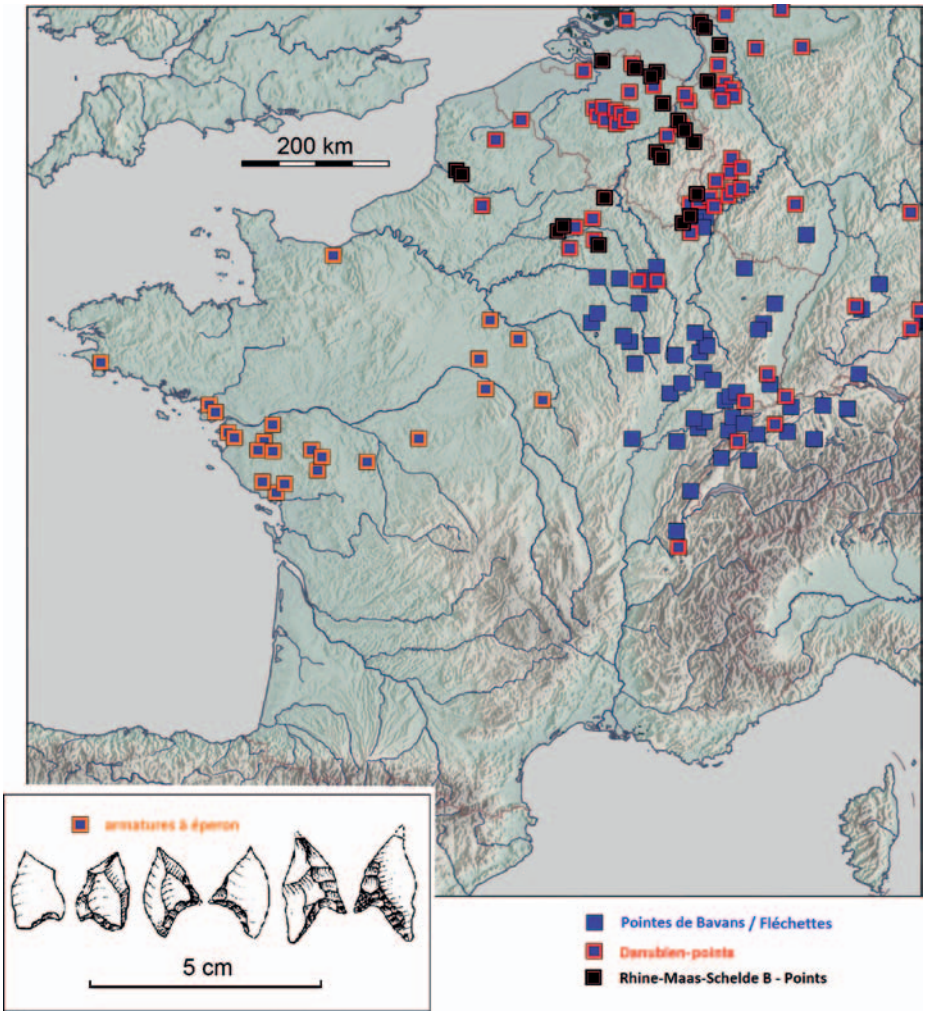

Fig. 10 In the west, the distribution of the arrowheads with dorsoventral retouched base from Fig. 9 is c. 5,600/5,200 BC supplemented by arrowheads with dorsoventral base reduction of the types 'Pointes de Sonchamps', 'Pointes de Falaise' and 'armatures à éperon', so that, along with the arrowheads from the 'Retzien', the Atlantic coast is reached.

are to be separated from each other, when we want to explore and, finally, understand the dynamics and meaning of both processes. Currently, the traditional image (Fig. 1) remains unaffected, with only the ceramics seeming to play a more complex role, also outside of the previous picture of distribution. This is not surprising, however, as the use of ceramics in the environment of hunter-gatherers is more the rule than the exception worldwide (Rice 1999; Jordan / Zvelebil 2009). This has recently been proved in northeastern Europe (Piezonka 2015; Ivanova-Biel 2016; Kirschneck in press), but apparently does not go back as far as with the La Hoguette (maximum) around 5,600 calBC.

Everything is under scrutiny

Considering the recent state of research, it is noticeable that in the past years a number of once cherished results concerning the Early Neolithic in western and central Europe have been put into perspective. For example the Bandkeramik settlement reconstruction as 'yard model' ('Hofplatzmodell') or 'row settlement model' ('Zeilensiedlung') are under discussion,[3] which will probably even affect the seriation of ceramics from house features, and results which started so brilliantly with Peter Stehli's findings (Stehli 1988) could become – in particular the assignment of pits to houses – questionable.[4] Likewise the origin of the Bandkeramik house type is no longer as sure as considered before. The theory from Christiane Frirdich, that the Bandkeramik house 'did not have any mesolithic role models' (Frirdich 2005, 89) has been put into perspective. Recently, large Mesolithic

3 Rück 2012; Zimmermann 2012; Lenneis / Schwarzäugel 2019, 301 f.; Cziesla 2019b, fig. 3.

4 Rück 2012, 24 f.; Stäuble / Wolfram 2012, 41 f.; Leuzinger 2012, 313; Stäuble 2013; Petrasch / Stäuble 2016, 375.

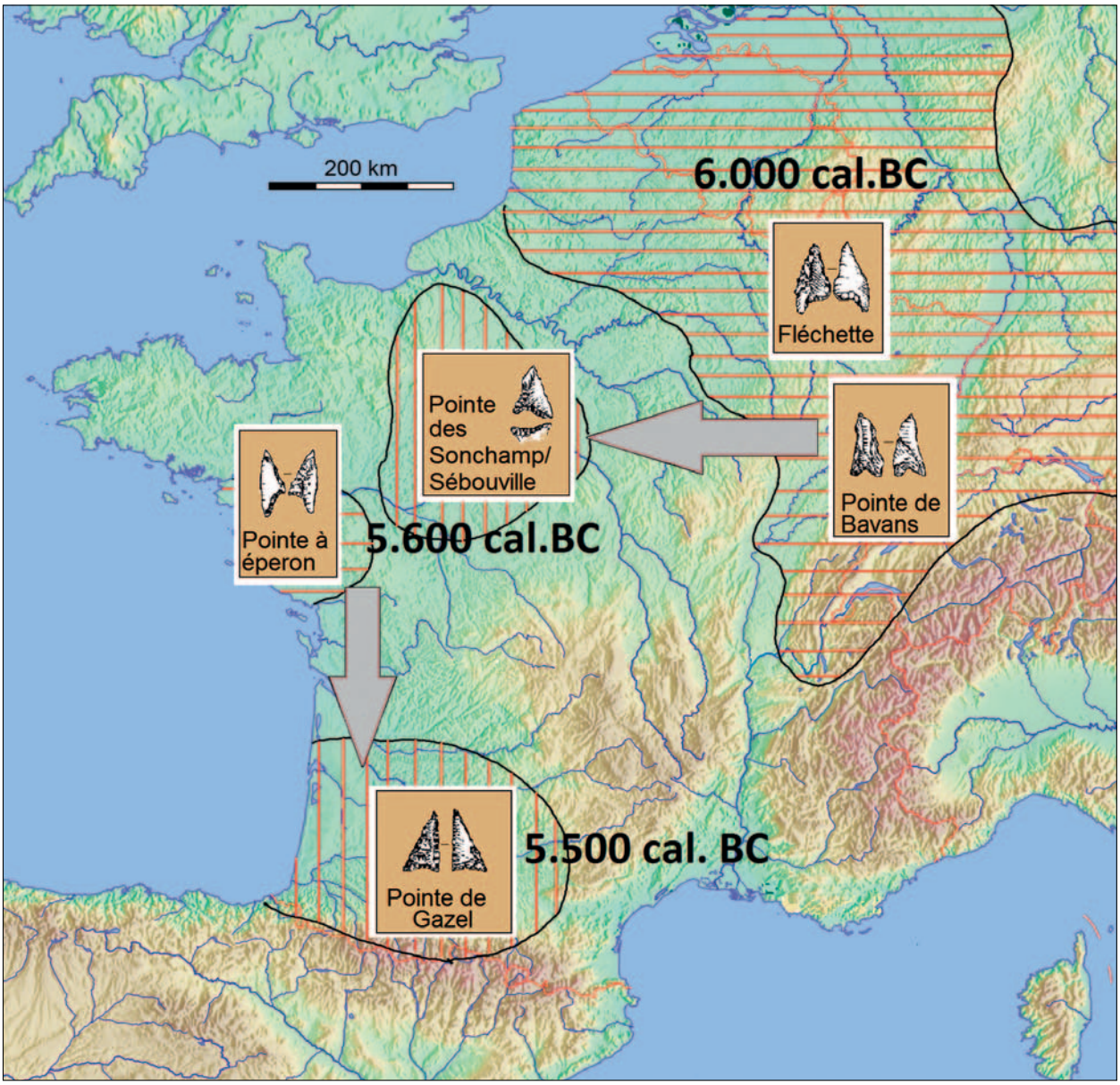

Fig. 11 Map showing the distribution of arrowheads with dorsoventral retouched base from central Europe to the Atlantic ('Retzien') and along the Atlantic coast to the south. Illustration form Cziesla (2015b, fig. 109). I have used the 'Fléchettes' and 'Pointes de Bavans' arrowheads from the Weidental caves (Cziesla 1992, 130) in this illustration, as the distribution of these arrowheads reaches into the Palatinate to the north (cf. different presentation in Jeunesse et al. 2019, fig. 32; cf. Fig. 3).

rectangular ground plans ('longhouses') have been published for the southern German site Siebenlinden (Kind et al. 2012) and for the site Jühnsdorf 8 in Brandenburg, eastern Germany (Cziesla 2017). These ground plans are c. 4.5 m wide and 6 to 8 m long (see also the site Veret´e I: Ošibkina 2007, Abb. 2), corresponding exactly to values known from small Bandkeramik buildings ('Kleinbau'; Coolen 2006; in detail see: Cziesla 2017; 2019a; 2020), the basic model or blueprint of all Bandkeramik houses in western Europe (Modderman 1970). This has already been foreseen, by the way, two decades earlier by Claus-Joachim Kind (Kind 1998, 18f.). The architecture of the small houses is also associated with the waste found there: while the Mesolithic hunters managed the small houses and left behind bones of wild animals, the large houses were the homes of farmers, who apparently preferred to consume domesticated cattle there (Elburg 1999, Figs. 2–3; Hachem 2000, 310). Also, we can now prove that Mesolithic arrowhead makers were to be found in Bandkeramik settlements, even in individual houses (Cziesla et al. 2014, fig. 4), which shows a tradition of dorsoventral base retouched arrowheads into the Bandkeramik culture (Cziesla 2015b; 2016; 2018a, fig. 3.F).

Bandkeramik vessels, long seen as unquestionable proof of the complete Neolithic material culture, just served as packaging for completely different

products (see Jennbert 1994). The numerous ceramic proofs have neither been compared with settlements, cemeteries or technical facilities (in detail: Cziesla 2010). The newest Bandkeramik sherds, published by Klaus Gerken, from the site Niedernstöcken 21, which lies far outside the Loess region, are not in question as remnants of a vessel. I have to associate, however, the feature in question (Gerken/Nelson 2016, figs. 3; 10) with a perhaps Mesolithic ground plan. Apparently the indigenous Mesolithic groups played an increasingly important role, whereas many colleagues would still like to deny that they had any knowledge of ceramic production and usage.

It is currently not possible to view the Cardial and/or Bandkeramik people as the producers of or masterminds for the origin of the La Hoguette ceramics tempered with crushed bones. It is much more likely that the 'hunter/gatherer ceramics'[5] developed in the western European region and influenced in turn both younger ceramic wares (Bandkeramik and Cardial). Also, from the geographical perspective, there are multiple indications for the existence of barriers that would have prevented the quick distribution of the Mediterranean developments to the north (Rasse 2008; Marchand 2014, fig. 8). If Jens Lüning and his colleagues were to comment again on the phenomenon of 'Limbourg and La Hoguette', then certainly not with the term 'western neighbours' in the title of the essay anymore. At the time of their publication, the 'neolithisation' was linked with 'ceramicisation', and there was really only one common origin and direction imaginable. This point of view is about to change.

Conclusion

It is assumed, therefore, that the 'ceramicisation' in most of Europe (southern, western and central Europe) was finished by the time the full Neolithic, as represented by the Bandkeramik, reached, around 5,300 BC, the Rhine-Valley. Then 'neolithisation' finally took place. Nevertheless, the hunter-gatherer culture lived on, whether, for example, spaciously as in the north European lowlands or in smaller, possibly isolated groups, as so impressively shown by the Blätterhöhle finds (Orschiedt et al. 2012). We have to expect parallel societies over the course of centuries, maybe for even up to two millennia. Which ceramics they used in the individual regions, and where the impulse for ceramics came from still needs to be explored. In the end the Dümmer ceramics, which are in the central focus of this conference, will likely also be associated with this Mesolithic ceramic traditions.

5 Michal Kobusiewicz has proposed the use of the terminology 'Paraneolithic' for the 'ceramic Mesolithic', the 'Epi-Mesolithic', 'Forest Neolithic' and the 'Subneolithic' (Kobusiewicz 1999). Until now, this term has not gained acceptance.

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Wetlands settlements and a wooden trackway: Swifterbant sites in the Dümmer basin

Marion Heumüller, Mirjam Briel, Florian Klimscha, Andreas Kotula, Hanns Hubert Leuschner, Reinhold Schoon and Tanja Zerl

Abstract For a long time the Hüde I site to the south of Lake Dümmer, Diepholz district, was the only known Swifterbant culture site in Lower Saxony. In the meantime, we can add two further sites in the region. An early Neolithic find horizon was discovered in the course of a research excavation at the site Hunte 3 (Damme FSt no. 113). While the flint artefacts indicate Mesolithic traditions, a few decorated ceramic fragments and ^{14}C-data between 4,300 and 4,000 calBC point to the sphere of the Swifterbant culture. The spectrum of animal bones covers both domestic and wild animals; other organic materials like botanical remains were not preserved. Much better preservation conditions were to be found in Campemoor to the east, where from 1992 to 2011 roughly 94 m of the wooden trackway Pr 31 were excavated. Dendrochronological data and ceramic finds suggest it belongs to the early Swifterbant culture. The three sites together suggest that the Dümmer basin and the adjoining Campemoor to the west had a certain attraction to the people of the Swifterbant culture over a period of several hundred years, and that the region, up to now, has presented an underestimated dispersal area of the Swifterbant culture.

Keywords Swifterbant, wooden trackway, wetland site, wetland dwelling, Lake Dümmer, Early Neolithic

Zusammenfassung *Lange Zeit konnte in Niedersachsen nur der südlich des Dümmers gelegene Fundplatz Hüde I, Ldkr. Diepholz, als Fundstelle der Swifterbant-Kultur benannt werden. Mittlerweile können ihm zwei weitere Fundplätze in der Region an die Seite gestellt werden. Am Fundplatz Hunte 3 (Damme FStNr. 113) wurde 2016 und 2017 im Rahmen einer Forschungsgrabung ein frühneolithischer Fundhorizont entdeckt. Während die Flintartefakte noch mesolithische Traditionen erkennen lassen, weisen wenige verzierte Keramikfragmente und ^{14}C-Daten in den Horizont der mittleren Swifterbant-Kultur (ca. 4300–4000 calBC). Das Spektrum der Tierknochen umfasst sowohl Haus- als auch Wildtiere. Botanische Reste oder andere organische Funde hatten sich kaum erhalten. Deutlich bessere Erhaltungsbedingungen liegen im östlich gelegenen Campemoor vor, wo in den Jahren 1992 bis 2011 der Moorweg Pr 31 auf ca. 94 m Länge aufgedeckt wurde. Dendrodaten und Keramikfunde weisen ihn in die ältere Swifterbant-Kultur. Die drei Fundstellen zeigen, dass das Dümmerbecken und das westlich anschließende Campemoor für die Menschen der Swifterbant-Kultur über einen Zeitraum von mehreren hundert Jahren eine gewisse Anziehungskraft hatte und die Region möglicherweise einen bislang unterschätzen Verbreitungsschwerpunkt der Swifterbant-Kultur darstellt.*

Introduction – Dümmer, Campemoor and the bordering Lowlands

On the southern extremities of the North German Plain between the foothills of the central uplands and the Damme hills, a broad sweep of lowlands consisting of valley sands stretches out. Here, between the modern towns of Barnstorf and Bramsche, one of the largest peatbogs in Germany was formed. At the time of its largest expanse it covered an area of some 180 km² with a maximum length of roughly 45 km. The bog comprises of a number of merging branches of which Campemoor in the southwest and Dümmer fen, with Lake Dümmer in the centre, constitute almost two thirds of the total area (Schneekloth / Schneider 1972, 68–77). Today Lake Dümmer, extending over an area of 15 km², is the second largest lake in Lower Saxony. Lake Dümmer, probably formed as a thermokarst lake, had a surface area of more than 80 km² in postglacial times, perhaps periodically of even more than 150 km². Sedimentation processes that began as early as the Boreal led to an ever-decreasing size of the lake (Dahms 1972, 181). However, until the introduction of man-made embankments in the 1950s, the dimensions of the lake varied considerably depending on the time of year, as water quickly spread

Fig. 1 The Dümmer basin and the adjoining Campemoor with the Swifterbant sites mentioned in the text. Mapped are known and more precisely located sites of different Stone Age periods (source: LBEG Bodenübersichtskarte, archaeological data: Adabweb, graphics: M. Heumüller, K. Dietrich/NLD).

over the wide plains and could cover an area of up to 100 km² (Dahms 1972, 196). Pollen analyses indicate that there was a similar shallow lake near the Campemoor site some 30 km to the southeast which silted up and became overlaid by peat bog during the Atlantic period (see Bauerochse / Leuschner this volume).

Wetland settlements around Lake Dümmer

The Dümmer and the surrounding fen areas are well known beyond the borders of Lower Saxony for their special wetland sites ranging from the Upper Palaeolithic, the Mesolithic and the Neolithic to the Bronze Age – and possibly even to the Iron Age and up to the early Middle Ages, too. Here, house and settlement ground plans with preserved construction timbers have been documented that are unique in the Neolithic Age of central and northern Europe. Other settlements with wetland preservation of the North German Plain were mostly located on sites in close proximity to bodies of water so that in saturated milieus only part of the settlement remains are preserved (cf. Müller 2012). The earliest reports of prehistoric finds from the lake come from the 17th century (Struckmann 1887, 13–14). Large-scale excavations took place between 1938 and 1941 under the direction of Hans Reinerth, who oversaw the almost complete excavation of the moorland village of Hunte 1 to the north of Dümmer (Reinerth 1939). Scientific evaluation of the finds and findings was not carried out until almost seventy years later by Rainer Kossian (Kossian 2007; 2009). According to his assessment the area was settled during the early and late Funnel Beaker culture, the early Corded Ware culture and the Bell Beaker culture – so in at least four settlement phases – between 3,300 and 2,000 BC.

According to the published information, ten prehistoric sites are known in the lowland fens along the river Hunte and in today's lake basin (Kossian 2007, 23 fig. 6). However, a glance at the sites archive at the State Office for Cultural Heritage of Lower Saxony indicates that today there are considerably more prehistoric sites around Lake Dümmer, which have yet to be processed or published (Fig. 1). The majority of these sites are located in drained areas used as farmland, which have been re-wetted by nature conservationists since the 1990s. It is uncertain how much of the potential older organic materials remain preserved.

The early Neolithic site of Hüde I

An extensive large-scale wetland excavation directed by Jürgen Deichmüller took place between 1961 and 1967 at the southern end of the lake. An area of some 1,100 m² of the site, known as Hüde I, was investigated. Although Deichmüller at that time found numerous timbers as well as a number of well-preserved organic objects he was unable to discover evidence of house features with wooden foundations or fireplaces, like those documented in Hunte 1. Instead the excavation yielded a wide range of finds from a variety of Stone Age cultures. Interdisciplinary analyses were presented in preliminary reports (e.g Deichmüller 1965a; 1968), and some of the outstanding finds were published (Deichmüller 1965b; 1974). Evaluation of the animal bones (Bossneck 1978; Deichmüller / Staesche 1974; Hübner et al. 1988; Hüster 1983) showed a clear predominance of wild animals, indicating a subsistence based on hunting. Furthermore, antler finds (Werning 1983) and man-made stone implements (Stapel 1991) were investigated. A dissertation on the ceramics (Kampffmeyer 1988) was not published, but the extensive work was widely circulated in academic circles. Various groups of finds, such as stone axes and other stone artefacts, remained unprocessed. Unfortunately, there was also no systematic evaluation of these finds, which is most unsatisfactory especially considering the range and, as far as Lower Saxony is concerned, the unique ceramic sequence containing elements of the Bischheim, Ertebølle and Swifterbant as well as the early Funnel Beaker culture.

Dutch archaeologists today ascribe most of the older components of the find collection to the Swifterbant culture and consider Hüde I to represent the most eastern extent of this culture which is mostly concentrated in the wetlands of the Netherlands (Ten Anscher 2015, 349–353; Raemakers 2013). The origins and development of the Swifterbant culture have lately been traced back to a long-term influence of the Danubian cultures of Rössen, Großgartach and Bischheim (Ten Anscher 2015, 346–353). At the same time, the Swifterbant culture is considered to have transmitted Neolithic innovations into the Ertebølle culture or, at least, made their achievements acceptable to a hunter-gather community. Hüde I can thus be seen as a key site for the neolithisation of northwest Germany, as it is the only site in Lower Saxony in which elements of the neighbouring archaeological cultures from the south, west and north are apparent.

In order to get an impression of the absolute chronological extent of Hüde I, some of Kampffmeyer's (1988, fig. 249) compiled data was re-calibrated. For this purpose only data was selected that fell within the Mesolithic to Neolithic periods, and that furthermore came from a secure archaeological context, and had a standard deviation of no more than ± 90 (Fig. 2). The new calibration of these 20 datings indicated four separate settlement phases at the time of the early to middle Swifterbant culture between 4,700 and 4,000 BC, followed by one or two settlement phases during the early Funnel Beaker culture in the first half of the 4th millennium.

Despite the excellent potential of the sites around Lake Dümmer new surveys only took place in 2004 at Hunte 2. The excavations have, up to now, yet to be entirely published (Drafehn 2006).

Hunte 3 – A new site of the Swifterbant culture

An earlier site known from Reinerth's preliminary investigations was chosen to make an exemplary check on the state of preservation of wetland sites in the Dümmer area. Reinerth himself had investigated three other bog sites in addition to Hunte 1, with varying degrees of intensity. The 'Hunte 3' site (Damme FStNr. 113; Gde. Damme, Ldkr. Vechta) is located on the now waterlogged western side of the re-directed bed of the river Hunte, almost 1.4 km from the embanked Dümmer and roughly 500 m north of Hunte 1. Reinerth documented here settlement layers with Neolithic finds. As the layers were relatively far from the surface in those days this site was considered most likely to offer the best chances for the preservation of organic materials.

Discovery and investigation

The site was discovered in October 1934 during survey work. In 1940, Reinerth had studied the sequencing of the various layers from one single trial hole and documented a 30 cm thick 'cultural layer' with 'sherds, bones, charred flint, wood and charcoal', beginning at a depth of 70 cm, which was embedded both in the alder carr peat and the algal gyttja or 'liverpeat' beneath it. An accompanying list of the now lost finds describes ceramic fragments, possibly from different periods of time, and stone and flint artefacts (Kossian 2007, 41). Below this find layer, Reinerth also documented three wooden piles indicating some form of prior building construction (cf. Heumüller et al. 2017, 16–17).

In 2016 and 2017 an area of 24 m² was examined as part of a research project. During this programme

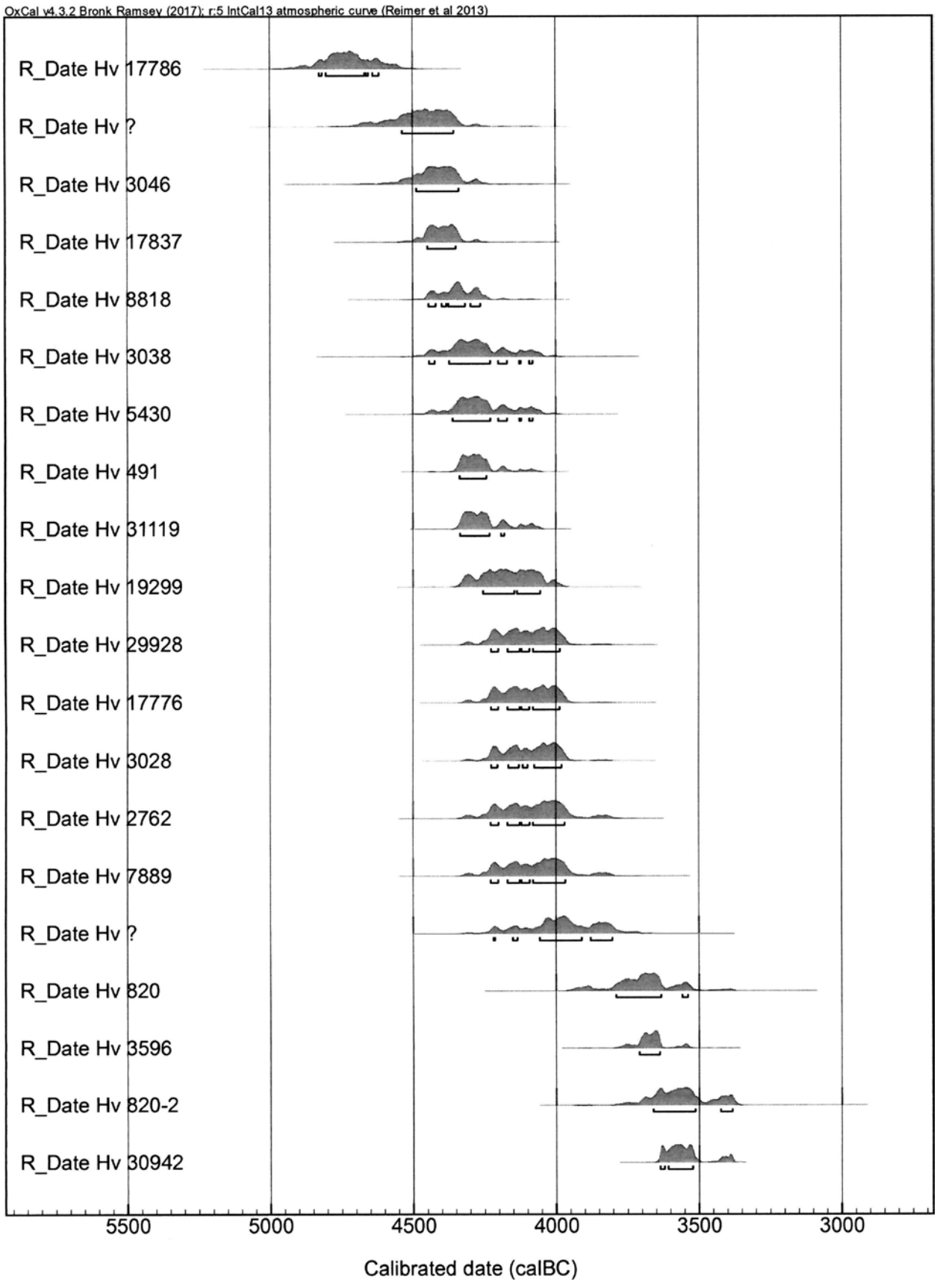


Fig. 2 Hüde I: Re-calibration of some of the data published by Kampffmeyer (1988, fig. 249) using OxCal 4.3 (graphics OxCal).

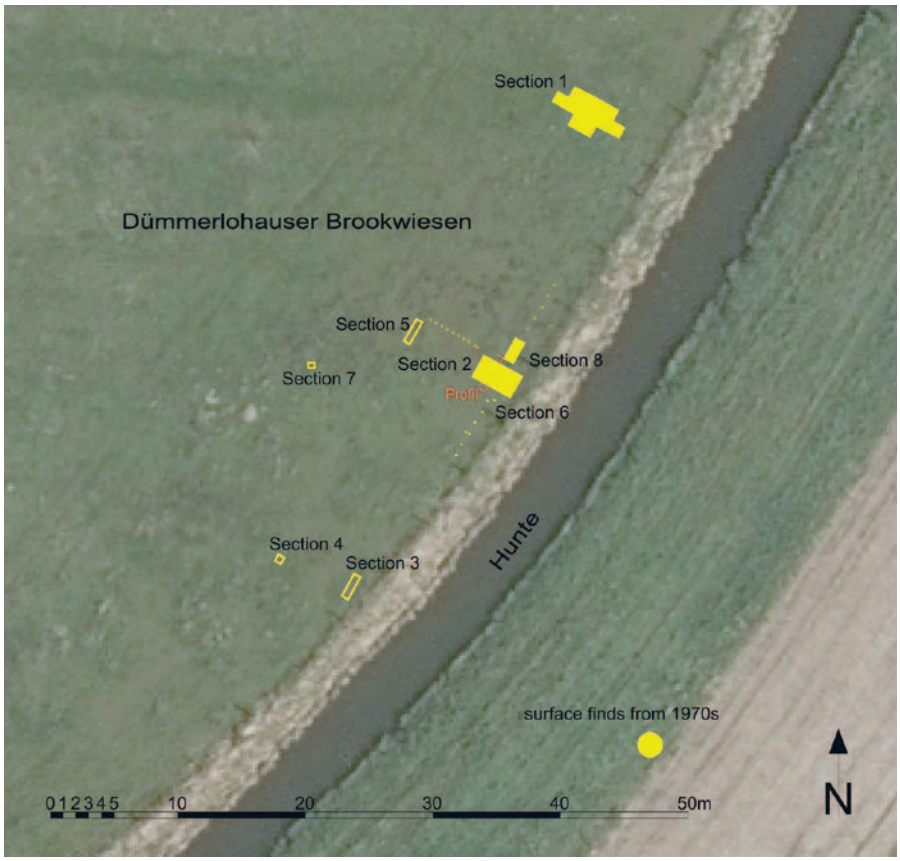


Fig. 3 Overview of the excavated sections and the drillings at Hunte 3. Sections with clusters of finds or a deep black find horizon interspersed with bone, ceramic and flint artefacts are marked yellow. Drillings with evidence of a cultural layer are also marked yellow. The marker east of the Hunte river pinpoints the site of surface finds from the 1970s. Together the completely yellow blocks denote the minimum extent of the settlement (graphics: A. Schwalke-Utku/NLD).

21 m² of layers rich in finds were discovered, which were excavated partly by following the archaeological layers and partly as artificial strata in quarter square metre blocks. The further extent of the cultural layer was recorded by drillings using a Pürckhauer borer (Fig. 3).

A comparison of the present situation with the documentation made in 1940 shows that at least 30 cm of the covering sediment have been lost to mineralisation and compaction (cf. Heumüller et al. 2017, 18–21 figs. 5; 8). The actual find horizon, on average 5 to 15 cm thick and consisting of strongly decomposed fen peat, was very homogenous, dark to black in colour from the charcoal and organic materials and found in sections 2, 6 and 8 and on the perimeter of section 1 at a depth of between 25 and 30 cm. The find layer is extensive but not continuous.

The eastern profile of section 2 (Fig. 4) represents the stratigraphic situation: directly beneath the top soil comes the find horizon, which is sometimes interspersed by a light grey band of gyttja. This division suggests that some parts of the already settled find horizon were later disturbed by a lake transgression. Many ceramic, flint and bone finds were recorded, but no building structures or organic materials were discovered. At the moment it is unclear whether these have decayed or didn't exist. Beneath the find layer there is a 30 cm thick layer of dark grey algal gyttja, in section 1 on the other hand there is a carr horizon. Several embedded dark, peaty bands derive from repeated silting up of the area, suggesting that when it was forming it lay on a flat peripheral zone of the lake.

While searching for the piles described by Reinerth, a part of the chalky gyttja in sections 1 and 2 was excavated to a depth of around 1 m. Parts of tree roots found there showed that wood preservation was definitely possible within the chalky gyttja layer, but no remains of piles or worked pieces of wood were found.

In all profiles the layer boundaries were conspicuously undulated. This must have been the result of drainage or dry phases and the accompanying contraction processes. This is also indicated by the dry cracks reaching to a depth of up to 1 m, which are typical effects of shrinkage and settling processes after de-watering (cf. Chmielsky 2006, 64). The fen peat, in which there were find layers with embedded charcoal as well as the algal gyttja found below the find layer were both dated to the Atlantic period by initial pollen analyses (conducted by Gerfried Caspers, Hannover, report from 02.02.2018). The sedimentation sequence points to a periodically wet milieu on the edge of a silting-up lake.

The feature of the find horizon as an almost black layer permeated with finds is a typical phenomenon

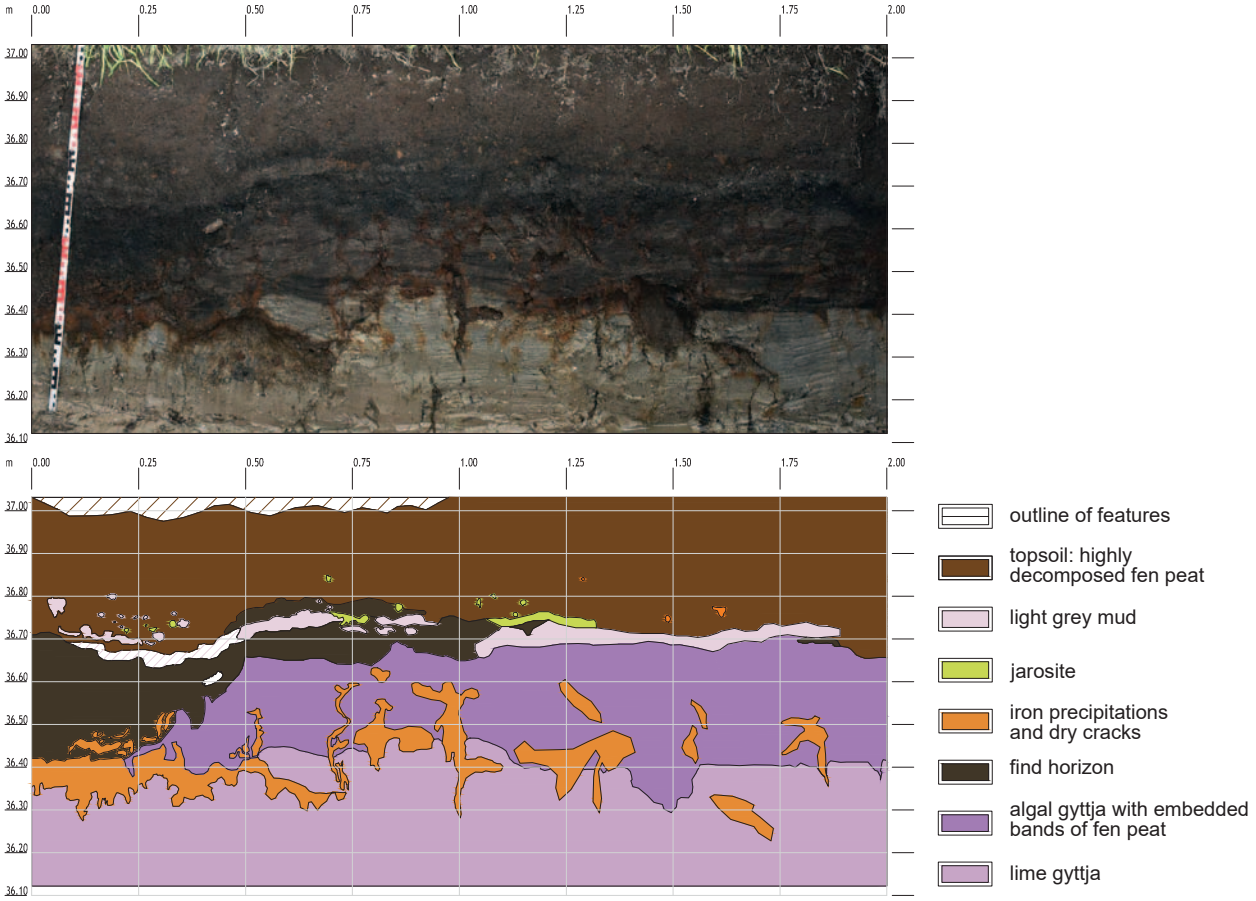


Fig. 4 The east profile of section 2 from Hunte 3. The find horizon lay here directly on top of a dark grey algal gyttja (graphics: A. Schwalke-Utku/NLD).

of the Swifterbant culture. At the site Swifterbant 4 (S 4) such a layer was identified as being a debris layer which in addition to find material consisted partly of charred plant materials and which had been re-arranged and re-deposited by flooding processes (Huisman / Raemaekers 2014). Whether the layer at Hunte 3 is also a re-located, anthropogenic debris layer or an, at least partially, *in situ* settlement layer cannot be determined with certainty at the present stage of research.

The find material

Ceramics

The mostly undecorated, severely fragmented ceramic has a grey-brown surface; reddish spots derive from iron oxidation. The sherds have to some extent rounded edges and have pocked, eroded surfaces; a sign that at least some of the material was covered by water. The preserved surfaces are mostly smooth. Profiles or dimensions of the vessels could not be reconstructed due to the severe state of fragmentation, and base fragments could not be identified which speaks for a round moulding of the base elements. The larger ceramic fragments reveal slightly curved profiles; distinctive features are missing. The wall thicknesses vary between mostly 7 and 10 mm. Tempering particles can be identified as macroscopic sand and grit.

Only nine sherds are decorated and allow closer inspection (Fig. 5). With one exception (find no. 233) they are fragments of rims, mostly coming from the carr or lowland peat layers. The sherds are decorated below the rim with horizontal, irregularly placed indentations in a variety of forms, either rounded pockmarks, short horizontal lines or elongated impressions. At least three of the sherds (find nos. 219, 358 and 396) are decorated with two parallel rows of embellishments. One fragment (find no. 368) features a notched rim. Find no. 365 is distinctive for its perforation from the outside of the vessel which could be closed on the inside by a small clay plate.

Such decorations are typical of the Swifterbant culture but also appear in the earliest Funnel Beaker culture or the Pre-Drouwen phase. Swifterbant ceramics and their development in the Netherlands from 5,000 to 3,400 BC have been recorded mostly in the studies of D. C. M. Raemaekers and J. P. de Roever (e. g.

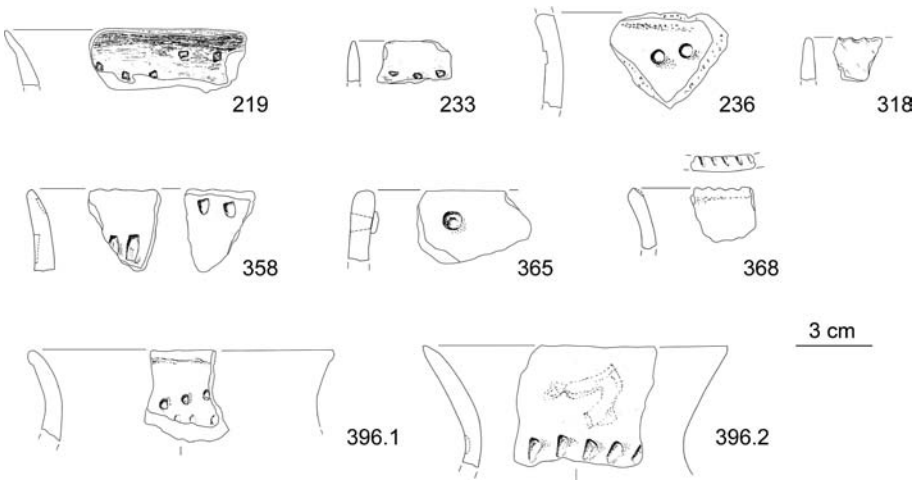


Fig. 5 Nine decorated sherds from Hunte 3 (graphics: A. Michalak/NLD).

Raemaekers / De Roever 2010; Raemaekers 2015) and T. J. Ten Anscher (e.g. 2015). According to these studies, the ceramics are characterised by more or less s-shaped profiles and round or pointed base forms and smooth surfaces. The vessels' diameters lie between 11 and 37 cm, with wall thicknesses varying between 5 and 14 mm (average 7–10 mm). Plant-based tempering particles, depending on local availability, dominate, but tempering particles of sand, grit and grog also exist (Raemaekers / De Roever 2010). Typical embellishments consist of one or a number of horizontal rows of elongated droplet-shaped or rounded impressions on the neck or shoulder of the vessels. Most of the sherds are very fragile due to the relatively low firing temperatures of below 600 °C (Raemaekers / De Roever 2010). The transition to the Funnel Beaker culture is poorly understood because of the rarity of sites between 4,000 and 3,400 BC in the Netherlands (Raemaekers 2015, 322–323). Recently, ten Anscher worked out the gradual transition using sequences at site Schokland P14. He defined the early horizon of the Funnel Beaker culture, the Pre-Douwen phase, as having typical decorative patterns like cord arches, zig-zag motifs, neck and belly fringes, grooves and stab and drag lines, together with the appearance of newer ceramic types like collared flasks or clay discs (Ten Anscher 2015, 341). The small find complex at Hunte 3 lacks the corresponding decorative and morphological attributes which suggests it should be assigned to the Swifterbant culture. On the basis of the ceramic features in the Netherlands Raemaekers / De Roever (2010, 135) distinguish early, middle and late phases, with the middle phase covering a relatively long period of time from 4,600 to 3,900 BC. Their indicators are the increasing use of decorations and the emergence of regional differences (Raemaekers / De Roever 2010). The Hunte 3 finds can be loosely associated here.

Flint artefacts

Up to now only the first batch of flint artefacts (n = 352) has been evaluated.[1] The artefact spectrum, dominated by unmodified basic forms and numerous typical flint processing wastes, such as trimming flakes and preparation debris, proves flint processing on site. There are fairly high numbers of blades, which together with blade cores indicate a production geared towards blade manufacturing. In addition to short blades with an average length/breadth index of 3 : 1 (but also some of 2 : 1), also micro blades with a ratio of 4 : 1 were found. Both the blades and micro blades are conspicuously even and with mostly parallel edges. Several blades show a clear distal shaft retouch on both lateral edges and can be included among the tools. In the site inventory there are also present two small burins, a thumbnail scraper and a blade with clear working traces on one lateral edge. Three microliths – a trapeze made from an even-edged blade, a transverse arrowhead and a micro point (see Heumüller et al. 2017 fig. 15) – are interesting as types due to their association on the same site. While micro points have a very long duration in north central Europe from the Preboreal to about the Middle Atlantic period, regular trapezes are more a phenomenon of the late Mesolithic and Early Neolithic.

Cores are proportionally numerous on site. They are very small (all < 6 cm) and almost exclusively show a steep knapping angle, almost 90°, with circumferential, uniform blade negatives. It is striking that – with the exception of the micro blade cores – the cores are predominantly fragments broken out of small flint nodules and were mostly knapped from just one side. The striking platforms show slight preparation marks

1 Analysed by Mirjam Briel (cf. Heumüller et al. 2017, 24–25)

Taxon	NISP	
	n	%
Cattle. *Bos primigenius f. taurus**	30	28.3
Sheep/Goat. *Ovis ammon* f. aries/*Capra aegagrus* f. hircus	9	8.5
Pig. *Sus scrofa* f. domestica	8	7.5
Domestic mammals	**47**	**44.3**
Wild horse. *Equus ferus*	11	10.4
Aurochs. *Bos primigenius*	5	4.7
Elk. *Alces alces*	3	2.8
Red deer. *Cervus elaphus*	10	9.4
Roh deer. *Capreolus capreolus*	1	0.9
Wild boar. *Sus scrofa*	5	4.7
Brown bear. *Ursus arctos*	1	0.9
Pine marten?. *Martes martes*	1	0.9
Beaver. *Castor fiber*	1	0.9
Wild mammals	**38**	**35.9**
Elk. *Alces alces*. or Cattle. *Bos primigenius* f. taurus	1	0.9
Aurochs. Bos *primigenius* or Cattle. Bos *primigenius* f. taurus	5	4.7
Wild boar. *Sus scrofa* or Pig. *Sus scrofa* f. domestica	5	4.7
Fox. *Vulpes vulpes* or Dog. *Canis lupus* f. familiaris	1	0.9
Wild- or domestic mammals	**12**	**11.3**
Fish. Pisces	8	7.5
Birds. Aves	1	0.9
Other Taxa	**9**	**8.5**
Total	**106**	**100**

Table 1 Hunte 3. Identified animal remains (vertebrates). NISP = Number of Identified Specimens; * incl. taxonomically uncertain fragments (n = 4).

with slightly convex platform remnants, typical of the middle and late Mesolithic in northern Germany. These characteristics indicate production in punch technique as well as direct (hard) knapping.

The flint materials consist of Baltic flints, which are typical of the North German Plain, of moderate quality. Even the smaller nodule debris was used for blade manufacturing which suggests the scant availability of raw materials.

The flint inventory together with the knapping techniques are typical features of the Atlantic Mesolithic in northern Germany. Burins and thumbnail scrapers tend to point towards an earlier period of the Mesolithic, the association with micro points and trapezes in the inventory suggests rather a later phase. Observations suggest that the site Hunte 3 represents a rather older period between the Mesolithic and the Neolithic, but the association of simple point and trapeze in one layer points toward a younger period. All in all, the flint inventory indicates a transitional period between the late Mesolithic und early Neolithic. Typical elements of this transitional period are, for example, the blades with shaft retouch. The soft knapping techniques can also often be observed in the early Funnel Beaker culture (cf. Hartz / Lübke 2012, 641).

Animal remains

During the 2016 and 2017 excavation campaigns, mostly bones of vertebrates were recovered from sections 1 and 2 (n = 975), as well as mollusc shells (n = 41) and human bones (n = 5). Of the available archaeozoological remains of vertebrates, 106 pieces (11 %) were able to be determined by species or taxonomy, 869 fragments (89 %) could not be classified.[2] The low level of determination reflects on the poor state of preservation of the bone remains. However, clear signs of fragmentation usually clearly identify the bones as the remains of domestic and wild animals used by the inhabitants for food purposes.[3]

The results of archaezoological analysis suggest the people living in Hunte 3 kept cattle, small ruminants (sheep or goats) and pigs in the household (Table 1). Hunting in the vicinity must have been an important sourse of meat as shown by the relatively broad spectrum of wild animal species. Hunting activities were directed particularly towards wild horse, aurochs, red deer and wild boar, while roe deer, brown bear and beaver were hunted to a lesser degree. Additionally, fish and game birds supplemented the diet.

Due to their unclear taxonomic status, all bones of domestic or wild animals (n = 12) were excluded from the livestock/wild animal ratio of the mammalia; furthermore, the antler pieces of red deer (n = 5) were not taken into account, as they could have come from shed antlers. On the basis of the remaining 80 skeletal remains there is a ratio of 59 : 41 % (n = 47/33) in favour of livestock animals, which suggests a slightly higher food-economic value of slaughter products compared to the yields from hunting.

This relation clearly deviates from the results of the archaeozoological investigations on the material of the Swifterbant and Funnel Beaker culture from Hüde I. Of the 6,510 mammal remains in question (excluding antler pieces and bones of *Bos* sp./ *Sus* sp.), only 4.1 % (n = 264) could be assigned to slaughter or domestic animals (Hübner et al. 1988,

2 Apart from 20 larger bone fragments, in which flint artefacts were embedded, all bone fragments were analysed by Reinhold Schoon (cf. also Heumüller et al. 2017, 25–28).

3 In addition to the taxonomic determination of the material, the degree of fragmentation of the bones, age characteristics, special features and bone measurements were documented (Von den Driesch 1976; Habermehl 1975; Heinrich et al. 1991; Zietschmann / Krölling 1955).

37 tab. 1). The significantly greater economic importance of domestic animals indicated for Hunte 3 is certainly not statistically valid due to the relatively small amount of material and has therefore to be verified with the help of further find complexes from the research region.

Archaeobotanical analyses

During the archaeological investigations at the Hunte 3 site a total of 25 soil samples were extracted, above all from the charcoal-rich cultural layer described above, but also from the carr peat.[4]

Only ten samples contained fruit and seeds (n = 51). Identified were fragments of hazelnut shells (*Corylus avellana*) and a drupelet of raspberry (*Rubus idaeus*), both of which can be considered as forage plants. Besides, diaspores of synanthropic species were found: fat-hen (*Chenopodium album*), white dead-/spotted dead-nettle (*Lamium album/maculatum*), pale persicaria/red shank (*Polygonum lapathifolium/persicaria*), the caryopsis of a grass (Poaceae), diaspores of goosefoots, knotweeds and docks or sorrels (*Chenopodium* spec., *Polygonum* spec., *Rumex* spec.) which were not possible to determine in more detail, and a probable seed of cabbage (cf. *Brassica* spec.). The fruit of a branched burr-reed (*Sparganium erectum* s. l.), a riparian and meadow plant, was also found. Sixteen diaspores could not be identified due to the bad state of preservation (Indeterminatae).

Most of the remains were subfossil, i. e. uncharred, just a hazelnut shell fragment and the fruit of the burr-reed were charred. Even though there is no evidence of cultivated plants, these charred residues together with the other finds document local anthropogenic activities.

The modest number of fruits and seeds as well as the low density at 2.8 n/l (remains per liter of sample volume) indicate that for the Hunte 3 site the preservation of subfossil plant remains must be classified as extremely poor. This is most likely the result of a considerable drop in groundwater levels in the past decades causing the once continuously moist fen to dry up.

4 Analysed by Tanja Zerl in the Archaeobotanical Laboratory of the Department of Prehistoric Archaeology at the University of Cologne. For the analysis of the sample material subsamples of 0.5 l, 1.0 to 2 l, resp. (18 l in total) were divided and processed. This involved dissolving the subsamples carefully, then rinsing the samples through sieves with mesh sizes of 2 mm, 1 mm, 0,5 mm and 0,25 mm. The fractionated sample material, kept in water, was then examined for plant remains under a stereo magnifier with up to 80x magnification.

Radiocarbon dating

Charcoal from the lowest planum of Section 1 was used for ^{14}C-dating. Initially animal bones were tried to avoid old wood effects. Radiocarbon measurements on these, however, proved unsuccessful due to the poor condition of the collagens. The charcoals from sample no. 460/3456.00113–28 1 (Lab. no. Poz-87927) originate from material taken from a number of square meters of planum 4, roughly 30–40 cm below the ground surface, whereas charcoals taken from samples 460/3456.00113–28 6.1 (Lab. no. Poz-87928) and 460/3456.00113–28 6.2 (Poz-87929) come from several square metres of the lowest level of planum 5, some 40–50 cm below the surface. A sample recovered from planum 4 was dated to 4,228–3,963 calBC and thus slightly younger than the two samples from the lowest level of planum 5, which dates to 4,328–4,054 calBC or 4,331–4,057 calBC (95.4 %). This age-range could represent both the latest Swifterbant and the earliest Funnelbeaker culture.

The wooden trackway Pr 31 in Campemoor – a Swifterbant timber construction

Site, discovery and course of investigations

Campemoor, southwest of Lake Dümmer, still covered an area of 46 km^2 in the 1970s. Towards the east it merges seamlessly with Dümmer moor (Schneekloth / Schneider 1972, 74–79). Here the bog, which in other places is up to 7 km wide, narrows to a roughly 3 to 4 km wide bog landscape.

For a long time only the Campemoor trackways at the bottleneck to Dümmer moor were known. Here, trackway Pr 25, discovered as early as 1826 during the construction of the causeway between Hunteburg and Damme, is particularly worth mentioning. It was built in the late Pre-Roman Iron Age and was used again in the early Roman Imperial Period (Fansa / Schneider 1990, 24–25; Bauerochse et al. 2012, 138).

However, in October 1991, two more trackways were discovered in Campemoor during peat cutting. Between 1992 and 2011 a variety of rescue excavations took place, during which three other Neolithic trackways were discovered. The five newly discovered trackways all run in a similar northwest to southeast direction and cross each other corresponding to their varying dates and levels. There is a time span of 1,600 years between the oldest (Pr 31, dendro-dated at 4,629–4,538 BC) and the most recent (Pr 32, den-

Fig. 6 Overview of the course and position of the studied sections of the Neolithic moorland trackway Pr 31 (graphics: C. Ludwig/NLD).

drodated at 2,909–2,882 BC) trackway, and a difference in height of around 1 m. After the individual trackways became covered with peat, the previous ones were probably no longer recognisable when the later ones were constructed. The topographic situation at the time of building the respective trackways and thus their starting points and destinations are largely unknown in the extensive landscape covered by raised bog. The bog trackways have been presented in various preliminary reports (e.g. Metzler 1993; 2003; Bauerochse et al. 2012), but a complete presentation of the features and findings is still lacking, as well as an allocation of the determined dating of the wooden construction. A synopsis of trackway Pr 31 is now presented here, which, thanks to ceramic fragments and dendro-dating, can clearly be associated to the Swifterbant culture.

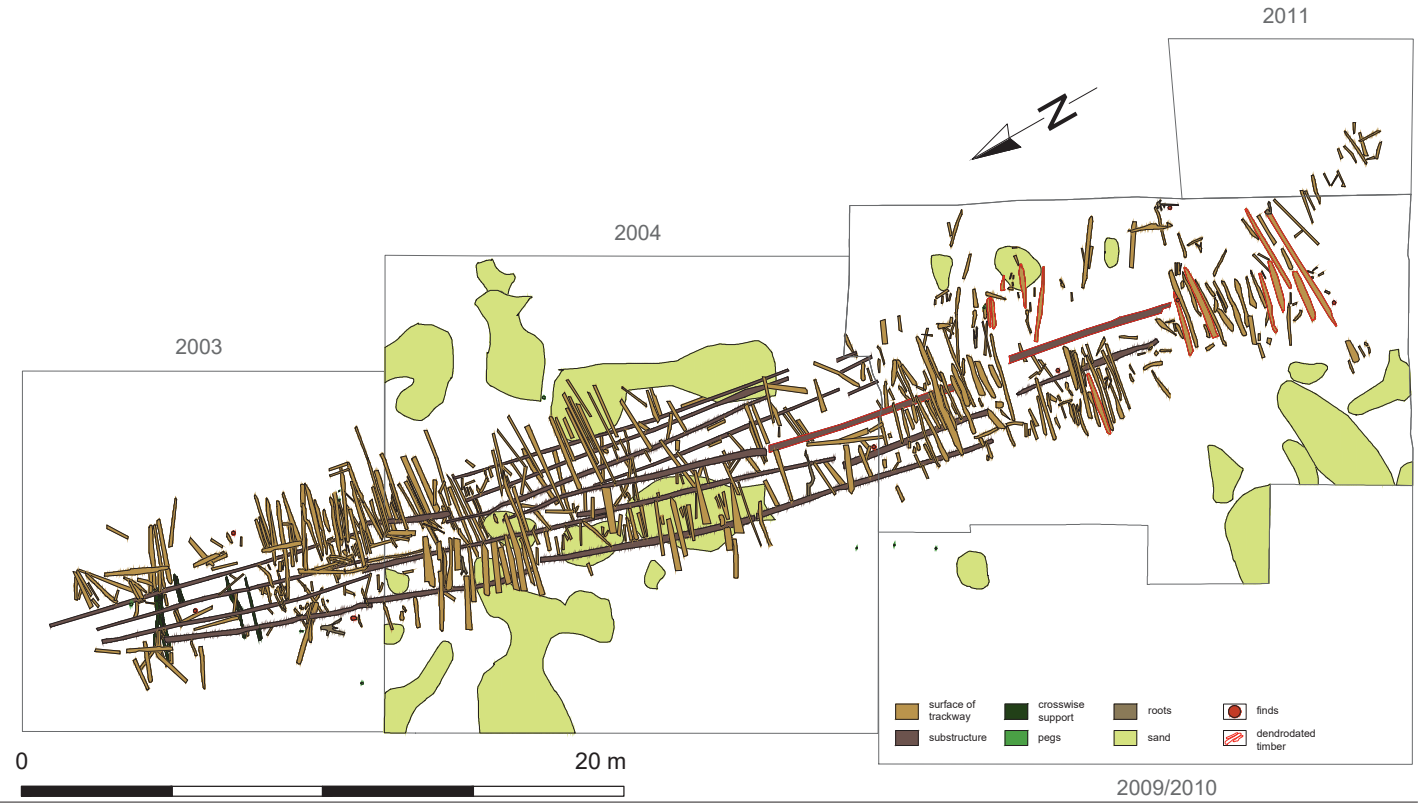
Dendrochronological dating

The excavations were accompanied by palaeoecological and dendrochronological investigations (most recently Bauerochse / Leuschner this volume). Hanns Hubert Leuschner was able to date 36 oak and pine samples from Pr 31 even though the outermost rings were mostly not available, due to the poor preservation of the wood. The exact felling dates could be precisely determined of only two of the construction woods. The dates measured range from 4,629 to 4,538 BC, so 91 years, but allowances must be made for the estimated final growth rings. During this span of time there were several felling phases, probably indicating repair cycles. Accordingly, the trackway was constructed in 4,629 and, especially in the following 40 years (in 4,614, 4,590 and 4,538 BC), it was improved or extended. Further repair work appears to have taken place in 4,606, 4,557 and 4,545 BC (cf. Achterberg et al. 2015, 25; Bauerochse / Leuschner this volume).

Construction of the trackway

Trackway Pr 31 was exposed to a length of some 94 m, with minor gaps (Fig. 6). In the southwest and in the northeast of the investigated section, the trackway rests directly on projecting sand ridges. In between it bridges a depression in which a few decimetres of fenland peat had formed. The southwestern end of Pr 31 was possibly reached with the investigations, at least there were no other structures observed in the vicinity. To the northeast of the studied area the trackway continues for an unknown distance beneath a 3 m thick peat overlay.

The state of preservation of the timbers can be described as poor; bark and sapwood were mostly



missing. The best preserved part of the trackway was the northeastern section which was investigated in 1992 and 1996. Here, the timbers of the superstructure were packed so tightly that Alf Metzler and his team had to excavate it in two layers. The structure consisted of pine trunks which had been placed perpendicular to the direction of the trackway, some with the slightly thicker base to the right, others to the left. They are mostly relatively small trunk segments with diameters between 8 and 15 cm and lengths of 2.5 to 3.5 m. Unusually for wooden trackways, the branches had been trimmed crudely – often stumps of branches up to 5 cm long were still protruding (Fig. 7). The track surface rested, in some places, on a substructure of two, but mostly of four longitudinal beams that marked the route with a width of 1.20 to 2 m. Somewhat more solid pinewood was used for these supporting beams, which were up to 4 m long and 20 cm wide (cf. Metzler 1993; Bauerochse / Metzler 2001, 113–116). In some places the longitudinal supports were underlaid with further birch branches as crosswise support. These were probably used in more waterlogged areas that needed to be additionally secured by extra layers of wood. Some timbers from the trackway surface were found in secondary positions to the east of the original construction, indicating that there must have been occasional flooding.

Trackway Pr 31 is a pile trackway (*Pfahlweg*), i. e. built of timber that has not been processed to planks or boards (Hayen 1957, 248), even though the term 'pile' may seem inappropriate for horizontal wood. The multi-layered, grid-like construction of transverse upper timbers on longitudinal foundations and, in some places, further underlaid by transverse timbers corresponds to the conventional designs of bog trackways in northern Germany. The grid-like construction spread the weight of the user over a wider area, generally allowing the constructors to do without vertical construction elements.

The northern part of the track section studied provided, however, an unusual and hitherto unknown feature. There, beams over 4 m long were discovered on both sides of the trackway which had been placed with a roughly 2.5 m gap between them on top of the actual transverse track surface (Fig. 8). Pegs, around 50 cm long and partly made of birch, had been driven vertically through the wood to anchor the longitudinal timbers (Bauerochse / Metzler 2001, 115; see Fig. 9).

The pincer-like construction was evidently intended to secure the superstructure of the trackway. It was only completely preserved in the section studied in 1996. The row of pegs continues to the northeast (cf. Fig. 8) without the upper longitudinal timbers, which do not appear to have survived. When two pegs

Fig. 7 The superstructure of the section of trackway Pr 31 investigated in 1992 (photo: NLD)

appear opposite each other the distance remains 2.5 to 3 m. Significantly, the transverse timbers beneath the upper longitudinal trunks are still in place, while in the adjacent section only the pegs remain of the former upper woods and the transverse timbers have shifted to the east. The poor state of preservation of the longitudinal timbers, with only fibers remaining, indicates that details of the woodwork involved or the kind of perforation could not be observed.

Corresponding pincer- or clasp-like constructions with anchored longitudinal timbers to secure underlying transverse woods were used in ancient bridge building. Such construction elements of prehistoric trackways have been recorded in the bogs of northwest Germany from the Late Bronze Age and Iron Age on (Hayen 1989, 26), they are also found in southwest Germany (Heumüller 2016, 422–423). However, this form of construction of a bog trackway is up to now unique for the late Mesolithic or Neolithic.

In the adjacent section to the southwest, the track splits into two parallel paths (Figs. 10–11), thus widening to up to 5 m. Based on the stratigraphic conditions alone it is difficult to say whether the paths were synchronous and that the trackway was 5 m wide, or whether the two paths were built one after the other with presumably a time gap in usage. However, the localisation of the dendrodated wooden remains suggest a successive construction of the two track segments.

All dated samples come from the more recent excavation campaigns of 2004 to 2010 and therefore from the southwestern part of the studied section. The dates from individual woods are listed in the detailed drawing (Fig. 10). In two cases wooden substructures could be dated, while the rest of the samples derive from the upper timbers of the trackway. The construction of the western part of the two parallel trackways can be dated by two pieces of wooden substructure. They belong to the more recent construction timbers with estimated felling dates of around 4,583 and 4,577 BC, a time when the path had already existed for almost 50 years. Conversely, most of the other samples which were dated before 4,600 BC come from the extension of the eastern stretch of the trackway. This suggests a sequence of two building phases or two separate tracks. It is striking that the younger, western track is around 15 m longer than the older, eastern one. It can be assumed that almost 50 years after the first track was built, an extension became necessary due to an increased water level. Presumably, the upper transverse timbers documented in the excavated sections during the 1992 and 1996 campaigns as well as the longitudinal trunks anchored by pegs found in 1996 can also be classified as subsequent repair constructions.

The find material

27 finds were discovered at 15 different places in the excavated section, a relatively modest number, but quite usual for a bog trackway. The small assortment included a vessel broken into numerous individual parts, further sherds, a stone axe and 24 flint artefacts.

The broken vessel (find no. 2003–3; Fig. 12) was found on the western edge of the trackway in 2003. It is an s-shaped curved vessel with a diameter of 20 cm and a wall thickness of between 6 and 8 mm, made using the ‘U’ technique. The dark grey clay is sand- and grit-tempered, the surface smoothed. The

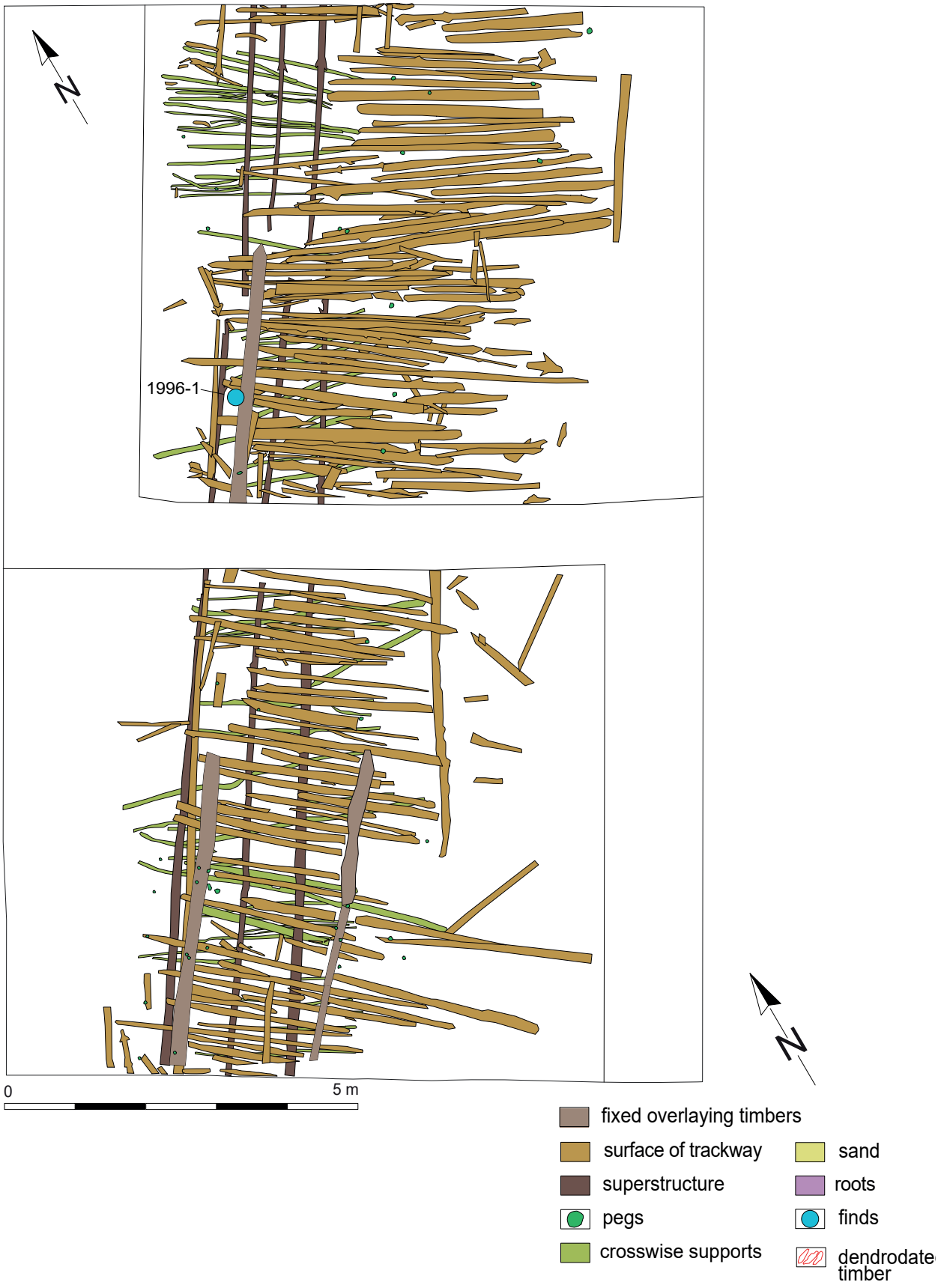


Fig. 8 Detailed drawing of the construction. On the western edge of the trackway Pr 31 the longitudinal beams with anchoring pegs above the trackway surface are still intact. The presence of further pegs and longitudinal beams suggests a similar construction on the eastern edge (drawing: NLD).

Fig. 9 In the section excavated in 1996, the longitudinal beams with anchoring pegs above the trackway surface are still intact (photo: NLD).

only decoration was applied to the tip of the rim, whereby some of the impressions were made by a sharp object, others by a rounded one. The base is not preserved. The vessel is typical for the early phase of the Swifterbant culture, which is the only phase with impressions made on the tip of the rim. The closest parallels are found more than 200 km to the west at the Swifterbant site of Hoge Vaart-A27 (Raemaekers / De Roever 2010, 137–138). Raemakers / De Roever (2010, 137–138) date this early phase between 5,000 and 4,600 BC, a time span corresponding to the earliest construction phase of Pr 31. Trackway Pr 31 is currently the only context in which this vessel type can be dated by dendrochronology.

The flint material consists of 23 pieces with a total weight of 165 g.[5] The majority are unmodified flint pieces, some of which showed signs of having been affected by fire (eight pieces), suggesting a link to human activities. Only two irregular blades, a flake, a flake core and a transverse arrowhead could be identified (Fig. 13). The artefacts fit into an everyday *ad hoc* tool production suggested for the Swifterbant culture (Devriendt 2014). Hereby mostly flakes were obtained from small cores and processed into tools. A pragmatic local production at Pr 31 is underlined by the transverse arrowhead made from a flake, and a rather poor blade technology.

An important find with a direct link between the trackway and its dating is a small tongue-shaped axe blade (Fig. 14).[6] The cutting edge is 4.5 cm wide, and the axe has a maximum length of 9 cm and thickness of 2.2 cm, the cross section is oval. Both sides shows clear signs of birch tar used for shafting. According to Brandt's definitions it is an oval cross-section stone axe. These artefacts are typical in northwest Germany but are very difficult to date (Brandt 1967, map 30). The distribution of axes with oval cross-section (*Felsovalbeile*) is mutually exclusive from that of the typical 'Danubian' stone axes. Regarding their distribution, axes with oval cross-section rather seem to be closely related to axes with roundish cross-section (*Felsrundbeile)*. Brandt defined the distribution of the latter as to west and south of the line between the lower Weser and the river Aller (Brandt 2002, 98). Nevertheless, there is also a clear focus west of the Hunte between the rivers Ruhr and Lippe (Brandt 2002, 95 fig. 7). Based on this, Brandt concluded that this axe type had an important role in connecting both areas during the neolithisation; he saw them within the context of the Michelsberg culture and its 'outposts' in the Münster region (cf. Hülsebusch / Jockenhövel this volume). So far, these considerations have only been based on undated old finds (Brandt 2002, 98–99). The dating result on the axe from Pr 31 represents the first absolute date for stone axes with oval cross-sections. The date itself, at 4,629–4,538 BC, is surprisingly early, and while this strongly argues against a Michelsberg connection, it places the axe securely into an earlier Rössen/Bischheim horizon (cf. Kreuz et al. 2014, 74 fig. 1). This is an important detail that will allow to re-evaluate the cultural relations of the Swifterbant culture – based on specific stone axe types – in the near future.

Dümmer and Campemoor – a central area of distribution of the Swifterbant culture

The excavation at Hunte 3 was the first investigation on a wetland site at Lake Dümmer in a long time. The state of preservation of the site, which has been known for more than 80 years, however, is sobering. Organic or botanical finds have not survived, but bones were preserved. This cannot be taken for granted in Lower Saxony with its lime-free sandy soils. The newly recovered material, both pottery and ^{14}C-data, fits in well with the context of the middle phase of the Swifterbant culture, where ceramics are in use from the early

5 Examined by Andreas Kotula.

6 Examined by Florian Klimscha.

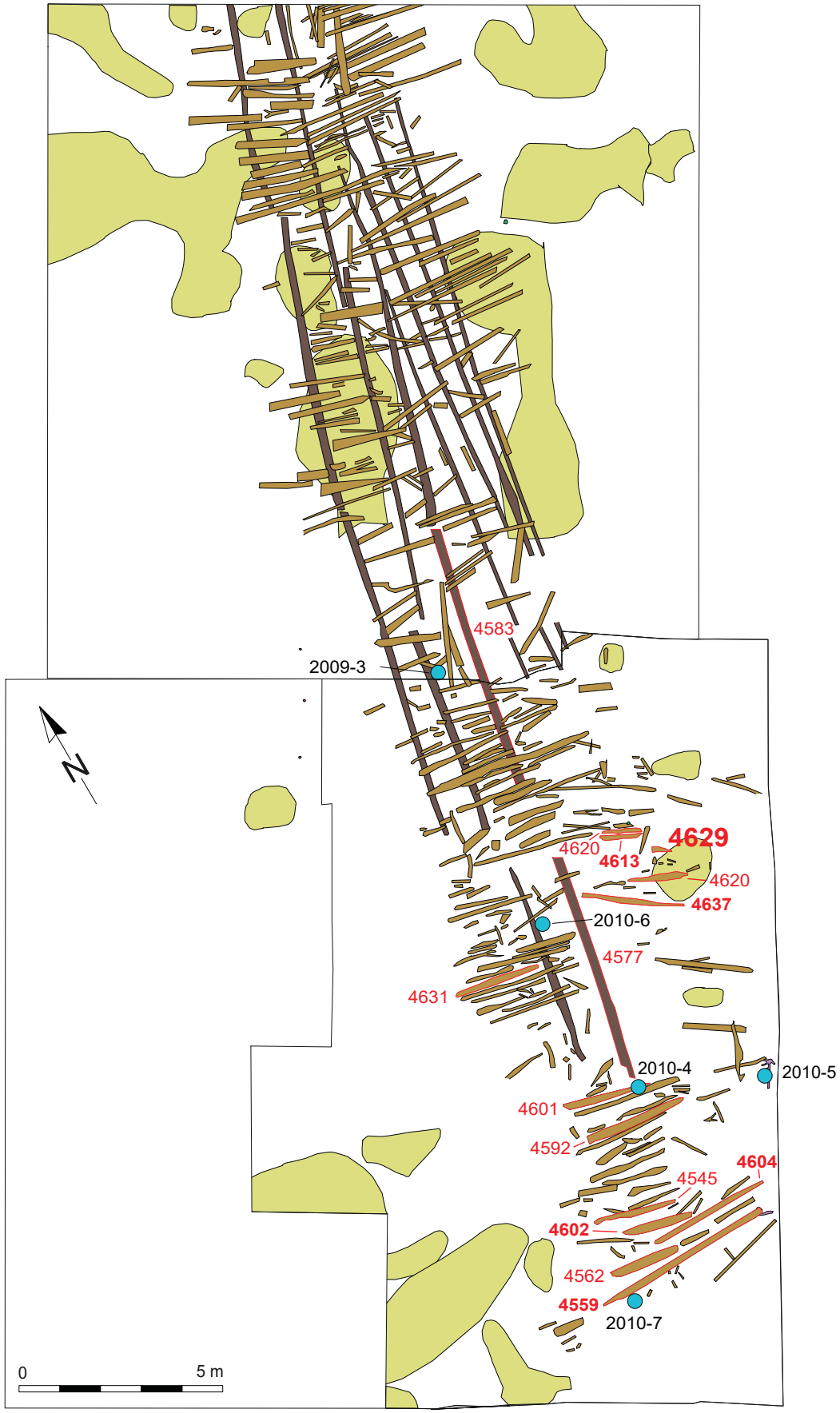


Fig. 10 A detailed plan of the south-west section of Pr 31. Dendrodated woods are marked in red. The assigned year indicates the last measured growth ring of the sample. Only one timber supplied the last growth ring, and so this one with its exact felling date is printed in bold red figures (4,629 BC). In some cases the end year could be fairly accurately estimated; these are marked in medium bold figures. (graphics: C. Ludwig/NLD)

Fig. 11 Exposing trackway Pr 31 in 2004 (photo: NLD)

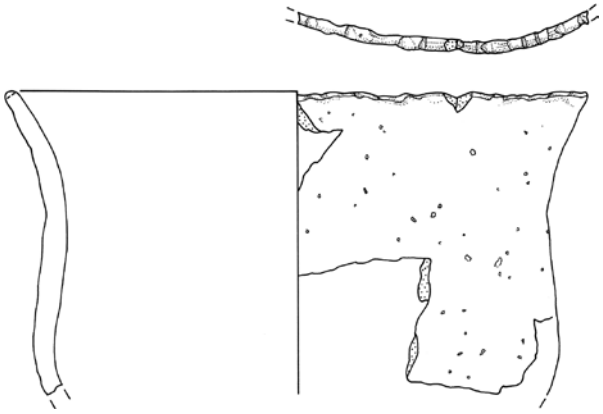


Fig. 12 A drawn reconstruction of the ceramic find. Scale 1:3 (graphics: V. Diaz/NLD).

Fig. 13 Flint artefacts from Pr 31: two irregular blades, a transverse arrowhead and a flake core (photo: A. Kotula/NLD).

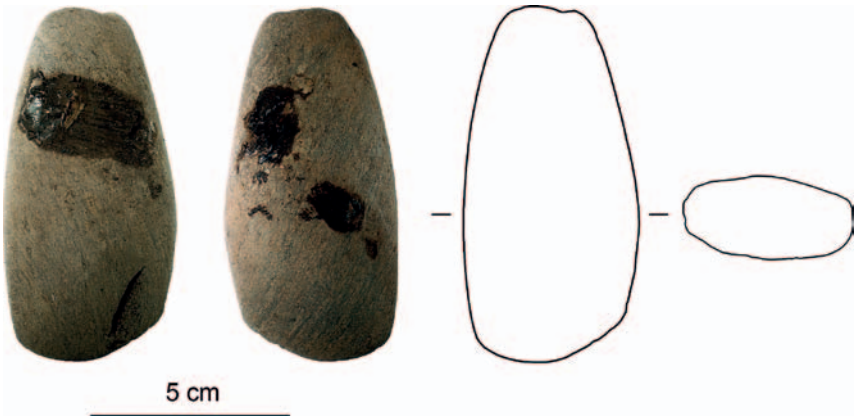


Fig. 14 Tongue-shaped axe blade with birch tar on both sides from Pr 31 (photo: Chr. Fuchs/NLD).

phase c. 5,000 BC onwards (Raemakers / De Roever 2010, 136). In this culture, evidence of the first domestic animals appears from 4,500 BC (Raemaekers 2015, 322–323), and from around 4,200 BC the cultivation of cereals appears to have become widespread (Cappers / Raemaekers 2008). Overall, the subsistence was based on hunting, gathering and cultivation (Raemaekers 2015, 325). Other findings from Hunte 3 have parallels with the Swifterbant culture, particularly the animal bones which mostly represent domesticated animals but also include a wide range of wild animals.

Trackway Pr 31 in Campemoor was investigated between 1991 and 2011, and this oldest wooden trackway in the world can now be included into the Swifterbant sites in the Dümmer region. The dendrodates and a ceramic find allow to associate it with the early Swifterbant culture. At the same time, Pr 31 is the only known path structure from the Swifterbant culture. With its advanced construction, it demonstrates a technique of wooden construction adapted to damp soils, hitherto unknown from subsequent phases of the Neolithic.

For a long time, Hüde I south of Lake Dümmer was the only known site in Lower Saxony assigned to the Swifterbant culture. Two further sites can now be placed alongside it – trackway Pr 31 and the wetland station Hunte 3. The concentration of sites indicates a focal area of Swifterbant activities around Lake Dümmer with a chronological range from the older to the middle phase of the Swifterbant culture, a period of several centuries. The habitats around the Dümmer and Campemoor correspond very well to wetlands in the Netherlands, where the main distribution of the Swifterbant culture was located. The Swifterbant site of Schokland P14 (Ten Anscher 2015, 337) highlights easy accessibility via the river Vechte, and the same applies to the sites north and south of Lake Dümmer, with the river Hunte providing good connections both to the north and south.

The lack of further Swifterbant sites on the dry areas of the Netherlands and Lower Saxony has been discussed in several papers, particularly by Raemaekers. He blames the fragility of the pottery, which has little chance of preservation on dry sites, and the lack of specific features of the flint for this absence of traceability (Raemaekers 2013, 116). Further research is needed to answer the question of whether the region around the Dümmer including Campemoor was not only an occasionally used outpost, but possibly belonged to a central distribution area of the Swifterbant culture. Suitable sites for this purpose can possibly be found at the base of Campemoor and the wetland of the Dümmer lowlands, which seem to offer some potential as a cultural archive with its numerous settlement or activity areas proven by old and more recent discoveries.

Acknowledgements

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Neolithic colonisation of the southwestern Dümmer basin (NW Germany) – evidence from palaeobotanical data

Andreas Bauerochse and Hanns Hubert Leuschner

Abstract Dendrochronological, dendroecological, and palaeobotanical investigations have been carried out at Campemoor (southwestern Dümmer basin) to trace early Neolithic colonisation. The analyses of the tree ring sequences of bog pines and trackway timbers document changes in water level and increasing paludification that caused humans to build wooden trackways. Environmental changes in the Dümmer basin are discussed as a part of supra-regional changes, triggered by climate change.

Keywords Dümmer basin, wooden trackways, palaeobotanic proxies, Neolithic landscape development, palynology, dendrochronology

Zusammenfassung *Um die Entwicklung der neolithischen Besiedlung im Bereich des Campemoors (südwestliche Dümmerniederung) nachzuzeichnen, wurden dendrochronologische, dendroökologische und paläobotanische Untersuchungen durchgeführt. Analysen an Jahrringen von Kiefern von Moorstandorten und Bauhölzern von Moorwegen belegen einen ansteigenden Moorwasserstand und fortschreitende Vermoorungen in Verbindung mit dem Bau von Moorwegen. Umweltveränderungen in der Dümmerniederung werden im Kontext mit klimainduzierten überregionalen Veränderungen diskutiert.*

Introduction

The understanding of settlement processes is often the subject of archaeological investigations. Therefore, in addition to artefacts, various proxies like palaeobotanical data play an important role. Their synthesis allows the processes of settlement to be traced as well as their relationships with changes in the ecosystem and their effects on the environment. This is particularly interesting in case of the Dümmer basin, which is one of the most important regions for considering early Neolithic colonisation in northern Germany.

The Dümmer-Geest lowland is a shallow basin that is largely paludified, with Lake Dümmer in its south. It is located in southwestern Lower Saxony and famous for its archaeological discoveries (Figs. 1; 9). Its formation is the result of cryo-karst processes during the last postglacial. The northern border of the basin is formed by end moraines of the Weichselian (c. 115,000–12,000 BC; cf. Dienemann 1963; Pfaffenberg / Dienemann 1964; Dahms 1974). In the south it borders the northwest German upland, the Wiehengebirge. To the east and west it is bordered by end moraines of the Saalian glaciation (c. 300,000–126,000 BC). Its surface is covered by

Fig. 1 Situation of research area (graphics: A. Bauerochse).

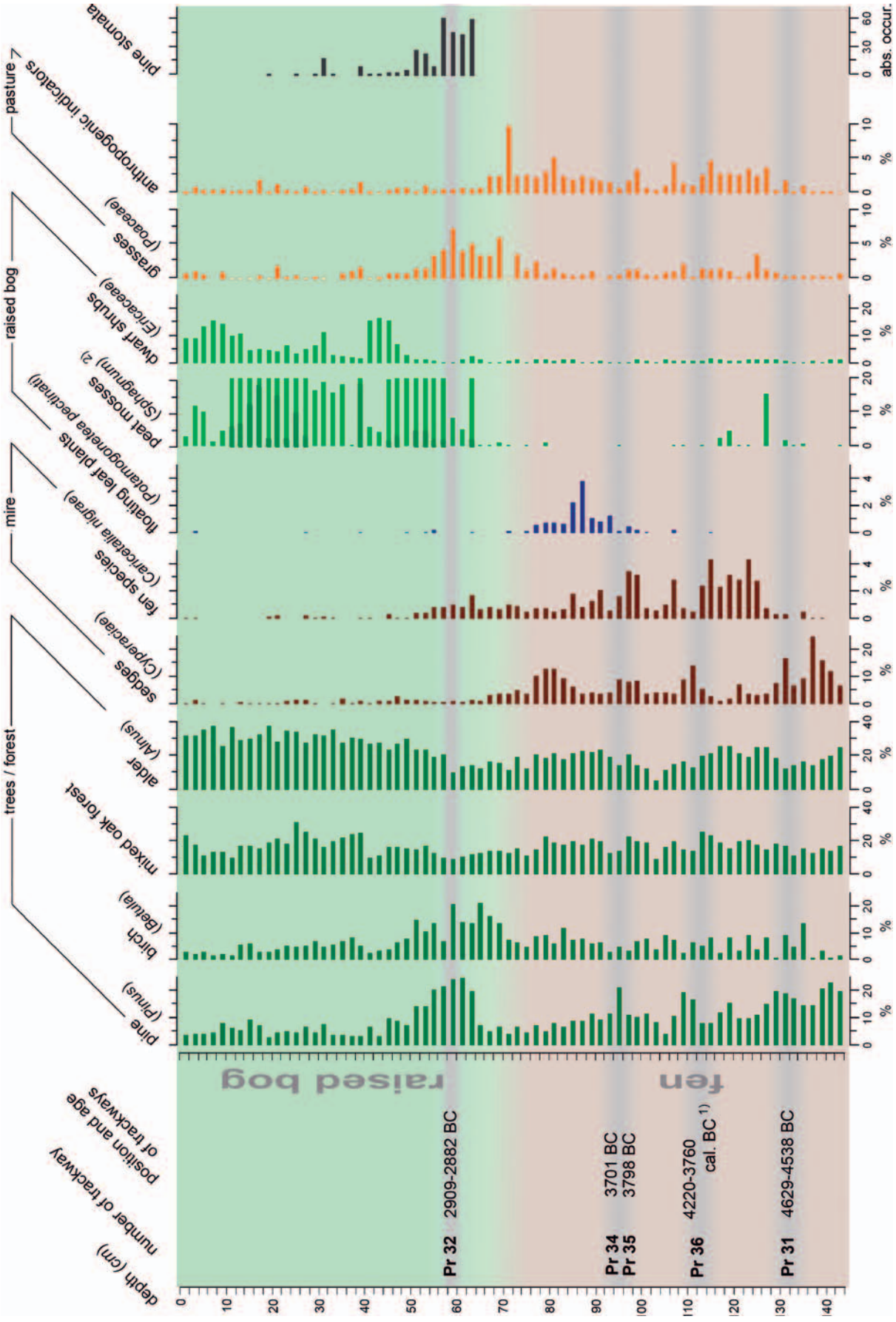

Fig. 2 Summarised pollen diagram from site Campemoor (after Bauerochse 2003, modified). Trackways (grey bars) are shown in their position. All age data, except the ^{14}C-data of Pr 36, are dendro-data. For the entire pollen diagram and a more detailed description of landscape development, see Bauerochse 2003.

Fig. 3 Section of trackway Pr 31. The trackway, conserved at the basis of the mire, was built when paludification started at Campemoor at about 4600 BC (excavation season 2004; photo: A. Bauerochse).

glacio-fluvial sands, largely covered by peatlands (bogs and fens), and with small patches of Saalian ground moraines (Lüttig 1958; von Drachenfels 2010; Menning / Hendrich 2016). Today the area is characterised by farmland, areas of peat cutting, rewetted peatlands, and nature reserves.

As early as the first half of the 19th century, archaeologists had found many traces of early human activities in this area, most notably wooden trackways.[1] Archaeological investigations in the 20th century revealed the importance of the area for early Neolithic colonisation, as they uncovered the remains of settlements around Lake Dümmer and at the margin of the peatland.[2]

In the early 1990s two wooden trackways found in the Campemoor, a raised bog in the southwestern part of the Dümmer basin (Schneekloth / Schneider 1972), attracted attention. These finds, discovered during peat cutting, focused research in an area about eight kilometres southwest of Lake Dümmer (Metzler 1993). Their excavation was also the starting point for palaeoecological investigations including peat stratigraphy and pollen analysis, as well as dendrochronological and dendroecological studies. From this time on, Campemoor became the centre of trackway research in Lower Saxony for more than 20 years. Ultimately the remains of five trackways situated close to each other and covering the period from the first half of the 5th millennium to the beginning of the 3rd millennium BC were excavated (Metzler 2003; 2005; Bauerochse et al. 2012). Pollen profiles from the excavation site itself and from the surrounding area were analysed (Bauerochse / Metzler 2001; 2003; Bauerochse 2003), the timbers of the trackways, as well as trees from subfossil forests conserved in the peat, were dendrochronologically and dendroecologically investigated,[3] and large areas south of Lake Dümmer were subject to archaeological prospection by field survey (Gerken 2003).

Methods

Pollen analysis

During the preparation for pollen analysis in the laboratory, the botanical macro-remains were separated. The preparation for pollen analysis followed the caustic potash-acetolysis method after Erdtmann (1954). All samples were counted to a total pollen sum of about 1,000 pollen. Stomata are given in absolute occurences (for a detailed description of preparation see Bauerochse 2003, 71).

Wood analysis

For dendrochronological / -ecological investigations a collection of slice sections was obtained encompassing

1 Nieberding 1817; 1840; von Alten 1879; 1888; Prejawa 1894; 1896.

2 Reinerth 1939; Deichmüller 1968; 1975; Kampffmeyer 1988; Bischop 1997; Kossian 2003; 2007; Selent 2019.

3 Leuschner et al. 2007; Eckstein et al. 2010; 2011; Bauerochse et al. 2012.

samples from trees with different morphology. Trees with a diameter of less then 20 cm and stumps were not sampled. All samples were cut with a chain saw.

The preparation of the samples followed standard procedures (e.g. described by Leuschner 1994; for a detailed description of the preparation see Leuschner et al. 2007, 185–186). The tree ring series have been cross-dated and the matches statistically evaluated by calculating the coefficient of parallel variation and *t*-values (Baille / Pilcher 1973).

Results

At the bottom of the diagram, the presence of pollen from pine (*Pinus sylvestris*) and alder (*Alnus glutinosa*) presents a picture of a mosaic of wet depressions and drier sites poor in nutrients, covered by pines and species of the mixed oak forest (mainly oaks). Increasing pollen of peatland species and the decrease of the pine curve in the course of the lower centimetres of the diagram show increasing wetness and paludification (Fig. 2). Almost at the same time when the first trackway, PR 31 (Fig. 3), was built, pollen of herbs and emerging anthropogenic indicators (after Behre 1981) mark an increasing human impact in the area. Dendrochronological data from the trackway timbers document its construction in 4629 BC at the latest, and following maintenance for at least 100 years (Fig. 4; cf. Achterberg et al. 2015).

Partly built directly on the mineral ground, its construction reflects the beginning of the paludification, showing a number of features indicating soft and muddy subsoil. A multilayered substructure and a superstructure – up to about 5 m wide – partly fixed by longitudinal stems put laterally across the construction and pierced with dowels, stabilised its position (Fig. 3).[4] The timbers were cut in four felling episodes, starting at 4629 BC, 4614 BC, 4590 BC, and 4538 BC, all of which coincided with times when the trees were characterised by growth depressions (Fig. 4). However, we have merely 36 timbers dated, out of which only six were completely preserved to include the waney edge (Fig. 4; Achterberg et al. 2015), and so we cannot be sure whether our data cover the entire period during which the trackway was used.

The remains of a further trackway, Pr 36, situated about 100 m west of Pr 31, demonstrate the presence of a second corduroy road conserved at the basis of the mire (Fig. 5). Like Pr 31, the construction dates to the early Neolithic. Radiocarbon data spanning the periods 4220–4040 calBC (5170 ± 60 BP, Hv 25659), 4040–3930 calBC (5310 ± 50 BP, Hv 25660), and 4070–3760 calBC (5100 ± 60 BP, Ki 4619) classify the construction (cf. Bauerochse / Metzler 2001, tab. 1; Bauerochse et al. 2012, 150).

Some metres east of Pr 31 and situated in the peat about 50 cm above, two more trackways, Pr 34 and Pr 35, were preserved. From its technical features, Pr 34 was similar to trackway Pr 31: a wooden construction made of a lengthwise substructure covered by a superstructure made of pine stems laying laterally. For stabilisation stems were put longitudinally at the edges of the superstructure, fixed by oak dowels stuck in the ground (Fig. 6; Bauerochse / Metzler 2001; Metzler 2003). All dendrochronological data – all coming from the dowels – show the same felling year: 3798 BC.

Next to Pr 34 the remains of Pr 35 were preserved; a few planks and two rows of oak piles stuck in the peat in a distance of about 50 cm presumably formed a narrow footbridge or landing stage (Fig. 6). Dendrochronological data from the oak piles date its construction to 3701 BC (cf. Bauerochse et al. 2012; Achterberg et al. 2015). Pollen of floating leaf plants like pondweed (*Potamogeton*), pond lily (*Nuphar*), and water lily (*Nyphaea*) document the temporary expansion of the lake from the beginning of the 4th millennium BC onwards (cf. Fig. 2; Bauerochse / Metzler 2001). Pollen samples taken from a core some 200 m north of the excavation site demonstrate the existence of a lake in the immediate vicinity already since the Atlantic period. Probably it was this lake that expanded as a consequence of a rising ground water level and flooded the area.

Drier conditions during the second half of the 4th millennium BC caused the lake to disappear before, at the transition to the 3rd millennium, pines germinated and formed a bog forest (Figs. 2; 8). Buried pines, excavated when cutting peat, demonstrate this process, which started about 3050 BC.

From about 2930 BC a change in growth patterns (depressions of the annual growth rings) again displays a change in site conditions. According to the dendrodatings trackway Pr 32 was built in 2909 BC and was maintained subsequently over a period of about 20 years (Fig. 7). For these years distinct growth depressions (c. 2885–2860 BC), followed by a period without any evidence of tree growth (c. 2860–2850 BC), display a period of wetter conditions (Fig. 8). Approximately at the same time, emerging spores of peat mosses (*Sphagnum*) indicate initial raised bog growth (Fig. 2).

Only a few years later, in the middle of the 28th century BC, conditions became drier again, and from

4 Metzler 1993; 2003; Bauerochse / Metzler 2001; cf. Heumüller et al., this volume.

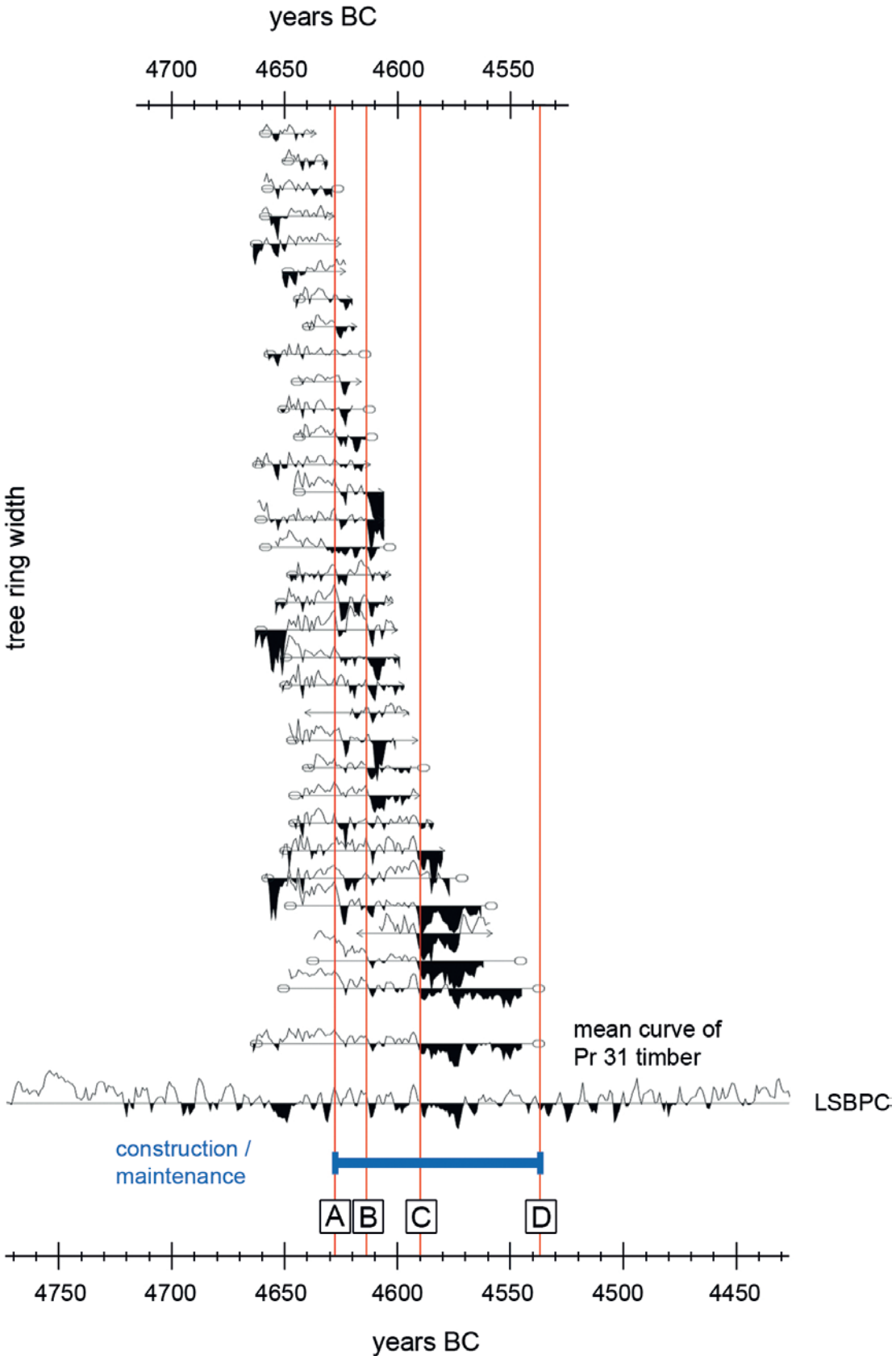

Fig. 4 Life spans and annual growth curves of Pr 31 timbers plotted against the mean curve of all Pr 31 timbers and the Lower Saxony bog pine chronology (LSBPC). Each curve displays the life span of a tree and its annual growth rate. The horizontal lines within the growth curves mark the average growth rates. If the curve runs above this line, the annual growth rate is above average, black curve sections indicate growth depressions with growth rates below average. The trackway was built in the middle of the 47th century BC and, as reflected by the dying-off / cutting data of the timbers, used over a period of about 100 years. A, B, C, and D mark phases of construction work (tree cuttings). According to the data, last maintenance works were done in 4538 BC. Clear periods of growth depressions indicate a continuing water level increase, which finally can have led to the trackway being abandoned (graphics: H. H. Leuschner).

Fig. 5 Remains of trackway Pr 36. The trackway, made of birch and alder, was preserved at the basis of the mire. The white shreds are remains of birch bark (photo: A. Bauerochse).

about 2840 BC pines expanded again. A forest became established, and for the following c. 120 years large areas of Campemoor were wooded. But from c. 2770 BC the tree ring evidence again displays changing site conditions. Affected by expanding peat mosses and the resulting wetness, growth conditions for pines became worse (narrow tree rings). As a consequence, after a period of about 40 years of suffering, most trees died (Fig. 8). It was at this time that the ecosystem finally changed into a raised bog.

Already starting from the end of the 5th millennium BC, increasing pollen of grasses, anthropogenic indicators, and herbs document the presence of man in the area (cf. Bauerochse / Metzler 2013). But as several archaeological findings prove, there had already been earlier human activities in the area. Most of the artefacts are documented from the riverbanks of the river Hunte and around Lake Dümmer (Bischop 1998; Gerken 2003; Kossian 2007, 21). Nearly all of them were situated in fen areas. One spot, a Mesolithic site, was explored in striking distance to the excavation site Campemoor (Fig. 9; Bauerochse / Metzler 1999, 146; 2002 fig. 1). Here, in a test trench, where the peat cover was completely removed, and the underlaying mineral soil layer uncovered, an Atlantic period surface yielded several flint artefacts.

From about 5000 BC the pollen diagram displays human impact over a period of about 2,000 years on a scale more-or-less similar to that of Campemoor today. At that time peat moss became established and raised bog formation started, while the ratio of anthropogenic indicators clearly decreased (Fig. 2; cf. Bauerochse 2003).

Discussion

Archaeological investigations show that, already from the Palaeolithic onwards, people were attracted by this area.[5] From the beginning of the first half of the 5th millennium BC, when pollen data demonstrate an increasing paludification, people started to build the first wooden trackway (Pr 31; Fig. 2). Like all trackways excavated at Campemoor, Pr 31 ran in a north-south course, starting from the margin of the Wiehengebirge to gain access to the lowland of the Dümmer basin.

Like the timbers of the trackway, trees of the former forest are preserved in the peat. Their dendrochronological and dendroecological investigations provide insights into the ecological situation of the times in which they grew. In this context especially the investigation of pines deliver valuable information, as peatlands form the border zone of this species' occurrence (ecotone). Pines are very sensitive to water level changes, showing wet phases by growth depressions / dying-off, so they can be used as indicators for changes in hydrological site conditions.[6]

The annual growth curves of the investigated trees (individual tree curves), the mean curve of all bog pines (Fig. 4), and the pollen data (Fig. 2) all demonstrate that the trackway was built in a period of overall wetter conditions (Figs. 2; 4). This period marks the beginning of colonisation in the area of today's Campemoor.

5 Schlüter 1994; Bischop 1997; Bauerochse / Metzler 1999; Gerken 2003.

6 Kokkonen 1923; Rydin / Jeglum 2006, 139; Eckstein et al. 2011; Edvardsson 2016.

Fig. 6 Trackways Pr 34 and Pr 35. Next to each other and on the same level, Pr 34 and Pr 35 were built in a time interval of about 100 years (**a**). While Pr 34 was a regular trackway (**b**), Pr 35 was a landing stage or built when rising water level created a lake at this spot (**c**) (photos: A. Bauerochse).

The earliest radiocarbon data document settlement at site Hüde at this time (Deichmüller 1968, 1975). This spot is situated south of Lake Dümmer, some eight kilometres east of Campemoor site.

Dendrochronological data of the trackway timbers suggest four phases of increased tree felling: starting at 4629 BC (A) when the trackway was built, and 4614 BC (B), 4590 BC (C), and 4538 BC (D) for maintenance work (Fig. 4). All four phases are characterised by reduced annual growth rates of the trees, indicating an increased water table (Fig. 4). As contemporaneously dying-off phases of pines and

oaks from Totes Moor (Steinhuder Meer area, Hanover District [Fig. 10: TOMO 1]; Achterberg et al. 2018), Vehnemoor (Ammerland District), and Huvenhopsmoor (Rotenburg District, Fig. 10: HUVE) document rising water tables, we suggest a more general increase and equal annual distribution in precipitation rather than single significant rainfall events causing floods.

For the following centuries, anthropogenic indicators display continuous human impact. Whether the construction of Pr 36 some 500 years later was the answer to increasing paludification or the resumption of an earlier road connection remains open at the moment. Contemporaneous dying-off events of bog pines from Vechtaer Moor (VECMO 1, VECMO 2, about 30 km north of Campemoor) and Totes Moor (TOMO 3, some 70 km east of Campemoor) and the decrease of anthropogenic indicators (Fig. 2) support the suggestion of increased wetness during this period (Fig. 10). At this time radiocarbon dates for site Hunte 3, one of the settlements north of Lake Dümmer, also document colonisation near the lake, some 13 km northeast of Campemoor site (Heumüller et al. 2017; cf. Heumüller et al., this volume).

Fig. 7 Trackway Pr 32. The trackway indicates the end of a period characterised by a lowered water table. Built within a bog pine forest, its construction marks the start of raised bog formation at Campemoor (photo A. Bauerochse).

Some generations later, in 3798 BC, people built trackway Pr 34 about 100 m further to the east (Fig. 6). This happened probably without even knowing about the previous constructions – which were probably already covered by peat at that time – and in a period for which dendroecological investigations on trees from other north German peatlands suggest increased germination of bog pines (Fig. 10: TOMO 2, TOMO 3, VECMO 1, VECMO 2). Initially this seems to be a contradiction. But already a couple of years later, the first of these sites again show dying-off events (Fig. 10: OY, TOMO 3). So we assume that Pr 34 was probably built in a short-term drier phase, and as all timbers examined were cut in the same year and no maintenance work was documented, we assume a short-term use of this trackway. Subsequently a significant increase in water level, documented on site by pollen of floating leaf plants, created a lake, which then flooded the construction. Pollen samples taken from a core some 200 m north of the excavation site (Bauerochse unpubl.) prove the existence of a lake nearby already since the Atlantic period. Probably it was this lake that expanded.

This suggestion of a rising water table is also supported by dendrochronological data from adjacent peatlands like Vechtaer Moor (northern Dümmer-Geest lowland, VECMO 3), Totes Moor (Steinhuder Meer depression, TOMO 2, TOMO 3), and the Oythener Moor (northern Duemmer-Geest lowland, OY). From these sites dying-off events of pines and oaks are documented, starting from the middle of the 38th century BC (Fig. 10; cf. Achterberg et al. 2018).

As the Dümmer basin is a shallow depression, small changes in precipitation (quantity and / or annual distribution ratios) had great effects on changes in groundwater levels and flooding. Until Lake Dümmer was embanked in the 1950s, winter precipitation and snow melt caused annual floodings of large parts of the Dümmer basin. In his reconstruction of Holocene lake development Dahms (1974) documented

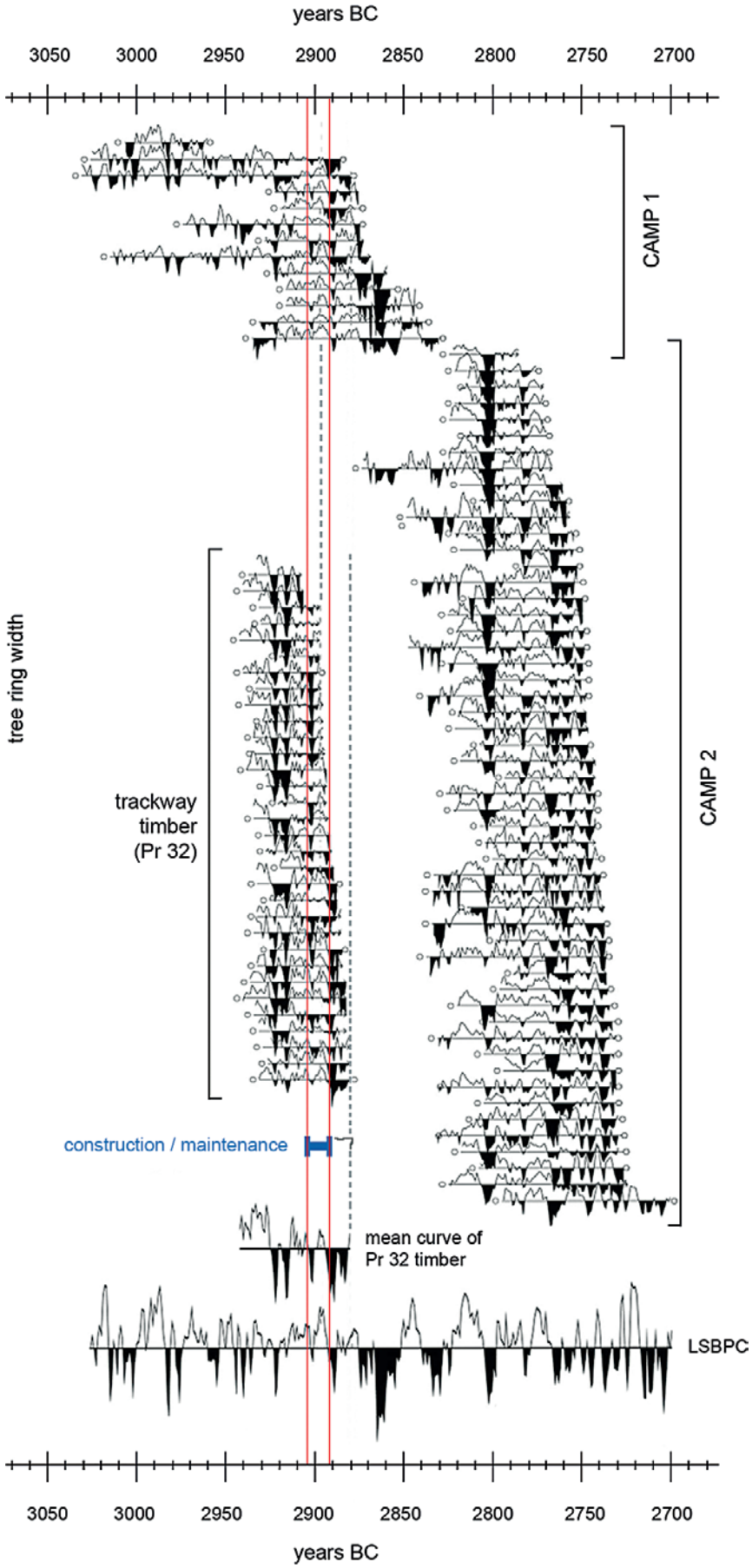

Fig. 8 Life spans and annual growth curves of Pr 32 trackway timbers plotted against the mean curve of Pr 32 timbers and the Lower Saxony bog pine chronology (LSBPS; graphics: H. H. Leuschner).

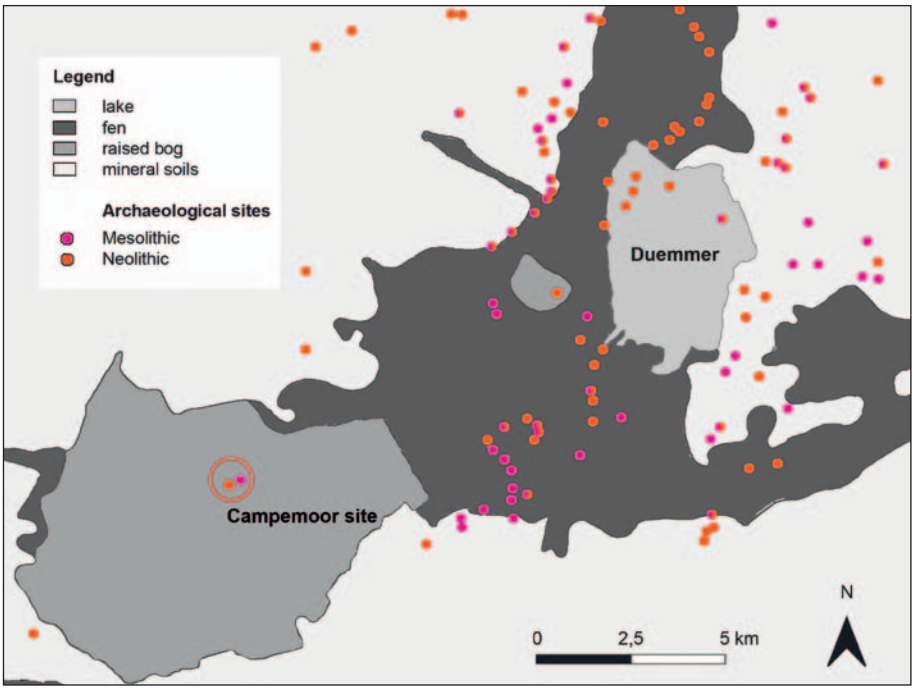

Fig. 9 Mesolithic and Neolithic findings and find spots in the southwestern Dümmer basin (data from ADABweb). Beside the sites shown here, there are more archaeological sites in the area belonging to the discussed period but which have not been finally chronologically allocated so far. Some of them may date to the period under consideration (cf. Gerken 2003; Heumüller et al. 2017). For a more differentiated mapping, see Fig. 1 in Heumüller et al., this volume (graphics: A. Bauerochse, after Heumueller, this volume, modified).

different lake stages. Reinerth (in Kossian 2007, 21) did the same for the Mesolithic, so one can infer how the Dümmer basin would be effected by changes in water supply.

In the context of changes in water level, beavers (*Castor fiber*) and their activities also have to be taken into account as potential causes of flooding (see Coles 2003). But as we have indications of synchronous higher water levels from the surrounding peatlands, it is not likely that these animals were responsible for the event at Campemoor.

However, a changing water table, expanding lakes, and proceeding paludification obviously did not prevent humans from staying in the Dümmer basin – not even when the lake expanded, as the footbridge, trackway Pr 35, demonstrates. As for Pr 34, there are no concrete data on how long this construction was used. But, from the occurence of water plant pollen, it seems that the high water table lasted at least for centuries (Fig. 2). Thus the situation in the Dümmer basin shows the consequences of wetter conditions not only reported for northwest Germany for this period, but also found in other regions of Europe at this time.[7] Probably the sea level rise of the North Sea, reconstructed for the 4th millennium by Behre (2013), may also have had an impact on the hydrological situation of the hinterland, due to the backing up of groundwater.

For the second half of the 4th millennium BC, a shift in site conditions is documented. The water table sank and the lake retreated. At the end of this process pines started to spread over the peatland, and large areas of Campemoor became forested (Leuschner et al. 2007). This expansion started from about 3050 BC. It seems that during this time the peatland could be easily crossed for a period of nearly 100 years. Then conditions became wetter again, so humans were forced to built another corduroy road. This trackway, Pr 32, was built within the forest, using pines from the site. It was the time when increasing humidity favoured the spread of peat mosses and the dying-off of most of the bog forest. Even though it was only a short-term deterioration at the beginning of the 29th century BC, it had a strong influence on human activities in the area. Trackway Pr 32 was man's last attempt to come to terms with the conditions at Campemoor (Fig. 7; cf. Bauerochse 2003; Metzler 2003). When conditions became drier again and the next tree generation spread from about 2840 BC, people had already left the area. Obviously humans didn't withstand this drastic environmental change, when mineral sites were constricted by transgrading peat mosses and pastures were narrowed. Pines growing on the trackway prove that it had finally been abandoned (Fig. 7).

As well as the events described above, these environmental changes were climate-triggered, as regional processes from e. g. the Borsteler Moor (eastern Dümmer-Geest lowland, cf. Fig. 10: BOR) and supra-regional

7 Cf. compilation of Tipping et al. 2012, 11–13; see also Magny et al. 2009, 584; Borgmark/Wastegård 2008, fig. 7, graphs C and E for south-central Sweden; Zurek et al. 2002 for eastern Poland; cf. also compilation in Bauerochse/Metzler 2001, 122–123.

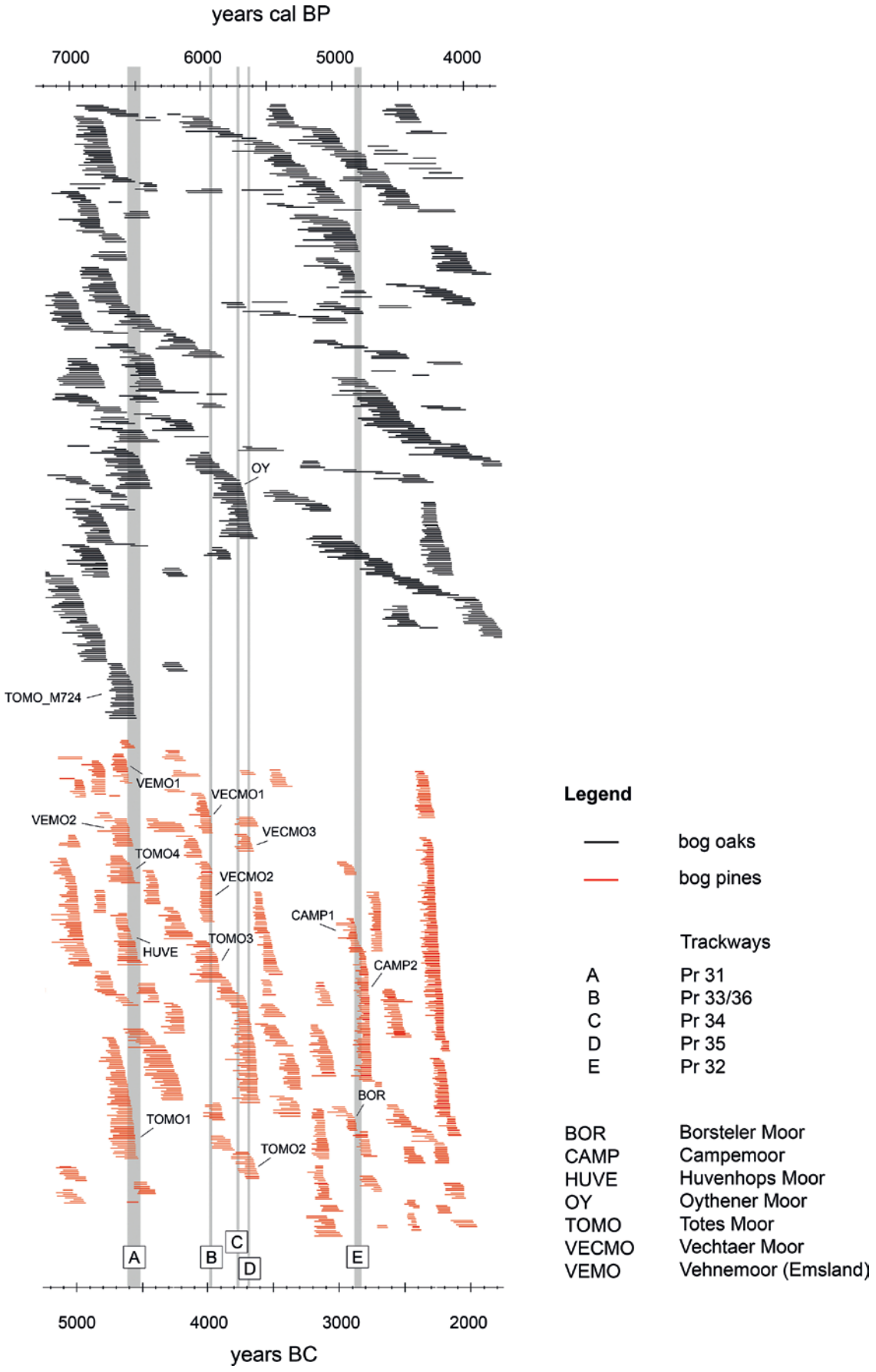

Fig. 10 Lifespans of dendrochronologically dated pines and oaks from northern Germany. Lines combined in groups belong to the same peatland. Subareas within peatlands are distinguished by numbers (e. g. TOMO 1). Grey lines mark dated trackways and the periods in which they were maintained (graphics: H. H. Leuschner).

equivalents in other European regions show. While for instance forestation at Borsteler Moor shows the same picture as Campemoor, at other sites wetter conditions, raised lake levels, and glacier advances are documented in various ways for the transition from the 4th to the 3rd millennium BC; for example, in south-central Sweden (Borgmark / Wastegård 2008, 171 fig. 7, graph F), the Swiss Jura (Deák et al. 2018), northern and eastern Poland (Zurek et al. 2002, fig. 2, graphs A–B; Lake Gościąż), central Poland (Starkel et al. 1988, table 8.9; cf. Magny 2004), north Scotland (Moir et al. 2010; Moir 2012), and the Alps (e.g. at Schwarzensteinkees, Ziller Valley, Tirol, Austria; Pindur / Heuberger 2008, 49–50; cf. Wanner et al. 2011, fig. 3b).

We only have indirect evidence that it was climate change that prompted humans to leave the area, however. Sociological causes are also conceivable, although it is reasonable to assume that the changed environmental conditions – formation and transgression of a raised bog – were responsible for the distinct decrease of human impact in the Campemoor area (Fig. 2). Thus after a period of more then 2,000 years of colonisation, during which neither increasing paludification nor flooding had driven humans out of the area, it seems that the formation of raised bog finally left no possibility for them to stay (cf. Schneekloth / Schneider 1972; Diekmann 1998; Bauerochse 2003).

The demography of the Dümmer lowland shows that all trackway constructions at Campemoor correspond to settlement phases of sites Hüde 1 und Hunte 1. For Hunte 1 colonisation contemporaneous to trackway constructions is documented for the transition from the 5th to the 4th millennium and the beginning of the 3rd millennium BC.[8] For the area south of the lake ^{14}C-dating results of artefacts from site Hüde 1 document three or four settlement periods between 4700 and 3500 BC (Geyh, documented in Deichmüller 1975, 46 [newly calibrated by Heumüller et al., this volume]; cf. Lanting / Van der Plicht 2002, 58). But in contrast to Campemoor, where a transgressing raised bog finally caused strong landscape changes, people in the more eastern fen area around the lake could adapt to the changing hydrological conditions.

Whether the people from the lake area were also the builders of the corduroy roads at Campemoor, or whether other societies, coming from the Wiehengebirge, for instance, built these constructions, is not known yet. We also have no idea why so many trackways accumulated at the Campemoor site. But over a period of about 2,000 years Campemoor has taken key position in the settlement area of the western Dümmer basin.

It is also unknown whether it were topographical or other reasons that caused humans to build the trackways in such restricted space. However, it is certain that later builders did not know of the earlier constructions, as they were already covered by peat. To resolve these questions more archaeological information from the surrounding area is needed.

Conclusion

Evidence suggests that during the Holocene Thermal Maximum the Dümmer basin and its surroundings were settled by human communities, starting from the second half of the 5th millennium BC. Artefacts and the remains of settlements – especially from the area around Lake Dümmer and the course of the river Hunte[9] – as well as trackways (Metzler 2003; Bauerochse et al. 2012), and proxies from pollen[10] document this process. At Campemoor people built trackways for about 2,000 years, adapting to deteriorating site conditions (rising water level, proceeding paludification). It must have been the richness in resources which attracted humans to this area from such an early date, which also made it worthwhile to build infrastructure like trackways to manage the environment and its changes over millennia. Only when peat mosses came up and spread, and Campemoor became a raised bog, did people leave the area.

Although we have the trackways from Campemoor and settlements around Lake Dümmer, we have no evidence on whether the people from the settlements were the same people who built the trackways, or if these constructions were made by societies coming from other areas of the adjacent mountainous environment of Wiehengebirge or Dammer Berge. We also do not know if these trackways were built to open the lowland or to connect the higher areas of Wiehengebirge and Dammer Berge. And finally we cannot be sure whether people stayed in the area permanently or came only periodically, e.g. for the summer. Therefore to obtain a better understanding of colonisation at one of northwest Germany's most important early

8 Kossian 2003, 83; Grootes 2007; Schmidt 2007; Heumüller et al. 2017, 29.

9 Pfaffenberg / Dienemann 1964, 77; Deichmüller 1968; 1974; 1975; Kampffmeyer 1988; Bauerochse / Metzler 1999, 2003; Gerken 2003; Kossian 2003; 2007.

10 Pfaffenberg 1933; Diekmann 1998; Bauerochse / Metzler 2001; Bauerochse 2003.

settlement sites, the Dümmer basin, future research should consider two aspects: (a) its supra-regional role in (early) Neolithic socio-cultural development (meso-level) of northwest Germany / Europe, and (b) how people living in the Dümmer basin did respond to environmental changes (micro-level).

Nevertheless it can be emphasised that the southern Dümmer basin, and especially the Campemoor area, takes a key position in the early Neolithic colonisation of northern Germany. We can learn from the investigations what effort former people made to manage and to adapt to different environmental conditions. Finally, it seems that a strong shift in environmental conditions was needed to squeeze people out of the southwestern Dümmer basin: the formation of a raised bog and its transgression. This may give an idea what effect raised bog development had on settlement in northwest Germany, where about 30 % of the landscape became peatland – half of it raised bog – until peatland melioration started from about the 17th century.

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Lipid residue analysis of ceramics from Hüde I (Lower Saxony, Germany): New data to understand the transition to farming

Özge Demirci, Alexandre Lucquin, Florian Klimscha, Oliver E. Craig and Daan C. M. Raemaekers

Abstract This project is a pilot study aiming to question the use and function of the pottery from Hüde I (4,700 – 3,500 calBC), distr. Diepholz, in Lower Saxony, Germany, through lipid residue analysis. The results from this project not only demonstrate that lipids can be extracted from Hüde I vessels, but also indicate that the vessels were directly associated with food preparation and/or cooking. The results also show a functional variation in pottery use, including processing aquatic (freshwater) resources, terrestrial animals (both ruminant and non-ruminant), and dairy products as well as possibly food plants.

Keywords Lipid residue analysis, early pottery use, Mesolithic-Neolithic transition, northern central Europe, Hüde I

Zusammenfassung *Der Beitrag stellt Ergebnisse einer Pilotstudie zum Gebrauch und zur Funktion der Gefäße der Fundstelle Hüde I, Lkr. Diepholz, in Niedersachsen, anhand von Lipidanalysen von Krustenresten an Keramik vor. Die Ergebnisse zeigen nicht nur, dass Lipide aus den Gefäßen von Hüde I extrahiert werden können, sondern belegen die Verwendung der Keramik in der Nahrungszubereitung und/oder beim Kochen. Sie demonstrieren zudem eine funktionale Variabilität im Gefäßgebrauch. Dazu gehören die Verarbeitung von Süßwasser-Ressourcen, Wildtieren, Milchprodukten und vielleicht auch pflanzlicher Nahrung.*

Introduction

The site of Hüde I, distr. Diepholz, Lower Saxony, plays a key role in the discussion about the neolithisation of Europe. It is particularly important in reference to the transition from the Ertebølle culture to the Funnel Beaker culture in southern Scandinavia and northern Germany, but also in reference to the Swifterbant culture chronology that spans the Mesolithic-Neolithic transition. It maintains this crucial position thanks to its long occupational span – on the basis of the discovered ceramic finds, dated 4,700–3,500 calBC (Raemaekers 1999, 87), the preservation of bone material, and its location – in-between the hunter-gatherer and farming communities (Fig. 1). More recently, researchers have stressed the need to consider the transition at a regional or sub-regional scale, moving away from the grand narratives regarding the degree of migration versus autochthonous change that have polarised the debate, particularly during the latter half of the 20th century. In northern Germany, during the majority of the 5th millennium calBC, hunter-gatherer societies of the Ertebølle culture to the north in southern Scandinavia and of the Swifterbant culture to the west in today's Dutch wetlands, and early farming groups such as Linearbandkeramik (LBK) established to the south and east of the river Elbe (Fig. 1; Terberger et al. 2009; Sørensen / Karg 2014) met and interfaced each other. The contacts between these hunter-gatherer and early farming groups are evident by the presence of shared material culture through exchange, especially of perforated adzes ('durchlochte Schuhleistenkeile') and perforated wedges ('Breitkeile').[1]

While the earliest Swifterbant pottery appeared at c. 5,000 calBC (Raemaekers 2011) and was used in a purely hunter-gatherer context, domesticated animals and cereal cultivation were introduced at around 4,400–4,300 calBC (Out 2008; 2009;

1 Fischer 1982; Czekaj-Zastawny et al. 2011; Raemaekers 2011; Raemaekers et al. 2011; Verhart 2012; Povlsen 2014.

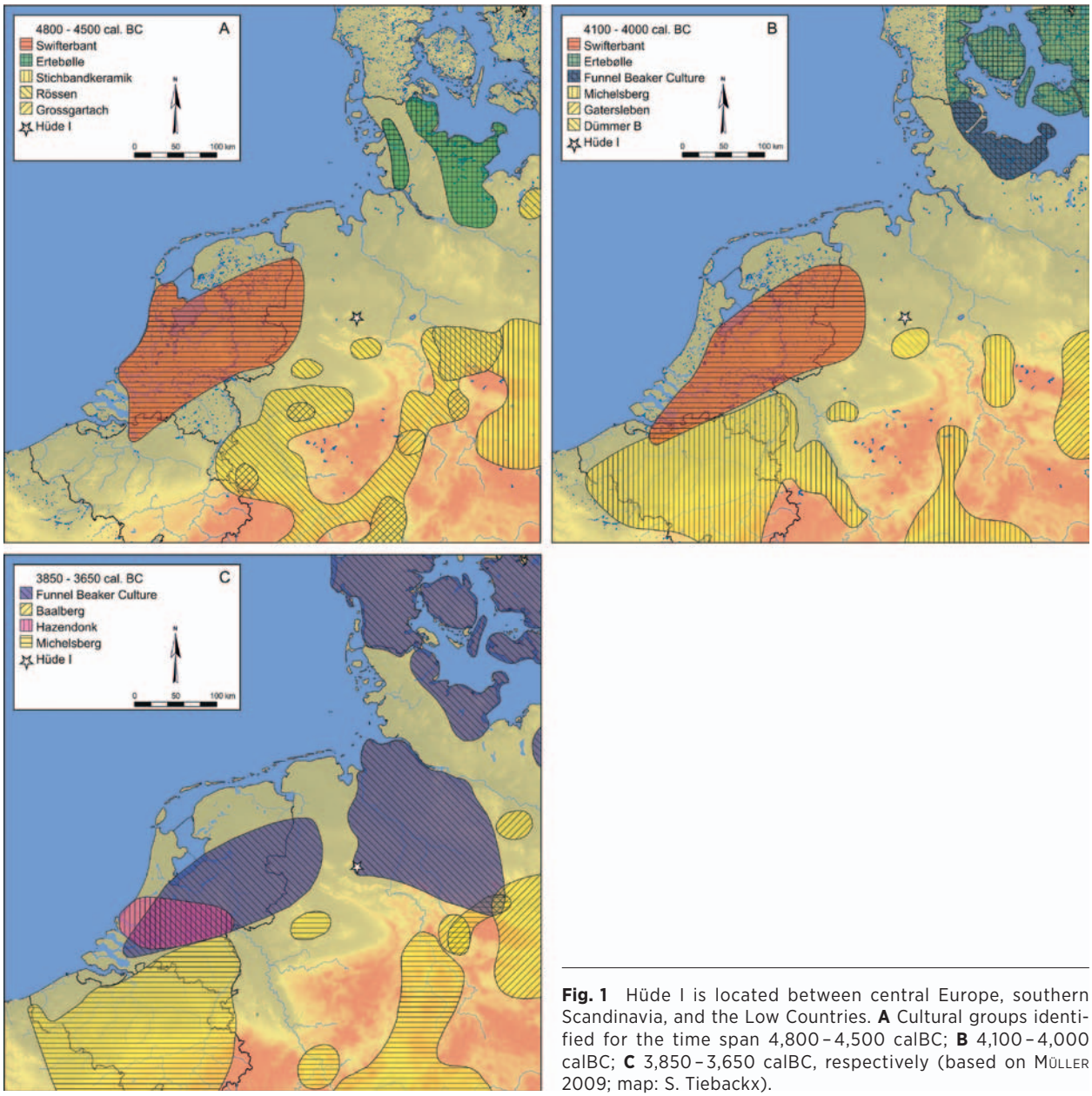

Fig. 1 Hüde I is located between central Europe, southern Scandinavia, and the Low Countries. **A** Cultural groups identified for the time span 4,800–4,500 calBC; **B** 4,100–4,000 calBC; **C** 3,850–3,650 calBC, respectively (based on Müller 2009; map: S. Tiebackx).

Çakirlar et al. 2020), probably as a result of interaction with the adjacent farming groups. In southern Scandinavia, the earliest Ertebølle pottery appeared at around 4,800–4,600 calBC (Andersen 2010). However, the arrival of the Funnel Beaker culture (TRB) at around 3,950 calBC (Fischer 2002; Hartz / Lübke 2006) marked the introduction of domesticated animals and cereals into the region as new elements in the subsistence economy.

The evidence for and the knowledge of the transition from hunter-gatherer to farming communities in large parts of northern Germany and the Netherlands is scarce, as the sandy soils of this area do not allow a good preservation or easy detection of sites (Nösler et al. 2011). This sandy zone (part of the north European plain) is located between the Dutch wetlands and the Baltic coastal zone on the one hand, and the central European loess zone on the other hand. To understand the transition to farming and the role of the central European communities therein, we are dependent on well-preserved sites from the sandy zone. Even some 50 years after excavation, Hüde I at lake Dümmer, distr. Diepholz, remains an exceptional 'steppingstone' in understanding the expansion of the Neolithic to the Dutch wetlands, northern Germany, and southern Scandinavia.

In this paper, we study the role of Hüde I as a crossroad between hunter-gatherers and early farming communities by means of a functional analysis of ceramics, through a pilot study of lipid residue analysis, and aim to address three main questions:

(1) Is the methodology of lipid residue analysis applicable to the ceramics from Hüde I?,
(2) If so, what was the role and function of ceramic vessels in Hüde I?, and
(3) Where do these ceramic vessels fit within the discussion of functional variation of pottery through the transition from hunter-gatherers to early farming communities in Europe?

In order to answer these questions, we follow analytical procedures combining analysis of lipid biomarkers[2] and compound-specific isotopic analyses of the fatty acids, palmitic ($C_{16:0}$) and stearic ($C_{18:0}$) acids.[3]

Hüde I (c. 4,700–3,500 calBC)

Hüde I is located on the southern edge of lake Dümmer, in Lower Saxony, Germany. It was discovered when the area around lake Dümmer was drained in 1953. After a test excavation in 1956, large-scale excavations were carried out by J. Deichmüller from 1961 to 1967, resulting in an area of 1,100 m^2, almost the total site surface, being excavated.[4] Hüde I was located on a patchy dry terrain in the middle of freshwater marshes separated by small creeks. The site was situated at a low peat elevation, not much higher than the surrounding environment, and was connected to the lake through a creek on the northwestern edge of this elevation. During the occupation of the site, this creek was filled with a sequence of gyttja, alluvium, and brushwood peats as well as archaeological material, resulting in the formation of layers of natural and archaeological deposition.

The potential of the site to study the development of the Neolithic is restricted due to the lack of a clear stratigraphy. This not only holds true for the central part of the site (cf. Stapel 1991, 10), but also for the neighbouring creek. Younger and older materials are found together throughout the creek fill as much as on the site proper (Stapel 1991, cf. various maps on pages 210–285; Raemaekers 1999, 74–89). As a result, the pottery assemblage can be considered a catalogue of pots of which some can be attributed to pottery styles defined elsewhere. The majority of the assemblage lacks specific characteristics and is therefore difficult to assign to a cultural group based on technological, morphological, or decorative criteria. This problem is illustrated by comparing pots from Hüde I to similar pots found in a wider region and in different cultural settings (Fig. 2). We conclude that caution is needed when assigning cultural labels to Hüde I pots without further research focusing on the technology and direct ^{14}C-dates of food crusts, organic temper, and/or organic residues (Casanova et al. 2020).

Available archaeozoological data from Hüde I indicate the exploitation of both wild and domesticated animals. About 90 % of the mammal bone remains are from wild species, dominated by wild boar (*Sus scrofa*), aurochs (*Bos primigenius*), deer (*Cervidae*), beaver (*Castor fiber*), and otter (*Lutra lutra*; cf. Hübner et al. 1988). The contribution of domesticates to the overall faunal spectrum at the site is small; these species consist of pig (*Sus domesticus*), cattle (*Bos taurus*), and sheep/goat (*Ovis aries/Capra hircus*; cf. Hübner et al. 1988, tables 30; 44). Birds and fish were also present at Hüde I. White-tailed eagle (*Haliaeetus albicilla*) and mallard (*Anas platyrhynchos*) are the main bird species found at the site (Boessneck 1978, cited in Raemaekers 1999, 91). Hüde I also yielded remains from six fish species. Five of these are freshwater fish species – pike (*Esox lucius*), perch (*Perca fluviatilis*), bream (*Abramis brama*), tench (*Tinca tinca),* and pope (*Acerina cernua).* The remaining sixth is eel (*Anguilla anguilla*), a catadromous fish species (Hüster 1983, table 24). It is important to note here that the archaeozoological data cannot be associated with any of the 'phases' defined by the pottery subjected to this study.

Regarding the archaeobotanical data from Hüde I, the only evidence for the presence of cereals, naked barley (*Hordeum vulgare var. nudum*) and einkorn wheat (*Triticum monococcom*), came from the impressions of cereals in three sherds, supplemented by an archaeobotanical study on charred material (Hopf 1981). These sherds could not be assigned to any specific occupation phase (Kampffmeyer 1991, 312). The carbonised remains of gathered plants included the shells of hazelnuts (*Corylus avellana*) as one of the most common fruits, while the fruits and seeds of black alder (*Alnus glutinosa*) and willow (*Salix spp.*) trees, raspberry (*Rubus idaeus*), nettle (*Urtica dioica*), wild buckwheat (*Fallopia convolvulus),* and some other herbs were also present at the site (Kampffmeyer 1991, 313).

2 Hansel et al. 2004; Craig et al. 2007; Regert 2011; Cramp / Evershed 2014; Lucquin et al. 2016; 2018.

3 Evershed et al. 1997; 2002a; b; 2008a; b; Copley et al. 2005; Craig et al. 2005; 2007; 2012; Colonese et al. 2017; Pääkkönen et al. 2020.

4 Deichmüller 1964; 1965a; b; 1968; 1969; Kampffmeyer 1991, 35–40; Stapel 1991, 3.

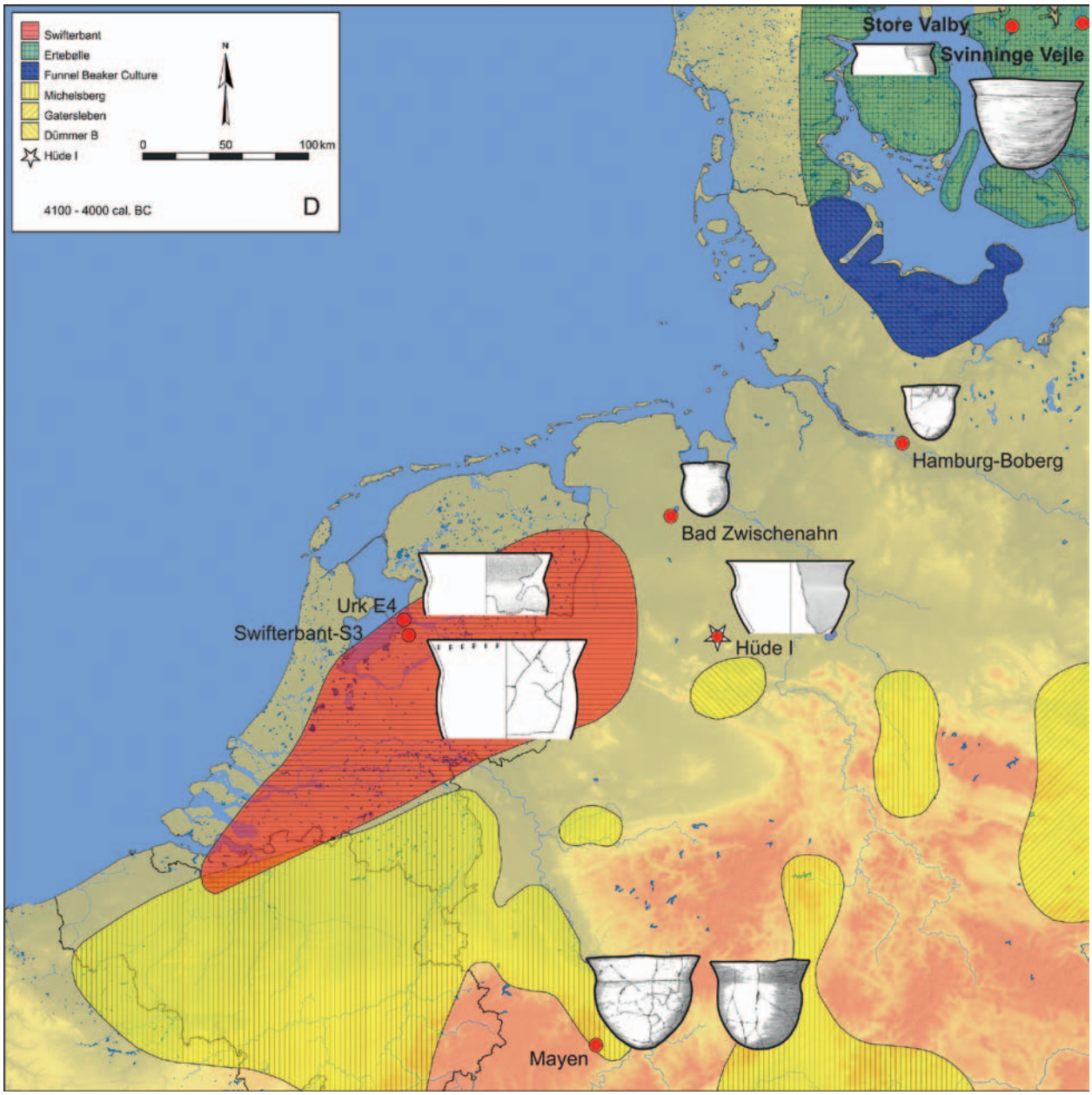

Fig. 2 Short-necked beakers found across central Europe, southern Scandinavia, and the Low Countries (after Schwabedissen 1967, fig. 10 [Store Valby, Svinninge Vejle], fig. 24 [Bad Zwischenahn, Hamburg-Boberg, Mayen]; De Roever 2004, fig. 11a [Swifterbant-S3]; Raemaekers 2005, fig. 6 [Urk-E4]; map: S. Tiebackx).

Material and Methods

Sampling strategy and material

A total of 37 samples were subjected to lipid residue analysis, representing 35 individual vessels. Of all samples, 21 sherds had carbonised surface remains (food-crusts), on interior and/or exterior, indicating that they had been used for cooking. This study was designed as an exploratory research to test the applicability of the lipid residue analysis on ceramic material of this site. The sampling strategy was aimed at comparing the use of pottery by morphological and decorative attributes available (Drews 1977; Kampffmeyer 1991). The samples were selected from collections of the Landesmuseum in Hanover, Germany. Prior to actual sampling, form, size, decoration, rim diameter, wall thickness, and temper of each pottery fragment were studied (Table 1).

The selected sherds present two main vessel forms: S-shaped / carinated vessels and deep bowls. S-shaped / carinated vessel fragments (n = 34) consist of seventeen rim, six base, and eleven body pieces. While the base fragments vary between slightly pointed,

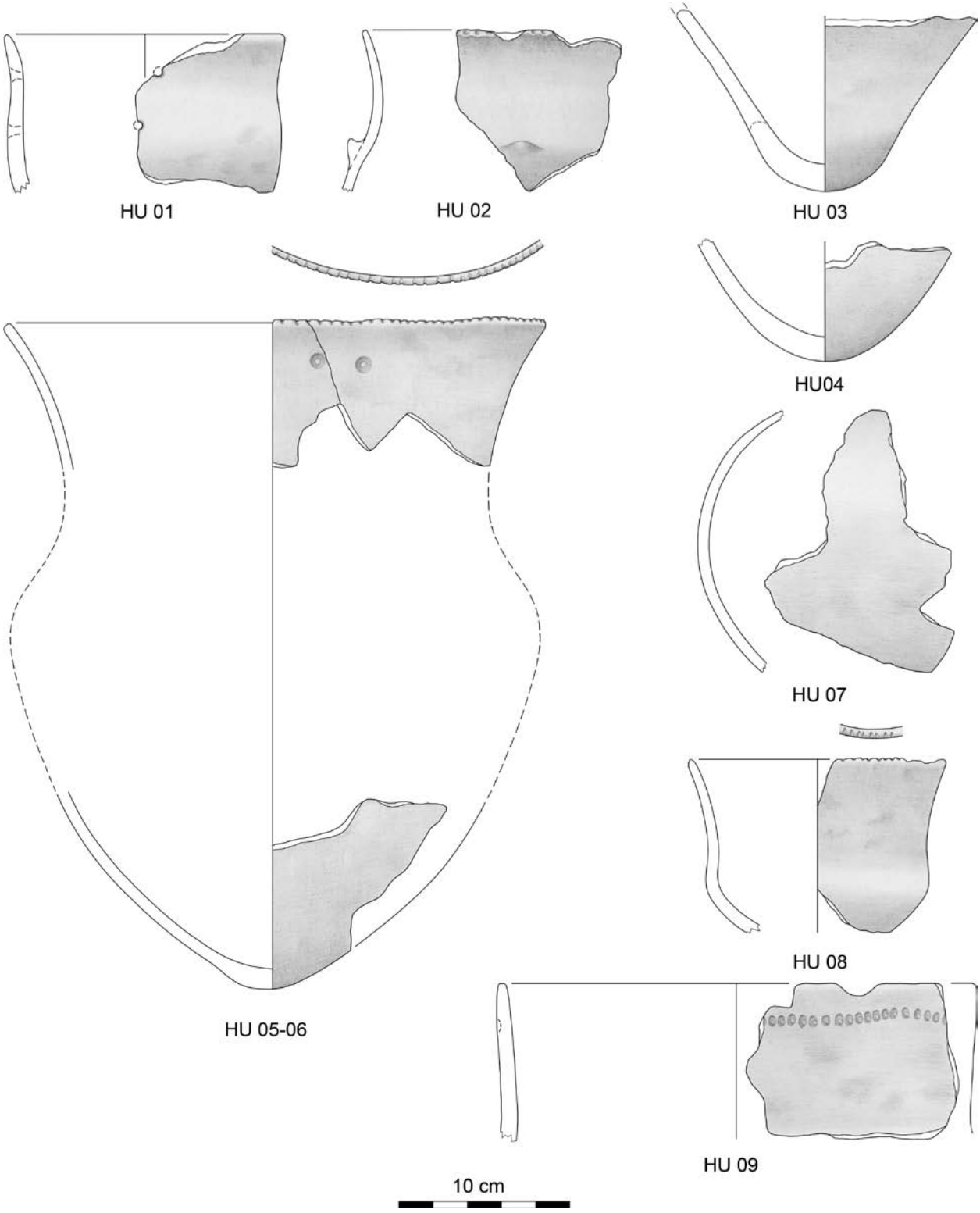

Fig. 3 Drawings of analysed pottery fragments from Hüde I. Scale 1 : 3 (drawings: M. A. Los-Weijns).

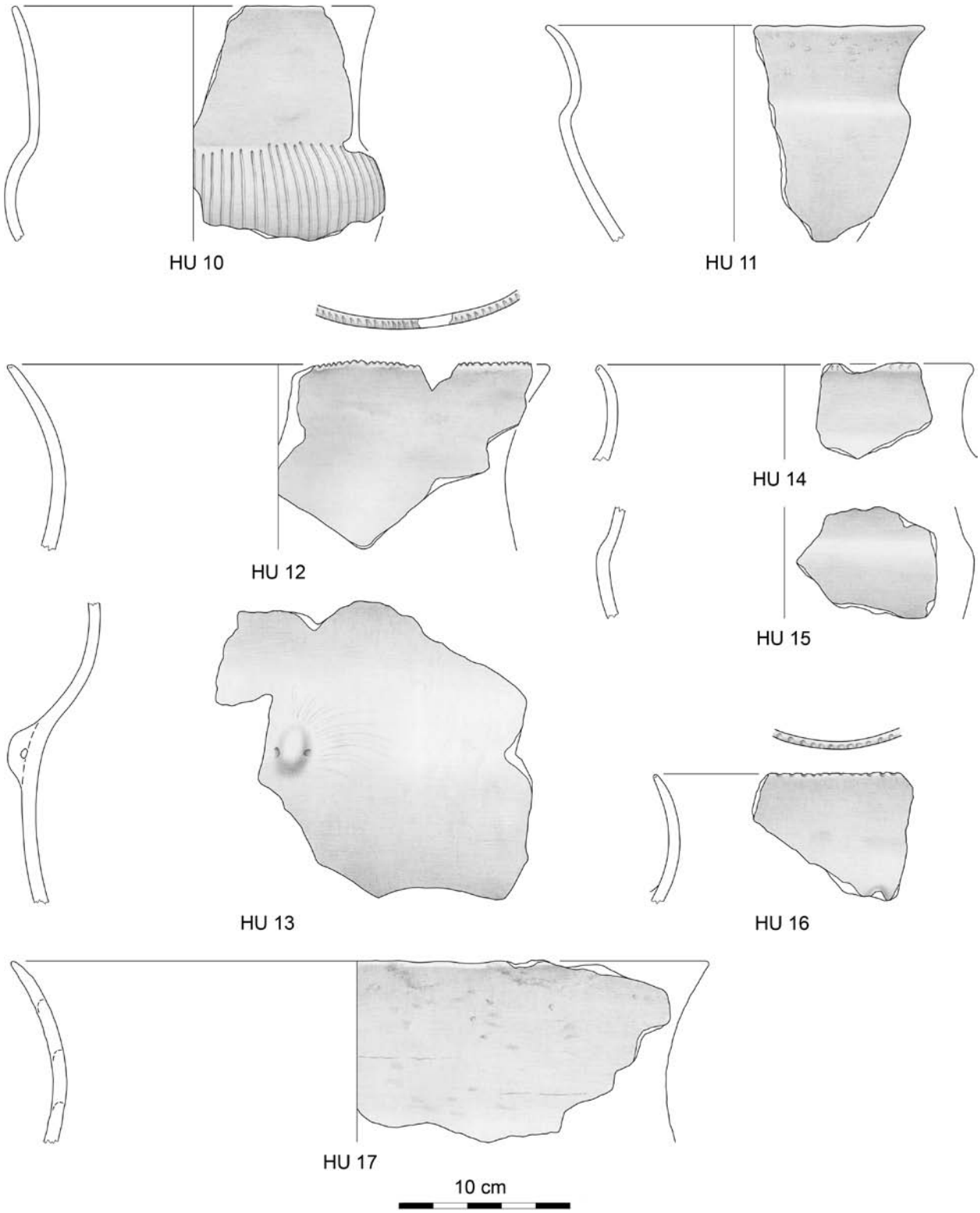

Fig. 4 Drawings of analysed pottery fragments from Hüde I. Scale 1:3 (drawings: M. A. Los-Weijns).

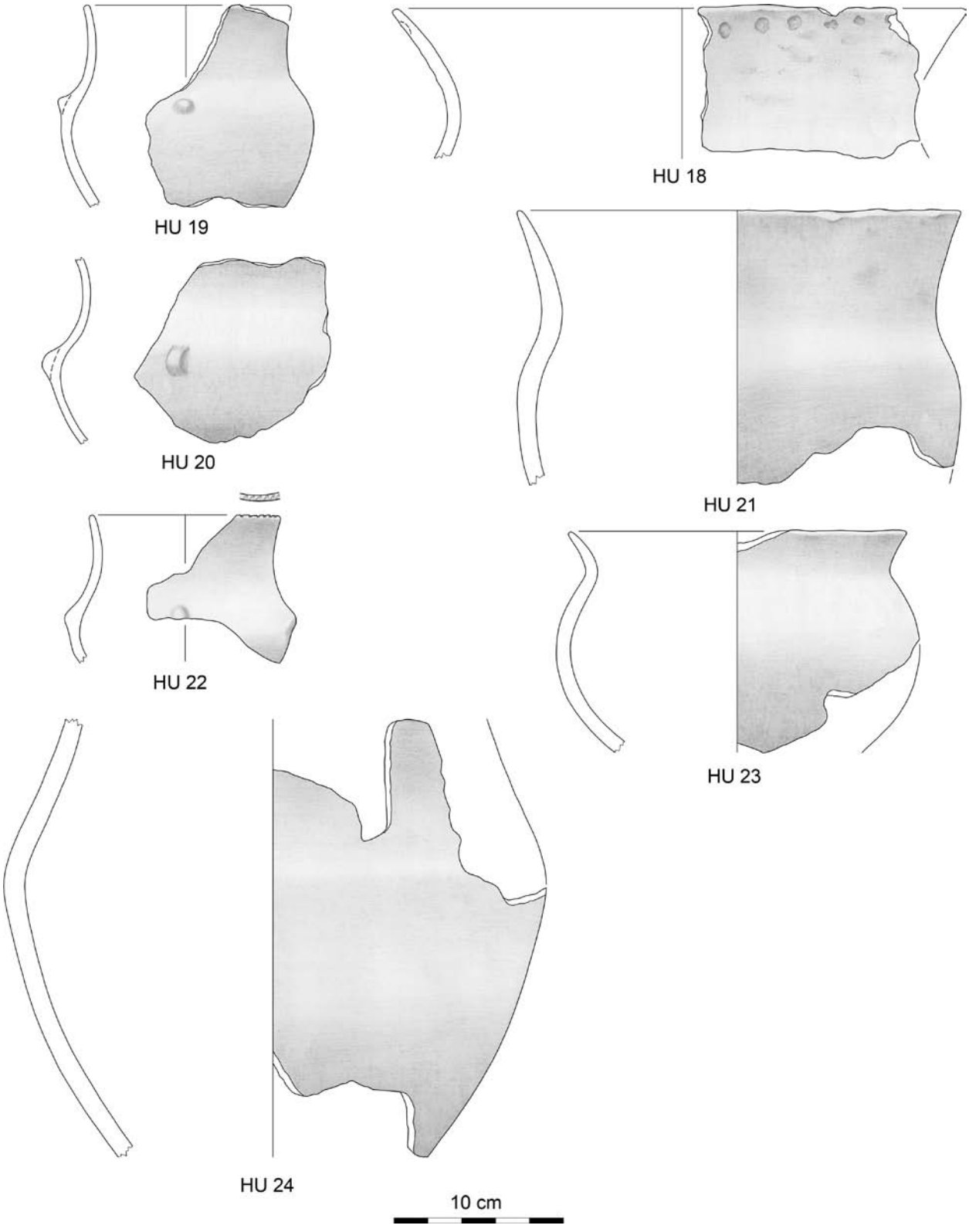

Fig. 5 Drawings of analysed pottery fragments from Hüde I. Scale 1:3 (drawings: M. A. Los-Weijns).

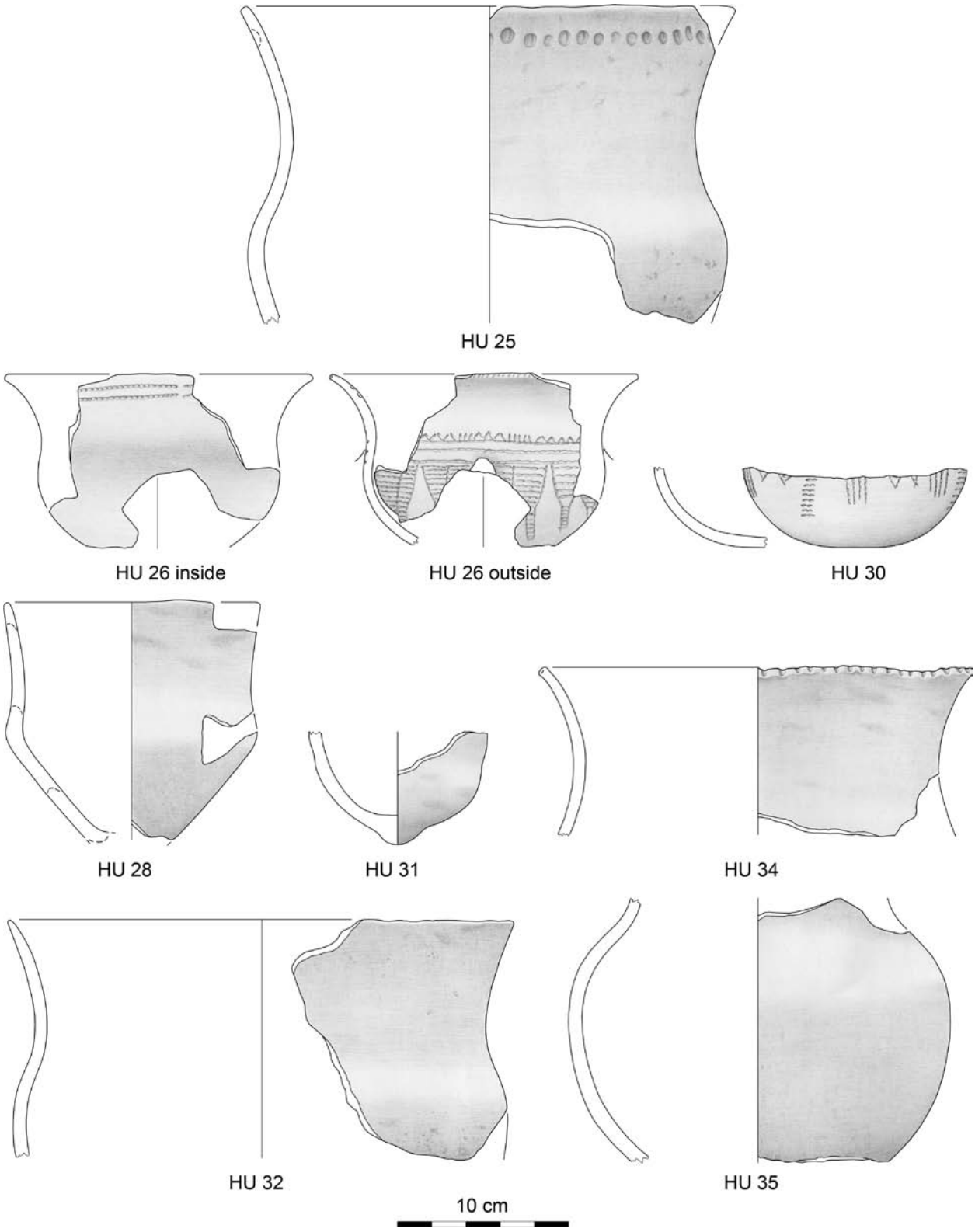

Fig. 6 Drawings of analysed pottery fragments from Hüde I. Scale 1:3 (drawings: M. A. Los-Weijns).

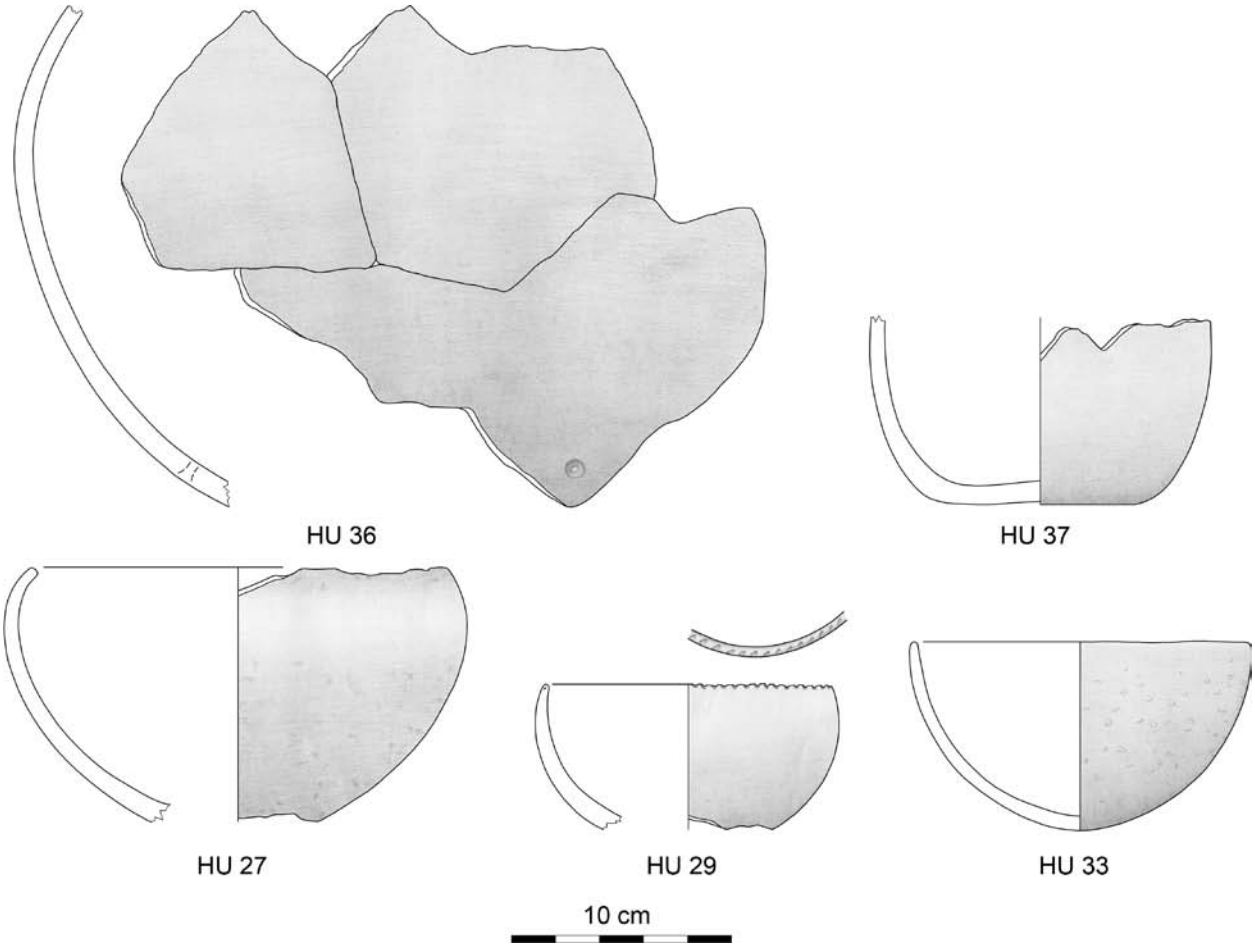

Fig. 7 Drawings of analysed pottery fragments from Hüde I. Scale 1:3 (drawings: M. A. Los-Weijns).

rounded, and flat bases, two body fragments have shallow vertical handles, and another three have unperforated knobs. There are small, medium and large size pots, often with everted rims, but straight ones are also present. Six of the S-shaped / carinated vessels are of small size (rim diameter < 20 cm), six are of middle size (rim diameter between 20 and 25 cm), and five are larger sized vessels (rim diameter between 26 and 30 cm; see Table 1). The majority of the sampled S-shaped / carinated vessel fragments were undecorated (22 out of 37). Within the ones with decoration, the most common form is represented by spatula impressions on the top of the rim. Two rim fragments show decorations with hollow circular impressions and/or thumb impressions, right below the rim on the exterior. There are only three fragments with body decoration covering the lower neck and belly sections of the vessels. These decorations consist of double incisions, forming triangles. The wall thickness of these vessel fragments varies from 5 to 11 mm, with an average of 8 mm; it does not indicate any correlation with the size of the vessel or the decoration.

In general, it is not possible to assign the selected vessels to specific cultural groups, except for two Rössen culture pots that exhibit clear morphological and decorative characteristics (samples HU26 and HU30; see Figs. 3–7). These pots are small-sized S-shaped and carinated vessels with diameters of 17.5 and 10 cm (based on drawings in Kampffmeyer 1991, 554 table 5), respectively. They both have burnished exteriors and double incision decorations covering their lower neck and upper belly parts, indicating distinctive characteristics for Rössen culture pottery (Bogucki / Grygiel 1993).

There are three bowls in the selected assemblage, all with slightly rounded bases. All three bowls have a diameter of 23–24 cm with a wall thickness of 7–9 mm. One of the three bowls is decorated with spatula impressions on the top of the rim, while the remaining two have no decoration.

Sample ID	Find number	Vessel type	Vessel form	Vessel part	Decoration	Other features	Rim diameter (cm)	Weight (mm)	Wall thickness (mm)	Main temper material
HU-01	31206	Cooking pot	S-shaped/carinated vessel	rim	no		20	123.7	10	grit-sand
HU-02	31840 (3A)	Cooking pot	S-shaped/carinated vessel	rim	no	knob	15	87.7	9	sand?
HU-03	30655	Cooking pot	S-shaped/carinated vessel	base	no			200.9	8	fine sand / grit
HU-04	31233	Cooking pot	S-shaped/carinated vessel	base	no			172.2	9	grit-sand //quartz
HU-05	31145a	Cooking pot	S-shaped/carinated vessel	rim	yes		26	104.5	6	grit (granite)
HU-06	31145b	Cooking pot	S-shaped/carinated vessel	base	no			101.6	6	grit (granite)
HU-07	30984	Cooking pot	S-shaped/carinated vessel	body	no			96.6	7	grit-sand?
HU-08	31176	Cooking pot	S-shaped/carinated vessel	rim	no		17.5	107.9	8	grit-sand
HU-09	31224/13224	Cooking pot	S-shaped/carinated vessel	rim	yes		28	122.4	11	grit-sand
HU-10	31029/31426	Cooking pot	S-shaped/carinated vessel	rim	yes		15	194.8	8	grit
HU-11	30996	Cooking pot	S-shaped/carinated vessel	rim	no		>20/25	166.4	9	flint
HU-12	30974	Cooking pot	S-shaped/carinated vessel	rim	yes			141.2	8	grit? quartz
HU-13	31359	Cooking pot	S-shaped/carinated vessel	body	no	handle		45.7	8	grit-sand
HU-14	30979c	Cooking pot	S-shaped/carinated vessel	rim	yes			30.1	8	grit-sand
HU-15	30979a	Cooking pot	S-shaped/carinated vessel	body	no			52.3	7	grit-sand
HU-16	30985	Cooking pot	S-shaped/carinated vessel	rim	yes		19	56.8	7	flint // granite?
HU-17	30972	Cooking pot	S-shaped/carinated vessel	rim	yes		26	274.1	8	grit-sand (granite)
HU-18	30997	Cooking pot	S-shaped/carinated vessel	rim	yes	handle	31/32	175.7	9	grit-sand
HU-19	31157	Cooking pot	S-shaped/carinated vessel	body	no	knob		127.7	6	sand?
HU-20	31273	Cooking pot	S-shaped/carinated vessel	body	no	handle		99.5	5	grit-sand?
HU-21	30959 a+b	Cooking pot	S-shaped/carinated vessel	rim	no		27	78.6	9	grit (granite)
HU-22	9125A	Cooking pot	S-shaped/carinated vessel	body	yes	knob		19.7	7	grit-sand?
HU-23	9258	Cooking pot	S-shaped/carinated vessel	rim	no		~20	179.0	9	grit-sand
HU-24	9452	Cooking pot	S-shaped/carinated vessel	body	no			89.5	11	grit (granite)
HU-25	4532	Cooking pot	S-shaped/carinated vessel	body	no			161.3	10	flint // grit - quartz?
HU-26	3002+30352	Cooking pot	S-shaped/carinated vessel	rim/ body	yes		17.5	19.0	6	grog?
HU-27	29191	Cooking pot	Deep bowl	rim	yes		23	131.9	8	grog // grit-sand?
HU-28	22900	Cooking pot	S-shaped/carinated vessel	rim	no		14-15	61.9	8	grit
HU-29	30669	Cooking pot	Deep bowl	rim	yes		11	90.6	9	sand?
HU-30	30732	Cooking pot	S-shaped/carinated vessel	body/ base	yes		10*	130.1	6	grit-sand
HU-31	30727	Cooking pot	S-shaped/carinated vessel	base	no			84.2	7	sand
HU-32	29928	Cooking pot	S-shaped/carinated vessel	rim	yes		29/30	198.0	8	flint // quartz?
HU-33	28742	Cooking pot	Deep bowl	rim	no		>20	225.0	7	grit? quartz
HU-34	22522/22552/ 25649	Cooking pot	S-shaped/carinated vessel	rim	yes		25	139.9	6	grit
HU-35	30644	Cooking pot	S-shaped/carinated vessel	body	no			89.7	8	grit
HU-36	29937	Cooking pot	S-shaped/carinated vessel	body	no			186.2	8	grit-sand
HU-37	30733	Cooking pot	S-shaped/carinated vessel	base (flat)	no			135.0	7	flint? grit?

**The sample selection was based on the morphological and decorative variability of the pottery fragments available to us at the time of the research, therefore it is not representative for the whole Hüde I pottery assemblage.
*Based on the complete drawing of the pot in Kampffmeyer 1991: Table 5 (554).

Table 1 Sampled pottery information.

There is no significant difference between the fabric of the S-shaped / carinated vessels and the deep bowls. The most common inclusion for all the selected assemblage is grit, although there is also a rare appearance of sand, flint, and grog. While the S-shaped / carinated vessels present examples of both extremely coarse pottery with no surface treatment and relatively fine pottery with smoothed, polished, or burnished surface, all three bowls indicate fine pottery with polished or burnished surface treatment.

Lipid extraction

Lipids were extracted by using the established acidified methanol protocol (Craig et al. 2013; Papakosta et al. 2015). Briefly, an internal standard (alkane C_{34}, 10 µL) and 4 mL methanol was added to 1 gr of ceramic powder. The suspended solution was sonicated for 15 min, then acidified with concentrated sulphuric acid (H_2SO_4, 800 µL) and heated for 4 hours at 70 °C. Lipids were sequentially extracted with n-hexane (2 mL × 3). The extracts were combined into vials, and copper

sheets were added in order to remove cyclic octaatomic sulphur that was present in all of the samples. All the samples were dried under nitrogen at 35 °C. Finally, an additional internal standard (n-hexatriacontane $C_{36:0}$, 10 µL) was added to all samples prior to their analysis by gas chromatography-mass spectrometry (GC-MS) and gas chromatography-combustion isotope ratio mass spectrometry (GC-C-IRMS). To control for any contamination introduced during the sample preparation, a negative control, containing no ceramic powder, was prepared and analysed with each sample batch.

Gas Chromatography-Mass Spectrometry (GC-MS)

GC-MS analysis was undertaken using an Agilent 7890A series Gas Chromatograph coupled to an Agilent 5975C inert XL mass-selective detector equipped with a quadrupole mass analyser (Agilent technologies, Cheadle, Cheshire, UK). A split/splitless injector (used in splitless mode) was maintained at 300 °C. The column was inserted into the ion source of the mass spectrometry directly. Helium was used as the carrier gas, with a constant flow rate at 2 mL/min. The ionisation energy was 70 eV, and spectra were obtained by scanning between m/z 50 and 800. Samples (n = 37) were analysed by using an Agilent DB-5 ms (5 % phenyl) methylpolysiloxane column (PN 122–5532; 30 m x 250 µm x 0.25 µm; J&W Scientific technologies, Folsom, CA, USA). The temperature started at 50 ºC (for 2 min), increasing by 10 ºC per minute up to 325 ºC. The final temperature was maintained for 15 min. Compounds were identified by comparing them with the library of mass spectral data and published data.

In order to identify ω-(o-alkylphenyl) alkanoic acids and isoprenoid fatty acids and to calculate the ratio of phytanic acid diastereomers, all samples (n = 37) were also analysed by using a DB23 ms (50 %-Cyanopropyl)-methylpolysiloxane column (60 m × 0.250 mm × 0.25 µm; J&W Scientific technologies, Folsom, CA, USA). Briefly, samples were re-dissolved in hexane and 1 µL was injected with a splitless injector at 300 °C. The temperature was set to 50 °C for 2 min. This was followed by a rise of 4 °C per minute up to 140 °C, then 0.5 °C per minute up to 160 °C, and then 20 °C per minute up to 250 °C. The temperature was then held at 250 °C for 10 min. The SIM (Selective Ion Monitoring) mode was used in order to target the specific markers trimethyltridecanoic acid (TMTD), m/z 74, 88, 101, 312 for pristanic acid, m/z 74, 101, 171, 326 for phytanic acid, and m/z 74, 105, 262, 290, 318, 346 for the detection of ω-(o-alkylphenyl)alkanoic acids of carbon lengths C 16 to C 22 (APAA 16–22). In addition, separation of the two phytanic acid diastereomers (3S,7R,11R,15-phytanic acid or SRR and 3R,7R,11R,15-phytanic acid or RRR) was obtained, which enabled the calculation of the percentage of SRR in total phytanic acid (SRR %) by integrating the m/z 101 ion (48). The carrier gas used was helium with a flow rate of 1.5 mL/min. Quantifications for the peak measurements were calculated by the integration tool on the Agilent ChemStation enhanced data analysis software.

Gas Chromatography-Combustion Isotope Ratio Mass Spectrometry (GC-C-IRMS)

All samples (n = 37) were analysed by GC-C-IRMS in duplicates based on the existing protocol (Craig et al. 2012), in order to measure stable carbon isotope values of two fatty acid methyl esters, methyl palmitate ($C_{16:0}$) and methyl stearate ($C_{18:0}$). Samples were analysed by using Delta V Advantage isotope ratio mass spectrometer (Thermo Fisher, Bremen, Germany), linked to a Trace Ultra gas chromatograph (Thermo Fisher) with a GC Isolink II interface (Cu/Ni combustion reactor held at 1000 °C; Thermo Fisher). All samples were diluted with hexane. Then 1 µL of each sample was injected into DB5 ms ultra-inert-fused-silica column (60 m × 0.25 mm × 0.25 µm; J&W Scientific). The temperature was fixed at 50 °C for 0.5 min and raised by 25 °C/min to 175 °C, then raised by 8 °C/min to 325 °C. The temperature was then held at 325 °C for 20 min. Ultra-high-purity-grade helium was used as the carrier gas with a constant flow rate at 2 mL/min. Eluted products were ionized in the mass spectrometer by electron ionization, and the ion intensities of m/z 44, 45 and 46 were recorded for automatic computation of $^{13}C/^{12}C$ ratio of each peak in the extracts (Heron et al. 2015). Isodat software (version 3.0; Thermo Fisher) was used for the computation, based on the comparison with a standard reference gas (CO_2) with known isotopic composition that was repeatedly measured. The results of the analyses were recorded in per mil (‰) relative to an international standard, Vienna Pee Dee belemnite (VPDB). N-alkanoic acid ester standards of known isotopic composition (Indiana standard F8–3) were used to determine the instrument accuracy. The mean ± standard deviation (SD) values of these n-alkanoic acid ester standards were −29.60 ± 0.21 ‰, and −23.02 ± 0.29 ‰ for the methyl ester of $C_{16:0}$ (reported mean value vs. VPDB −29.90 ± 0.03 ‰) and $C_{18:0}$ (reported mean value vs. VPDB −23.24 ± 0.01 ‰), respectively. Precision was determined on a laboratory standard mixture injected regularly between samples (28 measurements). The mean ± SD values of n-alkanoic acid

esters were −31.65 ± 0.27 ‰ for the methyl ester of $C_{16:0}$ and −26.01 ± 0.26 ‰ for the methyl ester of $C_{18:0}$. Each sample was measured in replicate (average SD is 0.07 ‰ for $C_{16:0}$ and 0.13 ‰ for $C_{18:0}$). Values were also corrected subsequent to analysis to account for the methylation of the carboxyl group that occurs during acid extraction. Corrections were based on comparisons with a standard mixture of $C_{16:0}$ and $C_{18:0}$ fatty acids of known isotopic composition processed in each batch under identical conditions.

Elemental Analysis Isotope Ratio Mass Spectrometry (EA-IRMS)

A total of 21 carbonised surface deposit (foodcrust) samples, all coming from individual vessels, were collected and analysed. The samples were collected by scraping the food crust from the surface of the sherd with a sterilised scalpel at a sterile lab environment and were grounded to a homogeneous powder level weighted out in duplicates into tin capsules (c. 1 mg). After the preparation, they were analysed by elemental analysis isotope ratio mass spectrometry. The values of bulk stable nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) isotopes were measured based on the methods described by Craig et al. (2007). Precision of the instrument on repeated measurement was ±0.2 ‰ (standard error of the mean), $\delta^{13}C$, $\delta^{15}N = [(R_{sample}/ R_{standard} - 1)] \times 1000$, where $R = {}^{13}C/ {}^{12}C$ and ${}^{15}N/ {}^{14}N$. Accuracy was determined by measurements of international standard reference materials within each analytical run. These were IAEA 600 $\delta^{13}C_{raw} = -27.69 \pm 0.02$, $\delta^{13}C_{true} = -27.77 \pm 0.04$, $\delta^{15}N_{raw} = 1.49 \pm 0.38$, $\delta^{15}N_{true} = 1.0 \pm 0.2$; IAEA N2 $\delta^{15}N_{ra} = 20.9 \pm 0.33$, $\delta^{15}N_{true} = 20.3 \pm 0.2$; IA Cane, $\delta^{13}C_{raw} = -11.76 \pm 0.10$, $\delta^{13}C_{true} = -11.64 \pm 0.03$. Data were normalised to these international standards.

Results and discussion

Lipid residue analysis

All samples (n = 37) yielded sufficient lipids required for interpretation (> 5 µg g^{-1}) with a mean value of 374 µg g^{-1} (ranging from 74 µg g^{-1} to 956 µg g^{-1}, cf. Table 2). In general, the lipid profiles obtained from each sample contained saturated fatty acids, ranging from $C_{10:0}$ to $C_{30:0}$. The main saturated fatty acids are the lauric ($C_{12:0}$), myristic ($C_{14:0}$), pentadecanoic ($C_{15:0}$), palmitic ($C_{16:0}$), margaric ($C_{17:0}$), and stearic ($C_{18:0}$) acids, maximising at $C_{16:0}$ and $C_{18:0}$, respectively. The $C_{16:0}$ and $C_{18:0}$ ratios (P/S ratios) of all the samples are listed in the Table 2. Thirty-three of all the samples yielded unsaturated fatty acids from $C_{11:1}$ to $C_{26:1}$, dominated by oleic ($C_{18:1}$) and palmitoleic ($C_{16:1}$) acid, respectively. Branched fatty acids (C_{11}–C_{29}) were also identified in all samples. Dicarboxylic acids are present in 32 samples, ranging from C_9 (azelaic acid) to C_{12}. A total of 32 samples yielded cholesterol and its derivatives, indicating the presence of animal fats. In all samples, traces of plasticizers were found, most likely deriving from packing materials. The levels of these were low; they did not interfere with the analysis.

Evidence of aquatic biomarkers

Overall, many of the samples had biomarkers for aquatic products. Of 37 samples analysed, 20 yielded *ω*-(*o*-alkylphenyl) alkanoic acids (APAAs), with carbon atoms ranging from 18 to 22, and isoprenoid fatty acids which are TMTD (4,8,12-trimethyltridecanoic acid), pristanic acid (2,6,10,14-tetramethylpentadecanoic acid), and phytanic acid (3,7,11,15-tetramethylhexadecanoic acid; cf. Table 2). The co-occurrence of *ω*-(*o*-alkylphenyl) alkanoic acids (APAAs ranging from 18 to 22) and isoprenoid acids is an established criterion for identifying aquatic lipids in ancient pottery.[5] Since APAAs are formed by heating (> 270 °C, > 17 h) of mono- and polyunsaturated fatty acids, their presence confirms that they are derived from the use of the vessels (Hansel et al. 2004; Craig et al. 2007). A further six samples yielded partial aquatic biomarkers, containing C_{18} APAA and TMTD (Table 2). This is also an indication of possible process of aquatic resources in these vessels (Evershed et al. 2008a; Heron / Craig 2015), although not definitive. All these results confirm that aquatic products were regularly processed in the majority of Hüde I vessels.

Among the isoprenoid fatty acids, which are degradation products of phytol originating from phytoplankton, TMTD is considered more of a characteristic of aquatic oils (Ackman / Hooper 1968), whereas pristanic and phytanic acids are present in both aquatic and ruminant resources (Ackman / Hooper 1968; Heron / Craig 2015). We calculate the ratio of the two diastereomers of phytanic acid (3S,7R,11R,15-phytanic acid [SRR] and 3R,7R,11R,15-phytanic acid [RRR]) in order to understand the origin of the phytanic acid found in the samples. The SRR isomer tends to predominate in aquatic oils (> 75.5 % relative abundance) compared to ruminant fats (Lucquin et al. 2016). Only four of our samples meet this criterion. Twenty sam-

5 Evershed et al. 2008a; Hansel et al. 2004; Craig et al. 2007; Cramp / Evershed 2014; Heron et al. 2015.

Sample ID	Lipid _conc. (ug/g)	P/S ratios (C16/C18)	δ13C16:0	δ13C18:0	Δ13C	Aquatic biomarkers	SRR%	Fully aquatic	Partially aquatic	Other identified lipid markers
HU-01	803	1.08	-26.6	-27.1	-0.5	APAA(C16-22), tmtd, phy	88.2	x	-	SFA(C10:0-30:0), UFA(C15:1,16:1,18:1,26:1), br, chol, campesterol
HU-02	597	1.46	-25.7	-26.4	-0.7	APAA(C16-20), tmtd, phy	55.7	x	-	SFA(C11:0-28:0), UFA(C18:1,22:1,26:1), br, chol, campesterol
HU-03	76	1.54	-26.9	-27.8	-0.9	APAA(C18), tmtd(tr), phy	69.3	-	x	SFA(C12:0-24:0), br, chol, campesterol
HU-04	168	1.33	-28.1	-28.6	-0.6	APAA(C18), tmtd, phy	76.2	-	x	SFA(C12:0-30:0), br, chol, campesterol
HU-05	366	1.19	-28.2	-31.7	-3.5	APAA(C16-20), tmtd(tr), phy	51	x	-	SFA(C11:0-30:0), br, chol, campesterol
HU-06	83	1.06	-28.2	-29.0	-0.8	tmtd(tr), phy	n/a	-	-	SFA(C12:0-24:0), DA(C9:0), br, chol, campesterol
HU-07	738	1.56	-26.2	-26.4	-0.2	n/a	n/a	-	-	SFA(C10:0-26:0), UFA(C16:1,18:1), DA(C9:0), br, chol, campesterol
HU-08	706	0.69	-28.6	-30.2	-1.6	APAA(C16-20), tmtd, pri(tr), phy	70.9	x	-	SFA(C10:0-20:0), UFA(C16:1,18:1), DA(C9:0), br, chol, campesterol
HU-09	436	1.92	-27.7	-28.0	-0.3	APAA(C16-22), tmtd, pri(tr), phy	72.2	x	-	SFA(C10:0-23:0), UFA(C11:1,16:1), DA(C9:0), br, chol, campesterol
HU-10	724	1.34	-28.8	-28.8	0.1	APAA(C16-20), tmtd, pri(tr), phy	81.1	x	-	SFA(C10:0-25:0), UFA(C16:1,18:1,19:1,26:1), DA(C9:0,10:0), br, chol, campesterol
HU-11	879	0.88	-28.8	-33.3	-4.5	phy	59.2	-	-	SFA(C10:0-28:0), UFA(C18:1), A(C9:0,11:0), br
HU-12	124	1.13	-28.9	-30.9	-2.1	APAA(C16-20), tmtd, pri(tr), phy	59.8	x	-	SFA(C12:0-19:0), UFA(C16:1,18:1), DA(C9:0,11:0,12:0), br, chol(tr), campesterol
HU-13	498	1.12	-28.1	-30.3	-2.3	APAA(C16-18(tr)), phy	29.2	-	-	SFA(C12:0-30:0), UFA(C16:1,18:1), DA(C9:0,11:0), br, chol, campsterol
HU-14	531	1.48	-26.9	-27.0	-0.1	APAA(C18(tr)), tmtd, phy	n/a	-	-	SFA(C10:0-21:0), UFA(C16:1,18:1,21:1), DA(C9:0,11:0), br, chol, campesterol
HU-15	246	1.82	-28.9	-28.6	0.2	APAA(C16-20), tmtd, phy	n/a	x	-	SFA(C12:0-24:0), UFA(C16:1,17:1,18;1), DA(C9:0), br, chol(tr), campesterol
HU-16	956	1.49	-26.8	-26.1	0.7	APAA(C16-22), tmtd, pri(tr), phy	41.1	x	-	SFA(C10:0-23:0), UFA(C16:1,18:1),DA(C9:0), br, chol, campesterol
HU-17	130	0.70	-28.4	-30.8	-2.4	APAA(C16-22(tr)), tmtd(tr), phy	57.3	x	-	SFA(C10:0-23:0), UFA(C16:1,18:1),DA(C9:0), br, chol(tr), campesterol(tr)
HU-18	125	0.79	-29.2	-29.1	0.0	phy	n/a	-	-	SFA(C12:0-24:0), UFA(C18:1), DA(C9:0), br, chol, campesterol
HU-19	108	0.80	-29.5	-34.4	-4.9	APAA(C18), tmtd(tr), phy	49.1	-	x	SFA(C12:0-30:0), UFA(C18:1), DA(C9:0), br, campesterol
HU-20	121	1.75	-25.3	-25.2	0.1	APAA(C18-20), tmtd(tr), phy	67.4	x	-	SFA(C10:0-23:0), UFA(C16:1,18:1), DA(C9:0,11:0), br, campesterol
HU-21	74	0.66	-28.0	-32.0	-4.1	tmtd(tr), pri(tr), phy	55.4	-	-	SFA(C11:0-24:0), UFA(C16:1,18:1), DA(C9:0,11:0), br, chol(tr), campesterol
HU-22	595	0.96	-27.6	-32.0	-4.4	APAA(C16-22(tr)), tmtd, phy	33.5	x	-	SFA(C10:0-26:0), UFA(C16:1,18:1), DA(C9:0,11:0), br, chol, campesterol, stigmasterol(tr)
HU-23	641	0.91	-27.0	-29.7	-2.7	APAA(C16-22(tr)), tmtd, pri(tr), phy	68.2	x	-	SFA(C11:0-26:0), UFA(C18:1), DA(C9:0,10:0,11:0), br, chol(tr), campesterol
HU-24	489	1.15	-28.1	-28.0	0.1	APAA(C16-22), tmtd, pri(tr), phy	79.3	x	-	SFA(C11:0-24:0), UFA(C16:1,18:1), DA(C9:0,10:0,11:0), br, chol, campesterol
HU-25	635	0.81	-27.2	-30.3	-3.2	APAA(C16-22), tmtd, phy	n/a	x	-	SFA(C12:0-26:0), UFA(C16:1,18:1), DA(C9:0), br, chol, campesterol
HU-26	488	1.06	-27.3	-28.6	-1.3	tmtd(tr), pri(tr), phy	n/a	-	-	SFA(C12:0-27:0), UFA(16:1,18:1) , DA(C9:0,10:0), br, chol, campesterol
HU-27	442	1.02	-28.3	-32.0	-3.6	APAA(C16-20(tr)), tmtd, pri, phy	61.6	-	x	SFA(C12:0-28:0), UFA(16:1,18:1), DA(C9:0), br, chol, campestenol
HU-28	130	0.69	-28.5	-31.2	-2.7	tmtd(tr), phy	n/a	-	-	SFA(C11:0-26:0), UFA(C16:1,18:1), DA(C9:0), br, chol(tr), campesterol, stismasterol(tr)
HU-29	386	1.90	-26.6	-28.1	-1.6	APAA(C16-22(tr)), tmtd, pri, phy	24.9	x	-	SFA(C10:0-24:0), UFA(C16:1,18:1), DA(C9:0,10:0,11:0,12:0), br, chol, campesterol
HU-30	119	0.66	-28.6	-34.0	-5.4	APAA(C16-18), tmtd	n/a	-	x	SFA(C10:0-27:0), UFA(C16:1,18:1), DA(9:0,10:0,11:0,12:0), br, campesterol, stigmasterol(tr)
HU-31	112	1.68	-28.3	-29.1	-0.9	APAA(C16-18(tr)), tmtd, pri, phy	25.9	-	-	SFA(C12:0-26:0), UFA(C16:1,18:1), DA(C9:0,10:0,11:0), br, chol, campesterol
HU-32	104	0.89	-29.3	-32.7	-3.4	APAA(C16-22), tmtd, pri(tr), phy	65.6	x	-	SFA(C12:0-26:0), UFA(C18:1), DA(C9:0,10:0,11:0,12:0), br, chol, campesterol
HU-33	110	1.03	-27.5	-32.2	-4.7	APAA(C16-22(tr)), tmtd, phy	66.9	x	-	SFA(C10:0-24:0), UFA(C16:1,18:1), DA(C9:0,11:0,12:0), br, chol(tr), campesterol, stigmasterol(tr)
HU-34	164	1.01	-24.0	-28.0	-4.0	APAA(C16-22), tmtd, phy	61.7	x	-	SFA(C10:0-26:0), UFA(C16:1,18:1), DA(9:0,11:0,12:0), br, campesterol
HU-35	495	1.11	-26.0	-29.3	-3.3	APAA(C16-20), tmtd, phy	59.1	x	-	SFA(C10:0-26:0), UFA(C16:1,18:1), DA(C9:0,10:0,11:0,12:0), br, chol(tr), campesterol
HU-36	221	2.02	-28.3	-27.4	0.9	APAA(C16-18), tmtd, pri, phy	n/a	-	x	SFA(C12:0-24:0), UFA(C16:1,18:1), DA(C11:0), br, chol, campesterol
HU-37	216	1.27	-26.1	-28.2	-2.2	phy	n/a	-	-	SFA(C11:0-21:0), UFA(C16:1,18:1), DA(C9:0,11:0), br, chol(tr), campesterol

Cn:x) - carboxilic acids with carbon length n and number of unsaturations x, SFA – saturated fatty acid, UFA – unsaturated fatty acids, DC - α,ω-dicarboxylic acids, APAA - ω-(o-alkylphenyl) alkanoic acids, br -branched chain acids, tmtd - 4,8,12-trimethyltridecanoic acid, pri – pristanic acid, phy – phytanic acid with the percentage contribution of SRR diastereomer in total phytan acid, chol - cholesterol or derivatives.

Table 2 Results of organic residue analysis.

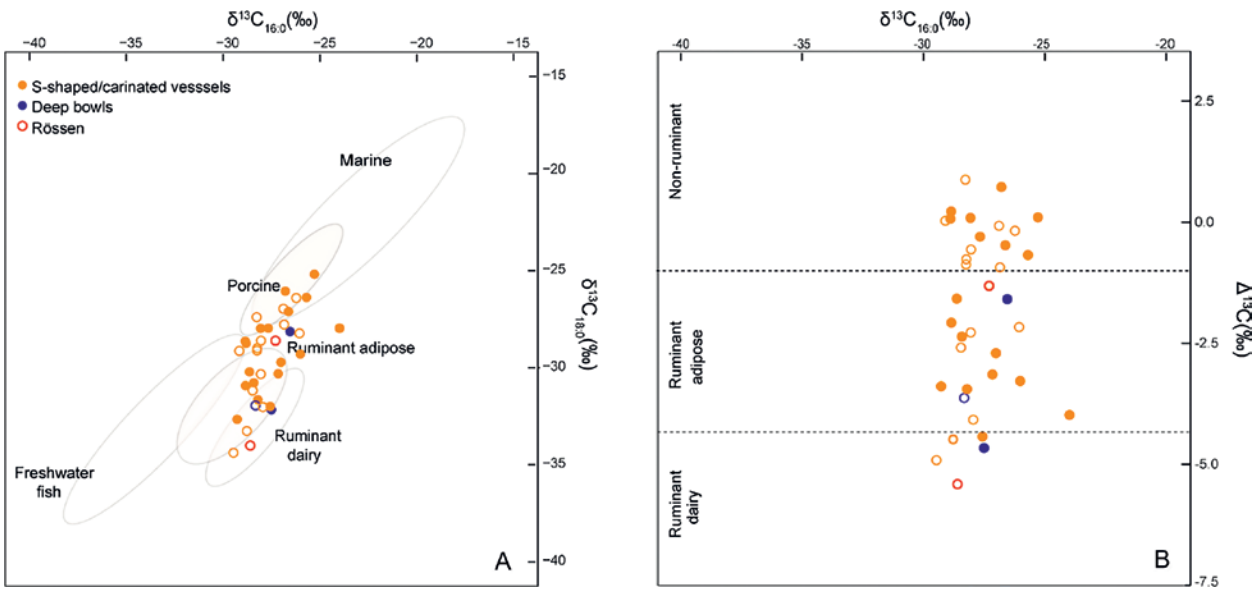

Fig. 8 **A** GC-C-IRMS results showing isotopic values of $C_{16:0}$ and $C_{18:0}$ fatty acids of Hüde I samples. S-shaped / carinated vessels (n = 34) are marked yellow, deep bowls (n = 3) blue, and Rössen samples (n = 2) red. 95 % confidence ellipses indicate areas of authentic reference values for each group of origins from the western Baltic; **B** Plot of $\Delta^{13}C$ ($\delta^{13}C_{18:0}$ – $\delta^{13}C_{16:0}$ values) against $\delta^{13}C_{16:0}$ values of Hüde I pottery, collected from only ceramic matrices. Dotted lines indicate areas of authentic reference values for each group of origins from the western Baltic. Samples with the full set of aquatic biomarkers are shown by filled circles in both plots.

ples have a SRR/RRR ratio below 75.5 % (ranging between 24.9 % and 72.2 %), falling within both the aquatic and ruminant range, while the remaining 13 samples have no available SRR/RRR ratio.

To further investigate the sources of the lipids, the carbon stable isotope values of their palmitic ($C_{16:0}$) and stearic ($C_{18:0}$) acids were examined for each sample (n = 37). Palmitic ($C_{16:0}$) and stearic ($C_{18:0}$) fatty acids were used to distinguish lipids derived from ruminant meat and milk fats, following the approach of Evershed et al. (2002a; b; 2008b). Dietary sources of these lipids are distinguished by characteristic $\delta^{13}C$ value ranges defined by $\delta^{13}C_{18:0}$ versus $\delta^{13}C_{16:0}$ values, as well as the isotopic difference between the two, $\Delta^{13}C_{18:0-16:0}$. The data from the samples (see Table 2) are plotted in Figure 8 against the reference ranges which were adapted from authentic modern animal fats collected from western Baltic. Overall, the $\delta^{13}C$ values of C16 : 0 and $C_{18:0}$ fatty acids coming from the samples indicate a mixture of a wide range of foodstuffs including porcine, ruminant, and dairy (Fig. 8A). Of all 37 samples, only three samples plot in the freshwater range. Considering that the majority of the samples have fully aquatic biomarkers, this may indicate a mixture of aquatic and ruminant animal fats in the Hüde I vessels.

The inland location of the site on the border of a freshwater lake supports the argument of these pots being used for exploitation and processing of freshwater resources. Fish account for ~6 % of the total identified bones at the site (n = 11,299; Hüster 1983). While the freshwater fish species – pike, perch, bream, tench, and pope – account for 74 %, 18 %, 5 %, 1 % and 0.09 % of total fish remains, respectively (n = 1,075; Hüster 1983), eel, the only catadromous fish species found at the site, accounts for only 1 % (Hüster 1983). Catadromous fish species are migratory species which move down freshwater rivers to the sea for spawning. If caught at the river mouths before entering the freshwater river systems, they would be expected to have marine carbon isotope signatures (Robson et al. 2012; 2016). However, eel bone remains coming from inland sites, of fish caught in freshwater river systems, proved to indicate carbon isotope values more consistent with freshwater residency, or in between freshwater and marine carbon ranges (Robson et al. 2012). Therefore, processing eel in these pots is also possible.

Evidence of ruminant adipose and ruminant dairy fats

Based on the molecular analysis, the presence and the results of the diastereomeric ratio (SRR/RRR ratio) of phytanic acid and the presence of branched chain C_{15} and C_{17} fatty acids found in some of the sherds are indicative of ruminant products (Table 2; Regert 2011; Lucquin et al. 2016). In addition, fifteen samples have $\Delta^{13}C$ values lower than −1 ‰ (Fig. 8B), values typical for ruminant adipose fats.[6]

6 Dudd et al. 1998; Evershed et al. 2002b; Copley et al. 2003; Craig et al. 2012.

Zooarchaeological records from Hüde I present *Bos* sp. as the most dominant species at the site. It accounts for a total of 31 % of identified mammal bones (n = 10,600; Hübner et al. 1988). This is followed by the presence of red deer, elk, and roe deer (4.8 %, 4.6 %, and 3.8 % of identified mammal bones, respectively; n = 10,600, excluding antler). Additionally, the high amount of waste material coming from antler tool production (Deichmüller 1965a) indicates that deer was important to the economy at Hüde I and was used both for meat and raw material for the manufacture of artefacts. Moreover, sheep/goats were also present at the site. Sheep and goat were not domesticated locally, as they are not native to the area (Luikart et al. 2001). Therefore, it is certain that these animals must have been introduced to the site from regions to the south, where animal husbandry and agriculture were already established (Müller 1964; Piening 1998). While sheep/goat remains cover a relatively small percentage (0.6 %, n = 10,600) of identified mammal bone material at the site, the few mandible fragments allow us to identify the presence of at least five individual specimens (Hübner et al. 1988).

The lipid residue analysis helps us to understand the role that ruminant animals played in the subsistence strategy and the diet at Hüde I. Ruminant meat may have been processed and / or cooked in several different ways, including roasting or grilling meat on open fire. However, based on our results of molecular and isotope analyses, we are able to confirm that ceramic vessels were one of the common ways of processing and/or cooking ruminant animal products at the site.

In addition, five of 37 samples have $\Delta^{13}C$ values below −4.3 ‰, the limit for wild ruminant carcass fats (Craig et al. 2012), meeting the widely accepted criteria for prehistoric dairy fats (Copley et al. 2003; Evershed et al. 2008b; Debono Spiteri et al. 2016). Reconciling the presence of dairy in the pots with the zooarchaeological assemblage is currently problematic, due to the issues that come with the high fragmentation of the remains and the lack of up to date zooarchaeological analyses on the bone assemblage. Our current knowledge on the presence of domesticated cattle and sheep/goat at Hüde I comes from a relatively detailed but technologically limited osteological analysis (Hübner et al. 1988). Hübner et al. (1988) attest the presence of domesticated cattle solely based on the smaller size of few bone remains. However, similar interpretations done at contemporaneous sites in northern Europe have been disputed (Kabaciński et al. 2009; Sørensen / Karg 2014; Schmölcke / Nikulina 2015). The best-known example to this is the mtDNA analysis on a small number of presumed domesticated cattle remains from Rosenhof LA 58, reidentifying them as small individuals of aurochs that were present in northern Germany during the Late Mesolithic (Scheu et al. 2008). Regarding the presence of sheep/goat, our current knowledge also does not go beyond the presence of few lower jaw fragments identified at the site. As a result, it is not possible to determine the presence of cattle at the site, and whether these animals were kept for their meat or were also exploited for dairy products. Further analysis of the zooarchaeological remains with AMS ^{14}C-dating, stable isotope, and palaeogenomic analyses is needed to address this issue.

Interestingly, ten out of the seventeen samples that plotted in the ruminant adipose range have fully aquatic biomarkers. In addition, two out of five samples in the dairy range also have fully aquatic biomarkers. This may indicate mixing of aquatic resources (freshwater fish) and ruminant carcass fats as well as dairy fats in these vessels. These results are consistent with the molecular and single compound isotope results.

Evidence of non-ruminant animal fats

The isotope data presented in Figure 8B suggest that 16 of 37 samples yielded $\delta^{13}C$ values that match with non-ruminant terrestrial animals (i. e. wild boar/domesticated pig). Based on the faunal remains from Hüde I, *Sus* sp. is among the most abundant terrestrial animal species, covering 17.9 % of the identified mammal remains at the site (n = 10,600; Hübner et al. 1988). Hübner et al. (1988) argue that domesticated pigs were present and thus subjected to fully developed pig farming and breeding activities carried out at the site. We are less certain because the identification of domesticated pig, similar to domesticated cattle, was solely based on the measurements of the few bone remains available.

Similar to the samples with ruminant adipose and ruminant dairy fats, samples with heavy porcine fats indicate a possible mixing with aquatic, mainly freshwater fish, resources as seven of them have fully aquatic biomarkers (Fig. 8B; Table 2).

Evidence of food plant residues

Our analysis based on acid extraction does not indicate a clear evidence of processing food plants in any of the Hüde I vessels. As we have not undertaken further solvent extraction to identify cereal-derived lipids in any of our samples from the site, it is difficult

to know whether any of the vessels analysed here were used for processing cereals. However, recent studies done on plant lipids showed that plants contain substantially lower lipid concentrations than animal products, therefore animal fats may dominate the lipid extracts where vessels have been used to process both plant and animal products (Colonese et al. 2017; Hammann / Cramp 2018). This makes it very difficult to detect them through lipid residue analysis. Therefore, we cannot exclude a possible food plant processing in any of our samples. Although identifying plant lipids is not straightforward, 36 of the 37 samples yielded plant derived lipids such as campesterol (ergost-5-en-3b-ol), of which four of them also had traces of stigmasterol (stigmasta-5,22-dien-3b-ol; cf. Table 2) indicating a possible contributions from food plants. Campesterol and stigmasterol are the most common steroids (phytosterols) in vascular plants (Baker 1982; Bianchi 1995) which is consistent with the vegetation at and around the site (see above).

Our knowledge on the cereals present at the site is primarily based on the three sherds with carbonised remains of cereals (i. e. naked barley and einkorn wheat); however, these sherds were not accessible at the time of our research and therefore morphological and functional analyses on them were not possible. In addition, to our knowledge, no archaeobotanical analysis of the carbonised remains has been carried out. The pollen analysis (Schütrumpf 1988) does not report any human impact on the vegetation or evidence for agricultural activities and provides scarce identification of cereal-type pollen at the site. Even if local cultivation was carried out, this comes as no surprise. In northern Germany, agriculture has been assumed to have started around 4,100 calBC with the arrival of the Funnel Beaker culture to the region, but archaeobotanical evidence is reported to be scarce for the first 500 years of the Neolithic, and pollen grains of cereal-type and further evidence for human impact on the environment are only visible after 3,700 calBC (Kirleis et al. 2012). Further residue analysis on the pottery, in conjunction with Scanning Electron Microscopy (SEM) analysis of carbonised surface deposits, is required to contribute to this topic.

Results of bulk stable isotope analysis by (EA-IRMS)

Twenty-one carbonised surface deposits (foodcrusts), found only on the S-shaped/carinated vessels, were analysed in order to measure the bulk carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope values with the aim of broadening our understanding of Hüde I pottery. Bulk stable isotope measurements obtained from carbonised surface deposits from our samples (n = 21) are plotted in Figure 9 (also see Table 3).

The bulk $\delta^{13}C$ isotope values of the Hüde I samples range from −22.0 ‰ to −27.3 ‰ (mean = −24.6 ‰), which is considered to represent C_3 plants and/or animals consuming C_3 plants, relatively depleted in ^{13}C. However, it is argued that these values are affected and can be altered by loss of proteinaceous material in the post-depositional environment in various degrees and therefore are difficult to interpret.[7] Nitrogen stable isotope ($\delta^{15}N$) values of protein that is available in the foodcrusts provides the information on the trophic level of different organisms processed in the pottery. $\delta^{15}N$ values that are above c. +7.0/+9.0 ‰ are usually indicative of aquatic resources (Craig et al. 2013), whereas lower ones are more consistent with terrestrial organisms (Craig et al. 2007; 2011). The $\delta^{15}N$ isotope values of the samples discussed in this study range from +5.4 ‰ to +8.7 ‰ (mean = 7.2 ‰), which are consistent with proteins from terrestrial herbivores, although the presence of fish, specifically anadromous species based on the low $\delta^{15}N$ isotope values, cannot be ruled out. The results of this analysis are consistent with molecular and single compound isotope analyses.

The C/N ratios may indicate the contribution of proteins versus lipids and/or other non-nitrogenous compounds such as carbohydrates. The low C/N ratios of the Hüde I samples, varying between 5.4 and 11.3, suggest that these foodcrusts were formed from a mixture of low lipid content and protein rich animal (both aquatic and terrestrial) tissues. This is again consistent with the results of our molecular and isotope analyses.

In addition, the offsets between averaged fatty acid $\delta^{13}C$ values ($\delta^{13}C_{16:0-18:0}$) and the corresponding bulk $\delta^{13}C$ values in foodcrusts from the same sherds ($\Delta^{13}C_{16:0-18:0}$−bulk $\delta^{13}C$) can be used as a tool to understand the composition of the foodcrusts. Small offsets and high C/N ratios generally indicate that the foodcrusts are mainly formed from fatty adipose tissues or aquatic oils, as both analytic techniques are measuring the $\delta^{13}C$ value of the lipid component. In contrast, foodcrusts derived from a higher proportion of protein-rich tissues, such as muscle tissues, would be expected to have a higher $\Delta^{13}C_{16:0-18:0}$−bulk

7 Craig et al. 2007; 2011; 2013; Heron et al. 2015; Heron / Craig 2015.

Sample ID	EA-IRMS	Sampling location	%C	$\delta^{13}C$	sd	%N	$\delta^{15}N$	sd	C/N ratio	$d^{13}C$ offset
HU-01	x	interior	50.6	-25.0	0.8	8.5	8.1	0.2	6.9	1.87
HU-02	x	interior	52.9	-24.1	0.1	8.2	8.0	0.0	7.5	1.91
HU-03	-									
HU-04	x	interior	33.8	-24.1	0.2	6.4	7.8	0.0	6.2	4.23
HU-05	x	interior	50.4	-26.6	0.8	5.2	7.5	0.0	11.3	3.33
HU-06	x	interior	24.6	-26.5	0.2	3.6	7.1	0.0	8.0	2.16
HU-07	x	interior	26.7	-22.0	11.3	5.2	7.0	2.8	6.6	4.29
HU-08	x	interior	53.1	-27.3	0.1	5.9	7.1	0.3	10.5	2.09
HU-09	-									
HU-10	x	interior	40.6	-24.9	0.1	7.0	7.4	0.2	6.7	3.89
HU-11	-									
HU-12	x	interior	32.2	-24.6	0.3	7.0	6.3	0.0	5.4	5.34
HU-13	x	interior	43.9	-24.0	0.1	7.5	6.1	0.0	6.8	5.22
HU-14	x	exterior	42.0	-25.7	0.6	4.8	8.0	0.1	10.2	1.27
HU-15	x	interior	45.9	-24.1	0.5	8.5	8.1	0.1	6.3	4.63
HU-16	x	interior	43.6	-23.8	0.6	7.8	7.7	0.1	6.5	2.66
HU-17	x	interior	38.5	-25.1	0.6	4.1	6.2	0.1	11.1	4.46
HU-18	-									
HU-19	-									
HU-20	x	interior	48.8	-23.4	0.3	7.7	8.6	0.1	7.4	1.89
HU-21	x	interior	47.6	-22.7	0.1	9.0	7.0	0.0	6.2	7.28
HU-22	x	interior	42.7	-26.3	0.3	5.9	5.4	0.0	8.5	3.54
HU-23	-									
HU-24	x	interior	49.2	-24.5	0.5	8.4	7.0	0.1	6.8	3.56
HU-25	-									
HU-26	-									
HU-27	-									
HU-28	-									
HU-29	-									
HU-30	-									
HU-31	-									
HU-32	-									
HU-33	-									
HU-34	x	interior	45.27	-24.11	0.03	7.17	7.4	0.01	7.4	1.87
HU-35	x	interior	36.11	-24.05	0.16	6.08	7.0	0.03	6.9	3.61
HU-36	x	interior	30.35	-24.02	0.77	6.26	7.3	0.16	5.7	3.82
HU-37	-									

Table 3 Results of bulk stable isotope analysis on foodcrust.

offset as a result of mixing carbon from protein and fat which have different isotope values.

All 21 of our foodcrust samples yielded a high offset varying between 0.13 and +7.28, C/N ratios between 5.4 and 11.3, and $\delta^{15}N$ values between +5.4 and +8.7 (Table 3). These values may indicate that the foodcrusts consist of both aquatic oils and protein-rich tissues of animal products and/or plants. Although all these samples contained plant biomarkers (Table 2), the C/N ratios are too low and the $\delta^{15}N$ values are too high to have a notable plant contribution (Bondetti et al. 2019). Therefore, we suggest that our foodcrust data is indicative of mixing aquatic oil (from freshwater fish) and protein-rich tissues of animal products. This eliminates the oil production as a possible use of these vessels and demonstrates that they were used for food preparation/cooking activities.

Conclusion

The lipid residue analyses of Hüde I vessels have shown that lipid residues are preserved in large quantities in the fabric of the vessel fragments studied, and that the origin of these lipids can be identified through the application of our chosen methodology. The results of the lipid residue analyses clearly show that Hüde I vessels were indeed directly associated with preparation, storing and/or cooking of foodstuffs included aquatic (freshwater) resources, terrestrial animals (both ruminant and non-ruminant), and dairy products as well as possibly food plants, although the latter requires further analysis. This is in agreement with the extensively analysed osteological assemblage from Hüde I, which shows the presence of both aquatic and terrestrial animal resources at the site.

The results furthermore indicate that there is no clear functional differentiation in the sample of Hüde I vessels presented here. On the contrary, our study shows that both S-shaped / carinated vessels and deep bowls have been used for processing freshwater and terrestrial products, regardless of vessel form, size, or decoration. Traces of dairy products also appear in both vessel types. It is important to note here that the small number of deep bowls sampled in this study may not be representative of the whole assemblage and therefore should be addressed in a future analytical work on the pottery from Hüde I. It is difficult to correlate the use of Hüde I pottery to the occupation history of the site due to its problematic stratigraphy. However, the consistency of the results of lipid residue analyses lends weight to the assumption that vessels had a similar function throughout the site's occupation span.

Regarding the two Rössen pots, our results indicate that while one of these vessels (HU30) was used processing ruminant meat, the other one (HU26) was heavily used for processing dairy products (Fig. 8A–B). This is consistent with the mixed agricultural practices of the Rössen culture, in which domesticated animals were part of the main economy and were probably kept both for their meat and milk (Lüning 2000). Whether this also holds true for Hüde I is uncertain, due to the limited zooarchaeological analysis.

A recent study done by Cubas et al. (2020) indicated that there is a very clear difference in pottery use between the last hunter-gatherers and the first agrarian communities in western Europe, but there is clear continuity across the transition in parts of northern Europe (Craig et al. 2007). However, the early farming pottery from southern and southwestern Europe demonstrates a major focus on processing terrestrial animal and dairy products with a total lack of aquatic resources (Cubas et al. 2020). Interestingly, our results contradict this. Two of five dairy samples indicate a mixture of dairy and freshwater fish signals. Hence, even though we do not know the phasing of these vessels, we can eliminate the possibility that fishing was totally replaced with pastoralism in this area as in southern and southwestern Europe.

For further clarification concerning the problem of correlating the pottery use to the occupation history of Hüde I, further methodological work focusing on the combination of different analyses such as scanning electron microscope (SEM) analysis, petrographic analysis, and accelerator mass spectrometry (AMS) ^{14}C-dating is required. SEM analysis on the carbonised surface deposits is a highly valued methodology to examine the charred plant and cereal residues possibly preserved in the crusts through the cooking process (e.g. Raemaekers et al. 2013). As detecting plant biomarkers through lipid residue analysis is challenging due to their low lipid content, SEM analysis is needed to further advance our understanding of whether food plants had a role in the use of pottery, and if they did, what kind of plants were processed in the Hüde I vessels. Furthermore, the Hüde I vessels need to be examined through petrographic analysis in order to determine the origin of these vessels. Although Drews (1977) applied this method to a selection of sherds collected from Hüde I and its surroundings, the information provided is very limited, and the material requires a more detailed analysis. Understanding the origin of these vessels would allow us to possibly identify the

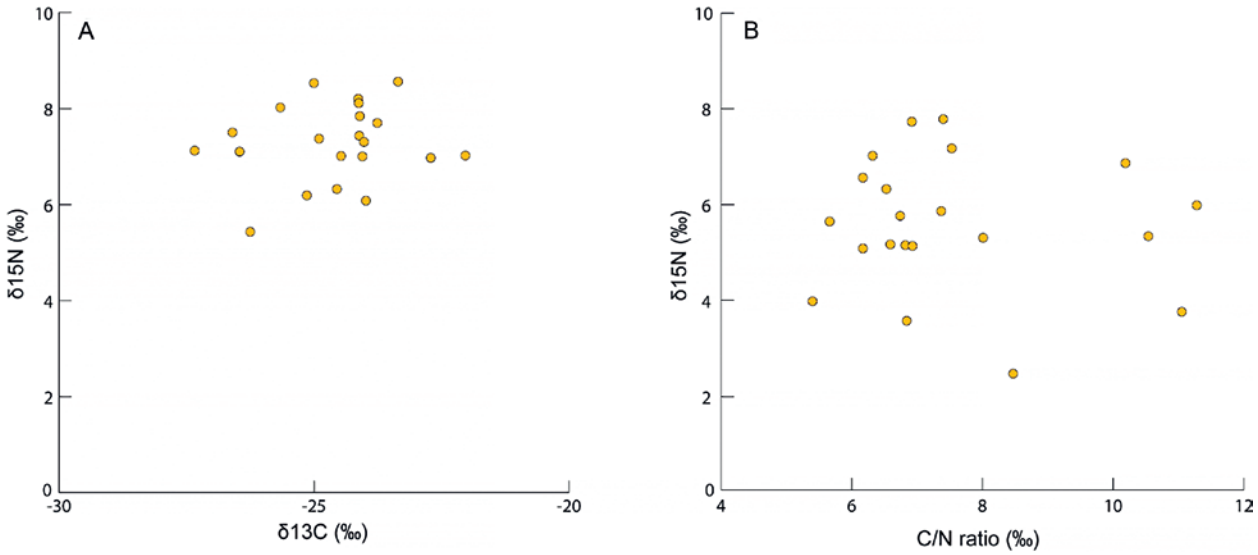

Fig. 9 **A** Bulk $\delta^{13}C$ and $\delta^{15}N$ data; **B** $\delta^{15}N$ and C/N ratio data of surface residues obtained from carbonised surface residues, collected from only S-shaped / carinated vessels of Hüde I.

different cultural groups present at Hüde I as well as to question the human mobility and/or interaction between different groups in the region. Finally, as there is a clear chronological association between the occupation of the site and the pottery, direct ^{14}C-dates of food crusts and/or organic temper (e.g. moss, see Teetaert et al. 2020) of the pottery would allow us to correlate vessels to specific occupational phases of Hüde I. Direct dating of food crusts should be targeted on samples without aquatic biomarkers in order to avoid freshwater reservoir effect on the pottery (Fischer / Heinemeier 2003; Philippsen 2013).

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Two new Swifterbant settlements at Nieuwegein-Het Klooster, the Netherlands: preliminary site interpretation and overview of human remains

Helle M. Molthof and Steffen Baetsen

Abstract In 2017, for the first time in almost twenty years, a site with the remains of multiple individuals from the Swifterbant culture was discovered at Nieuwegein in the Netherlands. Nowadays an industrial area on reclaimed land, the flat green meadows are hiding a former river system of levees and peat-filled channels, which appears to have been intensively used by Neolithic communities.

Together with the simultaneous excavations at Tiel-Medel, about 25 km to the southeast, the excavations at Nieuwegein comprise the first large scale Swifterbant research in the central delta area of the Netherlands (Fig. 1). As such, both sites will serve as key links between the known sites of the Swifterbant culture (spanning an area between Antwerp and Hamburg), and the more or less contemporary sites of the Rössen, Bischheim and Michelsberg cultures to the south and east.

The remains of at least sixteen human individuals were discovered at Nieuwegein-Het Klooster. Among them were the remains of a baby, found in the arms of a young woman, the oldest burial of this kind ever found in the Netherlands. The analysis of the DNA of both the woman and the baby made clear that the burial concerns a mother and her daughter.

Keywords Swifterbant culture, burials

Zusammenfassung *Im Jahr 2017 ist es nach nahezu zwanzig Jahren erstmals gelungen, in Nieuwegein in den Niederlanden einen Bestattungsplatz der Swifterbant Kultur mit zahlreichen Individuen zu entdecken. In dem heutigen Industriegebiet lassen die grünen Wiesen das dort befindliche, frühere Flusssystem, das im Neolithikum offensichtlich intensiv genutzt wurde, kaum noch erkennen.*

Gleichzeitig werden auch Ausgrabungen in Tiel-Medel etwa 25 km südwestlich von Nieuwegein durchgeführt und die beiden Fundstellen emöglichen die ersten großflächigen Forschungen zur Swifterbant Kultur im zentralen Deltagebiet der Niederlande. Sie sind als Schlüsselfundplätze der Swifterbant Kultur zwischen Antwerpen und Hamburg sowie den mehr oder weniger zeitgleichen Fundstellen der Rössener, Bischheimer und Michelsberger Kultur im Süden und Osten anzusehen.

In Nieuwegein-Het Klooster wurden die Überreste von mindestens sechzehn menschlichen Individuen entdeckt. Unter ihnen ist auch ein Baby, das in den Armen einer jungen Frau aufgefunden wurde. Es handelt sich um das älteste Grab dieser Art, das in den Niederlanden entdeckt wurde, und aDNA-Analysen zeigen, dass es sich um die Beisetzung einer Muttter mit ihrer Tochter handelt.

Paleogeography and excavation

The research at Nieuwegein was fuelled by the development of a large business park, 'Het Klooster'. An intensive augering survey, consisting of more than 10,000 corings in a close grid, provided a detailed insight into the palaeogeography (Sprangers 2019). Dominating the area is the residual channel of the river Wiersch, flanked by its levees and the floodplains beyond (Fig. 1–2). The Wiersch can be considered a predecessor of the Rhine. In the north of the research area, a smaller river or stream branches off from the main channel. Though this secondary stream probably originated as a crevasse when the Wiersch broke through its levees, it is likely that it developed into a relatively small but permanently flowing river branch.

The excavation areas are indicated in red and blue. The site denominations derive from the plot numbers of the future business park. The 2016/2017 campaign, which took place on site 1, yielded a large settlement area on the western levee of the main

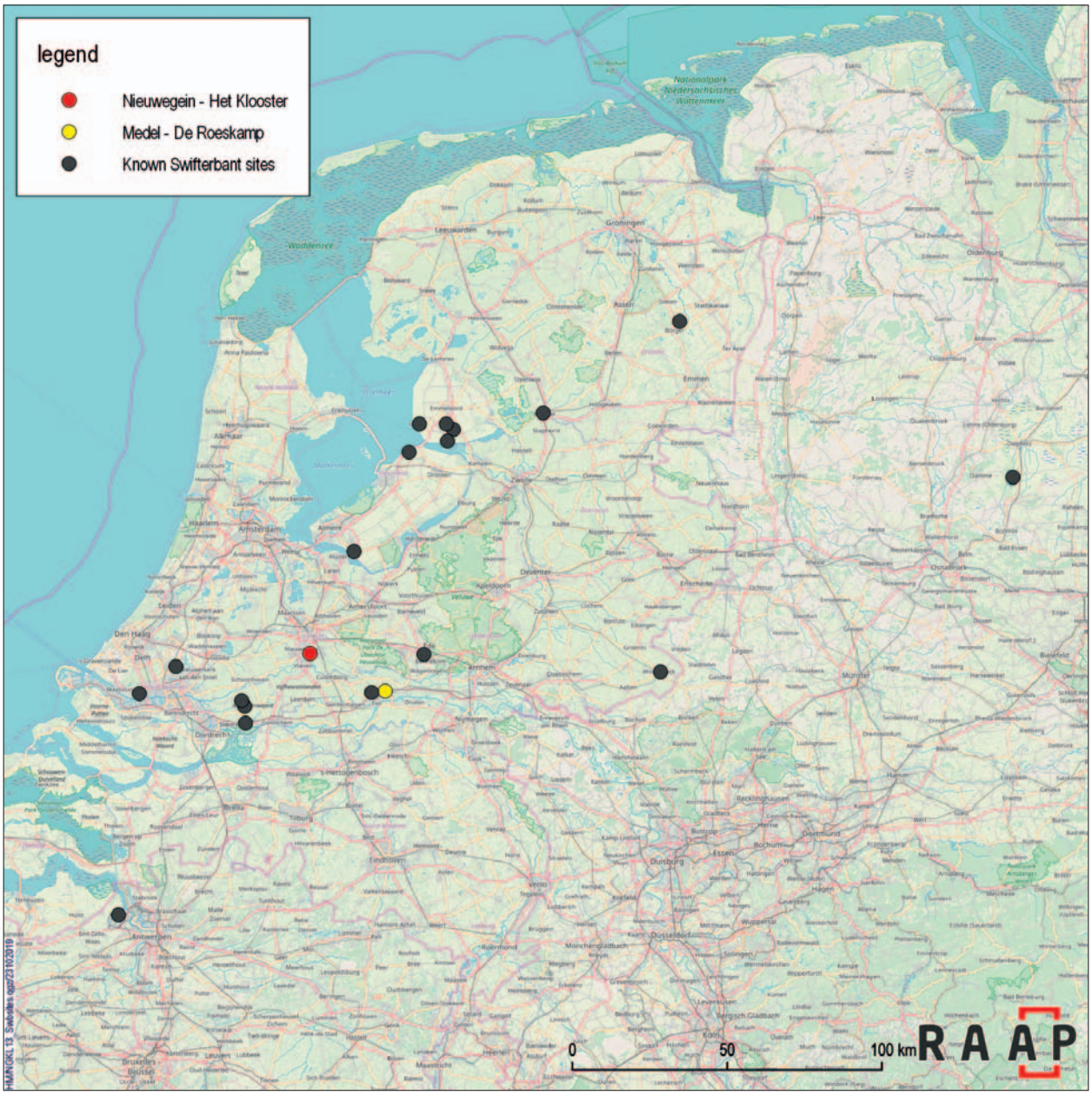

Fig. 1 Overview of main Swifterbant sites in the Netherlands and adjoining areas (after Raemaekers 1999, fig. 3.1 and Hogestijn / Peeters 2001, fig. 62).

channel. The 2018/2019 campaign was carried out on site B4/17, on the northern levee of the secondary stream. On both sites, the levee consists of silty clay, which was gradually covered with peat after the sites were abandoned (Fig. 3). This stratigraphy, combined with the fact that the find layer lies two metres below the surface and permanently under groundwater level, led to a very good preservation of the remains.

In the northwest, a coversand ridge is visible (Fig. 2, orange), which has been investigated by an augering survey (Jansen 2019). According to ^{14}C-dates, peat already covered the lower parts of the ridge by the end of the Mesolithic, but the higher parts were probably still accessible in the Early Neolithic. Only a few of the flint finds from the augering samples could be attributed to a specific period. They date to the Middle and/or Late Mesolithic, but it is possible that a part of the rest of the assemblage dates to the Neolithic (Van der Kroft / Molthof in prep.). Though it is unsure whether the conditions on the coversand ridge were dry enough for habitation during the Swifterbant period, it is likely that the area could have been visited and used by the people who lived at site 1 and site B4/17.[1]

1 As these business park plots will be turned into parking lots, to prevent damage to the site and avoid the costs of excavation, no further research is planned for the coversand ridge.

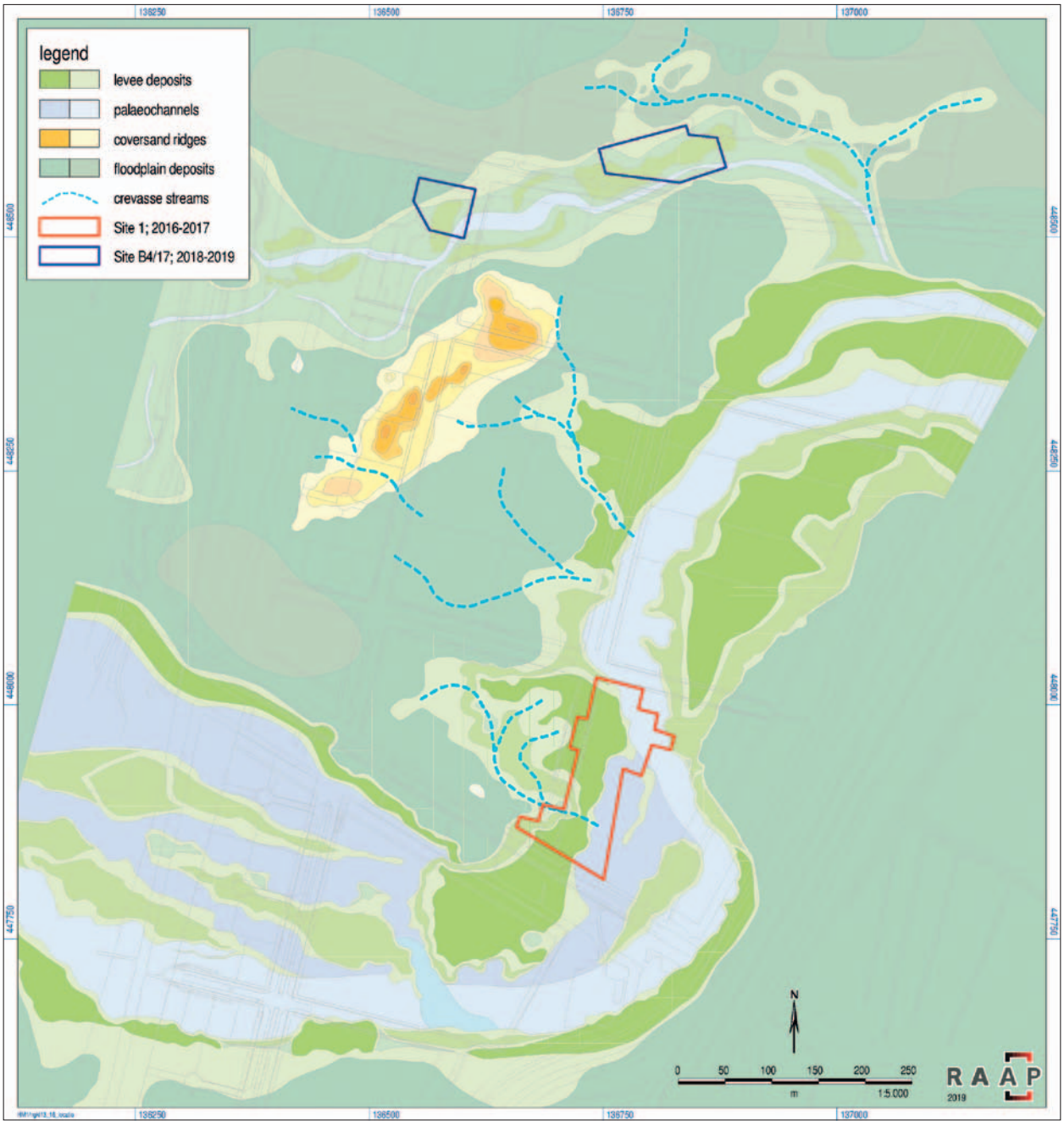

Fig. 2 Palaeogeographic map of the Neolithic river system and location of sites 1 and B4/17 (after Sprangers 2019, fig. 26).

Preliminary interpretation

The analysis of the excavation results is still in progress, but the current ideas about the types of sites we are dealing with will be presented here. The first impression is that there are similarities as well as differences between the two locations. As explained in the previous section, the landscape setting is very comparable, except for the scale. The levee on site 1 is at least 50 to 80 m wide, while the levee at site B4/17 only spans c. 20–25 m. On both sites, the filling of the residual channels has yielded hardly any artefacts, despite sieving of part of the filling. A possible explanation can be that erosion of the channel – and maybe also of the levee edges – took place after the abandonment of the site. This seems to be the case at least at site B4/17. Whatever the cause, the lack of stratigraphically separated material, combined with

Fig. 3 Cross-section of levee and residual channel on site B4/17 (photo: RAAP Archeologisch Adviesbureau).

Fig. 4 Pointed-bottomed pot with possible traces of black paint (photo: Restauratieatelier Restaura).

the fact that both sites yielded only a few features[2] and no house plans, makes it difficult to interpret the nature and sequence of the habitation.

The chronology of the sites is for now based on the typology of pottery and flint artefacts, since there are very few ^{14}C-dates available yet. The majority of the sherds from site 1 are considered to date to phase Swifterbant (SW) 2, 4,400–3,900 cal BC (Ten Anscher 2012, 5, 7). They are tempered with quartz and plant material (or sometimes sand), they originate from both pointed-bottomed and round-bottomed pots (and one flat-bottomed pot), and show little decoration except for a few spatula impressions, some fingertip impressions, and possible traces of black paint on one pointed-bottomed vessel (Fig. 4). On some pots, the surface is covered with an extra layer of roughened clay, which is also known from the pottery of Medel-De Roeskamp (see Ten Anscher / Knippenberg, this volume) and Swifterbant-S3 (De

2 The low number of features might very well be the result of the similarity in colour of the find layer and the underlying levee soil. It is not clear whether this is caused by postdepositional processes (e.g. decomposition or washout of humus), or whether there never was much difference at all. The fact that there were no burial pits visible around the inhumations teaches us to be careful to interpret (absent) features as never having existed.

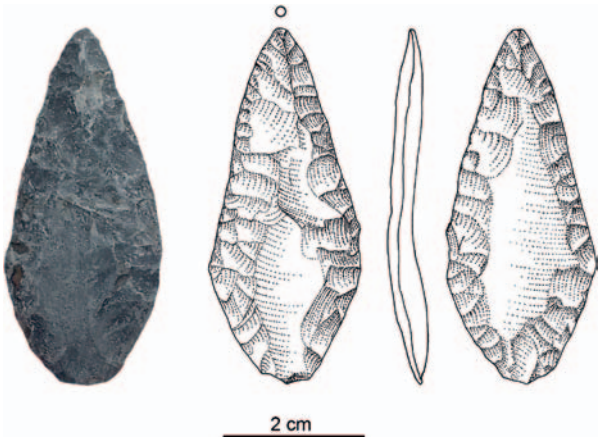

Fig. 5 Leaf-shaped point made of a basalt-like stone (drawing: M. Koeweiden).

Roever 2004, fig. 20). The pottery from site B4/17 is similar to that from site 1, except for some sherds that are tempered with a relatively large amount of sand.

The majority of the flint and stone artefacts from both sites seem to date to phase SW2 as well, although there are indications for an older phase (SW1; 4,900–4,400 cal BC) to the south of site 1, for example the emphasis on blade technology in this area, and the absence of relatively 'late' elements here (such as fragments of polished flint axes, triangles with surface retouch, and transverse arrowheads). In contrast, the northern part of site 1 yielded several of these tool types, including a leaf-shaped point made out of a basalt-like stone (Fig. 5). As the occurrence of leaf-shaped points at Swifterbant sites is usually interpreted as an influence of the Michelsberg culture (Raemaekers 1999, 142–143; Devriendt 2014, 255), this indicates that at least a part of the assemblage in the northern part of site 1 dates specifically to the latter half of SW2.

The most striking difference between site 1 and site B4/17 is that the first has yielded several inhumations and scattered human remains (which will be further discussed in the next sections), while on the latter site no human skeletal elements were found. This corresponds with the current idea that the broader levee by the main channel was inhabited more permanently and intensively than the smaller one in the north, which may have been used only for special activities. Some other aspects support a functional difference. Site 1 yielded several grinding stones while they are absent on site B4/17; on site B4/17 there are notable differences in the clustering of the various materials, while on site 1 they show more or less the same distribution patterns, and the faunal remains from site B4/17 seem to contain relatively many bones of birds and fish. Also, in the east of site B4/17, there are areas in which the find layer is dotted with specks of ochre. Ochre is often associated with ritual and burial activities, but it may also have been used for preserving hides.

One last remarkable difference, one we do not have a satisfactory explanation for yet, is that site B4/17 yielded the remains of at least eleven surface hearths, while these were absent (or not visible) on site 1. Although the assemblage from site 1 is generally more fragmented than that from site B4/17, pointing towards more intensive treading and disturbing of the area, one would still expect the surface hearths of the last occupation phase to remain preserved. Therefore, it is more likely that the explanation lies in differences between the post-depositional processes on each site.

In conclusion, the material from both sites seems to date to at least the SW2-period, but further typological analyses and ^{14}C-dates are necessary to obtain a more detailed chronology of the sites. At this moment, site 1 is interpreted as a settlement site with evidence for either year-round habitation or repeated – possibly seasonal – long-term occupation. On B4/17, we seem to be dealing with a less intensive (and/or shorter) habitation, and there are several clues that this site was used for special activities. Variations in functionality are known from other Swifterbant sites. Based on, for instance, the occurrence of structures and/or graves, the faunal assemblage, and the characteristics of the stone and flint industry, many different site types have been identified over the past years. In the Netherlands, the sites of Polderweg and De Bruin have been interpreted as settlement sites or base camps, the site of Hoge Vaart as an accumulation of several small hunting camps with evidence for pottery production, and the sites of Brandwijk en Hazendonk are interpreted as hunting and fishing camps (Devriendt 2014, ch. 6.3.4). The creek system at Swifterbant shows that this same variety also occurs within a smaller area, with site S3 as a main settlement site, S2 and S51 as special activity sites, and S4 displaying both similarities to S3 and distinguishing features like a child's grave. The stratigraphy of S4 moreover showed that chronological developments in function even occur within one site, with an alternation between cultivation layers and anthropogenic layers (Raemaekers / De Roever 2020, ch. 10.3; Devriendt 2014, 265). It is likely that sites 1 and B4/17 at Nieuwegein are similar to those at Swifterbant, with respect to the existence of functional differences between several sites on the same river system.

Individual	Zone	Bone and dental elements present	Age	Sex	Notes
ID1	2	Skull; no mandible or dental elements	14–18 yrs	Male	2nd/3rd degree relative of ID5 and ID6
ID2	2	Near-complete skeleton; skull absent	10–14 yrs	?	
ID3	2	Femur, fibula and long bone fragments	6–9 yrs	?	
ID4	2	Near-complete skeleton; feet absent	18–20 yrs	Female	Eight cattle incisor pendants scattered around neck
ID5	3	Near-complete skeleton; lower leg bones absent	20–25 yrs	Female	Mother of ID6
ID6	3	Skull-, long bone- and pelvis fragments; dental elements	0–3 mths	Female	Daughter of ID5
ID7	2	Near-complete set of dental elements	25–35 yrs	Female?	
ID8	2	Bone- and skull fragments, near-complete set of dental elements	12–18 yrs	?	
ID9	1	Skull fragments and three dental elements	6–15 yrs	?	
ID10	1	Two molars (and possibly two more, found ca. four metres away)	12–15 yrs	Male?	
ID11	2	Long bone-fragments and two dental elements	35–45 yrs	?	
ID12	2	One molar	25–35 yrs	?	Not from ID16 or ID17; overlap in dental elements)
ID13	3	One molar and long bone fragments	12–18 yrs	?	Long bone fragments may not be human
ID14	2	*Bone fragments and five dental elements*	12–18 yrs	?	*Could belong to ID1 or ID2*
ID15	2	*Two molars*	18–25 yrs	?	*Could belong to ID1*
ID16	2	One molar	25–35 yrs	?	Not from ID12 or ID17; overlap in dental elements)
ID17	2	Two molars	25–35 yrs	?	Not from ID12 or ID16; overlap in dental elements)
ID18	2	*One deciduous molar; three permanent teeth (not fully developed)*	2–7 yrs	?	*Could belong to ID3*
ID19	2	*One deciduous molar; four permanent teeth (slight traces of wear)*	6–12 yrs	?	*Could belong to ID3*
ID20	1	Three decidous teeth	3–6 yrs	?	Elements 61, 63 and 64; not lost by shedding

Table 1 Overview of the individuals of Het Klooster site 1. Skeletal elements which do not with certainty represent a single individual are noted in italics.

The human remains: discovery, grave goods, and first ^{14}C-results

As mentioned above, human remains were only found on site 1. All human remains are currently being analysed by Steffen Baetsen. Though this work is still in progress, an overview of the preliminary results will be presented here.

The human remains seem to be confined to three zones within the excavated area: zone 1 is located in the north of the site, zone 2 c. 50 m to the south, and zone 3 is located another 100 m further south (Fig. 6). The remains belong to at least sixteen, but possibly twenty individuals (Table 1). Five of them were recognised as inhumations during fieldwork: three in one grave[3] in zone 2 (grave 1; ID2, ID3 and ID4) and two in another grave in zone 3 (grave 2; ID5 and ID6). Because of the wet and muddy circumstances, the remains were uncovered just enough to determine the orientation and location of the skeletons. Subsequently, they were lifted *en bloc* together with the surrounding clay and transported to a hall for further investigation, to ensure dry and proper research conditions (Fig. 7). In addition to the five individuals in graves, a skull without a mandible was found a few metres from grave 1, and was also lifted *en bloc* (ID1).

The other individuals are represented by human bone fragments and teeth from the sieving residue of a number of sampling units. In two of those cases (ID7 and ID8), the assemblage of teeth and skeletal elements is too coherent and too complete to be interpreted as just scattered finds. They probably represent burials that unfortunately were not recognised as such during the excavation. Three more individuals (ID9, ID11, ID13) consist of dental elements and a few bones only, and five individuals are represented only by one to three dental elements from sampling

3 We are not entirely sure if ID2, ID3 and ID4 were buried at the same time, in one pit. However, with regard to their close proximity and similar position and orientation, and the fact that they were removed from the excavation and investigated in one block, this group of three individuals will in this paper be mentioned as 'grave 1'.

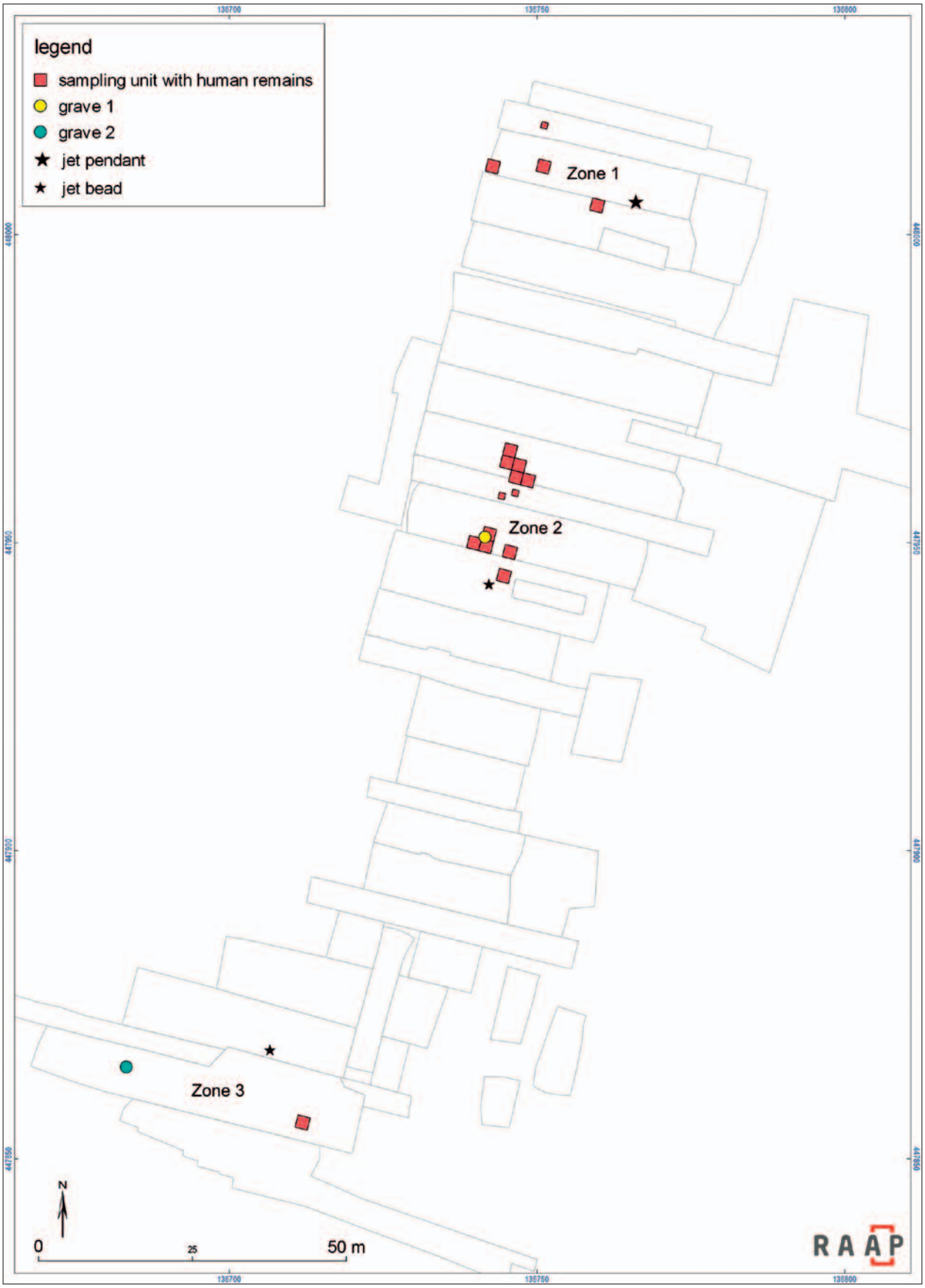

Fig. 6 Location of human remains and jet objects.

Fig. 7 The process of *en bloc* lifting of grave 1 (photos: BAAC Archeologie en Bouwhistorie).

Fig. 8 Jet pendant with traces of wear on the upper side of the perforation (photo: RAAP).

units (ID10, ID12, ID16, ID17, ID20).[4] The remains of these last eight individuals and also the skull near grave 1 possibly represent disturbed graves or partial (re)burials. Another explanation might be found in the fact that all Swifterbant settlements are characterised by the occurrence of stray human remains all through the settlement (Raemaekers et al. 2009, 543–544). This can either be because the sites were often used for a long time (so remains from earlier burials were distributed across the site over time), or because the Swifterbant people dealt with their deceased in a way that easily led to the presence of many loose bones and dental elements.

Grave goods were found with only one individual (ID4); these are eight perforated cattle incisors[5] (see 'Zone 2' below). Apart from these, no grave goods were found. However, the sampling units yielded three jet objects, a pendant and two beads, which were found in or near areas with human remains. The beads, found near zones 2 and 3, measure c. 6 mm in diameter. The pendant found near the remains of zone 1 measures c. 6 x 6 cm, which makes it the largest prehistoric jet object of the Netherlands so far (Fig. 8). Apart from a perforation that was probably made with a flint tool, there seem to be no alterations to the original piece. It is possible that the owner(s) did not want to reduce the size of such an extraordinary chunk of jet by modifying or polishing it. The perforation shows traces of wear from hanging on a string, which tells us that it was not just a valuable possession but that it was worn as an ornament for a considerable amount of time. Although these ornaments could not be directly linked to buried individuals or human remains, all

4 For ID14, ID15, ID18 and ID19, it is not certain whether they represent different individuals.

5 Among the cattle incisors, a wild horse incisor was also found. Skeletal elements of horses are very scarce in the animal bone assemblage of site 1, so it is possible that it concerns another grave good. However, the tip of the root – where a perforation would have been – is missing, so we cannot know for certain that it is a modified ornament.

three were located near zones with human remains, while the areas in-between did not yield any jet finds (Fig. 6). Considering that there is one known case of a jet ornament as a grave good for the Swifterbant culture (grave I at site Swifterbant-S22; see Devriendt 2014, 78–79), and that there are indications that post-depositional processes have disturbed the human remains at Nieuwegein,[6] it is possible that the jet objects at Nieuwegein were originally deposited as grave goods.

So far, five individuals have been sampled for ^{14}C-dating, of which four individuals yielded results.[7] They all date between c. 4,800 and 4,600 cal BC. It is probable that these dates are biased by a freshwater reservoir effect, making them seem older than they are. We are dealing with a community that lived by a river, there are many fish bones in the faunal assemblage, and one pottery sherd has a food crust containing still visible fish scales. Therefore the dates of the perforated incisors found as grave goods on one of the individuals (see below) will be crucial in determining the age of the burials and indicating the deviation of the ^{14}C-dates on human bone.

Sex and age of the individuals per zone[8]

Zone 1

In an area of c. 20 x 20 m, the remains of at least three individuals were found, all of which are non-adults. The youngest individual in this zone is a child of 3–6 years (ID20), represented by three milk teeth. Two of these have roots; the third consists only of a crown, but its edges show that it was not lost due to shedding either. Since it concerns an incisor, a canine and a first molar, all from the upper left jaw, they are interpreted as belonging to one deceased child. In the westernmost part of zone 3, skull fragments and teeth of another child were found, thought to have died at an age of 6–15 years (ID9). Finally, a sampling unit lying between ID20 and ID9 yielded two molars of an adolescent of 12–15 years (ID10). This individual might be a male one, considering the robustness and size of the molars. Apart from the three individuals mentioned here, zone 3 yielded six more dental elements that could not be attributed to either ID9/ID10/ID20 or a different individual with certainty.

Zone 2

This area yielded by far the majority of the skeletal elements from site 1. The first discovery of human remains on this site was a skull of an adolescent male of 14–18 years (ID1), without teeth or a mandible. Although broken into several pieces, which had been crushed by the pressure of the sediment covering it, it was still obvious that it was in an upright position when found.

About four metres to the east of the skull, three individuals were discovered together and documented as one burial with regard to their position and orientation (grave 1), though it is not certain that they were buried at the same time. They were identified as an adolescent of c. 10–14 years (ID2), a 6–9 year old child (ID3; too fragmented to determine the burial position), and an adolescent female of c. 18–20 years old (ID4). ID2 and ID4 were buried in supine position (Fig. 9); ID3 was too fragmented to determine the burial position with certainty. The skull of ID2 was absent, but a rather complete set of teeth from both the upper and lower jaw was scattered around the body. It seems logical to suppose that the skull of ID1 belongs to ID2. However, the physical features of the skull point towards an older individual than ID2, which is why it is regarded as representing a separate individual for the time being.

Around the neck of ID4, eight perforated cattle incisors (probably domesticated, not aurochs) were discovered (Fig. 10). Similar perforated incisors have been found at the site of Swifterbant-S3 (Clason 1978). Although it seems likely that they were worn as a necklace, since they were found near the chin of the individual, another possibility is that the pendants were fastened to their clothing. When discovered, they were scattered up to 20 cm away from the neck, probably due to postdepositional processes. Their original position and function are consequently lost.

Two additional burials in zone 2 which comprise quite complete sets of dental elements from sampling units, in one case found together with bone and skull fragments, concern a 25–35 year old individual, probably a female one considering the small size of the teeth (ID7), and an adolescent of 12–18 years (ID8).

6 For example, the skeleton of ID5 in zone 3 is not anatomically intact. The lower leg bones are missing, some of the vertebrae were located near the knees, and the axis was found behind the skull. An atlas that probably also belongs to ID5 was found seven metres away from the body.

7 ID1, ID2, ID3, ID4, ID5 were sampled. Only ID4 did not yield a result.

8 In this paper, the age classification of White et al. 2011 (p. 384) will be used: infant: 0–3 years, child 3–12 years, adolescent 12–20 years, young adult 20–35 years, middle adult 35–50 years, old adult 50+ years.

Fig. 9 Adolescent female (ID4) in grave 1 (photo: RAAP).

Fig. 10 A few of the perforated cattle incisor pendants found near the neck of ID4 (photo: RAAP).

Furthermore, there are scattered dental remains in zone 2 which could not be attributed to the abovementioned individuals and therefore represent at least four more persons. One of these is the oldest individual from the site, an adult of 35–45 years (ID11). The other three are all young adults of c. 25–35 years (ID12, ID16 and ID17). Even though they are only represented by one or two dental elements each, the second molar of the upper left jaw (element 27) is present for all. Therefore, we can be sure that there are three separate individuals represented.

Finally, some of the sampling units in zone 2 yielded human remains that might either represent new individuals, or belong to one or more of the abovementioned individuals from zone 2. They are documented as ID14, ID15, ID18 and ID19.

Zone 3

The only human remains from this area are represented by grave 2 and a molar from a sampling unit.

Fig. 11 Grave 2; a young woman with the remains of a baby near her right arm (photo: RAAP).

Fig. 12 Bone fragments and teeth of baby (photo: RAAP).

Some pieces of long bones were found in the same sampling unit as the molar. They are probably human, but were too fragmented to be sure of this. However, the molar concerns a wisdom tooth that was not yet fully developed. Therefore, it is likely that it was not lost by a living person, but originates from a disturbed grave of an adolescent (age c. 12–18 years). Considering the distance of over 100 m to the remains in zone 2, this molar is interpreted as a separate individual (ID13).

Grave 2 was at first thought to contain only the remains of a young woman of c. 20–25 years (ID5). However, her burial position showed a remarkable deviation from the standard supine position with stretched arms and legs: her right arm was bent, with the hand resting near the hipbone, and her head was turned towards the right (Fig. 11). Since there were also other anomalies in the skeletal representation of the woman (a couple of displaced vertebrae, missing shinbones), the curious position of the right arm and the head was at first considered as possibly unintentional or postdepositional. It soon turned out that it was not: when removing the clay around the right arm bone, the deciduous teeth and bone fragments of an infant were discovered (ID6; Fig. 12). Some of the teeth were positioned within jaw fragments. The development of one of the molars of the infant suggests an age of 3–9 months, but the shape and size of skull fragments seem to point to an age of 0–3 months at the time of death. It seems likely that the infant lived for a few weeks or even months, but the possibility that it died in the process of childbirth cannot be ruled out. The attribution of the burial to the Swifterbant culture makes this the oldest one including an infant in the Netherlands.

Though there were no obvious grave goods found in grave 2, the area of zone 3 shows some interesting site elements. Several complete pots were found here, at least one of which was certainly buried in an upright position. Also, a relatively high number of antler parts originate from zone 3, as well as the only feature that contained red ochre (a pit or layer that also contained charcoal and tiny fragments of burnt bone). It is possible that this means we should interpret zone 3 as some kind of funeral or ritual area.

DNA analysis: family ties and genetic origin

The discovery of the woman and baby naturally raised the question if they were related to each other. Fortunately, the petrous parts of the temporal bone of both were preserved, and in sufficiently good state to be sampled for DNA analysis. This analysis is part of a research project on the neolithisation of northwestern Europe, carried out by Harvard Medical School (D. Reich) and the LUMC Human Genetics Department (E. Altena). The results of this project, including the individuals from Nieuwegein, will be published in a separate paper. Though the expected paper will mainly focus on the genetic origin of the Swifterbant people buried in Nieuwegein, data on sex and family ties – relevant on site interpretation level – are already available to us.

The DNA analysis revealed that the baby is a girl, and that the woman and the baby are first degree relatives: either parent and child, or full sisters. In regard of the age difference of at least twenty years, the latter option is so unlikely that it is safe to say we are dealing with the burial of a mother and her daughter. It is the first time for the Stone Age in the Netherlands that we can take the burial aspect of family ties into account, and determine the sex of such a young infant. Another

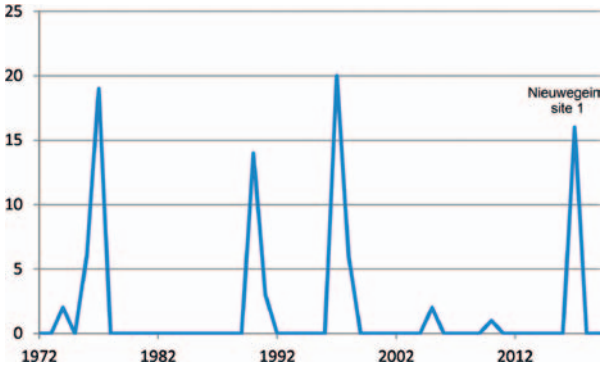

Fig. 13 Late Mesolithic and Swifterbant inhumations in the Netherlands.

piece of information which the DNA analysis brought to light is that the skull from zone 2 (ID1) concerns a male individual who is a second or third degree relative of the mother and daughter in zone 3. DNA samples of the other individuals are still under investigation.

Implications of the discovery

Human remains from the Late Mesolithic period / Swifterbant culture are only occasionally discovered in the Netherlands. Between 1974 and 1998, 70 individuals[9] were excavated in 25 years' time. However, during the next 20 years, only three more individuals were added to this record – in 2005 (Raemaekers / De Roever 2020) and 2010 (Hamburg et al. 2012; see Fig. 13). The recent discovery of site 1 in Nieuwegein is the first time in many years that a burial ground of some extent is excavated, with ten individuals buried there, plus at least six that are represented by dental elements. The discovery is therefore of great importance and will contribute to the existing data on Swifterbant burial practices, not least because the DNA results add new dimensions to the interpretations.

One of the first things that stand out when looking at the remains from Nieuwegein, is the relatively high number of children and adolescents in the record. Among the 73 individuals from previously known Late Mesolithic and Swifterbant sites there are just twelve specimen under eighteen years. They constitute c. 16 % of the burial record. Of these twelve, only five are certainly under ten years of age. Infants younger than two years old do not occur at all in this earlier sample. Of the ten individuals from Nieuwegein that were found in graves or are represented by both skeletal and dental elements, six are individuals under eighteen years. When the individuals represented only by dental elements are taken into account as well, the ratio of persons older / younger than 18 years on site 1 is 7 / 9. Moreover, only one of the adults documented at Nieuwegein reached an age of over 35 years (35–45), despite the fact that older ages were not uncommon during the Late Mesolithic and in the Swifterbant culture: 19 of the 73 individuals mentioned above lived to at least 35 years.

It is not yet clear how this should be interpreted. With regard to the under-represented number of non-adults in the burial record until now, it has been suggested that the death of children was subject to specific funeral practices and did not always lead to a formal burial (Raemaekers et al. 2009). The high number of children and adolescents present in Nieuwegein, and for example the care with which the mother and daughter in grave 2 were laid to rest, may lead to a revision of these notions. However, the overall record is still relatively small (< 100 individuals) and spans a time period of some 1,000 years, so it is to be expected that the discovery of new burial sites will further influence this research.

Considerations for future research and looking across the borders

When the analysis of both site 1 and site B4/17 is in a more final phase, the results will be placed in the wider perspective of the Neolithic in the Netherlands and interpreted in relation to the neolithisation process of northwestern Europe. Though this is already often done for artefact studies like pottery typologies and flint and stone tools, the comparison of Swifterbant burials is usually confined to other sites within the Dutch borders (as it consequently is in the current paper). The aDNA study of which the Nieuwegein individuals are part will automatically lead to an international view through the research on the European genetic heritage. It is important that we expand this approach to the developments in burial customs from the Mesolithic to the Neolithic, for the entire area of the northern European plain. The publications of Terberger (2006) and Teetaert (2010), for example, with overviews of burial sites in northwestern Europe in the Late Mesolithic and

9 This number includes burials as well as loose bones that with certainty belong to different individuals. Individuals represented only by dental elements found outside burials are not included.

Neolithic, provide a good starting point for this research. By means of studying variables like the presence of grave goods, the occurrence of multiple burials, and the role of children, we can explore how the human remains from Nieuwegein fit into or alter the existing picture.

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Niedernstöcken – a settlement of the Linear Pottery culture beyond the loess border in the land of hunters and gatherers

Klaus Gerken, Andreas Kotula, Clemens Ludwig, Hildegard Nelson and Alexandra Philippi

Abstract During a rescue excavation, the first settlement of the Linear Pottery culture (LBK) in the north German lowlands was discovered, located about 50 km northwest of the already known LBK settlements in the district of Hildesheim. Due to the relatively small area of excavation, no reliable house layouts were discovered. Numerous pits and post-holes as well as typical artefacts such as adzes, ceramics, flint tools with a glossy lacquer (sickle sheen), and whetstones were documented. The settlement can be dated to the younger Flomborn period. The location of the site raises many questions about the Neolithic north of the loess zone and the relationship between LBK farmers and Mesolithic hunter-gatherer groups. The discovery of two adzes on an adjacent piece of arable land in the spring of 2018 led to a geophysical investigation of this area in the summer of the same year and finally to a small research excavation in the summer of 2019.

Keywords Linear Pottery, Linienbandkeramik, neolithisation, settlement, younger LBK, younger Flomborn period

Zusammenfassung *Bei einer Rettungsgrabung wurde ca. 50 km nordwestlich der bisher im Lössgebiet bekannten bandkeramischen Siedlungen des Landkreises Hildesheim überraschend die erste bandkeramische Siedlung in der norddeutschen Tiefebene entdeckt. Aufgrund der relativ kleinen Untersuchungsfläche wurden keine sicheren Hausgrundrisse, jedoch zahlreiche Gruben und Pfostengruben sowie typische Artefakte wie Dechsel, Keramik, Flintgeräte mit Lackglanz und Schleifsteine entdeckt. Die Siedlung lässt sich der jüngeren Flombornzeit zuweisen. Die exponierte Lage wirft viele Fragen bezüglich der Neolithisierung nördlich der Lösszone und zum Verhältnis der linienbandkeramischen Bauern zu den mesolithischen Wildbeutergruppen auf. Der Fund zweier Dechsel auf einer nördlich anschließenden Ackerfläche im Frühjahr 2018 führte zu einer geophysikalischen Untersuchung im Sommer 2018 in diesem Bereich und schließlich zu einer kleinen Forschungsgrabung im Sommer 2019.*

Introduction[1]

A settlement of the Linear Pottery culture (Linearbandkeramik, LBK) was discovered in 2015 at the northern outskirts of Niedernstöcken (Neustadt am Rübenberge, Lower Saxony; Figs. 1; 9), during a rescue excavation on an area of approximately 30 x 60 m under the direction of one of the authors (Klaus Gerken). Additional geomagnetic prospections were carried out in 2015 and 2018. In 2019, it was possible to continue the work with a short field campaign as part of a project at the University of Göttingen funded by the German Research Foundation (DFG) and with resources from the State Office of Cultural Heritage Preservation for Lower-Saxony (Niedersächsisches Landesdenkmalamt; NLD).[2]

The site is located on flat terrain of the lower terrace with a soil fertility which is high for this region; the soil substrate is loess-like with a high proportion of silt and clay. To the west there is the Leine lowland at a level of about +29.0 m NN. The current distance to the river Leine is 1,150 m, to the edge of the valley meadow approx. 310 m.

1 This paper represents an updated and complemented version of Gerken / Nelson 2016.

2 The work was carried out within the framework of a DFG project headed by T. Terberger (TE/259/17–1) and supported by the NLD. We thank both institutions for their financial support.

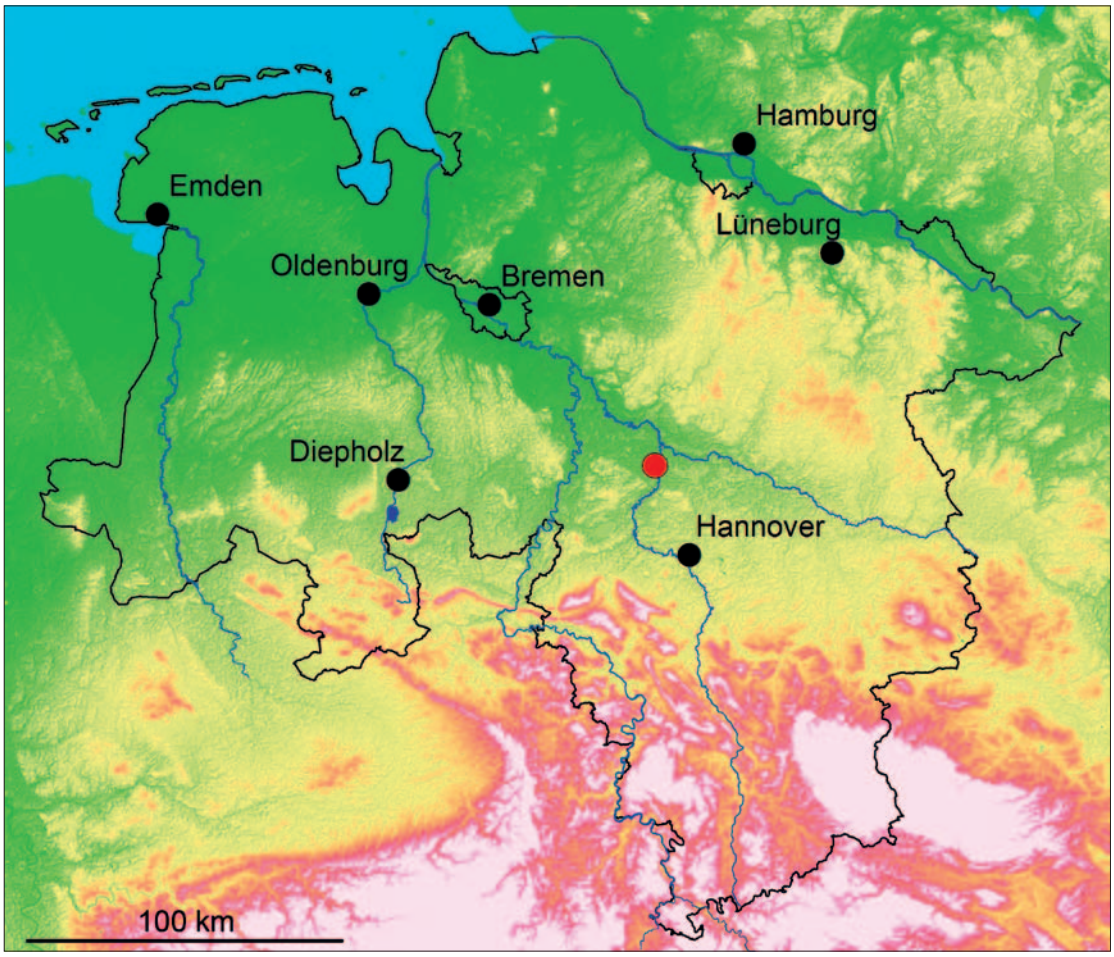

Fig. 1 Location of the sites Niedernstöcken FStNr. 21 and 24 (red dot) in Lower Saxony (map basis SRTM 3, graphics: A. Niemuth).

The paper gives an overview of the features and finds discovered so far. Furthermore, the location of the site significantly north of the previously known distribution area of the LBK is discussed.

Features from the 2015 excavation

During the excavation in 2015, numerous pits and post holes as well as characteristic find material were recorded; but definite house plans could not be identified. The findings have already been presented in detail (Gerken / Nelson 2016), so that only the results are summarised below.

After the removal of the topsoil and the upper brown soil horizon, the first features appeared in the west and south of the investigation area. However, the discolourations were not clearly recognisable in the planum. Only when cut did some of these features turn out to be post pits, filled with charcoal and burnt clay, with a preserved depth of up to 35 cm and a preserved width of about 25 cm. Somewhat east of the centre of the investigation area, a large discolouration (feature 17) was visible over an area of about 100 m^2. Only with the second planum did numerous pits and posts come to light, and decorated sherds and two adzes were found. Since the building depth had already been reached on this level, only some post holes and pits could be cut. Although several post pits lay in rows, they cannot be grouped into clear house plans. Post pits 4, 6, 5, and 41 in the western part of the investigation area formed a clear WSW-ENE oriented row, with regular distances of about 2 m. At the end of this row was pit feature 3 (225 x 245 cm; Fig. 2). Post pits 40 and 7 were located at right angles to it. Flint artefacts, a fragment of a hearthstone and some fragments of burnt clay suggest a connection with the LBK, and the feature might have been part of a Linear Pottery house. A W-E oriented row of posts about 11 m long was formed by post pits 8–15. The cut features contained large amounts of burnt clay and suggest a burnt building. At the northern edge of the central pit complex, post pits 19–21 formed another WSW-ENE oriented row. At a right angle to this were the post pits 33 and 34. The area between post pits

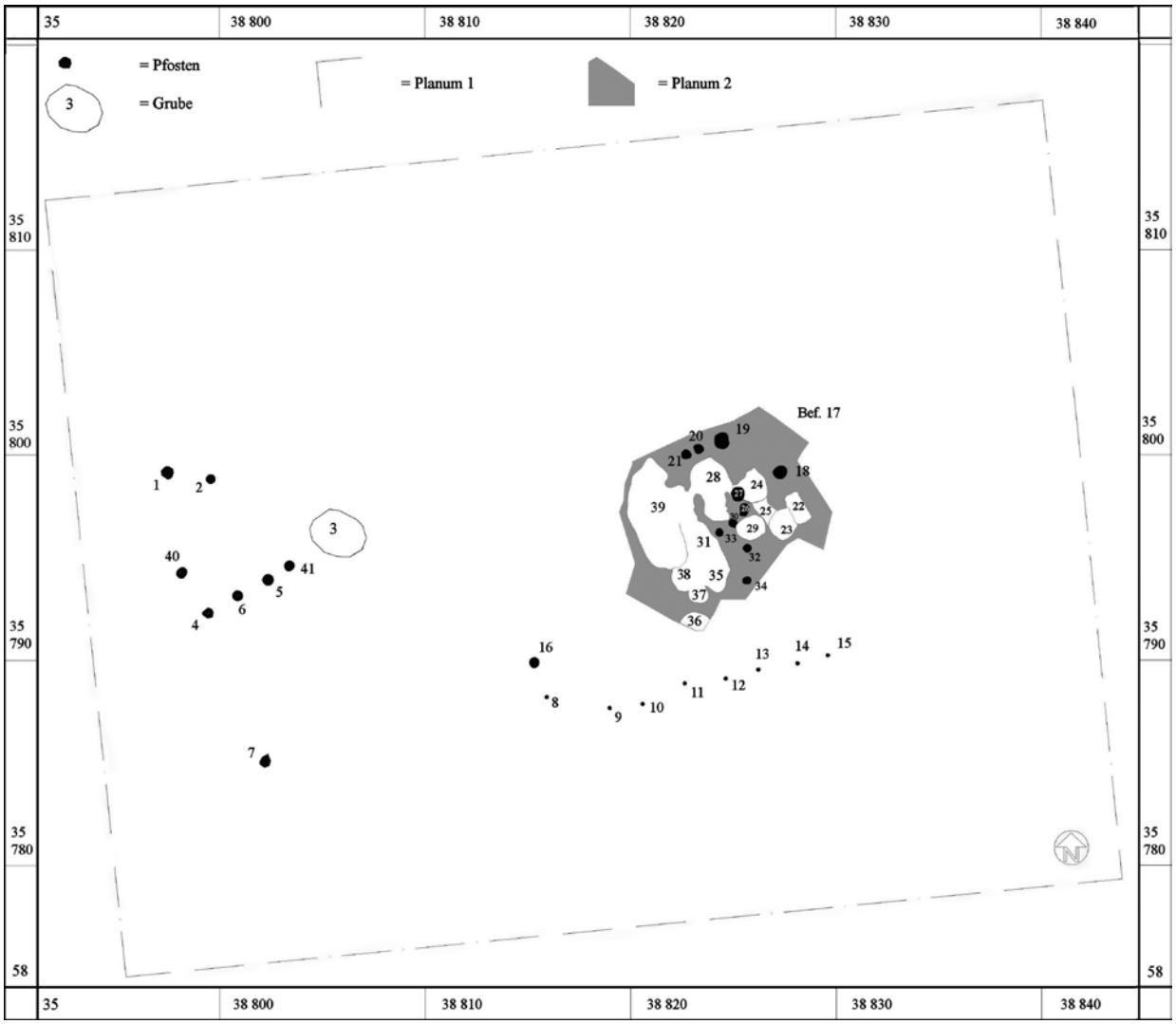

Fig. 2 Niedernstöcken FStNr. 21. General plan of the excavation area (graphics: P. Brunkert / K. Gerken / V. König).

21 and 33 was disturbed by pit 28. Post pits 30 and 26 may then have been part of the internal layout of a house; they were in line with post pit 33 and ran towards post pit 18.

The majority of the features at Niedernstöcken addressed as post pits had diameters of less than 50 cm and depths of max. 40 cm, which seems quite small compared to other LBK post pits. It is possible that not the post pits but only the posts themselves were recorded here. A reliable reconstruction of the supposed house features is not possible; perhaps only the peripheral area of the settlement with smaller outbuildings or fences was recorded. A large proportion of the find material (> 190 pottery sherds, > 40 flint artefacts, a spindle whorl, burnt clay, and six grinding stone fragments) can be assigned to feature 17 mentioned above. The majority of the pits had not been dug into the sandy soil. They presumably served to extract raw materials and were later backfilled.

The find material from the 2015 excavation

So far, 706 pottery sherds have been assigned to the LBK (418 pieces of coarse ware; 288 pieces of fine ware; Figs. 3–4). An identification of vessel units is only possible to a limited extent; therefore, single sherds often form a vessel unit. There are dome-shaped vessels with walls bending inwards (form 2 according to Moos 1996; vessel units 1, 4, and 30) and those with vertical walls (form 1 according to Moos 1996; vessel unit 2). Bottles (form 8 according to Moos 1996; vessel units 32 and 38) and so-called ‘Zipfelschalen’ (vessel units 42, 47, and 48) are detectable. A rim sherd from a wide-mouthed vessel (vessel unit 37) shows a single incised line. Furthermore, there is a rim piece decorated with small finger imprints (vessel unit 45). Unusual is a rim sherd of a small truncated vessel with a mouth

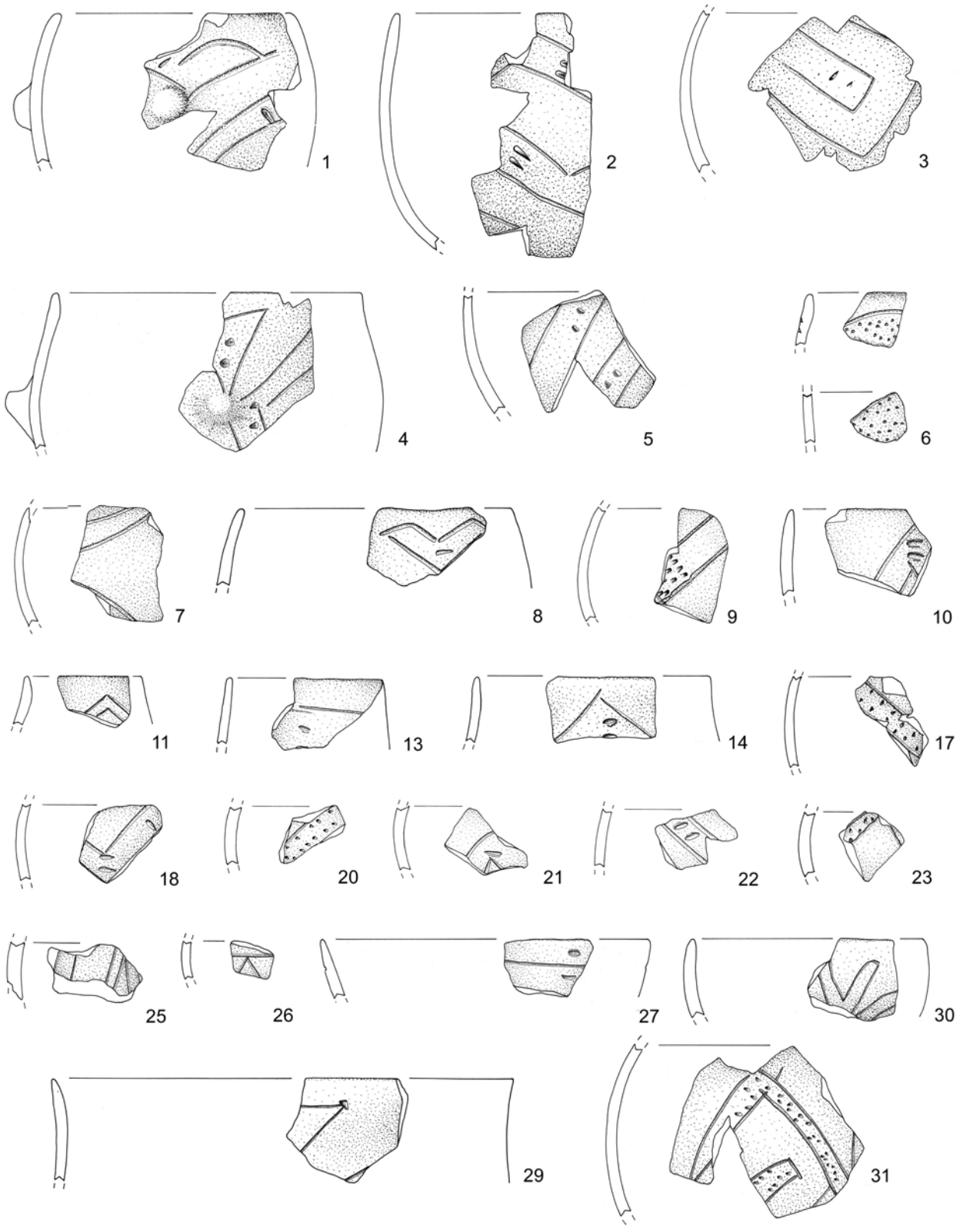

Fig. 3 Niedernstöcken FStNr. 21. Pottery vessel unit 1–31. Scale 1:3 (drawings: W. Köhne-Wulf).

diameter of c. 12 cm (vessel unit 30). The vessel is decorated with several narrow, unfilled bands. Vessel unit 39 can be reconstructed as a large vessel with a mouth diameter of c. 26 cm. The base of a knob as well as a line band with two short incised lines arranged one below the other are present (band filling 46 according to Strien 2010).

The clay colour of the fine ware varies on the outside and inside of the vessels between brown-grey, grey, and black-grey; in the fracture it is mostly grey,

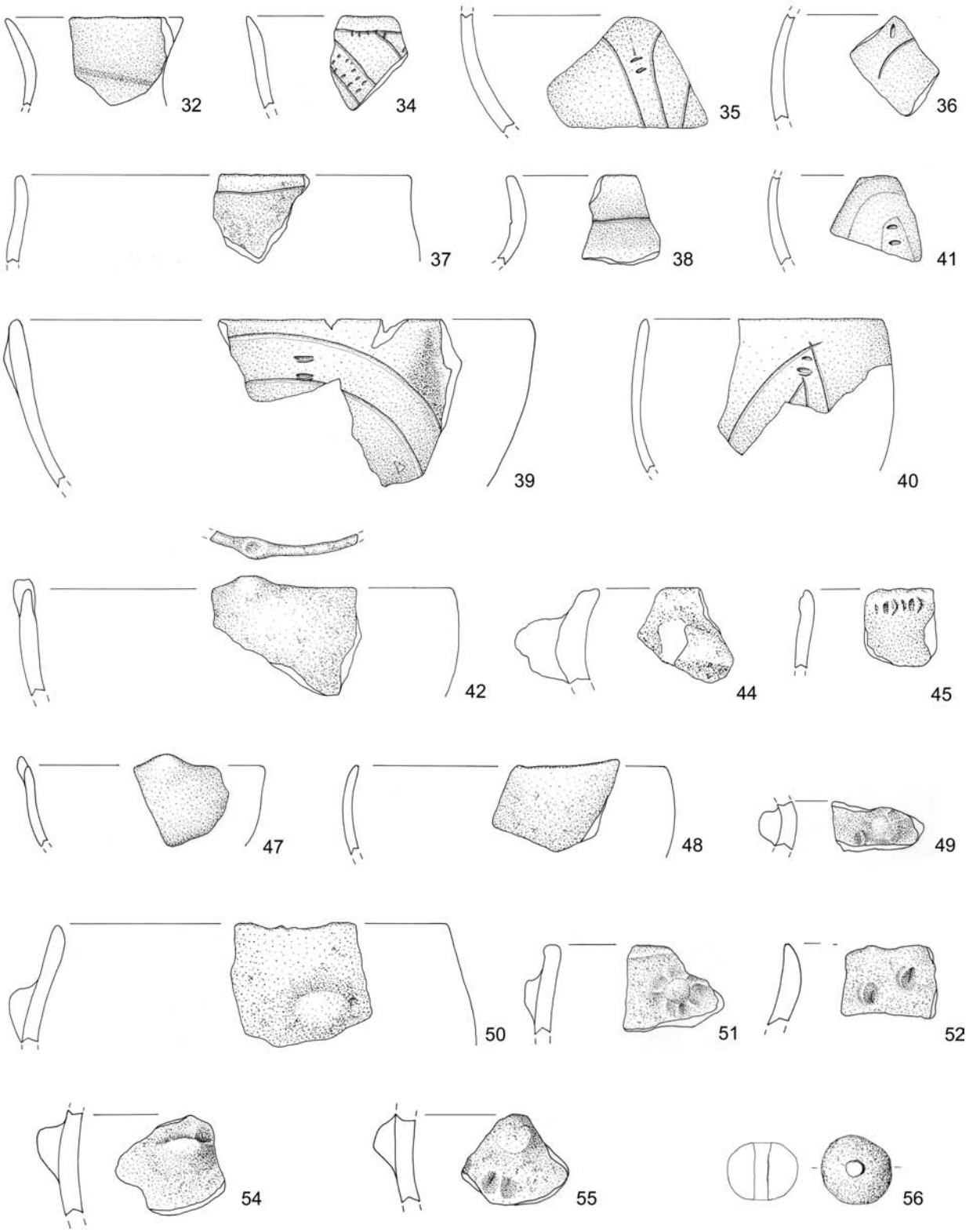

Fig. 4 Niedernstöcken FStNr. 21. Pottery vessel unit 32–56. Scale 1:3 (drawings: W. Köhne-Wulf).

rarely reddish. Macroscopically, a grain is hardly visible. The fine ware is predominantly decorated. Especially the black-grey fine ware is remarkably well smoothed. Several times it can be observed that a thin, fine coating has weathered. Incised lines and punctures as well as finger imprints are documented as decoration techniques; rim decorations on the fine pottery are the exception. A bowl rim (vessel unit 27) corresponds to type 12 according to Moos (1996). A rim sherd from a truncated bowl has a rim-parallel line

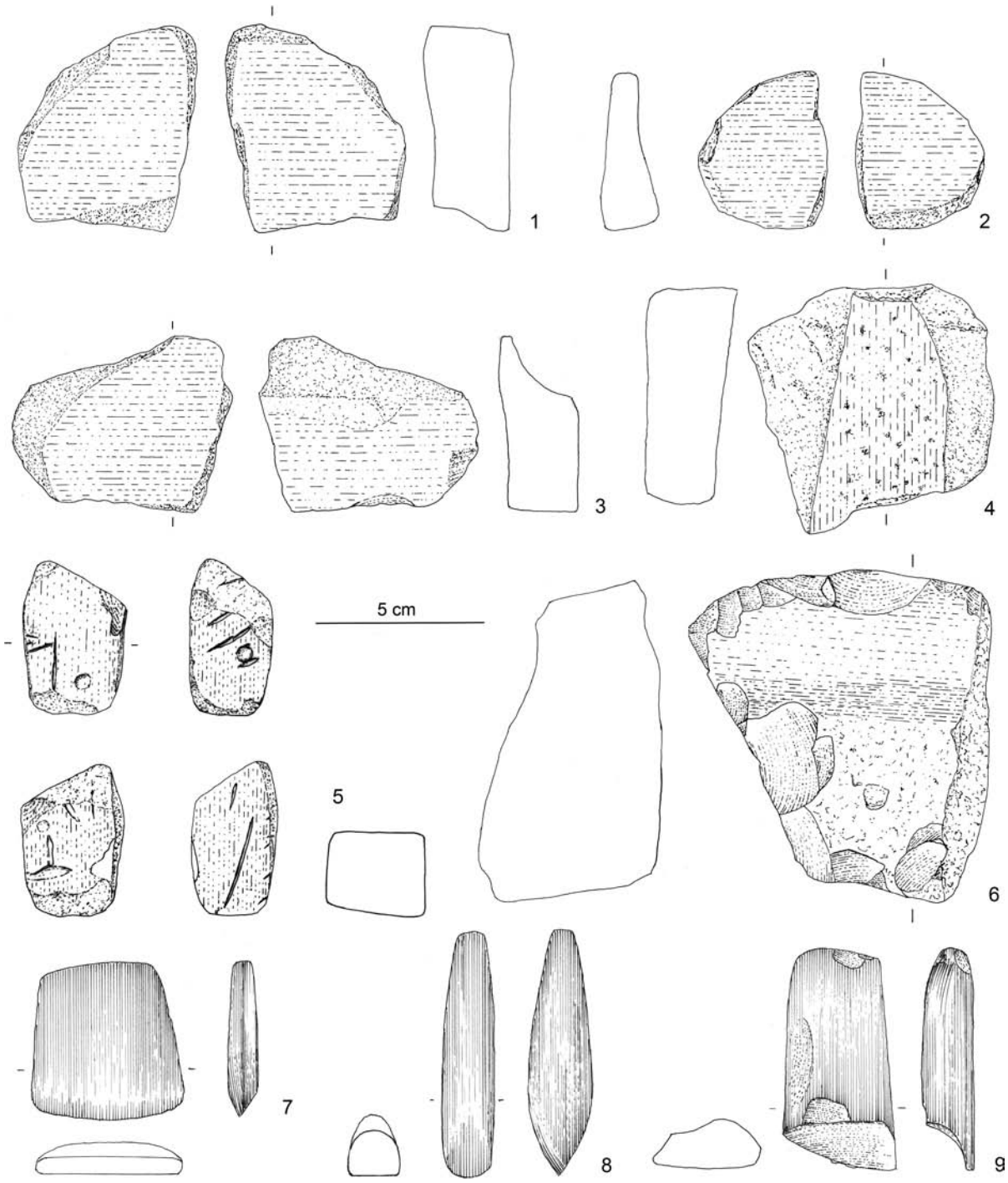

Fig. 5 Niedernstöcken FStNr. 21. Grindstones and axes. Scale 1:2 (drawings: K. Gerken).

cut by horizontal punctures (vessel unit 34, probably rim decoration 1 according to Strien 2010).

Currently only bands formed by two lines are documented. The ends of the line bands (Richter / Schwartz-Mackensen 2015, 102–104), which are also relevant for typo-chronological considerations, are only slightly represented in the find material. Straight (vessel units 3, 31, perhaps 30) and pointed ends occur (vessel unit 40). Most of the bands are filled, and the majority of them are filled with paired punctures / scoring lines at larger intervals. The punctures can be parallel (vessel units 2, 10, 18, 39, 40; band filling 46 according to Strien 2010), or transverse (according to pers. comm.: Strien band filling 521, a variant of band filling 46) to the band direction (vessel units 3, 5, 18, 22, 41). The combination of longer incised lines with one or more punctures occurs on four other vessel units (vessel units 1, 13, 14, 21; band filling 8

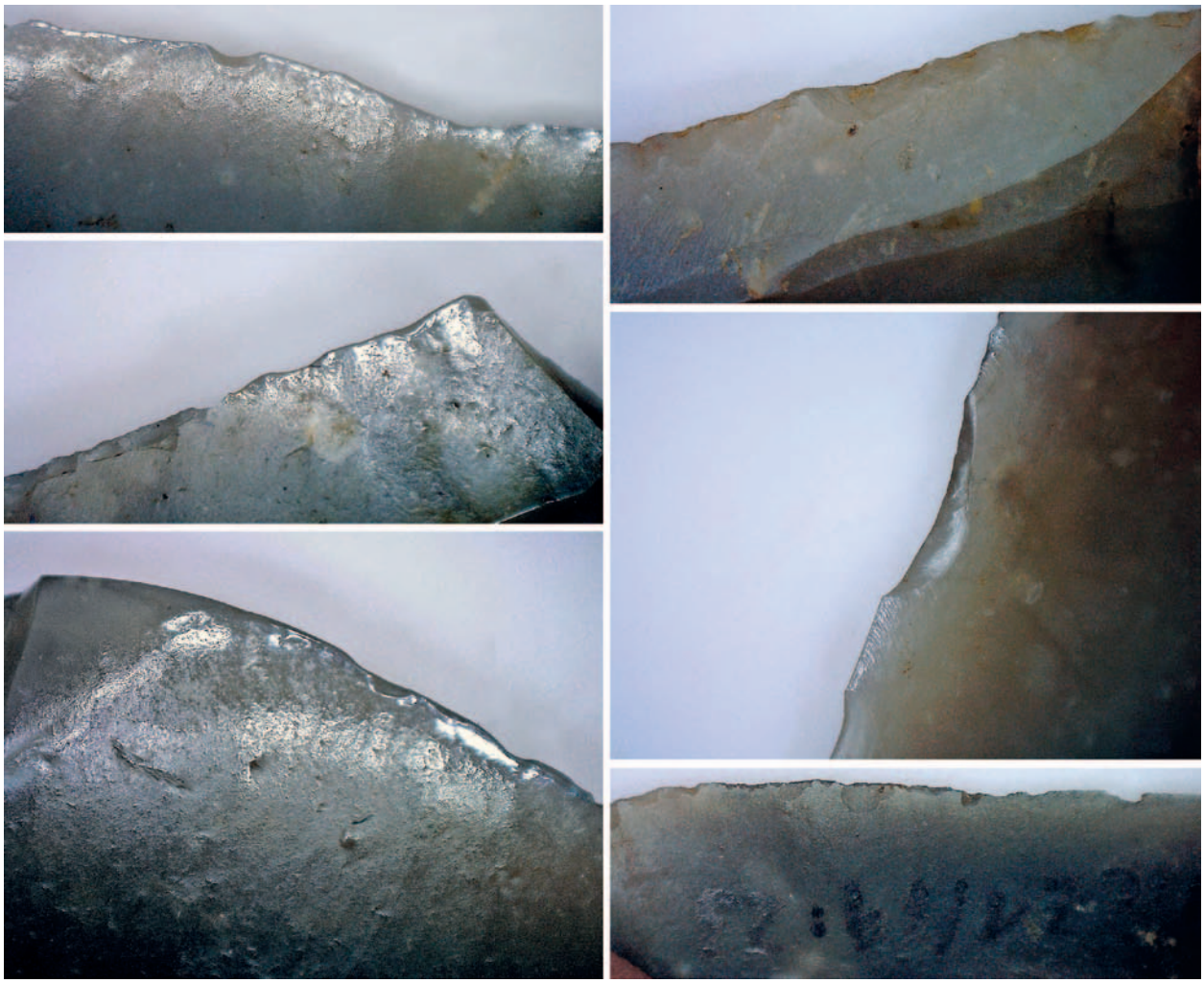

Fig. 6 Niedernstöcken FStNr. 21. Flint artefacts with sickle gloss and traces of use (photos: K. Gerken).

according to Strien 2010). The band of vessel unit 9 is provided with alternating three or four parallel band-parallel incisions, followed by an undecorated zone. Narrow linear bands occur in five cases, filled with more or less paired triangular or roundish punctures over a longer distance (vessel units 17, 20, 23, 31, 34); these pattern corresponds to band filling 10 according to Strien 2010. Finally, two sherds of a vessel are present, with the band (?) filled with disorderly small punctures (vessel unit 6). According to Moos (1996, 132) this corresponds to band type 52, which he considers typical for the younger Flomborn phase. A vessel fragment from Esbeck also bears a similar pattern (Richter / Schwarz-Mackensen 2015, plate 25,11). There is a comparable piece from Itzum available for vessel unit 26 (Wendland 2012, plate 11: vessel unit 141). For vessel unit 4 with line bands starting from a knob there is an equivalent item from Esbeck (Richter / Schwarz-Mackensen 2015, plate 13.10). The rim sherd of vessel unit 10 has an analogy in a find from Diemarden (Moos 1996, plate 15.1). The pottery finds also include a complete double conical spindle whorl (Fig. 4).

The coarse ware is mostly yellowish grey and reddish grey on the outside, but predominantly grey on the inside and in the fracture. The old surface is often eroded. It is exclusively tempered with inorganic material. The main material used was iron and manganese, and to a lesser extent quartz. The coarse ware often shows handles and knobs, but rarely other decorative elements.

The other artefacts also correspond to the usual find assemblage of LBK settlements (Gerken / Nelson 2016, 47–58). Burnt clay was recovered from several post pits, partly with impressions of wattle, and a small number of burnt bones is present as well. The rock artefacts include three adzes and one adze fragment. Among the other artefacts, grindstone fragments of reddish-grey red sandstone are predominant (Fig. 5). In addition, there are fragments of a grindstone and a grinding ball fragment. The axes are made most likely of actinolite-hornblende slate, for which the Jizera

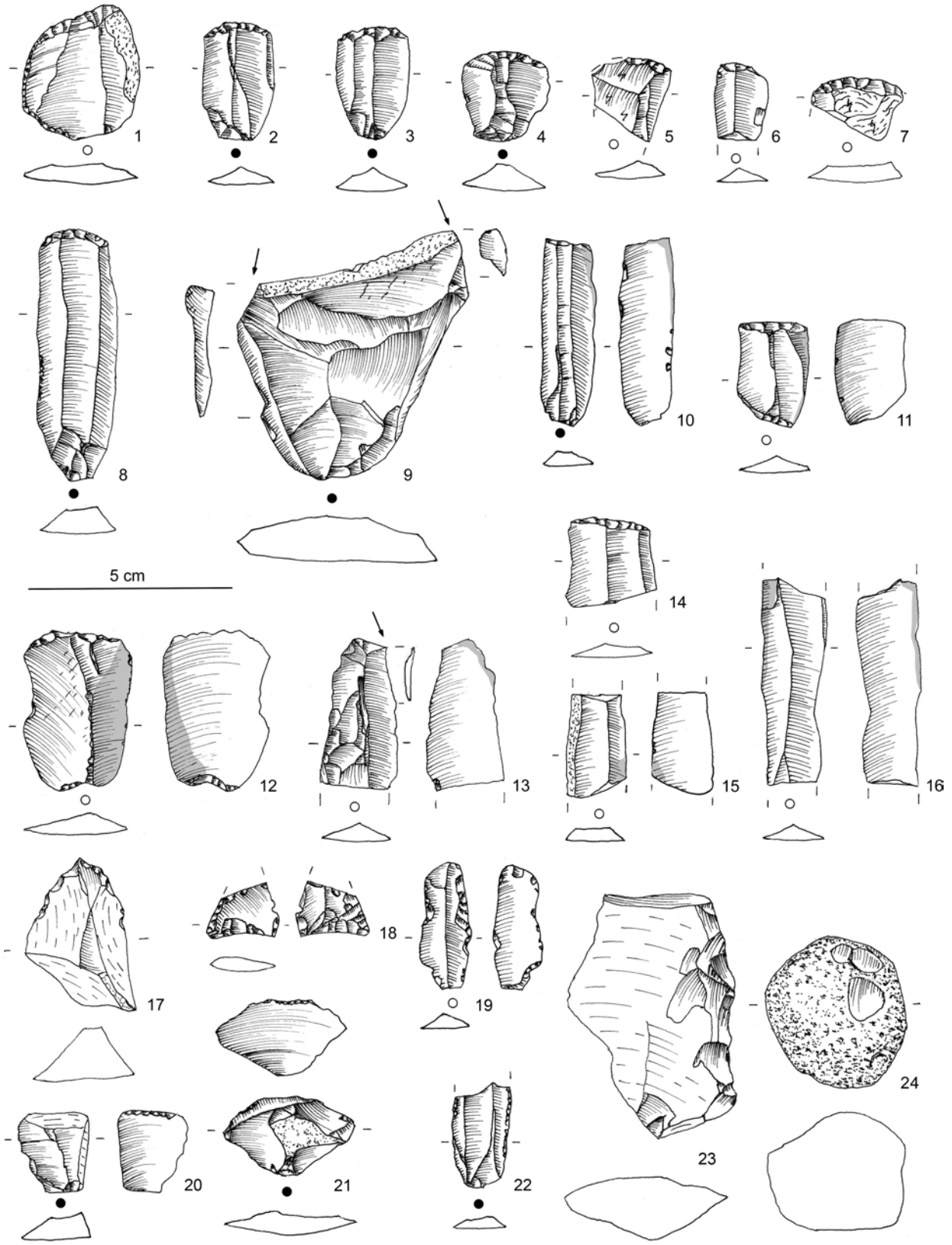

Fig. 7 Niedernstöcken FStNr. 21. Flint artefacts: **1–8** scrapers; **9** burin; **10–13** pieces with retouch and sickle gloss; **14** truncated blad; **15–16** blades with sickle gloss; **17** pointed tool; 18 surface retouched point; **19–23** blade fragments and flakes/chips with use retouch or partial retouch; **24** pounder. Scale 2 : 3 (drawings: K. Gerken).

mountains in the Sudetes mountains have been suggested as the scource of origin (e.g. Prostředník et al. 2005). All three axes show signs of use and can be assigned to types I-III as defined by Moos (1996). One of the completely preserved axes (Fig. 5) is remarkably flat and short with a very large width, which is probably due to reworking (cf. Klimscha 2016, 79–102). In the Niedernstöcken inventory there is also a spherical pounder (Fig. 7,24).

The composition of the flint artefact inventory from Niedernstöcken 21 largely corresponds to that of other LBK sites in the Leine valley. Both the proportion of implements in the flint inventory and the percentage frequency of the individual implement forms lie within the range determined, for example, by Weller (2003) for settlements in the Leine valley south of Hanover. The 196 flint artefacts consist of 98 flakes, 48 blades, 28 pieces of debris, and 18 cores (each including fragments). Ten flakes were modified into tools. Eleven intentionally retouched blades are present. In addition to the intentional retouching, traces of use can be seen on the artefacts under a binocular microscope as well as macroscopically, in the form of fractures and polish / varnish (Fig. 6) as well as pitting (for a closer description of the artefacts, see Gerken / Nelson 2016, 49–58). The relatively high proportion of debris (14 %) can be seen as an indication of a rather poor raw material situation in the area. Tool forms present are scrapers, pieces with end retouch, burins, partially retouched pieces, drills/sharpeners, microliths, surface retouched points, and other combined modifications. Scrapers are attested on basic forms of both blades and flakes(Fig. 7,1–8). Sickle sheen on end-retouched artefacts and two blade fragments suggest use as sickle inserts. (Fig. 7,15–16).

A microlith from the site can be addressed as a trapezoidal point. Such point forms are rather found in Early Mesolithic inventories, e.g. Duvensee 2 and 6 (Bokelmann 1981). The strongly deviating patination of this artefact and also of one core speak for an Early Mesolithic context of these finds; this is regionally significant for the period, also considering the soil milieu (Gerken / Piche in prep.).

Settlement expansion – geomagnetic prospection and verification of results

After the excavation in 2015, a first geomagnetic prospection was carried out to the south and west of the excavation area on a total of 5,000 m^2 in order to locate further features. Two axes picked up during systematic surveys (Gerken / Piche 2020) suggested that the settlement area also continued to the north. In November 2018, geomagnetic prospection was also carried out in this direction (Ludwig / Philippi 2019). The magnetogram showed numerous anomalies indicating an intensive settlement of the area (Fig. 8).

Most of the structures visible in the measurement image are round to elongated interferences with high magnetic radiation, which probably originate from pits or similar findings. They are distributed, sometimes in clusters, over almost the entire area, but seem to thin out towards the north. Several elongated positive structures occur in pairs in the southern part of the survey area. These are probably typical wall-accompanying pits of LBK longhouses (e.g. Posselt / Saile 2014, 137–140). The orientation of the presumed house layouts corresponds to the results of the geomagnetic survey of 2015. In view of their predominant NW-SE orientation, the majority of the detected anomalies probably belong to the LBK settlement of Niedernstöcken, which thus seems to continue to the east and west.

In August 2019 a short excavation campaign under the direction of A. Kotula took place to test the extension of the LBK settlement area to the north (FStNr. 24, Fig. 8; cf. Kotula 2021). In area 1, about 80 m northwest of the known site, the geomagnetic survey had revealed elongated (pit) structures running NW-SE. Initially, no such features were identified in the planum. However, in the western part of the planum a row of four smaller round pits, running NW-SE, appeared, which can be interpreted as a row of posts. A distinct discolouration was then visible about 0.2 m below the top of the planum, which is interpreted as a long pit according to the geomagnetic picture. Few undecorated pottery finds from this area correspond technologically to the known LBK ware of the site. About 150 m further north, oval to amorphous settlement pits were found in area 2, as well as some smaller features that can be interpreted as posts. Most of the features were poor in finds, but one pit yielded over 5.5 kg of pottery material as well as three almost complete adzes. In the lower area, the features were interspersed with charcoal and contained bone fragments and a few flint artefacts. The pottery largely corresponds to that of site 21.

The chronological classification of the site

The pottery corresponds well to material from the site of Itzum (district of Hildesheim; Wendland 2012), which is dated to phases II and III according to Meier-Arendt (1966). Find material from Bründeln (Heege 1989) also shows similarities with the pottery from

Niedernstöcken. However, since the Bründeln site also contains material from the younger LBK, including surface finds or material from undocumented pits, this comparison does not provide any reliable clues for dating the Niedernstöcken ware.

In comparing the Niedernstöcken pottery with the material from Esbeck (district of Helmstedt), the best analogies are found in ceramic phase 2 (Richter / Schwarz-Mackensen 2015, 132–133). A characteristic feature, among others, is band type Bf 46. However, according to Schwarz-Mackensen 2015, band type Bf 10, which is relatively common in Niedernstöcken, is said to occur as late as pottery phase 4. Moos (1996, 111), however, lists band type Bf 10, which he subsumes into his band type *52, together with *35, as characteristic of his phase 3, which he parallels with the younger Flomborn phase.

Band type Bf 46 or 68 (a), which dominates in Niedernstöcken, is also frequently represented in Thuringia. According to Einicke (2014, 234 fig. 103), this band filling has its maximum occurrence in the early middle LBK there (stage III a). Occasionally, however, band type Bf 68 also occurs in the Thuringian phase II. A complete synchronisation of the chronology applicable to eastern Thuringia with that for the regions west of the Harz mountains has not yet been conclusively achieved.

All in all, the majority of the Niedernstöcken pottery material can be assigned to the younger Flomborn phase (phase II according to Meier-Arendt 1966, i. e. style phase 3 according to Moos 1996). A transition into phase III according to Meier-Arendt, i. e. into the middle LBK according to Hessian terminology, is possible due to some long-lived band types like 68 and 79 according to Moos (1996, fig. 38). The Flomborn phase in the Rhineland stage is dated to the period between 5,300 to 5,150/5,125 calBC (Lüning 2005); Saile (2009, 43) postulates such a chronological approach for the area between Weser and Harz as well.

Four AMS dates were measured on charcoal samples from site 21 (Table 1). The sample from feature 39 (Poz-78700) is clearly older than expected, while the date from feature 33 (Poz-82655) is younger than would have been expected from the typological analyses. The other two samples are within the expected dating range.

Fig. 8 Niedernstöcken FStNr. 21 and 24: Geomagnetic surveys 2015 and 2018 and location of excavation sections 2015 and 2019 according to Gerken / Nelson 2016 and Ludwig / Philippi 2019 (graphics: A. Kotula).

Sample number	Feature	BP	calBC
Poz-78700	pit feature 39	6,940 +/- 40 BP	5,966–5,730 calBC 2σ
Poz-82654	post feature 21	6,070 +/- 40 BP	5,202–4,844 calBC 2σ
Poz-82655	post feature 33	6,020 +/- 40 BP	5,011–4,799 calBC 2σ
Poz-82656	post feature 34	6,160 +/- 40 BP	5,217–5,000 calBC 2σ

Table 1 ^{14}C-data of site Niedernstöcken (FStNr. 21; 24). Calibration of data: OxCal v4.2.4 (Bronk Ramsey 2013; Reimer et al. 2013).

LBK north of the loess areas

The Niedernstöcken site lies clearly north of the southern Hanoverian loess area. The nearest LBK settlement sites at Sarstedt (FStNr. 7 and 35; Heege 1989, cat. no. 139; Weller 2002) and Bründeln (FStNr. 2; Heege 1989, 85–102, cat. no. 228) are about 50 km away as the crow flies, and are all located east of the river Leine in the loess distribution area. In addition, Heege (1989, cat. no. 352, plate 57,1) lists a site near Pattensen (gravel pit, now Rethen FStNr. 6, Hanover region), which, however, only yielded a characteristic sherd with a knobbe, the assignment of which to the LBK is not entirely certain. However, about 40 unperforated adzes have been documented as single finds in the area between Niedernstöcken and the Hildesheim Börde (Fig. 9 and Table 2), which, according to Merkel (1999, 223–238), are essentially restricted to the LBK, in contrast to the perforated ones. The interpretation of these finds as indications of further LBK settlements, as objects left behind on LBK exploratory expeditions, or as implements used in a Mesolithic context is controversially discussed (cf. e.g. Steinmetz 1985, 317–320; in contrast, among others, Cziesla 2008, esp. 430–431).

Saile (2007, 45) assumes that the reason for the lack of settlements between the LBK density centres in

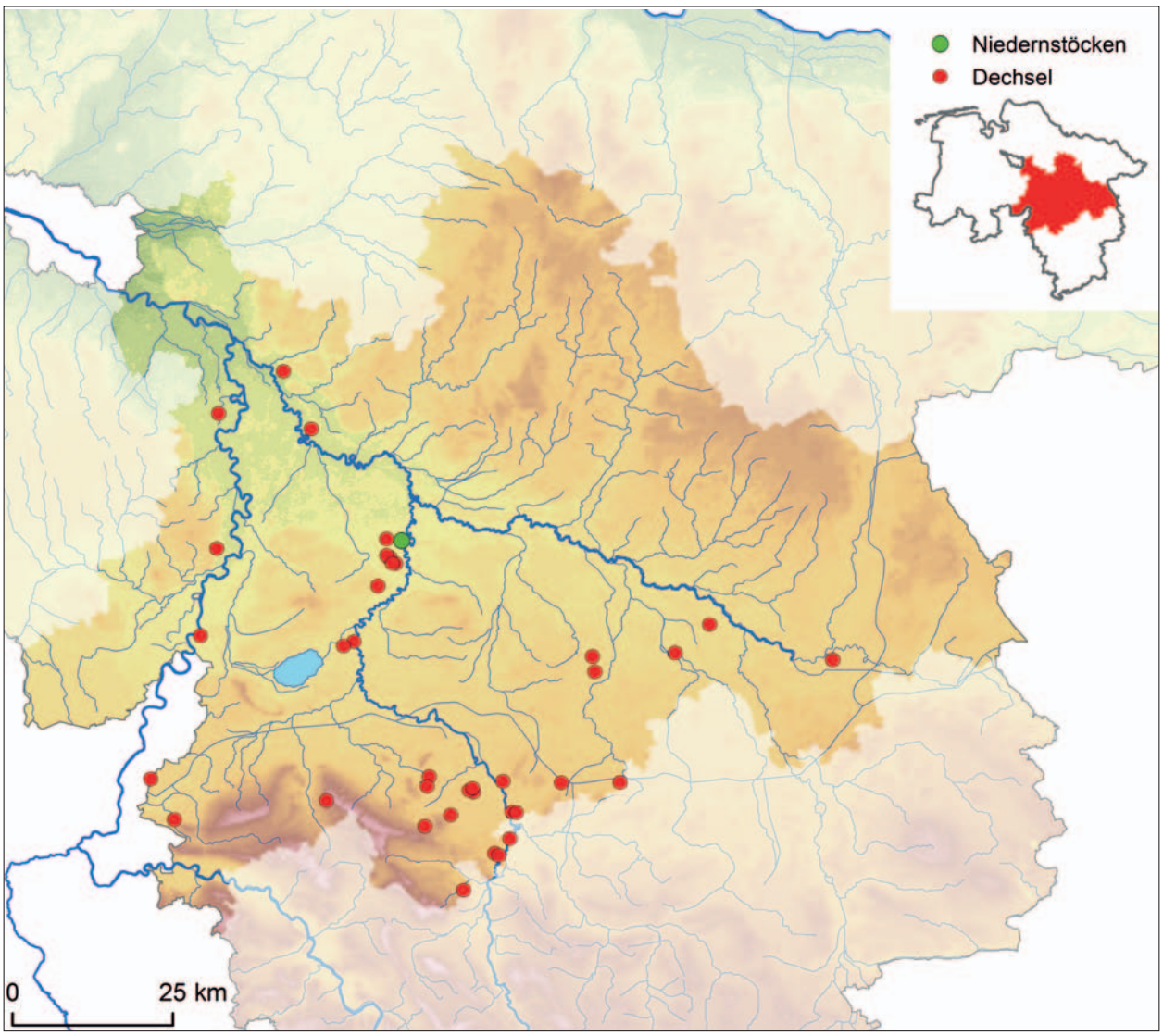

Fig. 9 Distribution of LBK pottery and unperforated adzes outside the LBK's core area; cf. Table 2 (map basis SRTM 3, graphics: A. Niemuth).

northern Lower Saxony – e. g. in the Calenberger Land – was the exhaustion of the LBK's expansion power. After the discovery of the Niedernstöcken settlement, however, this view may be questioned. Why would the LBK settlers have made a 50 km advance to the north, but not to the neighbouring other bank of the Leine?

Most of the features in Niedernstöcken only appeared about 0.5 m below the present surface and were initially hardly recognisable. Heege (1989, 181) already stated that the LBK settlements in alluvial plains or on level ground can only be recognised with deep ground penetration. The remarkable number of 38 LBK settlements newly discovered in lignite mines in the area around Leipzig during the last 15 years (Stäuble 2011) also shows that LBK settlements are only found with deeper earthworks. The settlement of Minden-Dankersen (North Rhine-Westphalia; Günther 1988) was discovered on the site of a railway track that had previously been laid up to 3 m (!) deep or on the neighbouring deeply ploughed field, respectively. It is probably only a matter of time before the first LBK settlement remains are also discovered in the Calenberger Land. Further LBK settlements can also be expected in the Leine valley north of Hanover, due to the fact that a clear accumulation of unperforated adzes has been documented on a narrow strip of land along the western bank of the Leine, where soil of the same type as in the immediate vicinity of the Niedernstöcken site can be found.

Presumably, the Niedernstöcken site offered the LBK farmers good combination of soil workability, quite high soil fertility, and remoteness from flooding, which largely corresponded to the conditions on the loess soils further south. Some time ago, W.-D. Steinmetz interpreted single finds of adzes and pottery vessels as evidence of settlement attempts by the LBK and stated that he would not be surprised 'if one day a settlement of the LBK were discovered in the north German lowlands'[3] (Steinmetz 1985, 319–320).

Even if the strong connection of the LBK to loess soils is repeatedly emphasised (e. g. Saile 2009), Heege (1989) already demonstrated that although Early Neolithic settlements are located in the loess zone on a large scale, other sites were also used on a small scale. Two of the 14 Early Neolithic settlements mapped by Heege 1989 are located in the floodplain and on the edge of the floodplain (Algermissen FStNr. 2 and 3, Rössing FStNr. 2, cf. Heege 1989). Due to the fact that these sites were only recognised in the case of massive ground interventions, their proportion is probably underrepresented (Heege 1989, 181). This choice of location is not only to be found in the Hildesheim area, as an example on a low terrace of the Rhine shows (Heinen 2010). In this context, the LBK colonisation far beyond the loess zones to the northeast, especially in the Uckermark, should be recalled, too (cf. Lindemann 2007; but see also Cziesla 2008).

The Late Mesolithic north of the loess border in the central lowlands of Lower Saxony

Can we assume that the area north of the loess zone – and thus also the area around the sites Niedernstöcken 21 and 24 – belonged to the foraging area of Late Mesolithic groups around 5,200–5,000 BC?

Looking at the area north of the loess zone in a radius of about 85 km around the site, to the eastern lowlands near Bremervörde in the north, lake Dümmer in the west, and the border to Saxony-Anhalt in the east, we can see that only a few sites with Late Mesolithic features and/or artefacts have been scientifically investigated.[4] Beyond that, a large number of surface sites is known, which, however, does not represent the result of systematic prospections, but essentially reflects the different state of research. Schwabedissen (1944) already stated that the discovery of 'pre-pottery age' sites depends considerably on the activities of local collectors, and this is still true today for Lower Saxony.[5]

The surface sites in the area between the Harz mountains and the river Aller were last comprehensively reviewed and presented by Schwarz-Mackensen (1978), those from the district of Gifhorn by Zeitz (1969). More recent data, apart from the work of Trebess / Eichfeld (2018), are not available. However, detailed analyses are available from the districts of Rotenburg (Wümme) and Celle (Breest 1993; 1997; Gerken 2001a), although the district of Rotenburg has only been partially processed. In contrast, only few data are available from the district of Uelzen (Richter 2002). In the districts of Nienburg, Hameln-Pyrmont, Schaumburg, Diepholz, and the Hanover region, only

3 Translated from the German original text: „wenn eines Tages eine Siedlung der LBK im Norddeutschen Tiefland entdeckt werden würde".

4 Dehnke 1964; Gerken 2009; 2012; 2015a; 2016; 2020; Trebess / Eichfeld 2018.

5 Cf. Metzger-Krahe 1977; Breest 1993; 1997; Gerken 2001a; Mahlstedt 2015.

a general survey of Mesolithic sites was carried out.[6] Most of the find material from the research area is still in private hands or in regional museums and has not yet been evaluated in detail. Thus, no systematic recording of Mesolithic features and finds has yet been conducted for the majority of the area under consideration here, and it therefore remains an area empty of finds on maps.

In addition, methodological problems have to be taken into account researching Mesolithic sites (Gerken 2016). Activity areas with a high number of lithic artefacts are detected on the surface, but likewise, in the excavations carried out in very large numbers within the framework of the causative principle, Mesolithic find scatters are perceived and documented only rudimentarily. Mesolithic pits and individual hearths are often not recognised as artificial features and rather attributed to natural, pedological processes or (fire) events. Even if such features are recognised that are not accompanied by stone artefacts, they are often assigned to a ceramic period. Erichshagen (FStNr. 91; district of Nienburg; Gerken 2020) represents a welcome exception; there numerous Mesolithic find scatters, pits, and hearth features were recorded, documented and excavated in the course of pre-construction measures. In Rullstorf (FStNr. 8; district of Lüneburg; Gebers 2002), Mesolithic find scatters were also identified during the excavation of younger settlement features.

On the other hand, at the site Hülsen 1 (district of Verden), more than 180 charcoal pits in an Iron Age settlement were initially identified as traces of burnt posts (Schirnig 1965), later as pits and, in connection with a few pottery sherds that had entered them through bioturbation, dated as at most 'Neolithic' (Nowatzyk 1990). Only four ^{14}C-results allowed an assignment to the Late Mesolithic at a later point of research.[7] More recently, large clusters of charcoal pits have fortunately been assigned to the correct time horizon.[8] But here, too, dating series are necessary to clarify the chronological depth of the numerous features. Thus, flint artefact scatters detected at Hülsen have also been incorrectly assigned chronologically and not documented accordingly.

Mesolithic burials have so far remained unrecognised in the lowlands of Lower Saxony, as the decalcified sandy soils do not offer any preservation conditions for organic material. However, features from the excavations of Oldendorf (FStNr. 69, Ldkr. Rotenburg) were discussed as possible Mesolithic graves due to their shape and red colouration (Gerken et al. 2016). Similar findings were documented by one of the authors (K.G.) in Donstorf, FStNr. 37, in 2011 (unpublished).

Against this background, a mapping of Late Mesolithic sites can only represent an interim status, whereas the original frequency of Late Mesolithic sites was probably much higher (Fig. 10). On the one hand, the mapping reveals the preferred areas of exploration by collectors. On the other hand, a regular location of Late Mesolithic sites on the dunes and smaller hilltops along rivers can be discerned. These types of sites can also be assumed for regions with similar topographical and ecological conditions that have so far been largely empty of finds. Systematic surveys and the examination of collections in recent years have revealed, for example, nine new Late Mesolithic sites in the immediate vicinity of the Niedernstöcken 21 site (Fig. 10). Since there are no larger and closed Late Mesolithic inventories from the surroundings of Niedernstöcken so far, no statement can be made about their composition.

In the following, Late Mesolithic sites with absolute dates from the research area will be considered. From the site Schwitschen FStNr. 42, district of Rotenburg (Wümme), only 35 km away (Gerken 2012; 2015a), seven dates are available. Four dates fall into the early trapezoidal phase with a range from 6,372 to 5,898 calBC (2σ).[9] Three further dates prove a younger phase with results between 5,719 and 5,330 calBC.[10] Both time phases are also evidenced by significant artefacts.

From Oldendorf FStNr. 52, district of Rotenburg (Wümme) (Gerken 2012), 17 dates are available; beginning at the transition from the Early to the Late Mesolithic and ending at the onset of the trapezoidal industry (6,420–6,110 calBC; Poz-7548: 7,430±50 BP). Accordingly, trapezoids occur in only a few specimens. From Oldendorf FStNr. 69, district of Roten-

6 Adameck 1993; Schween 1993; Bischop 1997; Moser 1998; Stark 2003.

7 Dr. Jutta Precht, Kreisarchäologie Verden, is thanked for providing the excavation documentation and the ^{14}C-data. Dating results are: Hv-16559: 6,815±65 BP (5,842–5,619 calBC); Hv-16560: 6,850±65 BP (5,876–5,633 calBC); Hv-16688: 6,855±70 BP (5,887–5,632 calBC); Hv-16689: 7,005±90 BP (6,046–5,721 calBC).

8 E.g. Eversten FStNr. 3, city of Oldenburg (Fries 2011); Stöcken FStNr. 24 (Assendorp 1985); Wohlendorf FStNr. 24 and Ahlden FStNr. 31, both distr. Heidekreis; Erichshagen FStNr. 91 and Holtorf FStNr. 9, both distr. Nienburg/Weser (Gerken 2016; 2020), and also Eydelstedt FStNr. 68, distr. Diepholz (Gerken 2016).

9 All the following dates mentioned in the text indicate age ranges in the 2σ range.

10 ERL-18750 (8,285±56 BP); ERL-18753 (7,550±55 BP); ERL-18755 (7,512±54 BP); KN-69 (7,430±60 BP); ERL-14453 (7,341±55 BP); HV-1348 (7,320±130 BP); ERL-14452 (7,239±69 BP); ERL-14451 (7,148 ± 54 BP); ERL-18751 (6,790±51 BP); ERL-18754 (6,724±51 BP); ERL-18752 (6,480±51 BP).

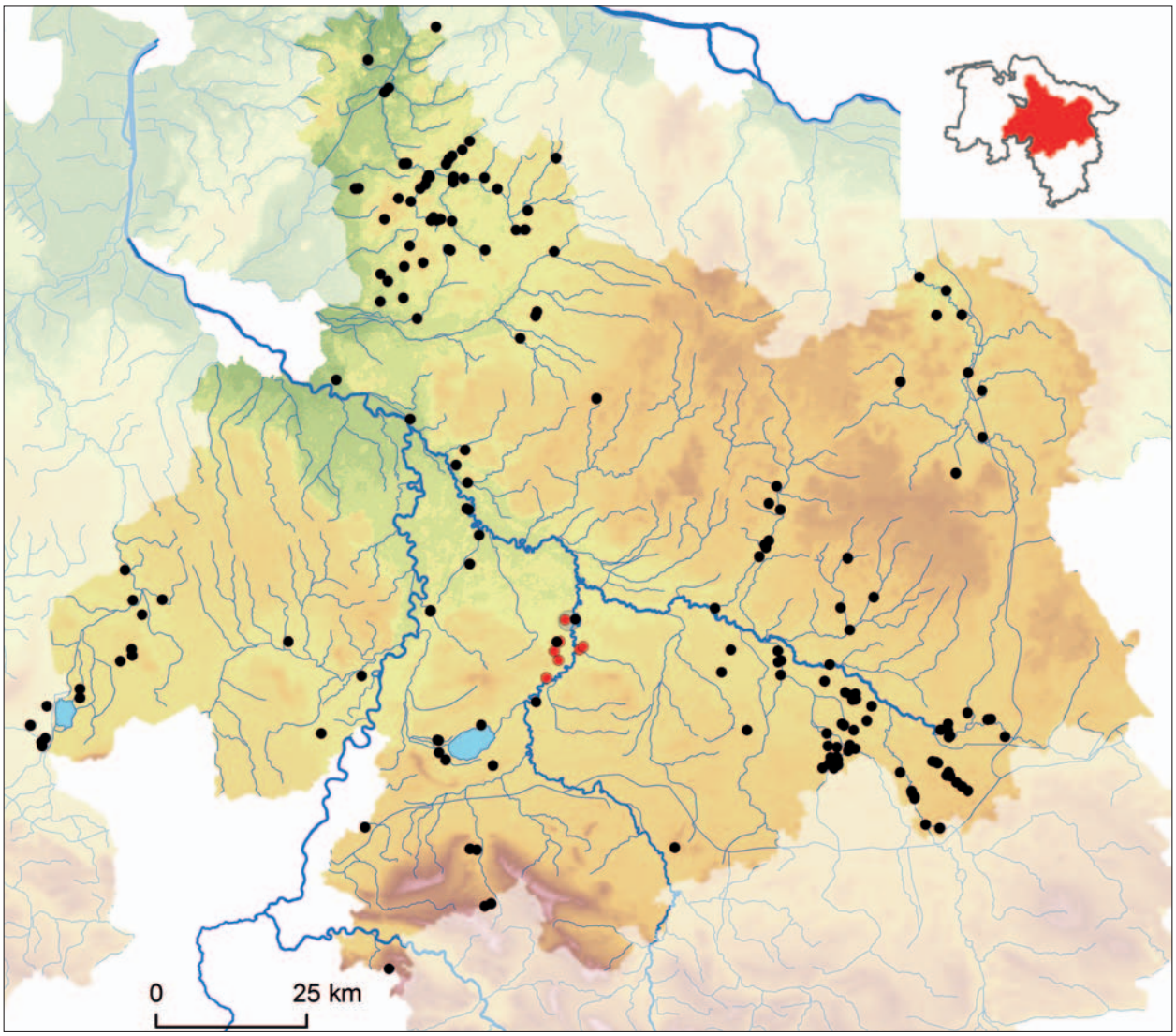

Fig. 10 Distribution of Late Mesolithic sites in central Lower Saxony (black dots). Red dots mark the newly recorded sites in the immediate vicinity of the Niedernstöcken settlement, the circle the location of Niedernstöcken FStNr. 21/24. For sites see Table 3 (map basis SRTM 3, graphics: A. Niemuth).

burg (Wümme) (Gerken 2009), 14 dates are available. The most recent date here falls within the time frame of 6,370 to 6,070 calBC (Poz-13789: 7,350±50 BP), although no trapezoids were recorded from this site. Furthermore, various dates are available from the charcoal pits already mentioned (Gerken 2016; 2020) and other Late Mesolithic hearths, from the surroundings of which, however, no datable artefact inventories were recorded.[11]

So far, there is not a single Mesolithic date from the area between Dümmer, Oste, the loess border, and eastern Lower Saxony that falls within the period of the LBK settlement of Niedernstöcken. However, it would be premature to deduce that the entire area was (largely) devoid of settlements in the late 6th millennium calBC. Rather, this reflects the insufficient state of research.

Against this background, our knowledge of the material culture of the Late Mesolithic groups in the central lowlands of Lower Saxony is very limited, especially since organic objects are completely lacking. Yet there are topographical situations offering promising starting points for research excavations. With the current state of research, it is not possible to make more detailed statements about technological differences or influences between Mesolithic and Neolithic cultural groups or about the neolithisation

11 Among these are Lauenbrück FStNr. 21, district of Rotenburg (Wümme) (Neumann 2006), Rehden FStNr. 38 (Gerken / Selent 2019), Rehden FStNr. 52 (Feierabend / Selent 2019), Hemsloh FStNr. 33 (Gerken et al. 2019), all district of Diepholz, as well as Otterstedt FStNr. 1 (Precht 2003), Hülsen FStNr. 1 and Westen FStNr. 7 (Precht 2020), all district of Verden. A further date is known from Wohlendorf FStNr. 24, district of Heidekreis. The dates from these contexts are also no later than between 5,400 and 5,200 calBC.

process in this area. However, the same applies to the central and eastern German inland areas (Wechler 1993, 6). According to Cziesla (2008, 408) 'the overall number of Late Mesolithic sites in inland areas is decreasing compared to previous periods'.[12] This statement cannot be followed as it stands, because on the one hand the figures he mentions for the Early Mesolithic compared to the Late Mesolithic refer to a significantly longer period of time. On the other hand, selected regions are presented here which cannot be regarded as representative for the Lower Saxon lowlands. Figures from four regions in Lower Saxony were used for comparison.[13] On average there are 40 % Late Mesolithic sites recorded for Lower Saxony. When the longer time span of the Early Mesolithic is taken into account, there is an increase rather than a decrease of Late Mesolithic settlement activity.

There are no indications of other cultural groups that might have influenced the regional Late Mesolithic or the neolithisation process from this part of the lowlands. It must remain open which influences from which cultural groups played a role in this area at a certain time.

A pollen diagram from a small bog of a Mesolithic site 20 km from Niedernstöcken with more than 80 fire pits (Assendorp 1985; Speier / Helmreich 2005; Gerken 2016), shows cereal pollen only from about 4,000 calBC. This might indicate that in the area adjacent to the north of the LBK settlement, agriculture was only practised from this time onwards. Evidence that the LBK settlers in Niedernstöcken actually had a Neolithic way of life oriented towards agriculture, on the other hand, has yet to be found. Pollen analyses of samples from the vicinity of the settlement are urgently needed to further outline the early phase of neolithisation in the lowlands of Lower Saxony.

Even though there is no evidence of a Late Mesolithic settlement in the area around Niedernstöcken around 5,000 / 5,000 calBC, we believe that this area was used by hunters and gatherers at that time (cf. also Saile 2007, 46). Ongoing systematic surveys, dating series and a number of finds have already led to the discovery and erudition of numerous Late Mesolithic localities not previously assigned to this period (see Fig. 10 and Table 3).

12 Translated from the original German text: „dass die Zahl der spätmesolithischen Fundstellen im Binnenland gegenüber den vorherigen Zeitabschnitten insgesamt abnimmt".

13 Breest 1993; 1997; Gerken 2001a; Mahlstedt 2015.

Outlook

More than 30 years after an overview of the LBK by Steinmetz (1985), its distribution pattern in Lower Saxony has become more distinct and can now be extended by 50 km to the north with the Niedernstöcken sites. In this context, the discovery of a LBK round-bottomed jar ('Kumpf') near Uesen in the district of Verden (Potratz 1941) appears in a new light. The accumulation of adze finds along the river Leine between Mandelsloh and Niedernstöcken also indicates that further LBK settlements are to be expected here. In order to better understand the neolithisation process in the north German plain, more detailed information about the Late Mesolithic development in this area is necessary. However, the Neolithic in the area north of Hanover has also been little researched so far.

Based on the investigations carried out at Niedernstöcken, it is clear that a LBK settlement of the Flomborn horizon extended here over an area of at least 250 m in a N-S direction; the E-W extension cannot yet be estimated. With this size, just a very short-lived settlement should not be assumed. The find material from 2019 will help to further outline the character of the first LBK settlement in the lowlands.[14]

14 We sincerely thank M. Heumüller, F. Klimscha and T. Terberger for reviewing the manuscript.

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District	Municipality	Local subdistrict („Gemarkung“)	Site no.	Object (adze, acc. to German terminology)	References
Celle	Celle	Hohnebostel	oF 1	flacher SLK	Brandt 1967, 167; Breest 1993 KatNr. 17
Gifhorn	Gifhorn	Gifhorn	oF	hoher Dechsel	Potratz 1941, 30; Brandt 1967, 165 Karte 1
Hannover	Burgdorf	Otze	7	hoher SLK	Moser 1998, 143 KatNr. 1119
Hannover	Burgdorf	Sorgensen	2	Flachhacke/Breitkeil ?	Moser 1998, 150 KatNr. 1170
Hannover	Hemmingen	Arnum	1	flacher SLK	Moser 1998, 284f., KatNr. 2319
Hannover	Hemmingen	Arnum	4	mittelhoher SLK	Moser 1998 284 KatNr. 2318
Hannover	Hemmingen	Arnum	oF	flacher SLK	Moser 1998 285f., KatNr. 2326
Hannover	Laatzen	Gleidingen	34	Dechsel	Cosack/ Zippel 2001, 2 Kat.Nr. 6 (listed under Koldingen)
Hannover	Laatzen	Gleidingen	35	Dechsel	Cosack / Zippel 1999, 2–4 KatNr. 4
Hannover	Laatzen	Grasdorf	21	hoher SLK	Potratz 1941, 32 ; Moser 1998, 290 KatNr. 2357
Hannover	Neustadt	Brase	8	hoher SLK	Moser 1998, 36 KatNr. 156
Hannover	Neustadt	Brase	22	flacher SLK	Moser 1998, 37 KatNr. 158
Hannover	Neustadt	Brase	41	Dechsel	unpubl., collection Schwarzlose
Hannover	Neustadt	Mandelsloh	52	flacher SLK	Moser 1998, 32 KatNr. 126
Hannover	Neustadt	Mandelsloh	54	flacher SLK	Moser 1998, 32 KatNr. 125
Hannover	Neustadt	Neustadt	oF	flacher SLK	Moser 1998, 69 KatNr. 469
Hannover	Neustadt	Stöckendrebber	7	mittelhoher SLK	Moser 1998, 39 KatNr. 183
Hannover	Neustadt	Welze	16	Dechsel	Cosack / König 2001, 6 KatNr. 6
Hannover	Neustadt		oF	hoher SLK	Moser 1998, 76 KatNr. 534.28
Hannover	Pattensen	Jeinsen	2	SLK	Moser 1998, 332 KatNr. 2731
Hannover	Pattensen	Jeinsen	27, formerly 5	5 SLK	Moser 1998, 330 KatNr. 2721; Zippel / Dahmlos 1999, 82f., KatNr. 119–120
Hannover	Pattensen	Schulenburg	16	SLK	Zippel / Dahmlos 1999, 109 KatNr. 167
Hannover	Ronnenberg	Ronnenberg	9	Dechsel	Cosack / König 2001, 6 KatNr. 5
Hannover	Ronnenberg	Weetzen	2	hoher SLK	Moser 1998, 277 KatNr. 2259
Hannover	Sehnde	Haimar	2	Dechsel	Breest 2014, 59 KatNr. 84
Hannover	Sehnde	Wehmingen	8	SLK	Moser 1998, 304 KatNr. 2475
Hannover	Springe	Alferde	2	flacher SLK	Moser 1998, 362 KatNr. 3021
Hannover	Springe	Lüdersen	1	hoher SLK	Moser 1998, 348 KatNr. 2881; Krull 1976, 347 Abb. 1.
Hannover	Uetze	Uetze	32	hoher SLK	Moser 1998, 158 KatNr.1233
Hannover	Wennigsen	Bredenbeck	43	Dechsel	Moser 1998, 315 KatNr. 2583
Heidekreis	Häuslingen	Klein Häuslingen	23	hoher SLK	Deichmüller 1968, 100–102; Brandt 1995, 4 KatNr. 1
Nienburg	Hilgermissen	Ubbendorf	2	flacher SLK	Berthold 2018, 171 KatNr. 206
Nienburg	Leese	Leese	229	Dechsel	Berthold 2019, 168 KatNr. 200
Nienburg	Marklohe	Qyle	oF	flacher SLK	Brandt 1967, 168
Schaumburg	Bückeburg	Bückeburg	oF 5	hoher SLK	Stark 1998, 47 KatNr. 193
Schaumburg	Bückeburg	Cammer	4	hoher SLK	Stark 1998, 35 KatNr. 141
Schaumburg	Lauenau	Feggendorf	39	flacher SLK	Stark 1998, 83 KatNr. 384
Verden	Verden	Luttum	92	3 SLK	Deichmüller 1968, 101f.; Schünemann 1979, 47

Table 2 Unperforated adzes discovered in the vicinity of the Niedernstöcken site (without excavation finds), outside the known distribution area of the LBK (SLK = “Schuhleistenkeil”; oF = without site no.: cannot be located precisely).

District	Municipality	Local subdistrict („Gemarkung“)	Site no.	References
Celle	Adelheidsdorf	Adelheidsdorf	6	Breest 1993, 45–46 KatNr.10, Taf. 16
Celle	Beedenbostel	Beedenbostel	11	Breest 1993, 51–52 KatNr. 25, Taf. 35
Celle	Bergen	Diesten	7	Breest 1993, 62 KatNr. 39–40, Taf. 56
Celle	Bergen	Diesten	37	Breest 1993, 62 Taf. 56
Celle	Bergen	Eversen	29	Breest 1993, 65 KatNr. 43, Taf. 60
Celle	Bergen	Eversen	31	Breest 1993, 55 KatNr. 33, Taf. 47
Celle	Bergen	Eversen	21	Breest 1993, 63–64 KatNr. 42, Taf. 56
Celle	Bröckel	Bröckel	1	Schwarz-Mackensen 1978, 97 KatNr. 195
Celle	Bröckel	Bröckel	2	Breest 1993, 49 KatNr. 20, Taf. 25
Celle	Celle	Celle	41	Breest 1993, 41–42 KatNr. 1, Taf. 5; 7
Celle	Celle	Altencelle	54	Breest 2002a, 16 KatNr. 10, Abb. 9
Celle	Celle	Altencelle	69	Breest 2002b, 32 KatNr. 42, Abb. 38
Celle	Eicklingen	Eicklingen	3	Breest 1993, 46 KatNr. 12, Taf. 19
Celle	Eicklingen	Eicklingen	9	Breest / Hinsch 1997, 20–21 Abb. 13
Celle	Eldingen	Eldingen	5	Breest 1993, 53 KatNr. 29, Taf. 38
Celle	Eschede	Eschede	22	Breest 1993, 54 KatNr. 31, Taf. 44
Celle	Hambühren	Hambühren	1	Breest 1993, 42–43 KatNr. 2, Taf. 9, 10,13
Celle	Hermannsburg	Baven	4	Breest 1993, 67 KatNr. 48, Taf. 68
Celle	Hermannsburg	Hermannsburg	18	Breest 1993, 67–68 KatNr. 50, Taf. 69
Celle	Hermannsburg	Hermannsburg	12	Breest 1993, 68 KatNr. 51, Taf. 71
Celle	Höfer	Höfer	9	Breest 1993, 52–53 KatNr. 27, Taf. 36
Celle	Langlingen	Hohnebostel	14	Breest 1993, 47 KatNr. 15, Taf. 22
Celle	Langlingen	Hohnebostel	11	Breest 1993, 49 KatNr. 19, Taf. 24
Celle	Langlingen	Hohnebostel	15	Breest 1993, 47 KatNr. 14, Taf. 22
Celle	Langlingen	Hohnebostel	13	Breest 1993, 47 KatNr. 13, Taf. 21
Celle	Langlingen	Hohnebostel	12	Breest 1993, 48 KatNr. 16, Taf. 22
Celle	Wienhausen	Offensen	3	Breest 1993, 46 KatNr. 11, Taf. 18
Celle	Winsen (Aller)	Stedden	5	Breest 1993, 43–44 KatNr. 4, Taf. 14
Diepholz	Barnstorf, Flecken	Barnstorf	34	Bischop 1997, 194 KatNr. 1175
Diepholz	Barnstorf, Flecken	Rechtern	28	Bischop 1997, 210 KatNr. 1255
Diepholz	Diepholz, Stadt	Diepholz-Graftlage	43	Mahlstedt 2015, 176 KatNr. 83, Taf. 16
Diepholz	Eydelstedt	Düste	8	Bischop 1997, 267 KatNr. 1566
Diepholz	Eydelstedt	Eydelstedt	26	Bischop 1997, 245–247 KatNr. 1465
Diepholz	Hemsloh	Hemsloh	33	Gerken et al. 2019, 32 Kat.Nr. 31, Abb. 30
Diepholz	Lembruch	Lembruch	7	Bischop 1997, 388 KatNr. 2386; Mahlstedt 2015, 176 Taf. 17,9
Diepholz	Rehden	Rehden	38	Gerken / Selent 2019, 42–44 Kat.Nr. 40, Abb. 49–50
Diepholz	Rehden	Rehden	52	Feierabend / Selent 2019, 44–45 Kat.Nr. 42, Abb. 52
Gifhorn	Didderse	Didderse	8 ?	Schwarz-Mackensen 1978, 61 KatNr. 69, Taf. 9
Gifhorn	Didderse	Didderse	5	Schwarz-Mackensen 1978, 62–63 KatNr. 72, Taf. 10
Gifhorn	Didderse	Didderse	2 ?	Schwarz-Mackensen 1978, 59 KatNr. 68, Taf. 9
Gifhorn	Didderse	Didderse	4	unpublished
Gifhorn	Gifhorn	Gamsen	oF ?	Schwarz-Mackensen 1978, 83 Taf. 28
Gifhorn	Gifhorn, Stadt	Gifhorn	49	Schwarz-Mackensen 1978, 81 KatNr. 135, Taf. 26
Gifhorn	Gifhorn, Stadt	Gifhorn	50	Schwarz-Mackensen 1978, 80 KatNr. 133, Taf. 26
Gifhorn	Gifhorn, Stadt	Gifhorn	51	Schwarz-Mackensen 1978, 80 KatNr. 131, Taf. 24
Gifhorn	Gifhorn, Stadt	Gifhorn	52	Schwarz-Mackensen 1978, 79 KatNr. 129, Taf. 23–24
Gifhorn	Gifhorn	Gifhorn	21	Zeitz 1969, 9 KatNr. 2, Taf. 30
Gifhorn	Hillerse	Hillerse	16	Schwarz-Mackensen 1978, 64 Taf. 12
Gifhorn	Leiferde	Dalldorf	10	Schwarz-Mackensen1978, 64 KatNr. 79, Taf. 12
Gifhorn	Leiferde	Leiferde	2	Zeitz 1969,14–15 Taf. 85
Gifhorn	Meine	Meine	8	Trebess / Eichfeld 2017
Gifhorn	Meine	Bechtsbüttel	oF ?	Schwarz-Mackensen 1978, 57 KatNr. 59, Taf. 7
Gifhorn	Meinersen	Päse	oF ?	Schwarz-Mackensen 1978, 96 KatNr. 193, Taf. 44
Gifhorn	Müden (Aller)	Flettmar	6	Schwarz-Mackensen 1978, 97 KatNr. 196, Taf. 45
Gifhorn	Ribbesbüttel	Ribbesbüttel	10	Zeitz 1969, 18; Schwarz-Mackensen 1978, 68–70 KatNr. 92
Gifhorn	Ribbesbüttel	Vollbüttel	12	Schwarz-Mackensen 1978, 74 Taf. 17
Gifhorn	Ribbesbüttel	Vollbüttel	2	Zeitz 1969, 13; Schwarz-Mackensen 1978, 74 KatNr. 102, Taf. 17
Gifhorn	Ribbesbüttel	Vollbüttel	3?	Schwarz-Mackensen1978, 74 KatNr. 101, Taf. 19
Gifhorn	Ribbesbüttel	Vollbüttel	13	Schwabedissen 1944, Taf. 25
Gifhorn	Rötgesbüttel	Rötgesbüttel	23	Schwarz-Mackensen 1978, 68 KatNr. 90, Taf. 13

Table 3.1 The list and the map are a complemented and updated version of the list published by Gerken / Nelson 2016 (oF = without site no.; cannot be located precisely).

District	Municipality	Local subdistrict („Gemarkung“)	Site no.	References
Gifhorn	Rötgesbüttel	Rötgesbüttel	100	Zeitz 1969, 19–20 Taf. 131–137; Schwarz-Mackensen 1978, 67 KatNr. 87
Gifhorn	Rötgesbüttel	Rötgesbüttel	7 oder 25	Schwarz-Mackensen 1978, 68 KatNr. 91, Taf. 14
Gifhorn	Sassenburg	Dannenbüttel	oF	Schwarz-Mackensen 1978, 77 KatNr. 116, Taf. 21
Gifhorn	Sassenburg	Westerbeck	5	Schwabedissen 1944, Taf. 25
Gifhorn	Sassenburg	Westerbeck	4	Schwabedissen 1944, Taf. 28
Gifhorn	Schwülper	Lagesbüttel	oF ?	Schwabedissen 1944, Taf. 35
Gifhorn	Schwülper		oF ?	Schwarz-Mackensen 1978, 58; Taf. 8
Hameln-Pyrmont	Bad Münder, Stadt	Beber	7	Schween 1993, KatNr. 37–39
Hannover	Burgwedel, Stadt	Wettmar	16	Moser 1998, 93 KatNr. 685
Hannover	Hannover	Bemerode	12, 89- 95	Moser 1998, 236 KatNr. 1890
Hannover	Neustadt a. Rbge., Stadt	Amedorf	26	unpublished, systematic survey
Hannover	Neustadt a. Rbge., Stadt	Brase	2	unpublished, systematic survey
Hannover	Neustadt a. Rbge., Stadt	Mandelsloh	71	unpublished, systematic survey
Hannover	Neustadt a. Rbge., Stadt	Niedernstöcken	23	Gerken / Piche 2018, 106f., Kat.Nr. 108, Abb. 108–110
Hannover	Neustadt a. Rbge., Stadt	Vesbeck	18	unpublished, systematic survey
Hannover	Neustadt a. Rbge., Stadt	Wulfelade	29	unpublished, systematic survey
Hannover	Neustadt a. Rbge., Stadt	Vesbeck	7	unpublished, systematic survey
Hannover	Neustadt a. Rbge., Stadt	Brase	24	Moser 1998, 35 KatNr. 150
Hannover	Neustadt a. Rbge., Stadt	Mardorf	10	Moser 1998, 65 KatNr. 428
Hannover	Neustadt a. Rbge., Stadt	Niedernstöcken	20	unpublished, systematic survey
Hannover	Neustadt a. Rbge., Stadt	Suttorf	4	Moser 1998, 60 KatNr. 375
Hannover	Uetze	Dedenhausen	12	Schwabedissen 1944, Taf. 36; Schwarz-Mackensen 1978, 85 KatNr. 153, Taf. 31; Moser 1998, 175 KatNr. 1366
Hannover	Uetze	Dedenhausen	3	Moser 1998, 162
Hannover	Uetze	Dedenhausen	4	Schwarz-Mackensen 1978, 86–87 KatNr. 158,Taf. 35; Moser 1998, 175 KatNr. 1361
Hannover	Uetze	Dedenhausen	5	Schwarz-Mackensen 1978, 87 KatNr. 160, Taf. 36; Moser 1998, 174 KatNr. 1360
Hannover	Uetze	Dedenhausen	1, 8, 9 (?)	Schwarz-Mackensen 1978, 87 KatNr. 162, Taf. 36–37; Moser 1998, 174 KatNr. 1358
Hannover	Uetze	Eltze	2	Schwarz-Mackensen 1978, 91–92 KatNr. 176, Taf. 41; Moser 1998, 172 KatNr. 1344
Hannover	Uetze	Eltze	39	Schwarz-Mackensen 1978, 91 KatNr. 174,Taf. 41; Moser 1998, 167–168 KatNr. 1308
Hannover	Uetze	Eltze	28	Schwarz-Mackensen 1978, 95–96 KatNr. 190,Taf. 44; Moser 1998, 170 KatNr. 1327
Hannover	Uetze	Eltze	37	Schwarz-Mackensen 1978, 95 KatNr. 189, Taf. 44
Hannover	Uetze	Eltze	20	Schwarz-Mackensen 1978, 91 KatNr. 172, Taf. 40; Moser 1998, 171 KatNr. 1336
Hannover	Uetze	Katensen	9	Moser 1998, 178 KatNr. 1389
Hannover	Uetze	Uetze	oF	Moser 1998, 166 KatNr. 1297
Hannover	Uetze	Uetze	2	Schwarz-Mackensen 1978, 88 KatNr. 163, Taf. 37–38; Moser 1998, 162 KatNr. 1267
Hannover	Uetze	Uetze	3	Schwarz-Mackensen 1978, 88 KatNr. 164, Taf. 38; Moser 1998, 162 KatNr. 1269
Hannover	Uetze	Uetze	7	Schwarz-Mackensen 1978, 88 KatNr. 166,Taf. 39; Moser 1998, 163 KatNr. 1275
Hannover	Uetze	Uetze	23	Schwarz-Mackensen 1978, 92–93 KatNr. 179, Taf. 42; Moser 1998, 165–166 KatNr. 1291
Hannover	Uetze	Uetze	31	Schwarz-Mackensen 1978, 94 Taf. 43
Hannover	Uetze	Uetze	oF	Schwarz-Mackensen 1978, 88 Taf. 39
Hannover	Wunstorf, Stadt	Steinhude	1	Moser 1998, 103 KatNr. 767
Heidekreis	Rethem, Stadt	Wohlendorf	24	unpublished
Nienburg	Heemsen	Anderten	6	Adameck 1993, 137–138 KatNr. 483
Nienburg	Nienburg, Stadt	Erichshagen	91	Gerken 2020, 186–196 KatNr. 233, Abb. 204
Nienburg	Nienburg (Weser), Stadt	Holtorf	9	Berthold / Gerken 2015, 123–127 KatNr. 174, Abb. 130–132
Nienburg	Raddestorf	Huddestorf	21	Adameck 1993, 583 KatNr. 2241
Nienburg	Rehburg-Loccum	Rehburg	81	Berthold 2014, 126 KatNr. 190, Abb. 164
Nienburg	Rehburg-Loccum	Rehburg	80	unpublished
Nienburg	Rehburg-Loccum	Winzlar	3	Berthold / Gerken 2019, 185 KatNr. 229, Abb. 216
Nienburg	Rehburg-Loccum	Winzlar	10	unpublished
Nienburg	Steyerberg, Flecken	Voigtei	2	Adrian 1931; Adameck 1993, 347 KatNr. 1210

Table 3.2 The list and the map are a complemented and updated version of the list published by Gerken / Nelson 2016 (oF = without site no.; cannot be located precisely).

District	Municipality	Local subdistrict („Gemarkung“)	Site no.	References
Nienburg	Steyerberg, Flecken	Wellie	26	Adameck 1993, 401–402 KatNr. 1487
Osnabrück	Bohmte	Schwege	73	Wulf 2011, 274 KatNr. 1270; Mahlstedt 2015, 175 KatNr.56, Taf. 12
Osnabrück	Bohmte	Schwege	76	Wulf 2011, 275 KatNr. 1273; Mahlstedt 2015, 175 KatNr.57, Taf. 12
Osnabrück	Bohmte	Schwege	114/115	Wulf 2011, 278–279 KatNr. 1311; Mahlstedt 2015, 175 KatNr. 62, Taf. 13
Peine	Edemissen	Eddesse	31	Schwarz-Mackensen 1978, 86 KatNr. 155, Taf. 33
Rotenburg	Breddorf	Breddorf	51	Gerken 2001, 68–69 KatNr. 21, Taf. 21
Rotenburg	Breddorf	Breddorf	50	Gerken 2001, 67–68 KatNr. 20, Taf. 23
Rotenburg	Breddorf	Breddorf	48	Gerken 2001, 67 KatNr. 19; Taf. 22
Rotenburg	Bremervörde, Stadt	Elm	81	Metzger-Krahé 1977, 84 KatNr. 79, Taf. 81
Rotenburg	Bremervörde, Stadt	Minstedt	66	Metzger-Krahé 1977, 101–102 KatNr. 106, Taf. 95
Rotenburg	Bremervörde, Stadt	Minstedt	5	Metzger-Krahé 1977, 100–101 KatNr. 105, Taf. 96
Rotenburg	Bremervörde, Stadt	Schwitschen	42	Gerken 2012, 23–68 Abb. 5–6; Gerken 2015, 208–210 KatNr. 298, Abb. 209
Rotenburg	Brockel	Brockel	60	Gerken 2015b, 228–229 Abb. 13
Rotenburg	Brockel	Brockel	54	Gerken 2015b, 220–221 Abb. 5
Rotenburg	Bülstedt	Bülstedt	108	Gerken 2001, 99–101 KatNr. 46, Taf. 77
Rotenburg	Gyhum	Bockel	7	Gerken 2001, 59 KatNr. 14
Rotenburg	Gyhum	Bockel	9	Gerken 2001, 60–61 KatNr. 16, Taf. 14
Rotenburg	Hamersen	Hamersen	51	unpublished; collection Maack
Rotenburg	Hamersen	Hamersen	40	Gerken 2015b, 216–217 Abb. 1
Rotenburg	Hamersen	Hamersen	77?	Metzger-Krahé 1977, 92–93 KatNr. 94, Taf. 90
Rotenburg	Hamersen	Hamersen	oF ?	unpublished
Rotenburg	Heeslingen	Heeslingen	224	Schwabedissen 1944, Taf. 51 Nr. 2; Metzger-Krahé 1977, 77–78 KatNr. 70, Taf. 109
Rotenburg	Heeslingen	Heeslingen	185	unpublished; collection Maack
Rotenburg	Heeslingen	Heeslingen	167	unpublished; collection Maack
Rotenburg	Heeslingen	Sassenholz	24	Metzger-Krahé 1977, 112–113 KatNr. 122, Taf. 109
Rotenburg	Heeslingen	Sassenholz	23	unpublished; Bachmann-Museum Bremervörde
Rotenburg	Heeslingen	Sassenholz	14	unpublished; Bachmann-Museum Bremervörde
Rotenburg	Heeslingen	Sassenholz	67	Metzger-Krahé 1977, 111 KatNr. 121
Rotenburg	Heeslingen	Sassenholz	82	Breest / Gerken 2003, 22 KatNr. 34, Abb. 30
Rotenburg	Heeslingen	Weertzen	56(??)	Metzger-Krahé 1977, 115 KatNr. 131
Rotenburg	Hemsbünde	Hastedt	2	Gerken / Linger 1999, 13–15 Abb. 11
Rotenburg	Horstedt	Horstedt	34	Gerken 2001, 106–107 KatNr. 53 Taf. 86
Rotenburg	Selsingen	Lavenstedt	178	Gerken 2011, 176–178 KatNr. 334
Rotenburg	Lauenbrück	Lauenbrück	21	Neumann 2006, 57 KatNr. 82
Rotenburg	Oerel	Glinde	9	unpublished; Bachmann-Museum Bremervörde
Rotenburg	Ostereistedt	Ostereistedt	79	unpublished; collection Maack
Rotenburg	Ostereistedt	Ostereistedt	77	unpublished; collection Maack
Rotenburg	Ostereistedt	Rockstedt	55	unpublished; collection Müller
Rotenburg	Scheeßel	Abbendorf	22	Metzger-Krahé 1977, 72–73 KatNr. 62, Taf. 64
Rotenburg	Seedorf	Godenstedt	63	unpublished; collection Müller /Maack
Rotenburg	Seedorf	Godenstedt	62	unpublished; collection Maack
Rotenburg	Seedorf	Godenstedt	47	unpublished; collection Maack
Rotenburg	Seedorf	Godenstedt	78	unpublished; collection Müller
Rotenburg	Seedorf	Granstedt	82	unpublished; Bachmann-Museum Bremervörde
Rotenburg	Selsingen	Lavenstedt	135(?)	Metzger-Krahé 1977, 97 KatNr. 100, Taf. 94
Rotenburg	Selsingen	Lavenstedt	130	Metzger-Krahé 1977, 96 KatNr. 98, Taf. 92
Rotenburg	Sottrum	Sottrum	26	Gerken 2001, 133–134 KatNr. 71, Taf. 102
Rotenburg	Vorwerk	Buchholz	28	Gerken 2001, 94–96 KatNr. 41, Taf. 72
Rotenburg	Vorwerk	Dipshorn	19	Gerken 2001, 103–105 KatNr. 49, Taf. 82
Rotenburg	Vorwerk	Vorwerk	41	Gerken 2001, 136–140 KatNr. 77, Taf. 104
Rotenburg	Westertimke	Westertimke	51	Gerken 2001, 180–182 KatNr. 86, Taf. 132
Rotenburg	Wohnste	Wohnste	22	unpublished; collection Maack
Rotenburg	Zeven, Stadt	Badenstedt	177	Gerken 2001, 57 KatNr. 11, Taf. 11
Rotenburg	Zeven, Stadt	Brauel	44	unpublished; collection Maack
Rotenburg	Zeven, Stadt	Brümmerhof	23	Gerken 2001, 77–78 KatNr. 29, Taf. 36
Rotenburg	Zeven, Stadt	Brüttendorf	41	Gerken 2001, 89–92 KatNr. 38, Taf. 62
Rotenburg	Zeven, Stadt	Brüttendorf	32	Metzger-Krahé 1977, 78–80 KatNr. 74, Taf. 69; Gerken 2001, 79–84 KatNr. 31, Taf. 42
Rotenburg	Zeven, Stadt	Brüttendorf	33	Gerken 2001, 84–86 KatNr. 32, Taf. 56

Table 3.3 The list and the map are a complemented and updated version of the list published by Gerken / Nelson 2016 (oF = without site no.; cannot be located precisely).

District	Municipality	Local subdistrict („Gemarkung“)	Site no.	References
Rotenburg	Zeven, Stadt	Brüttendorf	35	Gerken 2001, 86 KatNr. 33, Taf. 57
Rotenburg	Zeven, Stadt	Oldendorf	42	Gerken 2001, 110–112 KatNr. 58, Taf. 90
Rotenburg	Zeven, Stadt	Oldendorf	52	Gerken 2001, 118–130 KatNr. 66, Taf. 99
Rotenburg	Zeven, Stadt	Zeven	34	Metzger-Krahé 1977, 121 KatNr. 137, Taf. 109
Schaumburg	Hülsede	Hülsede	7	Stark 2003
Schaumburg	Hülsede	Schmarrie	3	Stark 2003, 88–89 KatNr. 421
Schaumburg	Rinteln, Stadt	Wennenkamp	4	Stark 2003, 144 KatNr. 626
Schaumburg	Rodenberg, Stadt	Rodenberg	21	Stark 2003, 78 KatNr. 369B
Schaumburg	Apelern	Soldorf	1	Stark 2003, 72–73 KatNr. 358 (listed as site Rodenberg)
Uelzen	Bienenbüttel	Hohenbostel	12	Richter 2002, Taf. 54,14.16
Uelzen	Bienenbüttel	Hohnstorf	15	Richter 2002, Taf. 56,1–4
Uelzen	Bruchtorf	Bruchtorf	52	Richter 2002, Taf. 49,5
Uelzen	Emmendorf	Emmendorf	29	Richter 2002, Taf. 49,23
Uelzen	Jelmstorf	Jelmstorf	90	Richter 2002, Taf. 59,11–14
Uelzen	Schienau	Stadorf	32	Richter 2002, Taf. 76,3
Uelzen	Uelzen	Oldenstadt	57	Richter 2002, Taf. 63,9
Uelzen	Wrestedt	Stadensen	11	Richter 2002, Taf. 75,2
Uelzen	Wrestedt	Stederdorf	33	Richter 2002, Taf. 78,7
Vechta	Vechta	Damme	200	Gerken 2003, 92 Fig. 4; Mahlstedt 2015, 175 KatNr. 64, Taf. 14
Vechta	Vechta	Damme	63	Mahlstedt 2015, 175 KatNr. 67, Taf.15
Vechta	Vechta	Damme	223	Mahlstedt 2015, 176 KatNr. 76, Taf. 16
Verden	Achim, Stadt	Bierden	8	Schünemann 1981, 95 KatNr. 22, Abb. 19
Verden	Dörverden	Westen	7	Precht 2020, 297–300 KatNr. 405
Verden	Dörverden	Hülsen	1	Nowatzyk 1990
Verden	Kirchlinteln	Luttum	98	Schünemann 1981, 86–89 KatNr. 15, Abb. 18; Breest et al.2006, 171 Abb. 239
Verden	Kirchlinteln	Luttum	88	Breest / Kehrbach 2002, 9–10 KatNr. 1, Abb. 1
Verden	Kirchlinteln	Otersen	101	Gerken 2014, 207–209 KatNr. 341, Abb. 274
Verden	Ottersberg, Flecken	Otterstedt	73	Schünemann 1981, 100–101 KatNr. 32, Abb. 24; Gerken 2001, 51–52 KatNr. 7, Taf. 4
Verden	Ottersberg, Flecken	Otterstedt	1	Precht 2003, 19f., Kat.Nr. 26, Abb. 23
Verden	Verden (Aller), Stadt	Eissel	15	Gerken / Precht 2015, 255 KatNr. 373, Abb. 267

Table 3.4 The list and the map are a complemented and updated version of the list published by Gerken / Nelson 2016 (oF = without site no.; cannot be located precisely).

Going north … The Middle Neolithic settlement of Nottuln-Uphoven (Westphalia) and the start of the neolithisation in the lowlands

Christian Hülsebusch and Albrecht Jockenhövel

Abstract Excavations from 1983–1985 and 2007–2008 brought to light a multi-periodic settlement site of the Middle and Late Neolithic (Rössen, Bischheim, Michelsberg, Funnel Beaker cultures) in Nottuln-Uphoven (Coesfeld, Münsterland, Germany) on a southern slope of the Baumberge hills. The site is located on a small loess island about 50–70 km north of the fertile Hellweg zone (between Dortmund and Soest) in the midst of less fertile sandy areas. Due to profound erosion the Rössen settlement could only be recorded in its lowest lying structures. The pottery shows direct connections with that of the Rössen settlements on the Hellweg. A grinding sandstone probably also originates from this area. This suggests the migration of a small Rössen population to the north, which started around 4,800 calBC. They settled as farmers on the site for several generations. Probably discontinuously, settlements of the Bischheim group, the Michelsberg culture and the Funnel Beaker culture followed. Nottuln-Uphoven represents the earliest expansion from the old settlement landscapes, characterised by full Neolithic farmsteads of the Linear Pottery (Linearbandkeramik) and Rössen culture, into the north. The site of Nottuln-Uphoven is therefore of particular importance for the neolithisation of the northwest German lowlands.

Keywords Nottuln-Uphoven (Westphalia), Middle Neolithic settlements (Rössen, Bischheim, Michelsberg, Funnel Beaker culture), earliest farmers north of the Hellweg zone

Zusammenfassung *Von 1983–1985 und 2007–2008 wurde bei Nottuln-Uphoven (Kr. Coesfeld, Münsterland) auf einem Südhang der Baumberge ein mehrperiodiger Siedlungsplatz des Mittel- und Jungneolithikums (Rössener, Bischheimer, Michelsberger und Trichterbecherkultur) ergraben. Der Fundplatz liegt etwa 50–70 km nördlich der fruchtbaren Hellweg-Zone zwischen Dortmund und Soest auf einer Lössinsel mitten in einem sonst wenig fruchtbaren Sandgebiet. Aufgrund der Erosion konnten nur noch die untersten Strukturen der Rössener Siedlung erfasst werden. Die Keramik zeigt deutliche Verbindungen zu den Rössener Siedlungen am Hellweg und der Sandstein für einen Mahlstein stammt vermutlich aus dieser Region. Daher wird angenommnen, dass eine kleine Rössener Population vom Hellweg die Siedlung Nottuln um 4800 v.Chr. begründet hat. Die Siedlung hat für mehrere Generationen bestanden. Später folgten – wahrscheinlich jeweils nach einer Unterbrechung – Siedlungsphasen der Bischheimer Gruppe sowie der Michelsberger und der Trichterbecherkultur. Nottuln-Uphoven repräsentiert die erste Expansionsphase der Bauern der Linearbandkeramik und Rössener Kultur nach Norden. Der Fundplatz Nottuln-Uphoven ist daher von großer Bedeutung für das Verständnis der Neolithisierung der nordwestdeutschen Tiefebene.*

Introduction

According to the current state of research, during the 5th millennium calBC the 'neolithisation' takes place in the northwest German lowlands ('Niederdeutsche Tiefebene') north of the fertile loess belt upstream from the central German uplands ('Mittelgebirge'). Ongoing research regards this transition from acquiring to producing subsistence strategies as an increasingly complex process. Mostly temporal and spatial relations of finds, pre-differentiated as 'Mesolithic' or 'Neolithic", are considered under certain aspects or neolithisation models in various ways. For, if one accepts the model of the spread of a Neolithic life-style from the Near East to central Europe, be it by human migration (together with domesticated animals and plants), transfer of ideas (stimulus diffusion) or by indigenous innovation, one has also to assume the existence of more or less stable 'border situations' in different regions and at different times: an 'Agricultural Frontier', where farm-

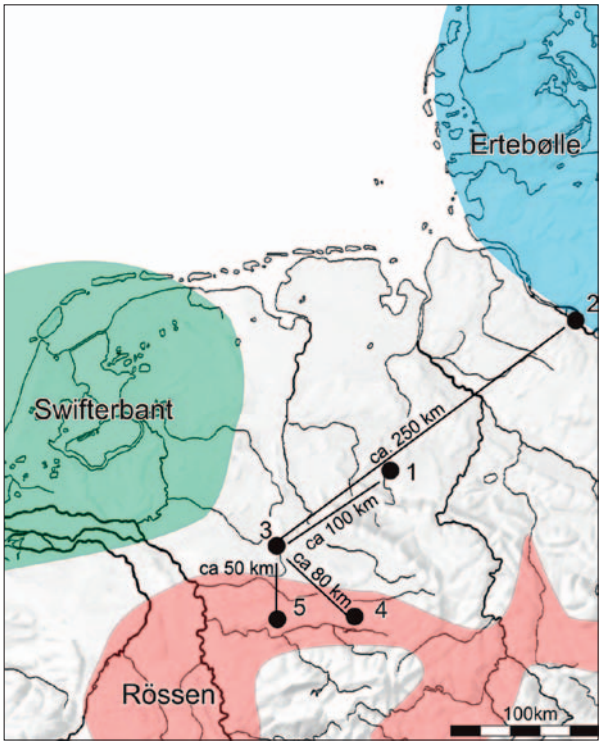

Fig. 1 The northwest German lowlands during the 5th millennium BC. Main cultural clusters and important sites mentioned in the article (with linear distances in km). **1** Hüde I (Dümmer); **2** Hamburg-Boberg; **3** Nottuln-Uphoven; **4** Deiringsen-Ruploh; **5** Dortmund-Oespel (map based on the Schweizer Nationalatlas; after Groer 2013b).

ers encountered foragers (hunter-gatherers). However, the 'Agricultural Frontier' or 'Neolithic Frontier' has not only to be understood as a simply geographical border but also in a broader cultural sense. The northwestern European lowlands (from the northwestern Netherlands to the western Baltic Sea) during the 5th millennium calBC are such a region for which studies of 'hither and thither' seem worthwhile.

North of the region characterised by the Linear Pottery culture (Linearbandkeramik [LBK]: Kneipp 1998) archaeological relics from the southern central European world (mainly the perforated "Danubian stone tools": Brandt 1967; 2002; Narr 1983; Merkel 1999) are often found together with remains from the Mesolithic period. Neolithic pottery is found in Late Mesolithic contexts as well, though only in a few places. During that period, the Ertebølle culture was spread in the north (northern Germany, Denmark) and the Swifterbant culture in the northwest (northern and western Netherlands). Considering their flint industries, both cultures are rooted in the respective Mesolithic traditions. Both cultures introduced their specific pottery styles prior to their respective shift to agriculture (marked by remains of cultivated crops and bones of domesticated animals). While the expansion of the LBK to central Europe from the Carpathian Basin was accompanied by a full 'Neolithic package', single elements of the Neolithic productive economy reached the zone north of the Early (LBK) and Middle Neolithic (Stroked Pottery, Bischheim, Rössen, Gatersleben cultures) during a long period from the late 6th to the 4th century calBC. The sites of these cultures (i. e. Hüde I, Hamburg-Boberg; Laux 1986; Thielen 2018), which have been termed 'Late Mesolithic', 'Proto-Neolithic', 'Sub-Neolithic' or 'Para-Neolithic', date to the same period as the purely Neolithic and purely Mesolithic settlements in the northwest German lowlands (Fig. 1).

We may perhaps never be able to answer the complex questions by means of generalising processual models. On the other hand, we need more knowledge based on archaeological and palaeoecological data from recently excavated sites in this decisive region. One important site of the neolithisation process is the settlement of Nottuln-Uphoven (Coesfeld distr., Westphalia), one of its earliest outposts north of the loess belt in the lowlands.

The mountain range of the Baumberge and the site of Nottuln-Uphoven

As one of few mountain ranges in the lowland zone of the northwest European mainland, the mountain range of the Baumberge, situated c. 20 km west of the modern city of Münster (Westphalia), offers a striking change in the landscape (hills of a height of 100–190 m above sea level). In the southern part of this island-like hilly landscape, small fertile loess sediments were deposited during the last glacial (Weichsel glacial). These small loess plots are exceptions from the less fertile sandy soil of the surrounding lowlands (c. 60–70 m a.s.l.). Furthermore, the Baumberge hills are a formative watershed in the northwestern lowlands with the springs of many rivers as tributaries of some important streams (Ems; Ijssel; Vechte; Lippe/Rhine).

The Baumberge region is located c. 50 km north of the fertile loess-soil-dominated Hellweg zone (between the modern cities of Dortmund and Soest) with its Early and Middle Neolithic settlement clusters of Linear Pottery, Rössen and Bischheim sites. Therefore it is not surprising that in the 1970–1980s archaeological research discovered a kind of pioneering settlement from Middle (Rössen) and Late Neolithic cultures (Bischheim, Michelsberg, Funnel Beaker; Figs. 2–4).

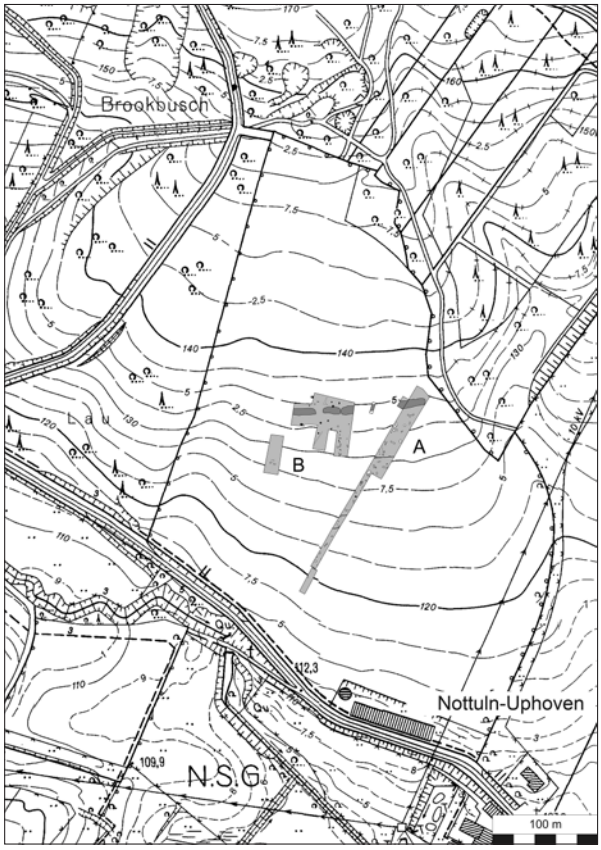

Fig. 2 Nottuln-Uphoven (Kr. Coesfeld). Location of the site on a southern slope of the Baumberge hills. Excavation areas. **A** 1983–1984 (J. Eckert); **B** 2007–2008 (Ch. Groer / Ch. Grünewald / A. Jockenhövel).

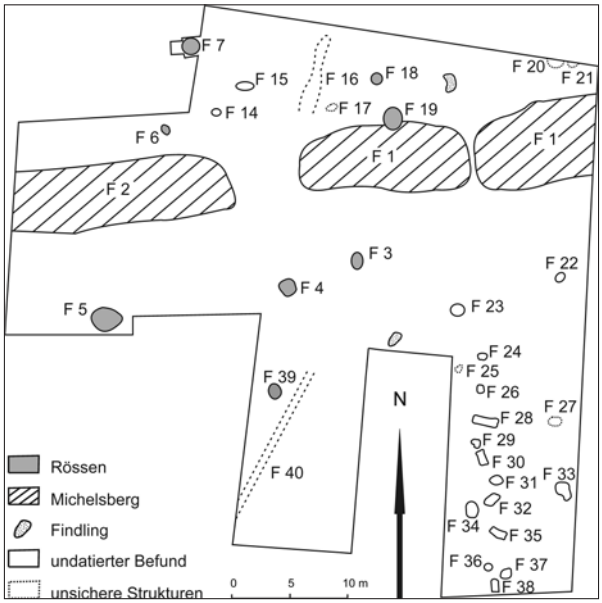

Fig. 3 Nottuln-Uphoven (Kr. Coesfeld). Settlement features: F 1. F 2 Michelsberg enclosure; F 3–F 7. F 16–19. F 30 Rössen pits (after Groer 2013a).

Nottuln-Uphoven – history of research

The Neolithic settlements of Nottuln-Uphoven were discovered during a systematic field survey by the amateur-archaeologist Wilhelm Tegethoff in 1973. Jörg Eckert then directed two excavation campaigns in the years 1983 and 1984 (Fig. 2,A). A lot of structures of the early Late Neolithic Michelsberg culture settlement were detected (remains of a causewayed enclosure, pits, post-holes of wooden buildings dated to the Michelsberg III-period: Eckert 1986; Knoche 2008; see Fig. 4,B). One single pit (F 8) contained a closed find of pottery of the Bischheim culture (Fig. 4,C) as a successor of the Rössen and a forerunner of the Michelsberg culture. In the upper part of the trenches there was a thin layer with rich finds from the Funnel Beaker West Group, indicating the latest occupation of this site (Fig. 4,A). At that time merely two finds on the surface – a small pottery sherd with typical decoration and a polished and perforated stone axe – hinted at an earlier Middle Neolithic settlement of the Rössen culture (Fig. 5,A; 6,B).

Based on the results of these excavations, the authors (in cooperation with Christoph Grünewald) initiated several surveys on the site, which finally resulted in an excavation project, funded by the German Research Foundation (DFG). Two campaigns of two months each were undertaken in the years 2007 and 2008 (Fig. 2,B). The excavation areas were targeted on the basis of geomagnetic mapping of the site (Langer / Elbeshausen 2004). The site shows substantial soil erosion due the inclination of the slope and persistent agricultural use (Richter 2008). Therefore only the lowest anthropogenic structures (post-holes, pits) could still be detected during the excavations. On an excavated area of 2,300 m^2 the causewayed enclosure from the Michelsberg culture was rediscovered, and different sections were excavated over a total length of 50 m. While the project was able to add more structures and finds from the Michelsberg (gateway of the causewayed enclosure) and Funnel Beaker cultures, its focus was the settlement of the Rössen culture (Groer 2008; 2010; 2013a; b; Fig. 3).

Settlement structures

Only a few meters to the west the causewayed enclosure of the Michelsberg culture superimposed the pit F19 with pottery typical of the Middle Neolithic Rössen culture (Fig. 5; 6,E). A total of eight Rössen pits were surveyed (F 3–F 7, F 18; F 19; F 30; Fig. 3).

The Rössen culture finds are currently the earliest settlement traces of Danubian Neolithic cultural groups both in this region and in the northwest German low-

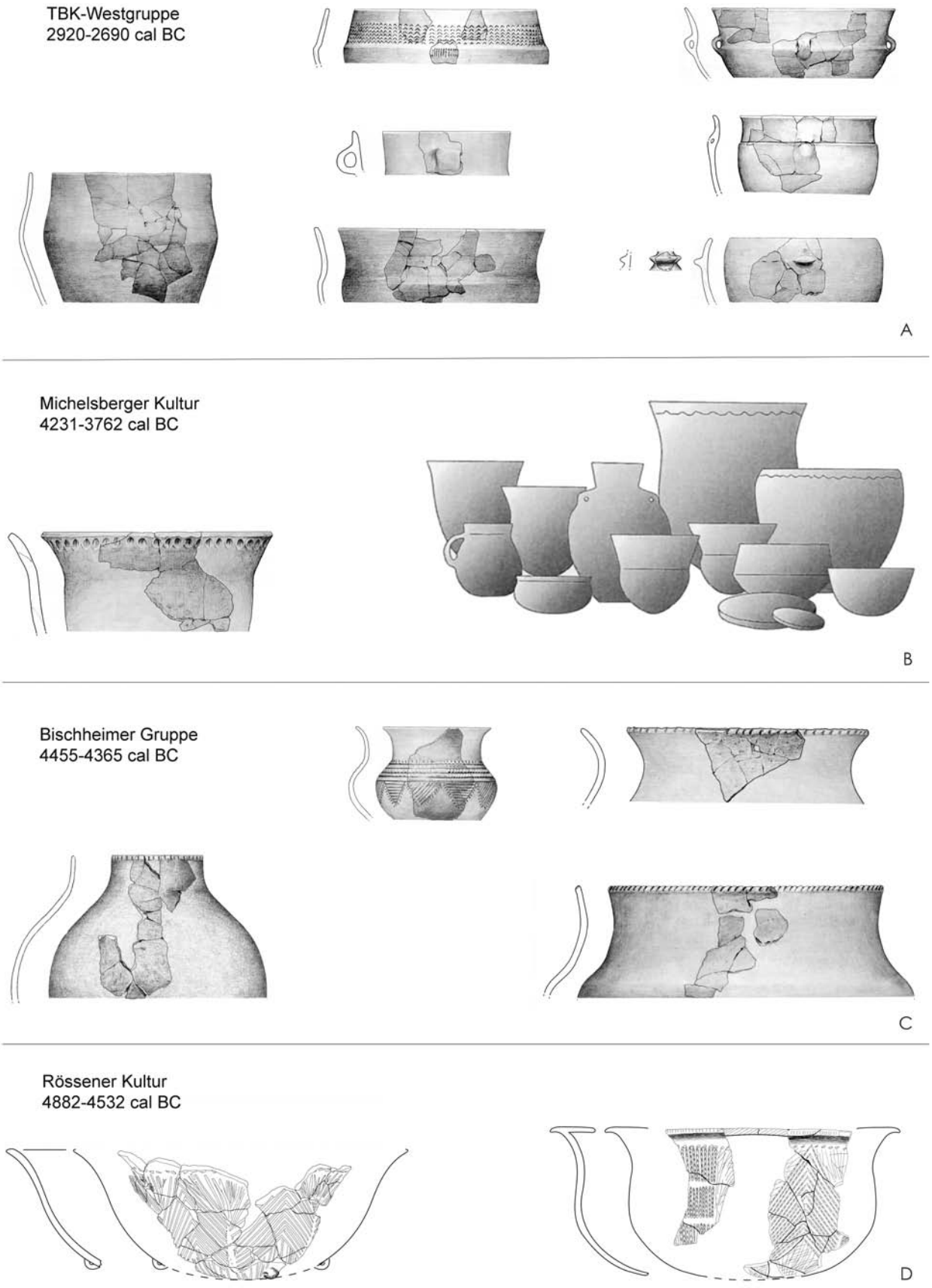

Fig. 4 Nottuln-Uphoven (Kr. Coesfeld). Sequences of the Neolithic settlements (after Eckert 1986, with additions). **A** Funnel Beaker culture; **B** Michelsberg culture; **C** Bischheim group [Pit F 8]; **D** Rössen culture (after Eckert 1986; Knoche 2008, with additions).

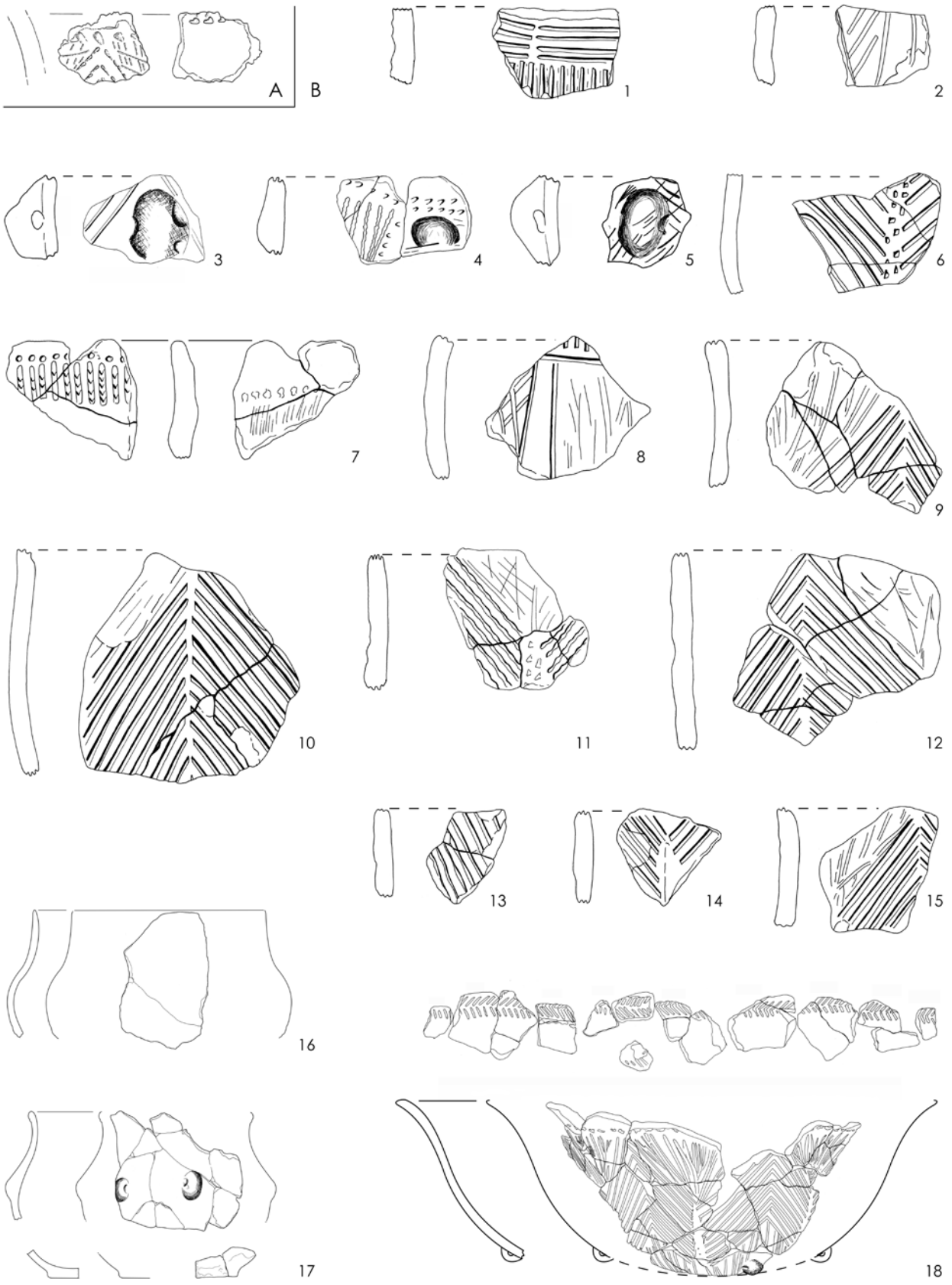

Fig. 5 Nottuln-Uphoven (Kr. Coesfeld). Rössen culture: **A** Stray find (after Eckert 1986); **B** Pit F 5 (after Groer 2013a).

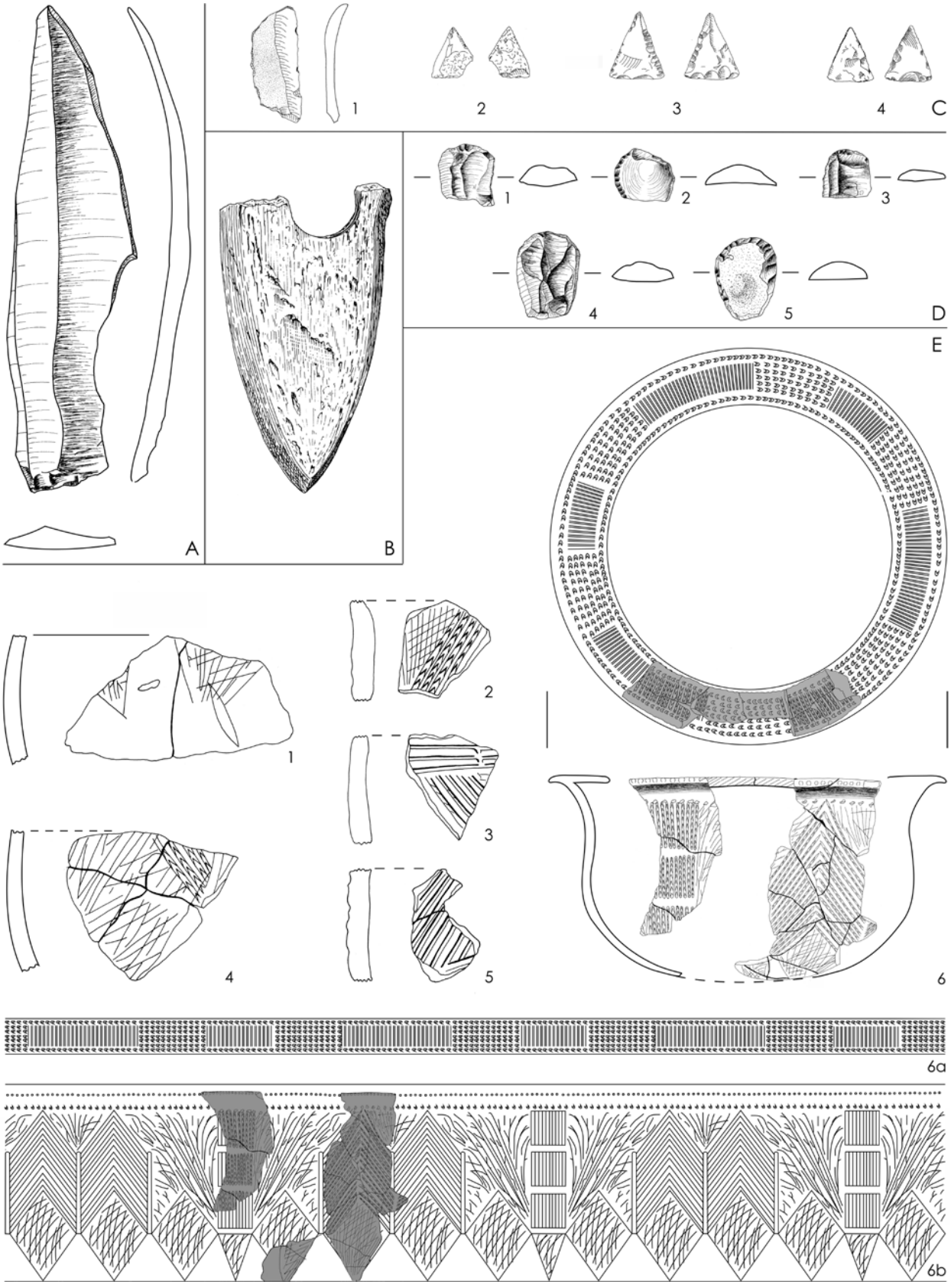

Fig. 6 Nottuln-Uphoven (Kr. Coesfeld). Rössen culture: **A** Pit F 1; **B** Stray find (after Eckert 1986); **C** Pit F 5; **D** Pit F 19; **E** Pit F 7 (after Groer 2013a).

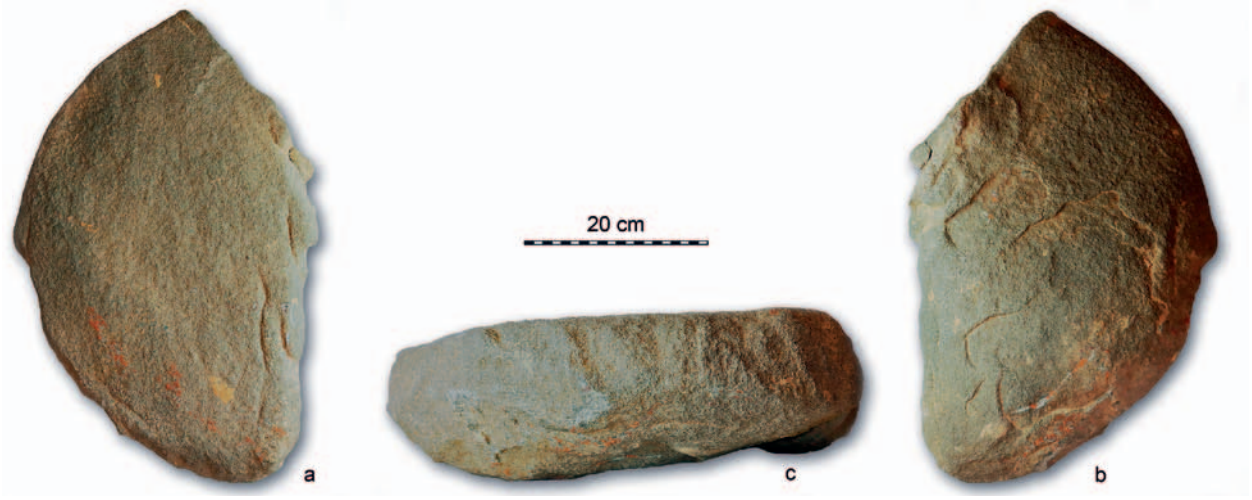

Fig. 7 Nottuln-Uphoven (Kr. Coesfeld). Pit F3 (Rössen culture). Grinding stone (fragment) of carbon sandstone with a weight of 13 kg (LWL-Archäologie Münster / J. Gryz).

lands in general. Because of the extensive erosion a typical trapezoid-shaped longhouse of the Rössen culture could not be ascertained, only some post-pits as the last remains of such post-built structures[1] were recorded.

Pottery

At Nottuln-Uphoven the Rössen culture is represented with about 70 decorated and undecorated vessels, mainly globular vessels and bowls, often incrusted with a white paste (selection: Figs. 5; 6,E). The composition of the pottery's decorations and motives allows its classification as an example of the typical chevron-banded style of the Rössen Rhine-Main cluster which belongs to a younger stage of the Rössen style (Dorn-Ihmig 1983). However, despite all similarities to the Rhinish Rössen style, some peculiarities appear at Nottuln-Uphoven. There is in the first place the enigmatic decorated bowl from pit F 7, which shows an extension of the decoration reaching 3.5 cm horizontally into the vessel's mouth, a unique feature among vessels from comparable cultural contexts (Groer / Bussmann 2010; Fig. 6,E6; 6a.b) . From the 'ceramic point of view' the Rössen settlement of Nottuln-Uphoven has to be interpreted in every respect as a direct 'outpost' located c. 40–70 km distant to the Rössen culture border of the Hellweg zone between Dortmund and Soest (see also Rörig / Knäpper 2018/2019).

1 Cf. Deiringsen-Ruploh: Günther 1976; Soest-'Rünstert': Buczka / Pfeffer 2015; Bad Sassendorf-Lohne: Schönfeld / Jörns 2015; Dortmund-Oespel: Brink-Kloke / Meurers-Balke 2003; Brink-Kloke / Schneider 2013.

Stone industry

Silex

About 2,500 artefacts from the Neolithic silex industry were discovered during the campaigns in 2007 and 2008. Only few typical triangular arrowheads with straight bases, scrapers and a blade for a sickle come from Rössen contexts (Fig. 6,C.D). During the Rössen period the local Baltic silex of morainic origin origin was almost exclusively used. There are only a handful of imported pieces. The Rullen silex variant, however, which is so dominant at the Rössen sites in the Rhineland, is totally absent. This suggests that the Rössen settlement had access only to local glacial deposits and no direct connections to the silex resources of the Rhineland, which is a significant contrast to the following period's settlement of the Michelsberg culture.

Grinding stone

Some fragments of querns and hammerheads are the only artefacts from rock material found during the excavations. Polished blades and axes were not found except from the single find of a perforated axe from the earlier excavation (Fig. 6,B). Concerning the material for grinding stones it is worth mentioning that the totally worn down 'Unterlieger' (weight 13 kg; reconstructed original weight c. 38 kg; for a grinding stone of the Rössen settlement of Dortmund-Oespel: Graefe 2009, 255f., Taf. 3; 5) unearthed from the Rössen pit F 3 (Fig. 7), consists of a distinctive variety of sandstone. This raw material must have been imported from the area of the Hellweg zone; it is totally absent in the glacial region of the Münsterland. In

contrast, all Michelsberg querns of Nottuln-Uphoven were made from local granites of glacial deposits in the neighborhood. This aspect indicates that the Rössen querns were directly brought to that site by immigrants who did not yet know or use the natural resources in the destination area.

Archaeobotanical and archaeozoological samples

Einkorn (*Triticum monococcum*) and Emmer (*Triticum dicoccum*) as well as barley (*Hordeum vulgare*) were grown during both the Rössen and the Michelsberg period. Cultivation of legumes has also been detected for these two periods due to sporadic charred seeds of pea and lentil. Hazelnuts were an important dietary supplement at all times. The charcoal finds show no essential differences in the wood species and the tree fruits available throughout all periods. Oak, ash, lime-tree, elm, and pome are common in the palaeoclimate of the Atlantic and Subboreal periods (unpublished report by U. Tegetmeier / R. Neef, University of Cologne). Unfortunately animal bones were not preserved due to the acidic loess soil. Rössen settlements of the Hellweg zone demonstrate the presence of domesticated animals (such as cattle, sheep/goat and pig: Günther 1976, 48–51; Buczka / Pfeffer 2015, 354).

Absolute Dating

A total of 14 AMS samples were selected from charred grain and hazelnut remains from most Rössen culture contexts and from several contexts of the Michelsberg and Funnel Beaker cultures (Fig. 8). The earlier dates indicate a settlement period from about 4,900 calBC to about 4,500 calBC for the time of the Rössen culture. They suggest that we do not simply deal with just an isolated short-time occupation, but that regarding the Rössen culture there was an extended period of settlement duration in this area north of the Hellweg zone.

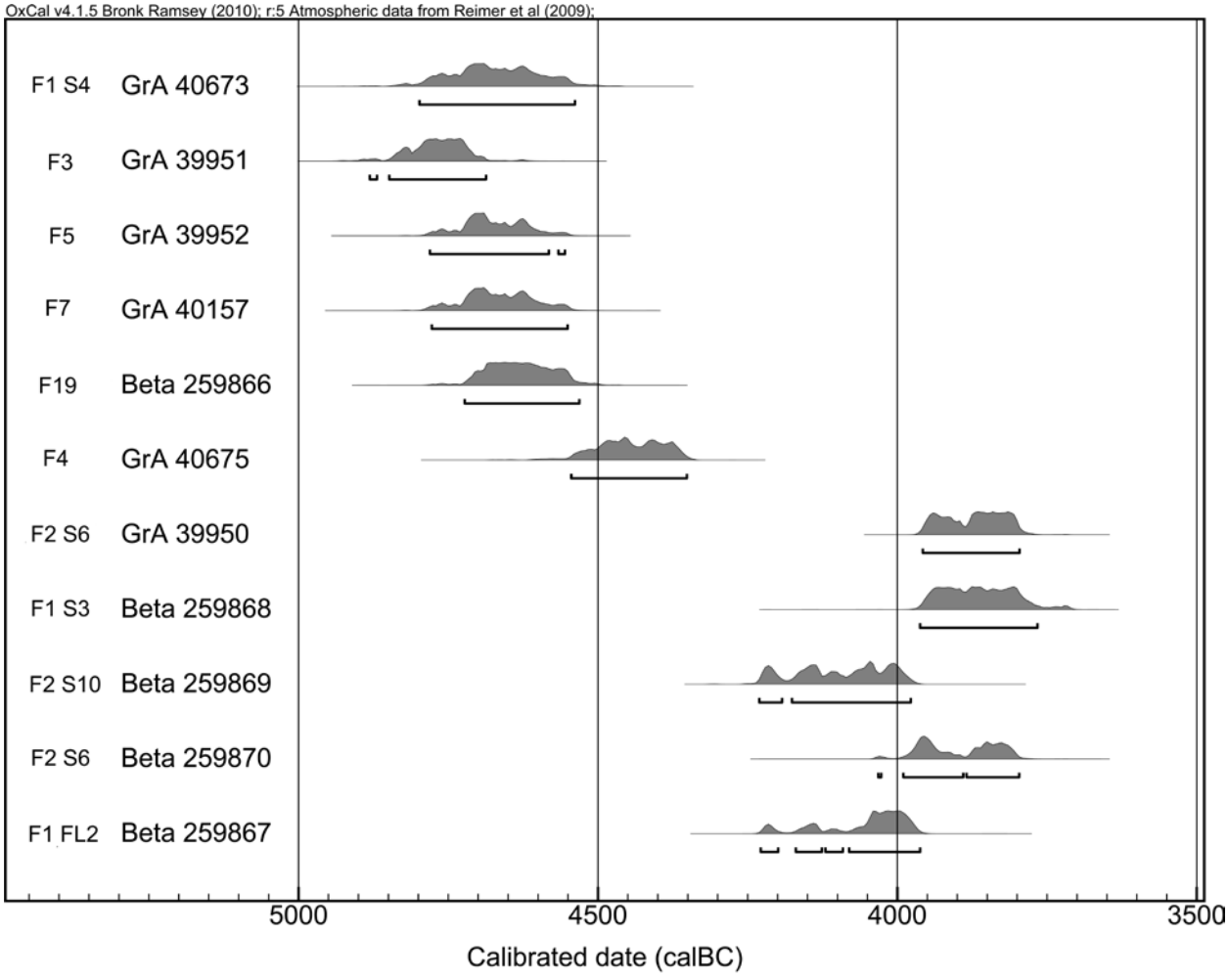

Fig. 8 Nottuln-Uphoven (Kr. Coesfeld). AMS dating of Nottuln-Uphoven (2007–2008): Rössen results to the left, Michelsberg results to the right.

Nottuln-Uphoven in the context of neolithisation in the northwest German lowlands

Regarding the neolithisation it seems that in the case of the Münsterland we have to envisage immigration during Rössen times originating from the settlement clusters of the Hellweg region c. 50–70 km south of the Baumberge hills (Figs. 1; 9). The shape and decoration of the Rössen pottery can be traced back almost exclusively to examples from inventories of the Rössen settlements in the region of Soest (Günther 1976). The import of a heavy sandstone quern refers to the same area of origin. The spectrum of the silex-varieties is similar to that of Deiringsen-Ruploh and other settlements from the Rössen Hellweg cluster. Furthermore a direct connection exists between the Rössen sites of the Hellweg zone and Nottuln-Uphoven via the river system of Stever/Lippe, which might have been navigable up to a certain point by logboats or canoes; or at least the rivers were simply used for orientation as landmarks when travelling by land. It is likely that the Neolithic pioneer-farmers of the Rössen culture were able to identify the small plots of fertile loess soil in the Baumberge region, for example by a particular kind of woodland and a different kind of vegetation.

The first occupation of the northwest German lowland by the Middle Neolithic Rössen culture was not the result of one single expedition. The series of the AMS-dates confirms a longer period of permanent colonisation at Nottuln-Uphoven over some generations (Fig. 8).

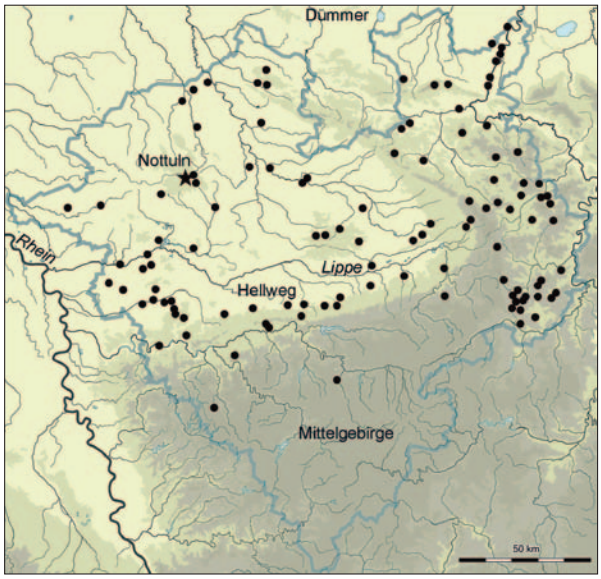

Fig. 9 Distribution of 'Danubian stone tools' (adzes/axes) in Westphalia. Star symbol: Nottuln-Uphoven (after Narr 1983, with additions after Groer 2013a).

The current map of distribution of the polished 'Danubian stone tools' assigned to the Rössen culture in the area of the Münsterland and the lowland might possibly treble the evidence known so far (Fig. 9). Unfortunately, these axes and adzes are mainly single finds without any archaeological context, and it cannot be definitely said whether their distibution represents Neolithic activities, exchange goods of local Mesolithic groups, or relics of premodern superstition ('Donnerkeil'). While Nottuln-Uphoven is interpreted as an outpost of the Neolithic world, evidence of contacts or coexistence with its Mesolithic neighbours is completely absent.

A natural overland link to the north into the northwest German lowlands existed via passes in the mountainous Teutoburg Forest and the Wiehen mountains along small rivers, mainly the Hunte, to the Dümmer lake (linear distance from Nottuln-Uphoven: c. 80–100 km). Near the Dümmer lake settlement with its mixture of Mesolithic and Neolithic elements (Hüde I) the oldest wooden pathway in the lowlands was detected (Campemoor Pr 31: Metzler 2004), dated to 4,614–4,540 denBC. This indicates contemporaneous activity with the Rössen settlement of Nottuln-Uphoven!

At the time of the northbound activities in the Early and Middle Neolithic periods southbound interactions existed as well. Inside a Rössen settlement in Soest-Rünstert (house V, pit 80) a piece of unprocessed amber was found (Fig. 10; Buczka 2013 Abb. 2,3). Most likely amber raw material comes from local glacial deposits in the lowlands or from farther north (Cimbrian peninsula: Woltermann 2016, 243 ff.; 247 Abb. 184–185). The interactions between Early Neolithic farmers and Mesolithic hunter-gatherers were certainly not always peaceful. Anyhow, the destruction of the LBK-well (well I) of Erkelenz-Kückhoven (Kr. Heinsberg, Rhineland), dated to c. 5,110 denBC, is interpreted as the result of an attack by hunter-gatherers living in the neighborhood or farther away: from the bottom of the

Fig. 10 Soest-Rünstert, Rössen settlement: House V, pit 80 (Kr. Soest). Unprocessed piece of amber with a length of 2,8 cm (Stadtarchäologie Soest / Chr. Theopold).

well there emerged a Holmegaard-type bow known from Mesolithic contexts and a perforated amber bead (Weiner 1995; 1998; Woltermann 2016, 85–86 fig. 46; 353 Nr. 586).

Summary

Obviously, the Rössen settlement of Nottuln-Uphoven with its full 'Neolithic Package' is not a site like Hüde I at Lake Dümmer or Hamburg-Boberg (Laux 1986; Thielen 2018). Nevertheless, during the 5th millennium calBC groups who maintained a purely Neolithic life-style are recorded in the northwest German lowland. However, there were complex hunter-gatherer societies at the same time, pursuing both an acquiring and producing economy, and even some communities existed who apparently maintained a purely foraging way of life. In this regard the neolithisation as a continuous process has to be questioned in general. Furthermore, differences between the find complexes of the Rössen, Bischheim, Michelsberg and Funnel Beaker cultures at Nottuln-Uphoven could be ascertained, which exceed the general cultural specifications (Fig. 1).

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Early and Middle Neolithic hoards in the area of the northern Mesolithic[1]

Michael Müller and Michael Schirren

Abstract In 2016 seven shaft-hole axe heads and two adze heads were discovered at Friedefeld in Mecklenburg-Western Pomerania (Germany). The discovery was dated to the Middle Neolithic period and interpreted as a hoard. In connection to this hoard, we are discussing here similar finds from the same and earlier periods. By comparing the composition of the different hoards and their distribution, we are debating several issues concerning Early and Middle Neolithic (5,500 – 4,400 cal BC) stone tool depositions from central and northern Europe. It will be argued that Neolithic exploration groups were the originators of these stone tool hoards from the territory of today's northern Germany and Denmark, which were at that time inhabited by Mesolithic hunter-gatherers. The authors furthermore interpret the depositions as spatial markers, which were used by the Neolithic groups to claim newly discovered or to demarcate existing settled areas.

Zusammenfassung *Im Jahre 2016 wurden bei Friedefeld in Mecklenburg-Vorpommern (Deutschland) sieben Axt- und zwei Dechselklingen entdeckt. Der Fund wird von den Autoren als mittelneolithischer Hort interpretiert, welcher im vorliegenden Aufsatz ausführlich besprochen wird. In die Auswertungen werden sowohl zeitgleiche als auch früher datierende Horte einbezogen, deren Komposition und Verbreitung miteinander verglichen werden. Des Weiteren werden verschiedene Aspekte der Niederlegungen mit Steingeräten des Früh- und Mittelneolithikums (5500 – 4400 calBC) in Mittel- und Nordeuropa debatiert. Es wird argumentiert, dass es neolithische Pioniere waren, die vergleichbare Deponierungen auf dem Gebiet des heutigen Norddeutschlands und Dänemarks niederlegten, welches zu jenem Zeitpunkt von mesolithischen Gruppen bewohnt war. Zudem werden die Deponierungen als Raummarkierungen neolithischer Gruppen interpretiert, die dazu dienten, neue Gebiete für sich in Anspruch zu nehmen oder bestehende Siedlungsareale abzugrenzen.*

Introduction

During an archaeological monitoring[2] in July 2016 in the district Friedefeld, west of the Pomeranian city of Penkun (Mecklenburg-Western Pomerania, Germany), a Middle Neolithic stone tool hoard was discovered (for location see Figs. 5; 8). The find was made while digging a 0.4 m wide trench with the aid of an excavator. Seven shaft-hole axe heads and two adze heads (Fig. 1) were scooped up by the excavator, with no outline of any archaeological feature visible on the surface of the find place.

All nine artefacts came out at once in one shovel, and no further finds could be made in the vicinity. Based on these circumstances, it was possible to reconstruct that the objects had been packed together in the ground, lying partly on top of one another. The stone implements were embedded at about 0.5 m below the top soil, in the genuine white-yellow glacial sand. With the exception of a chipping on the cutting edge of a shaft-hole axe head and small scratches on some of them, the objects had not suffered any significant damage.

The site is located about 800 m from the eastern edge of the Randow valley. The valley of the River Randow, draining from south to north, is of glacial origin and largely swampy today. The river flows through a relief-rich, Weichselian end moraine landscape of the Pomeranian phase. The banks of River Randow are to a large extent modeled by erosive processes, with jagged slopes of up to 24 m in height. The site itself is located at the northwestern foot of a distinctive hilltop, which was referred to in the Royal Prussian Land

1 In this paper we refer to the terminology proposed in Lüning 1996.

2 The monitoring was carried out by the Landesamt für Kultur und Denkmalpflege (State Office for Culture and Preservation of Monuments) of Mecklenburg-Western Pomerania. For more details see Müller et al. in prep.

Fig. 1 The Middle Neolithic hoard of Friedefeld (Mecklenburg-Western Pomerania) with the stone artefacts in front and side view.

Survey ('Urmesstischblatt') of 1835 as 'Hüttenberg'. The frequently detected black soils in the find area and in its immediate surroundings are today mostly secondarily relocated and only preserved as colluviums (Fischer-Zujkow 1998; 2000; Fischer-Zujkow et al. 1999).

The Friedefeld hoard is only the most recent discovery of several similar Neolithic depositions in the region, but also the largest one so far, judging by the number of contained items. Until now, this group of hoards is the northernmost concentration of its time and kind, while evidence of Middle Neolithic habitations in the same region has been unknown so far. Moreover, a great number of contemporary finds from Late Mesolithic groups in the area lead to many questions concerning the relation between local hunter-gatherers and Neolithic people. Who of them put those depositions into the ground, and how might one interpret them today?

Objects of the Early and Middle central European Neolithic in the area of the northern Mesolithic

While the Early Neolithic (5,500–5,000 cal BC) in central Europe was dominated by the Linear Pottery culture, in the following Middle Neolithic (5,000–4,400 cal BC) several new pottery decoration styles and tool types emerged. They were connected to cultures[3] named today Hinkelstein, Großgartach, Stroke-ornamented Pottery, Rössen or Bischheim.

Not only the material culture changed during the Middle Neolithic, but also the choice of inhabited territories and therewith the soils destined for agriculture and living. For the entire duration of the Linear Pottery culture, the choice of soils remained rather conservative, the habitation being bound to loess. However, during the Middle Neolithic period an expansion of the living space is visible, as also wet and forest soils, on clay or sand, were then incorporated.[4]

It were the fertile soils developing on the loess, especially black soils, that attracted the Early Neolithic settlers. In Germany, the northernmost loess soils extend approximately until the line Hanover-Magdeburg.

3 It is important to note that with the term 'culture' we refer here to a distribution of similar artefacts, burial practices and decoration styles of an area, and not to ethnic entities (see Lüning 1972; Furholt 2014).

4 Ehrhardt 1994, 67; Lönne 2003. If changing climatic conditions or other reasons are connected with this choice, shall not be discussed in this paper.

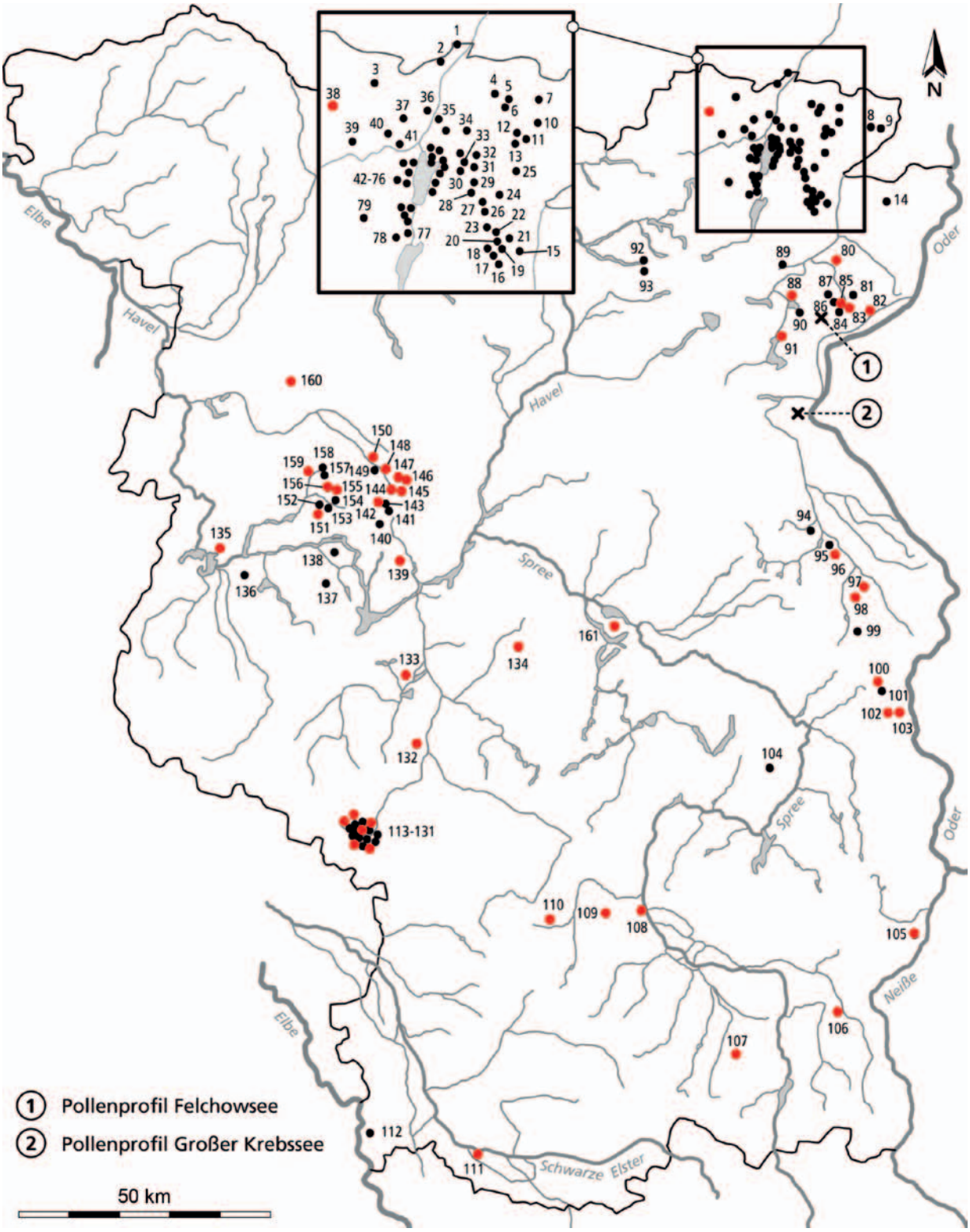

Fig. 2 Find places in Brandenburg for Early Neolithic (Linear Pottery culture; black dots) and Middle Neolithic (Stroke-ornamented Pottery culture and Rössen culture; red dots). Depositions were not included (modified after Czieśla 2008, 414 fig. 3).

During the late 6th and the 5th millennium the land north of this area was dominated by a Mesolithic 'lifestyle', as southern Scandinavia and parts of northern Germany were inhabited by people of the Ertebølle culture. The Swifterbant culture was distributed in the northern Netherlands and northwestern Germany (between the line Antwerpen-Hamburg; see Raemaekers 2016, 23), while south of the Mecklenburg lake plateau and in the region of the modern federal state of Brandenburg, still insufficiently in-

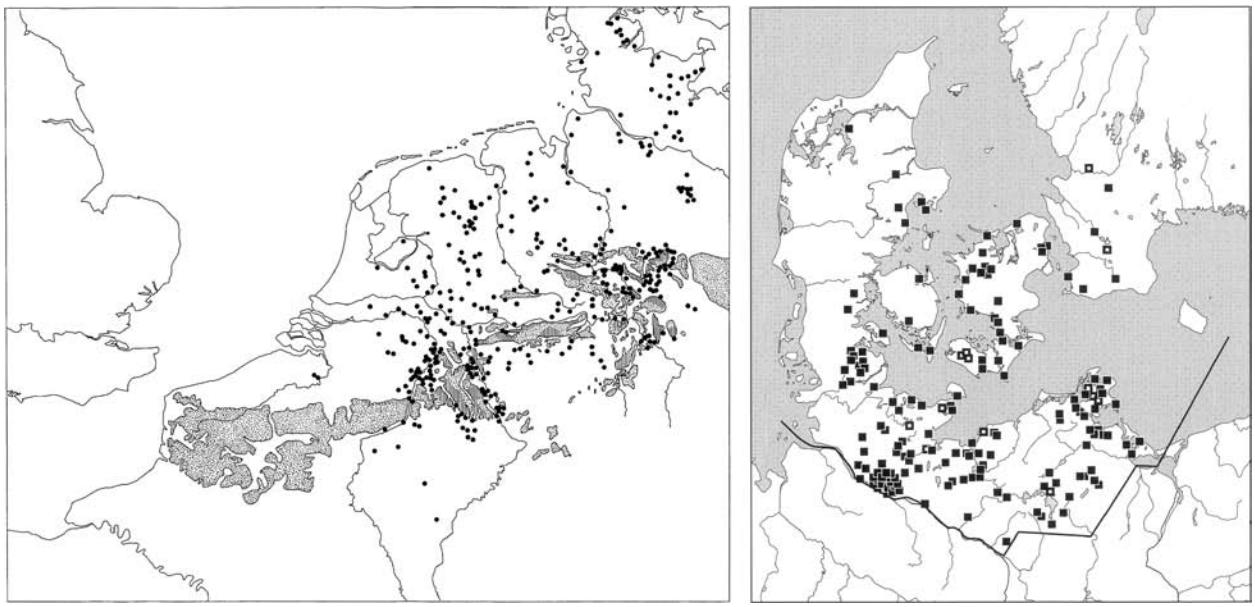

Fig. 3 Middle Neolithic stone axe heads with shaft-hole found in Mesolithic habitation layers or as single finds in the Mesolithic occupation area (left side mapped after Verhart / Wansleben 1997, 70 fig. 7; right side mapped after Klassen 2004, 49 fig. 31).

vestigated, there was the so-called 'inland Mesolithic' (Cziesla 2008, 408; Terberger et al. 2015).

In the Uckermark region, situated in the northeastern part of Brandenburg, beyond the large loess landscapes, areas with black soils developed on calcareous boulder clay.[5] It is worth noting that in the same region the northernmost settlement area of the late Linear Pottery and the succeeding Stroke-ornamented Pottery cultures is assumed (Fig. 2). This is based on the evidence offered by lithic industry, pottery, elongated pits and a few other house features as well as isolated graves (Parschau 1988; Wechler 1993, 61; Terberger et al. 2009, 261). However, palynological evidence has so far remained unsatisfactory (cf. Cziesla 2008).

Further north, in the area of Mesolithic hunter-gatherers, no less than a few hundred certainly Neolithic finds are known. This includes shaft-hole axe heads (Fig. 3a–b) and adze heads of stone as well as sherds of ceramic vessels assigned to the Linear Pottery, Stroke-ornamented Pottery and Rössen cultures. Yet, there is no evidence for contemporary Neolithic settlements in that area. Instead the Neolithic objects, particularly axe heads with shaft-hole, occur regularly in connection with Mesolithic features.[6] In Denmark, several dozens of axe heads with shaft-holes were revealed so far and around five times as many as in southern Sweden (Klassen 2004, 22). However, at a closer look we see that only an amount of around 15 % of these objects was discovered in direct Mesolithic contexts.[7] Additionally, it was suggested that these items came into the ground not long after reaching the Mesolithic area (Hartz et al. 2011). Until now, complete shaft-hole axe heads and fragmented ones were found in the Mesolithic area in a ratio of 2 : 1. Both the complete and the fragmented shaft-hole axe heads were connected with Mesolithic sites. Nonetheless, the majority of central European Neolithic items were found either as single finds in the area of the northern Mesolithic or without any available information of their find circumstances.

In addition to being found within settlements and as single finds, central European Neolithic heavy stone tools occur in hoards in the distribution area of the Mesolithic. A dense concentration of Middle Neolithic hoards was uncovered in the southeastern part of Western Pomerania, in the lower Oder region, while two more were discovered on the Danish islands Lolland and Askø (Fig. 5). In all these cases no contemporary Neolithic settlement could be identified until now.

5 Cf. https://mlul.brandenburg.de/Steckbriefe-BB-Boeden/a_sb_3_1.pdf (accessed: 02. November 2019).

6 General overview: Terberger et al. 2009; Mecklenburg-Western Pomerania: Mertens / Schirren 2000; Lübke at al. 2000; Netherlands: Verhart / Wansleeben 1997; northern Germany and southern Scandinavia: Klassen 2004; Poland: Czekaj-Zastawny et al. 2011.

7 This value and the following numbers are based on the information given in the catalogue by Klassen 2004 which involves the territories of Mecklenburg-Western Pomerania, Denmark and Sweden; see also Hartz et al. 2011, 53.

Neolithic depositions in central and northern Europe

The terms 'hoard' and 'deposition', which we are using in this article, need perhaps some further explanation. The term 'deposition' refers to hoards, which are defined as a minimum of two objects put in the same place at the same time, as well as to single object depositions (see Hansen 2002 for further discussions on that topic). Both terms describe finds which are neither grave goods nor settlement finds. First theories about hoards from prehistoric times were published in 1866 by the Danish archaeologist and director of the Danish National Museum, J. J. A. Worsaae (Worsaae 1866). While his examinations were exclusively connected to Bronze Age hoards, Worsaae's successor, S. Müller, was among the earliest archaeologists mentioning and characterising Neolithic hoards (Müller 1886). In 1914, K. Schumacher published an article about Neolithic hoards from all parts of Germany (Schumacher 1914). The presented finds come from the entire Neolithic period, starting with the Linear Pottery until the northern Final Neolithic phase. Early theories about the nature and the purpose of hoards varied considerably and included trade goods, caches, stashes or sacrificial offerings.[8]

Past decades' studies brought many arguments supporting a ritual interpretation for most of the Neolithic hoards. The recurring selection of objects, their often extraordinary sizes or surface treatments as well as their arrangements, and the choice of the places for the depositions suggest they might have served as ritual offerings,[9] dedicated to imagined supernatural beings. Nevertheless, cases exist where evidence strongly suggests that the depositions can sometimes be seen as left-behind caches, like in the case of blanks found close to exploitable resources (cf. Becker 1980).

The largest number of depositions for central and northern Europe is known from the time of the Funnelbeaker culture ('Trichterbecherkultur', c. 4,100–2,800 cal BC; hereinafter referred to as TRB complex); these have been studied for several regions.[10] The objects occurring most often and most widespread are flint axe heads, followed by amber beads, ceramic vessels, copper items and flint blades. A new study about the whole range of TRB depositions is in preparation (Müller in prep.). The two-sided pointed-butted flint axe head is the earliest axe head type of the TRB. It is still not sure how the deposition custom started in the northern Neolithic, but there is evidence that the practice was already established at the very beginning of the TRB (Müller in prep.). It is rather unlikely to see roots of TRB deposition practices coming from the preceding Ertebølle culture, due to the quantitative lack of recurring hoards with Ertebølle stone tools, especially flint axe heads. Over the past 15 years, the influences of the western / central European Michelsberg culture (4,400–3,500 cal BC) in the formation of the TRB complex were convincingly argued (cf. *inter alia* Klassen 2004; Sørensen 2014). In the distribution area of the Michelsberg culture depositions of two-sided pointed butted axe heads are also known. These are made of Alpine rocks, mostly eclogite, omphacitite and jadeitite, but also amphibolite and serpentinite, which were exploited from the late 6th millennium BC and were circulating through exchange networks even to the outer fringes of Europe (Pétrequin et al. 2008, 261). Following, we will refer to these items as axe heads of Alpine rocks or Alpine axe heads.

Due to the scarcity of finds of heavy stone tools in Michelsberg graves or settlements (Jeunesse 2010, 51; Ramminger 2010, 198) it was long unclear whether the depositions and single finds with axe heads of Alpine rocks occurring in the Michelsberg distribution area can indeed be connected to that culture. Taking all the pieces of evidence together, however, we can only see the people of the Michelsberg culture as the actors of those depositions (cf. Kreuz et al. 2014, 75; Bérenger 2015, 217). But it must be noted that even before the emergence of the Michelsberg culture axe heads made of Alpine rocks were of great importance to the people at the Gulf of Morbihan in Brittany (France) in the first half of the 5th millennium BC. There Alpine axe heads occur in depositions and in very large numbers inside the tumuli of

8 See, among others, Kauffmann 1913; Schumacher 1914; Petzsch 1928; Aust 1961; Stjernquist 1962/1963; Becker 1952; 1976.

9 *Inter alia* Rech 1979; Ebbesen 1995; Koch 1998; Klimscha 2009; Müller in prep.

10 *Inter alia* for Sweden: Karsten 1994; Denmark: Nielsen 1977; Koch 1998; Ebbesen 1995; the Netherlands: Wentink 2006; Germany and Scandinavia in general: Rech 1979. – The abbreviation 'TRB' comes from the German word 'Trichterrandbecher', which is tranlated into English as 'funnel-necked beaker' (after the shape of typical ceramic vessels). It became the standard abbreviation also in the English language.

assumedly high ranking people (Klassen et al. 2011; Pétrequin 2016, 419).

The depositions of the Michelsberg and especially the TRB groups, dating to the Younger Neolithic (4,400–3,500 cal BC), are not the first kind of Neolithic depositions known from Europe. Already in the Early and Middle Neolithic period (5,500–4,400 cal BC) the people of the Linear Pottery, Stroke-ornamented Pottery and Rössen cultures showed extensive deposition practices which involved mostly adze heads and axes with a shaft-hole. So far, there has been no coherent elaborate study about the hoards from the Linear Pottery, Stroke-ornamented Pottery and Rössen cultures, although many regionally focused articles provide detailed catalogues, giving a very good overview. Besides Schumacher's paper from 1914, especially an article by H. Quitta (Quitta 1955) provides a catalogue in which he included material from Germany, Poland, the Czech Republic and Slovakia.[11] For the Czech Republic and Germany, S. Vencl (Vencl 1975) needs to be referred to, while M. Salaš (Salaš 1986) focused on the Moravian depositions. The few Stroke-ornamented Pottery / Rössen hoards from Poland were mentioned in the catalogue about Neolithic depositions from Poland by J. Kaflińska (Kaflińska 2006).

Contents, compositions and sites of Early and Middle Neolithic depositions

The data on which this investigation is based derives mostly from catalogues as well as other relevant sources[12] and includes finds from the territories of modern Germany, the Czech Republic, Slovakia, Poland and Denmark. Some of the finds from northeastern Germany and Denmark were personally examined.

As mentioned before, the main content of Early and Middle Neolithic hoards in the study area are heavy stone tools. From the 113 depositions analysed here, only three do not contain heavy stone tools, but instead consist only of flint blades. Of these three only one hoard can be dated with certainty to the Stroke-ornamented Pottery culture, the remaining two possibly being Early or Middle Neolithic.

The German terminology – used to characterise the different or even the same types of Early and Middle Neolithic heavy stone tools – became very confusing over the decades (cf. Brandt 1995; Klassen 2004, 20–24). Those respective terms have sometimes little to do with the prehistoric reality, as they are more often connected with typological determinations, without any prior statistical analysis.[13] Because tool shapes were described in a rather individual manner, many different terms were formulated. This, of course, is an often discussed aspect, and we will not insist on it here. However, we choose to mention it, as in the following descriptions we will try to stay as technical as possible. Essentially, the heavy stone tool industry is dominated by three main types, namely adze heads, axe heads with shaft-hole and axe heads without shaft-hole.[14]

During the Early Neolithic Linear Pottery culture, adze heads represent the main heavy tool type, in general, but also within hoards. It can be differentiated between flat broad adzes (flat hoes / 'Flachhacken') and narrow adze heads (known as shoe-last celts / 'Schuhleistenkeile'). The latter type can be further divided into variants determined by height.[15] None of them have a shaft-hole, which is a general aspect for almost all heavy stone tools of the Linear Pottery culture (Biermann 2011, 37). Shaft-hole tools emerge only in its latest phase. One example is given by the so-called double-edged adze or double hoe, a perforated tool, made of soft stone, presenting two blunt edges pointing away from each other (Biermann 2011, 40).

The first perforated shoe-last celts can possibly be connected to the transition period from Early to Middle Neolithic. Because their shaft-holes are oriented transverse to their cutting edges, they are technically only perforated adze heads and not shaft-hole axe heads, in which case their shaft-holes would have to be oriented parallel to their cutting edges (Biermann 2011, 40).

11 Kaufmann 2012 shows that Quitta's catalogue still provides the actual state of art, at least for central Germany.

12 Mainly the following sources were used for the Czech Republic: Quitta 1955; Vencl 1975; Salaš 1986; Slowakia: Quitta 1955; Vencl 1975; Poland: Kaflińska 2006; Germany: Quitta 1955; Vencl 1975; Rech 1979; Denmark: http://www.kulturarv.dk/fundogfortidsminder, and personal communication with Dr. Lasse Sørensen (National Museum Copenhagen), whom we kindly thank.

13 See Ramminger 2007 as an example of the possibilities for statistical analysis on Early and Middle Neolithic heavy stone tools.

14 The differentiation between the last two types is made clearer in the German archaeological terminology: an axe head with a shaft-hole is an 'Axtklinge', while an axe head without shaft-hole is named 'Beilklinge'.

15 This division was also suggested by statistical analyses: Ramminger 2007.

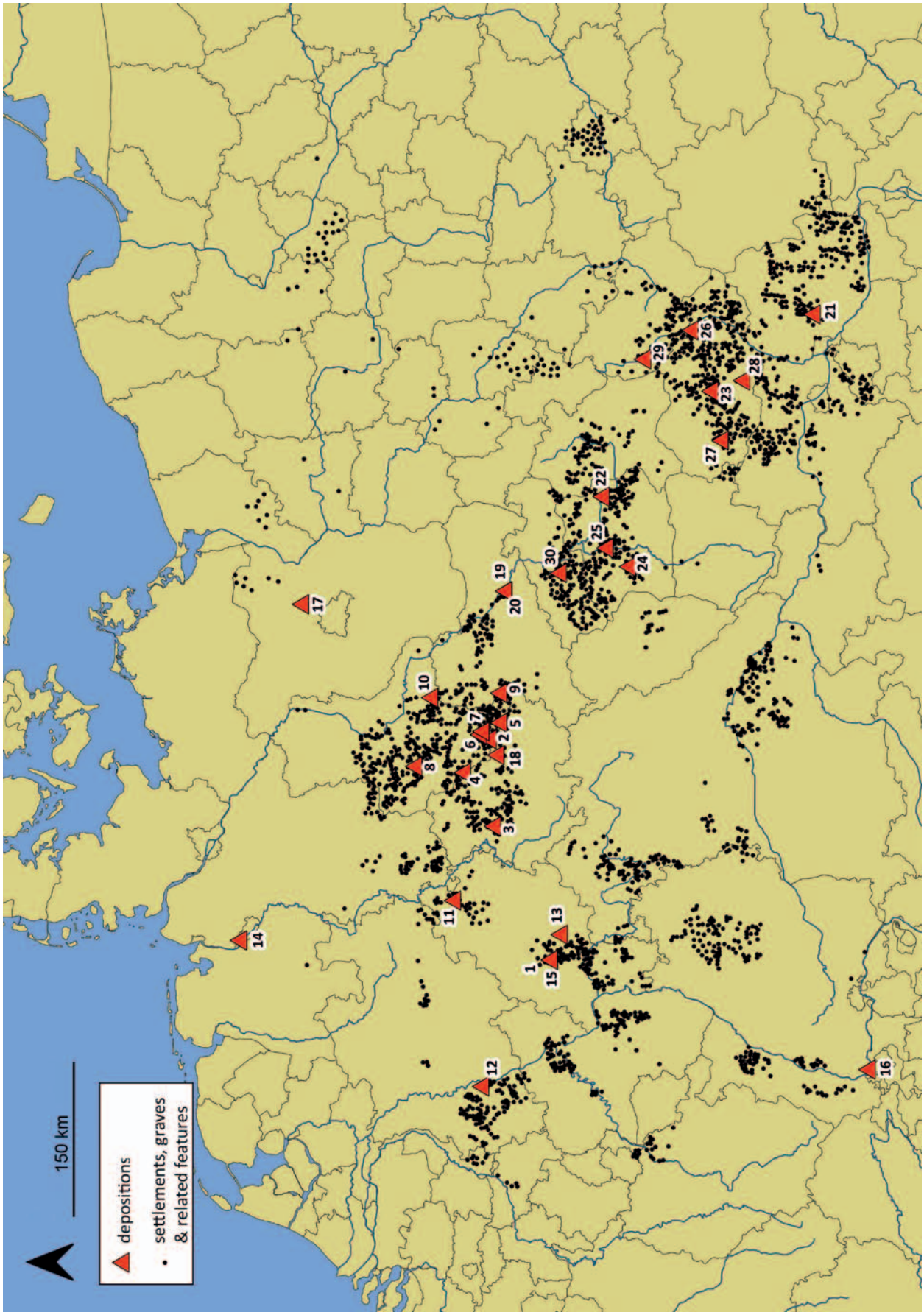

Fig. 4 Distribution of Early Neolithic finds in central Europe (base map with settlements, graves and related features modified after Preuss 1996, map 1). See attached catalogue for the site names and a short description of the depositions.

At the beginning of the Middle Neolithic, the unperforated shoe-last celts were still in use, but in a decreasing amount, with the first shaft-hole axe heads starting to be in use (Lönne 2003, 176). Yet, these are still just perforated adze-shaped tools, only with their shaft-holes oriented parallel to their asymmetrical cutting edges. Moreover, the first shaft-hole axe heads with a pointy triangular shape (so-called broad wedges) were employed. Their number increased gradually until the time of the Stroke-ornamented Pottery culture, while the shaft-hole axe heads represented by perforated adze heads became fewer in number (Biermann 2011, 41).

These changes in tool types, from the Early to the Middle Neolithic, and the introduction of different hafting methods, go along with new working methods and possibilities (e.g. Elburg et al. 2015). Even if it was often tried to connect some of the new tools exclusively to distinct Middle Neolithic cultures, in depth-research suggests that no definite assignment is possible (Lönne 2003, 177–178; 182; Kaufmann 2012). Furthermore, in nearly all cases, it was so far impossible to connect scientifically dateable material with the hoards. For this reason, and due to a lack of metric studies on the items from Early and Middle Neolithic hoards, we will restrain from making such assignments in this paper. Another shortcoming has to do with the lack of information concerning the stone tools from some of the hoards, as the items themselves got lost and the only few available details come from old field reports. Luckily, in many such cases the reports mention at least axe heads with shaft-hole, making a Middle Neolithic dating possible.

According to the criteria mentioned so far, 28 of the 110 depositions containing heavy stone tools included in our study can be dated to the Early Neolithic period, which is represented by the Linear Pottery culture. The remaining 82 depositions can be assigned to one of the Middle Neolithic groups, where Stroke-ornamented Pottery culture and Rössen culture make up the biggest part. However, the assignment is not certain in every case, especially due to the lack of basic information concerning discoveries by chance and/or without a proper archaeological examination. For this reason, the distribution maps and examinations presented here have to be considered preliminary until further research has been carried out.

The distribution map in Figure 4 displays find spots of depositions from the second half of the 6th millennium BC, i.e. the Early Neolithic period. Clusters of depositions are visible in Moravia, Bohemia and in central Germany, while in their surroundings the distribution is rather loose. In northern Germany, only two hoards are known, and none in Poland.

The number of objects in the Early Neolithic depositions is usually between three and nine. Only two hoards from central Germany contained 15 and 16 items, respectively. In Hesse one probable single deposition has been identified until now. It contained an adze head (shoe-last celt), which was found under a stone (site Rockenberg; see Quitta 1955, 45 no. 41). Flat adze heads and different variants of shoe-last celts are the most common items in these depositions. Rarely are flint blades connected with heavy stone tools. A particular exception is one hoard from Saxony-Anhalt, containing one club head and twelve flint blades, unique in its composition (site Naumburg-Kleinjena [Saale]; see Quitta 1955, 33 no. 12). Preforms of heavy stone tools were found in ten depositions, and half of these were accompanied also by finished items. Blanks were found in four depositions, out of which only one contained additionally finished stone tools.

Concerning the nature of the ground into which the hoards were put, this information is available for 25 out of the 28 depositions, and in all the 25 cases, it appears to have been dry ground. Out of these, ten depositions were found inside and six other nearby a Linear Pottery culture settlement. It was mentioned that hoards, amongst other things, are defined by not being settlement finds. But the term 'settlement find' refers only to ordinary left-behinds from settlements, such as house debris, garbage, production waste, and lost or forgotten objects. Hoards on the other hand represent a recurring specific selection and combination of items which were left behind on purpose. Inside settlements they can be identified due to their separation from usual garbage, their special arrangement or unusual placement. Inside the settlements, the depositions were found in pits and, once, in a ditch. Two of the remaining twelve depositions with no connection to any settlement were each found under a big stone. In another case the items lay in a semicircle on a ceramic bed. One example is known where the stone objects were placed crosswise one above the other. Finally, for one hoard deposited in a settlement a covering with red paint (ochre?) was reported (Kaufmann 2012, 401).

This distribution picture of depositions changes in the Middle Neolithic Period, during the 5th millennium BC (Fig. 5). The 82 depositions known for this period show, besides three concentrations in Moravia, Bohemia and central Germany, as in the Early Neolithic period, also a dense cluster in northeastern Germany. Additionally, some more hoards

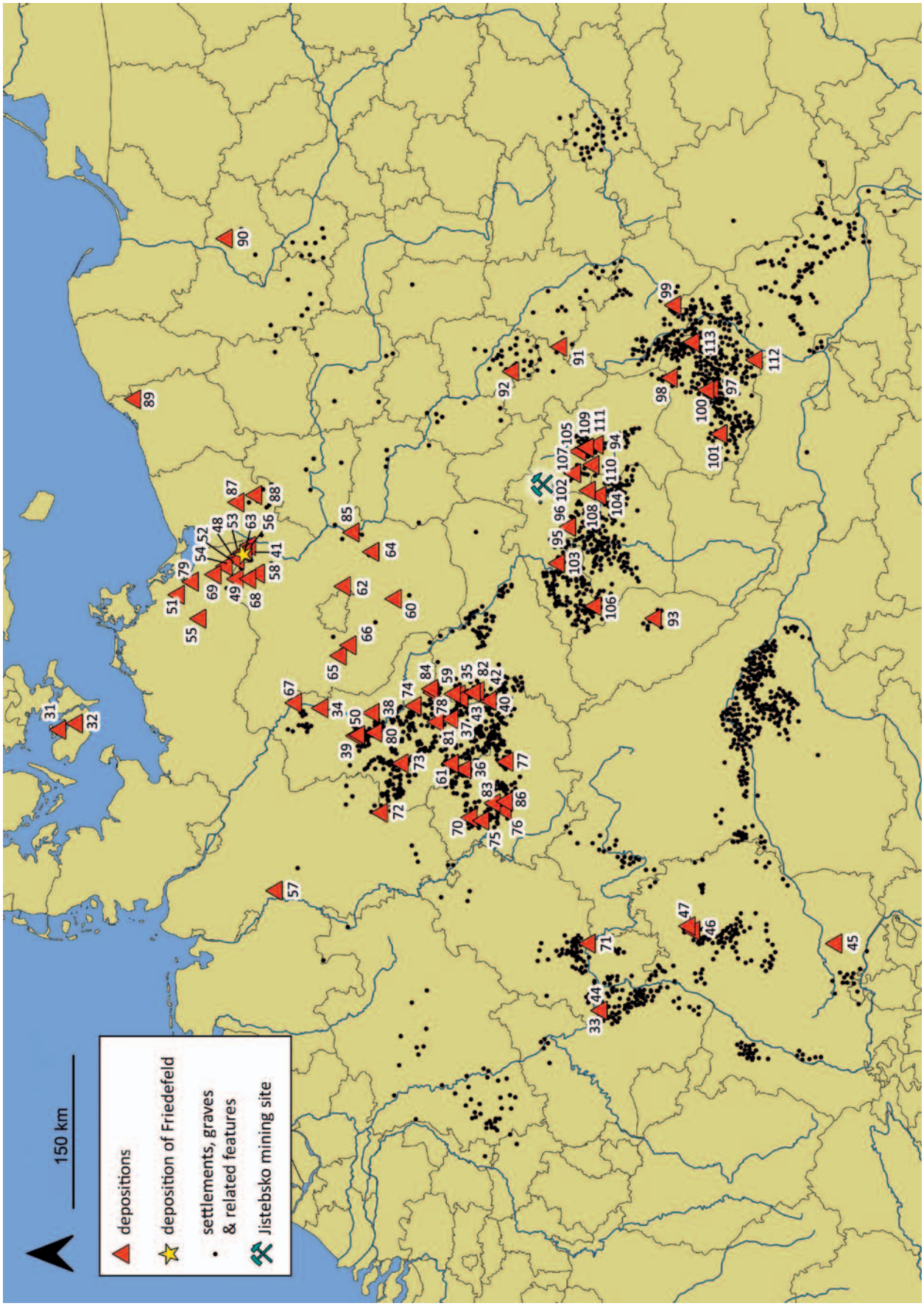

Fig. 5 Distribution of Middle Neolithic finds in central Europe (base map with settlements, graves and related features modified after Preuss 1996, maps 2–3). See attached catalogue for the site names and a short description of the depositions.

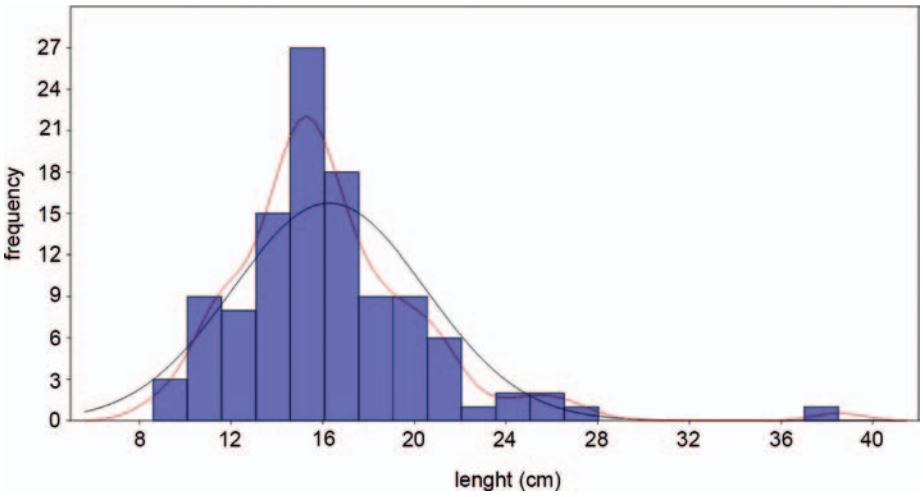

Fig. 6 Histogram showing the frequency of certain lengths of Middle Neolithic axe heads found in Mesolithic habitation layers or as single finds in the Mesolithic occupation area. The black line represents the ideal curve of a normal distribution and the red line the actual distribution curve.

were found in southwestern Germany, and for the first time finds appear in southern and northern Poland as well as in southern Denmark.

Most common is now a number between two and nine heavy stone tools in the hoards, although it is worth mentioning that 50 % (n = 41) of the hoards contain only two or three items. No certain single deposition could be detected so far, but many single finds are known, some of which are debatable (see below). Only three hoards show between 10 and 17 items, and in the case of one hoard, it may be that it contained up to 50 objects (site Čířtěves [Czech Republic]; see Vencl 1975, 13–18). 26 of the depositions consist only of axe heads with shaft-hole, in seven more depositions axe heads with shaft-holes were combined with axe heads without shaft-holes. In 15 cases, axe heads with shaft-hole are only combined with flat adze heads or shoe-last celts. Twelve hoards contained only flat axe heads and shoe-last celts, and could only be dated the Middle Neolithic period based on their find circumstances. Hoards with a mixture of all the tool types mentioned so far occur also rarely. Like in the Early Neolithic period, preforms were put into the hoards. Altogether 19 such cases are known, but only twice they were not combined with any other items.

For 57 of these Middle Neolithic hoards with heavy stone tools the nature of their find place was recorded: 52 come from dry ground, and five were found in connection with wet ground. These wet grounds were in three cases bogs or swamp lands, one time a river, and in the fifth case the items were found in the direct vicinity of a river. Besides the certain depositions discussed here, several single finds of axe heads with shaft-holes have been discovered in connection to water, for instance from the Elbe River (cf. Klassen 2004, 417). Out of the 52 hoards from dry ground, 13 were found inside a contemporary settlement, and two other hoards in the proximity of a settlement. Each out of five depositions not in any connection to contemporary settlements were found under a big stone. Observations on the arrangement of the objects are usually rare and, in most cases, they are limited to mentioning that the objects were found lying close together. In one particular case, it was noted that the objects in the hoard were arranged in a star-like shape (site Wollin [Mecklenburg-Western Pomerania, Germany]; see Quitta 1955, 41–42 no. 31). Also notable is a hoard in which the artefacts were put into the ground standing upright (site Möckern [Saxony-Anhalt, Germany]; Quitta 1955, 34–35 no. 13).

We attempt here to illustrate also the particular case study of the Middle Neolithic axe heads with shaft-holes from the northern Mesolithic distribution area. The data used for this examination included settlement and single finds from southern Scandinavia and northeastern Germany, as published by Klassen (2004), as well as shaft-hole axe heads from hoards from the same region and, additionally, from Brandenburg. Histograms, plotting the length of the items, indicate that Middle Neolithic shaft-hole axe heads from settlements as well as single finds show almost a normal distribution. The length variety lies between 7 and 22 cm (Fig. 6). However, notable is a small peak between a length of 22 to 28 cm, caused by one item from the Mesolithic pit at Rosenhof (Hartz et al. 2011) and seven single finds. The longest item, of 38.5 cm, is a single find from Tützpatz (Mecklenburg-

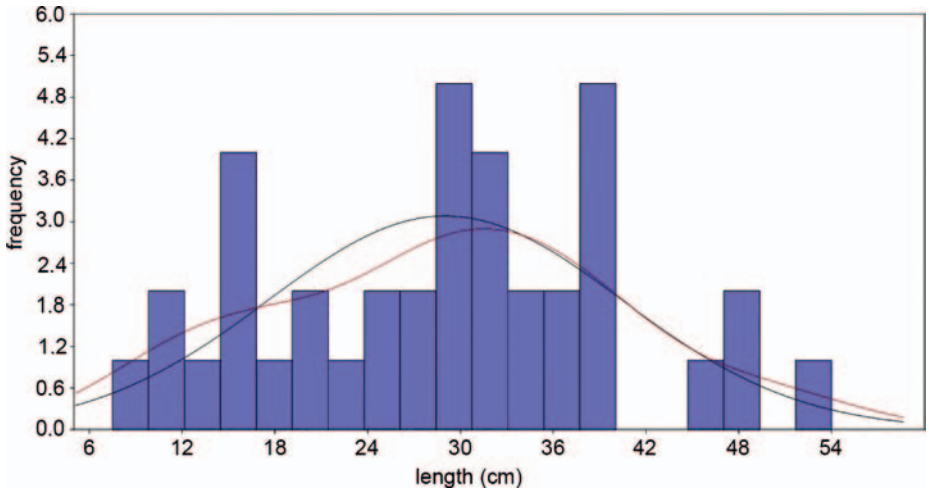

Fig. 7 Histogram showing the frequency of certain lengths of Middle Neolithic axe heads found in hoards in the Mesolithic occupation area. The black line represents the ideal curve of a normal distribution and the red line the actual distribution curve.

Western Pomerania; Klassen 2004, 421 no. 159). The average size of settlement and single finds is around 16 cm. Looking at the length distribution of axe heads from hoards (Fig. 7), a variety between 7.5 and 54 cm can be observed. The average size is around 29 cm. These results show that, judging by size, some of the single finds might have belonged to a hoard which was not recognised as such when found. Besides the long example from the Rosenhof pit, axe heads from northern Mesolithic settlements tend to be rather small (see below).

Alongside complete items, many fragmented axe heads were identified in the area occupied by Mesolithic groups. At a closer look, we can see that the amount of broken axe heads from the Mesolithic habitation layers is larger than the one of intact ones (at a ratio of 2 : 1; judging by information in the catalogue by Klassen 2004). It is, of course, a question whether also very small fragments are always correctly identified as parts of heavy Neolithic stone tools.

Discussion

When looking at the material and the find circumstances presented so far, two main questions arise: what does this picture show, and how do we interpret what we see? We will try to break down the debate into several parts, starting by discussing the hoards, in order to evaluate thereafter why they appear in the area of Mesolithic groups.

As shown so far, in the Early and Middle Neolithic, between 5,500 and 4,400 cal BC, most of the depositions consisted almost entirely of heavy stone tools with the number of items per hoard varying between two and nine objects. Only very rarely were stone tools combined with other items, like flint blades or sherds of ceramic vessels. This fact indicates that these deposition simply represent a deliberate selection of objects among all artefacts available at that time. There are, nevertheless, also examples of depositions which consist only of flint raw material or preforms (Biermann 2003, part 2) and others that consist only of ceramic vessels (Wetzel / Babiel 2016). These need to be investigated in the future to see how regularly they occur. The importance and value of heavy stone tools in the central European Neolithic has to be seen in connection with the clearing of the primeval forest. This additionally provided the users of such tools with the main building material for their impressive long houses, while the opened landscape offered the necessary space for practicing agriculture. Besides these obvious benefits, it became more apparent in the past years that the Neolithic in general was not necessarily a peaceful period, but one which also witnessed aggressive acts between groups of people, where heavy stone tools were used as weapons (cf. *inter alia*: Meyer et al. 2015). Finally, the expressions of Neolithic art confirm and add to the symbolic value of heavy stone tools (Trogmayer 1990; Zápotocká / Zápotocký 2014).

It has been stated that depositions with stone objects represent hidden trade goods, which were never recovered (Kaufmann 2012). If so, one should expect depositions preponderantly of raw material or preforms in the vicinity of the exploited resources and along possible trade routes. One of the main stone types used to produce the heavy stone tools of the

Early and Middle Neolithic was actinolite-hornblende schist, an amphibolites' variation. Mineralogical analysis showed that most objects made of this material originate from a quarry near the Bohemian village Jistebsko in the Jizera Mountains.[16] But, that being said, depositions at or near Jistebsko are lacking, and there are no depositions marking a possible trade route from or to the quarry, either. On the contrary, as shown, the depositions were found in the vicinity of settlement areas or inside settlements over central Europe and even in the Mesolithic areas of northern Germany and southern Scandinavia. Moreover, preforms occur comparatively seldom and, in many cases, intermixed with completed as well as used and re-sharpened items.

A well investigated case is the hoard from Friedefeld, containing seven axe heads with shaft-hole and two adzes. Seven of the Middle Neolithic items consist of actinolite-hornblende schist from the quarry of Jistebsko, which is about 300 km away. One of the axe heads was deposited as an unfinished piece, with only two of its four sides treated with the typical fine grinding, while the other two remained in a rough state. Additionally, all items from the Friedefeld hoard, except for this prework, show various direct and indirect use wear (Müller et al. in prep.).

Considering these aspects, it is hard to imagine lithic trade goods consisting of a combination of used stone tools and preforms. Why should an accumulation of tools which had already been used be traded, and why were they combined with objects which needed additional effort to become usable? And what might have been the reason to hide a part of these accumulations inside settlement pits, cover them with ochre or put them crosswise, upright or star-like? The trade hypothesis also cannot explain why the depositions were never retrieved by the people who had been hiding them. Additionally, it must be suggested that until today only a very low share of the depositions has been discovered and most of them probably still remain in the ground. From the combination and state of the items, one might get the impression that a certain moment determined the precise content of the depositions and that therefore in a limited time span all affordable and dispensable heavy stone tools were collected and put into the ground.

Coming back to the picture shown by the investigations on the length of the stone tools, we need to include here also the observations regarding the use wear of the axe heads. The functionality of the axe heads with shaft-hole is still under discussion. We would like to point further to the relation between the size of the axe head and the size of the shaft-hole. An ongoing debate is concerned with the rather small shaft-holes, especially when it comes to very large tool specimens. It was often doubted that these shaft-holes can hold a hafting strong enough not to break while chopping trees, which is why the items were imagined to have been used more like wedges for splitting tree trunks already on the ground, by holding the tool with the shaft in place and using a mallet to drive the shaft-hole axe into the wood (e.g. Kaufmann 2012, 394). In experiments, the wedge-idea was tested without much success, since it was not possible to drive the tools into the wood. What the experiments rather proved was that the axes can function very well for felling trees (Elburg et al. 2015). However, this could only be demonstrated for smaller specimens. Attempting to fell a tree with a 24 cm long shaft-hole axe blade showed that items of that size are already difficult to handle. It resulted also in the breakage of the axe head after a short time of usage (Elburg et al. 2015, 74). These observations, of course, make one wonder about the purpose of the very long shaft-hole axe blades with traces of use-wear, which were found in hoards. We also believe it is necessary to examine whether the shorter axe heads were intentionally produced in that size or represent repeatedly re-sharpened items.

A few hoards also include fragmented items. Judging only from the literature, it does not become clear if these objects were already broken when they were deposited. It is possible that, at least partly, the shaft-hole axes were destroyed only after being deposited, for instance due to intensive agricultural activities.

The selection of items which are included in the hoards represent all length categories, but a predilection for very long items is obvious. Especially in the Middle Neolithic hoard cluster from the lower Oder region (Fig. 8) some of the longest axe heads known were found (hoards of Friedefeld and Wollin; Rech 1979, 100 no. 57). Nevertheless, there are also hoards (for example Pasewalk [Rech 1979, 100 no. 65] and Waldeshöhe [Hellmundt 1964, 77]) with axe heads of smaller sizes, comparable to the ones found at Mesolithic sites. Even if there is so far no proof of contemporary Middle Neolithic houses in the area of the lower Oder hoard cluster, it is striking that these hoards were deposited in a manner

16 E.g. Nowak 2008; Kaufmann 2012. Besides mining, the use of river boulders, which were washed out of the quarry and might have had a more easily handable size, should also be taken into consideration.

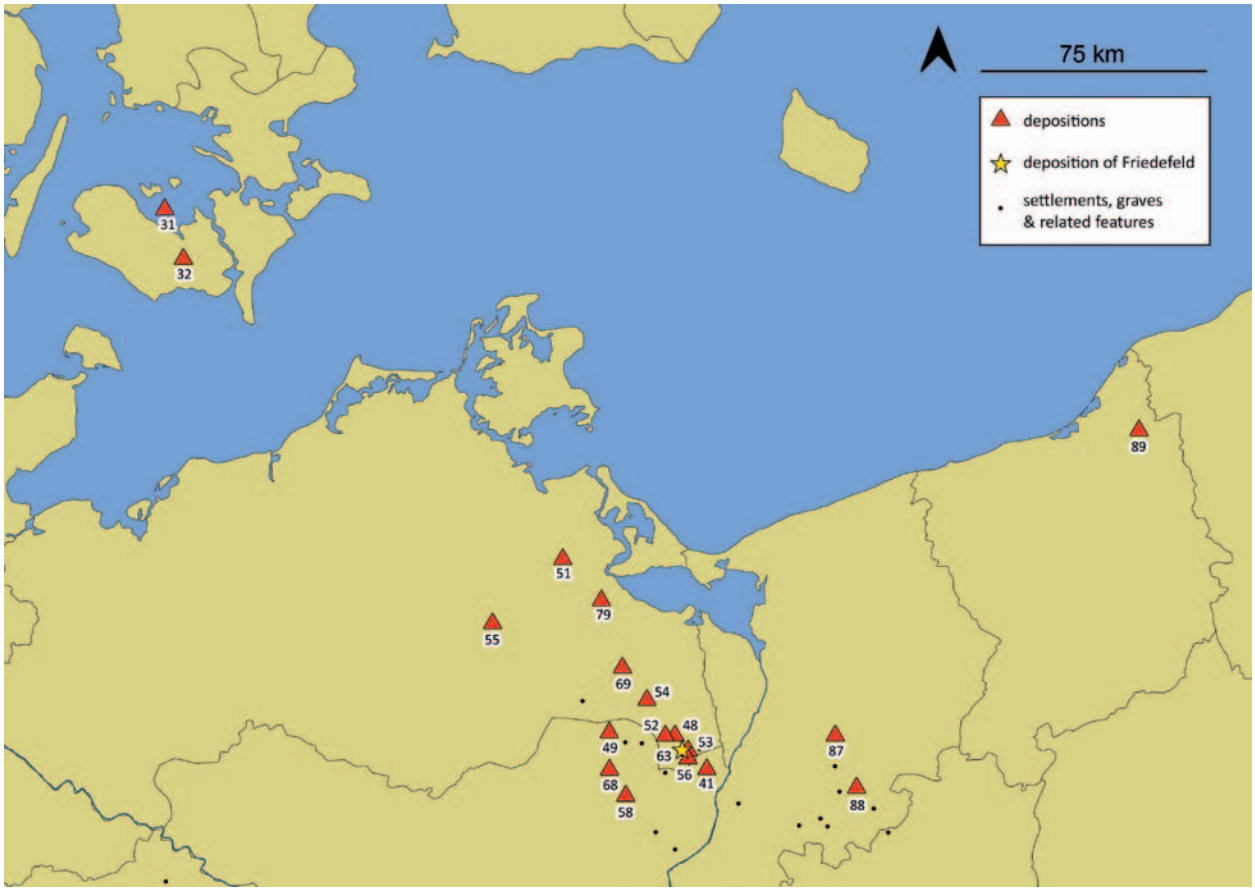

Fig. 8 Middle Neolithic hoards in northern Poland, northern Germany and Denmark (base map with settlements, graves and related features modified after Preuss 1996, maps 2–3). See attached catalogue for the site-names and a short description of the depositions.

comparable to the main distribution area of Middle Neolithic groups. Therefore, it can be suggested, that this was done by Neolithic groups and not Mesolithic ones, who were living in the area at the same time.[17]

The same can be assumed for the two northernmost axe head hoards known so far, which were discovered on the Danish islands Lolland and Askø. Even if they were put in the ground far away from the known Middle Neolithic settlements and even from the lower Oder hoard cluster, the chosen ground type for the depositions, the number of objects and their orchestration fits the established pattern perfectly. The hoard from Lolland, for instance, consists of two axe heads, each one c. 21 cm in length, and a pointed-butted axe or adze head of c. 16 cm length (Rech 1979, 110 no. 197). It was found on dry ground at a slope not far from a bog, which back then was most probably still an active water body. The two axe heads of the hoard from Askø, between 15 and 17 cm long, were found within some years at the same spot.[18] As far as we know, the Danish islands were not a place where people with Mesolithic and Neolithic backgrounds and lifestyles were sharing the land with each other during the 5th millennium BC, like it was the case in northern Brandenburg (Terberger et al. 2015, 151). Hence it can be stated that these hoards were deposited in Mesolithic territory most likely by Neolithic people, probably travellers or scouts. It is no surprise that the hoards were deposited on Lolland and its surroundings, because the distance between the German island Fehmarn and the Danish island Lolland is quite moderate, so this destination was easy to reach for travellers seeking new lands (Terberger et al. 2009, 263).

Summing up the observations, the following picture can be drawn: The 6th and 5th millennia BC can be described as a phase of contact between central European Neolithic groups and hunter-gatherers

17 Since in the area of the lower Oder no settlements have been detected so far, a merely temporary stay of the Middle Neolithic people should be considered.

18 http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/234254/ (accessed 01. November 2019).

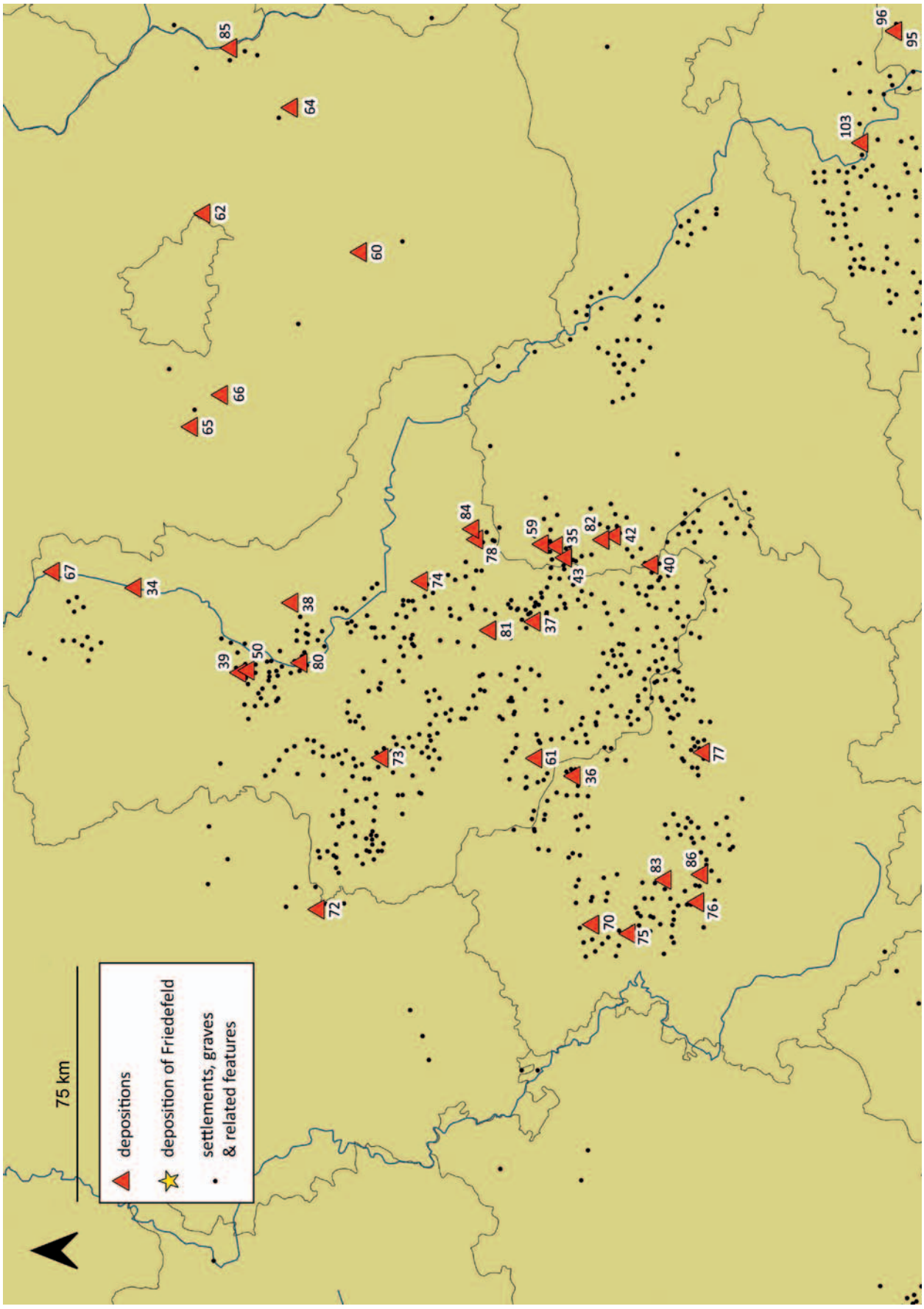

Fig. 9 Middle Neolithic hoards in central Germany (base map with settlements, graves and related features modified after Preuss 1996, maps 2–3). See attached catalogue for the site-names and a short description of the depositions.

from northern central Europe and Scandinavia. As far as we know, this contact did not have any recognisable effects on the Mesolithic economic system (cf. Verhart / Wansleben 1997, 69; Hartz et al. 2011, 54; Czekaj-Zastawny et al. 2012, 531–532, 535). It is impossible to tell how and where these contacts between farmers and hunter-gatherers took place. There are no settlements of farmers known in the area of the hunter-gatherers. We know of several hundred Neolithic artefacts from the Mesolithic area and hoards with Neolithic heavy stone tools which were deposited in the same manner as in the Neolithic main land. Especially the last fact implies an actual presence of Neolithic people in the Mesolithic area. Before trying to answer what they were possibly doing there, it is perhaps necessary to think about the likely reasons for the depositions.

It was shown before why the depositions discussed in this paper cannot have represented trading goods, which were then never retrieved. It is also very clear that they share a comparable composition, were arranged in a particular way and placed mostly under the surface in dry ground. The items for the depositions were selected in a used, unused or unfinished state and taken out of an actual or possible active usage for good. They were deliberately buried or placed under stones not ever to be taken back again. The deposited items are representations of the effort to get the raw material, of the invested time to shape, grind or haft them, and of their potential labour. All this was sacrificed along with them. If we accept imagined supernatural beings as the addressees of these offerings, perhaps in an attempt to thank or connect with them, to claim or to demarcate an area, then we would have perhaps a better way to explain the depositions.

Offerings are connected to the social institution of gift exchange, which was first investigated and defined by the French social anthropologist M. Mauss (1872–1950). Mauss showed that the gift exchange is based on three obligations: to give, to take and to reciprocate (Mauss 1990, 91). Due to these obligations all parts of the society are involved and interconnected. For this reason Mauss called the exchange of gifts a 'total social phenomenon' (Mauss 1990, 17). In the system of gift exchange with deities, offerings are not done by humans to ask or demand from the supranatural beings for something, but to reciprocate for what was already given by them. Only if humans pay back these gifts, it can be assured that the supernatural beings will give again (Mauss 1990, especially 39–46; cf. Hansen 2016, 218–221).

A sacrifice does not only connect the two parties involved in the gift exchange, but has also a certain effect on the place where the gift is executed. And such an effect is very likely to be the desired one or even the necessary one. Following the ideas of M. Eliade regarding holy space and the sacralisation of the world, we can imagine the depositions discussed here as a method to bring order into an unknown and chaotic world. With the sacrifice a fixed point can be built, which brings the surrounding space into the real and stands at the same time against an unreal, unknown outer world. Finally, this fixed point creates a connection between the living and the imagined supernatural beings (Eliade 2008, 15–48). Hence, areas in which people live or plan to live were consecrated by the act of deposition, by creating holy places, places where the connection to supernatural beings became physical. These places, even if not visible in the landscape, existed in people's minds, the story of their existence was presumably passed orally, and they were remembered collectively. In order to do so it is necessary, according to Maurice Halbwachs, to have common conditions and ideas that exist in the consciousness of the whole community. This does not require the actual participation of every single individual in the entire experience. Due to the collective memory every individual stays connected to the group, and nothing of what happened before his participation is foreign (Halbwachs 1991). In this way it is imaginable that the sacrificial act by Neolithic groups or individuals and the (presumed) acceptance of the gifts by the supernatural beings served as a legitimation for the inhabitation of any place.

When looking at a close up of the map showing the distribution of depositions and find places from the Middle Neolithic period in central Germany (Fig. 9), we recognise that the depositions are not randomly distributed and also do not show the same concentrations as the settlements or the burials. The depositions seem to lie mostly at the outer or inner borders of the inhabited space, and the only concentrations occur at the western and southwestern edge of it.[19] This picture, which shows only the final result of a long lasting deposition practice, is at the same time illustrating only a very minor part of all depositions ever put down into the ground. Nevertheless, it offers an idea about how the landscape was structured during the Neolithic period and shows us that depositions enclosed the settled areas. In this

19 Cf. also Kaufmann 2012, 395, who could observe a concentration of heavy stone tools at the eastern border of the central German Neolithic habitation area towards the Mesolithic habitation area. The high amount of stone implements Kaufmann recognised there might also partly go back to unrecognised hoards.

manner two things are accomplished at the same time: The inhabited area is clearly marked by 'holy' places as witnesses for the supernatural connection, and a border towards the 'unholy' places is set.

Comparable observations of a specific placement of depositions were made also for other periods and regions. The TRB societies, who succeeded the northern Mesolithic groups and were the first fully developed Neolithic societies in the north European plain, showed a comparable pattern in their depositions of flint axe heads and the way these are distributed in space (Müller 2020). In this case, it has been argued that even if the depositions were not visible anymore after burying them, the actors who were present at the event of the sacrifice will have spread this knowledge through oral transmission. We can also take the Bronze Age hoards from Bohemia as an example. T. Vachta was able to show that they were deposited at specifically chosen locations (i. e. are not randomly distributed), were partly connected to water, arranged in an aligned manner and placed at the edge of the inhabited world (Vachta 2016).

It is often not particularly relevant for a society to remember the exact place of a deposition as long as it is known and transmitted to further generations that a certain area was successfully marked, and, assuming the benevolence (cf. Hansen 2016, 220) of imagined supernatural beings, also protected (Hansen 2016, 222–223).

Conclusion

Starting from a recent hoard find containing nine Middle Neolithic heavy stone tools, found at Friedefeld (Mecklenburg-Western Pomerania) in the lower Oder region, it is suggested that this one and comparable finds from the same region and further north follow a similar pattern. This pattern consists of a specific selection, a specific number and a combination of items, as well as a specific place of their deposition. Our results suggest that these depositions were made by Neolithic and not by Mesolithic people.

These assumptions can now be connected with the observations made so far both at the edge and far inside the territories of Mesolithic groups. J. Parschau already recognised that the Middle Neolithic hoards from the lower Oder region trace the limits of the region settled by the farmers there (Parschau 1988, 12). In fact, we find here the same pattern which was already observed for central Germany, only in an even denser cluster. It might be a direct reaction to the presence of Mesolithic groups, who were surrounding the Neolithic settlers and were perhaps regarded as alien and different. All things considered, perhaps Middle Neolithic people tried nevertheless to reach further north to find new places to settle.

In an article published in 1990, David Anthony summarises theories about migration movements from neighbouring science areas (Anthony 1990). We will in short present them here: migration, as a basic human behaviour, is triggered by negative 'push factors' in the homeland and positive 'pull factors' at the destination; the knowledge about this destination is gathered by scouts whose purpose is to explore until they have success and find a promising place to live; when this place gets populated, slowly, but constantly, in the kind of a lasting stream, the new colony appears like an island, isolated from the homeland and surrounded by the unknown foreign land. This jumping over great distances and building new colonies is known as 'leapfrogging'.

Connecting the theories forwarded by Mauss, Eliade and Anthony, we can imagine Middle Neolithic scouts sent north into the Mesolithic territories to find new land for settling. They could not have known that their preferred loess soils and the black soils developing on them did not exist in that area. But perhaps they were also ready to adapt and try new soils. Their presence so far north becomes visible to us only through the depositions they are assumed to have made, even on the Danish isles, with the purpose to conquer a new place, to bring order into it, create a centre, and build a connection with imagined supernatural beings. These depositions can be thought of as a necessary sacrifice before the land could become inhabitable.

In the end, these scouting activities might have led to several networks between the Neolithic and the Mesolithic cultures which perhaps favoured, among others, a trade of heavy stone tools and pottery inside Mesolithic settlements. But, as far as we can say from the archaeological material, no Neolithic colonies were successfully built inside the Mesolithic territories, and no shift towards a Neolithic economy resulted from these activities. This was achieved only from 4,100 cal BC onwards, with the beginning of the TRB culture under the strong influence of the Michelsberg culture (cf. Klassen 2004; Sørensen 2014).

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CATALOGUE

The following catalogue of Early and Middle Neolithic depositions was compiled mainly based on information collected from publications. We will offer for now only a brief overview of the content of each hoard, since we were not able to examine most of the respective objects in person. However, we underline once again that these details might not always be fully correct, which is why we think it is necessary to reinvestigate the material.

depot no.	country	site	content	source
1	Germany	Rockenberg II	1 adze head (shoe-last celt)	Quitta 1955, 45 no. 41; Stein 1979, 18 no. 17
2	Germany	Abtlöbnitz	5 differently shaped raw material pieces, 1 flat axe head-prework	Quitta 1955, 28 no. 1
3	Germany	Behringen	2 adze heads (shoe-last celts), 1 axe head-prework, 2 flat axe head-preworks	Quitta 1955, 29 no. 2
4	Germany	Heldrungen-Braunsroda	7 raw material pieces of different shape	Quitta 1955, 29 no. 3
5	Germany	Buchheim	9–15 flint blades (10–15 cm long)	Quitta 1955, 29 no. 4
6	Germany	Naumburg-Kleinjena (Saale)	12 flint blades, 1 unperforated mace-head	Quitta 1955, 33 no. 12
7	Germany	Naumburg (Saale)	1 hoe, 1 adze head (shoe-last celt), 1 shoe-last celt-prework, 3 hoe-preworks, 2 hoe- or axe head-preworks, 1 undetermined raw material piece	Quitta 1955, 35–36 no. 15
8	Germany	Ballenstedt-Radisleben	2 flat hoes, 2 adze heads (shoe-last celts)	Quitta 1955, 36 – 37 no. 17
9	Germany	Rositz	8 axe head- or hoe-like tools as well as 8 flint tools and flakes, ceramic sherds from LBK pottery	Quitta 1955, 37 – 38 no. 19
10	Germany	Sandersdorf-Brehna	4 adze heads (shoe-last celts)	Quitta 1955, 38 no. 20
11	Germany	Kassel-Kirchditmold	2 adze heads (shoe-last celts), 2 adze heads-preworks	Quitta 1955, 43 no. 35; Stein 1979, 18 no. 15; Ramminger 2007, 28
12	Germany	Köln-Lindenthal	2 adze heads (shoe-last celts); 6 flint blades	Quitta 1955, 44 no. 37
13	Germany	Ortenberg	1 hoe or axe head-like tool, 2 adze heads (1 shoe-last celt, 1 shoe-last-like celt)	Quitta 1955, 44 no. 40; Stein 1979, 18 no. 16; Ramminger 2007, 26 – 28, 512 no. 1344
14	Germany	Aumund I	1 adze head (shoe-last celt), 1 axe head	Rech 1979, 100 no. 68
15	Germany	Rockenberg I	9 flint blades	Quitta 1955, 45 no. 41; Stein 1979, 18 no. 17
16	Germany	Grenzach-Wyhle	5–6 axe heads	Stein 1979, 15 no. 2
17	Germany	Prenden	2 adze head (1 shoe-last celt), fragment of 1 double hoe	Berlekamp 1966, 82
18	Germany	Apolda	3 preworks, 2 completed tools, 2 small diabase plates	Vencl 1975, 51
19	Germany	Dresden-Nickern I	1 adze head (shoe-last celt), 5 flat axe heads, 1 shaft-hole axe head, 1 prework	Vencl 1975, 51
20	Germany	Dresden-Nickern II	2 adze heads (shoe-last celts), 1 flat axe head	Vencl 1975, 51
21	Slovakia	Veľký Grob	6 preworks of hoe- or axe head- like tools	Quitta 1955, 46 no. 47; Vencl 1975, 50 – 51
22	Czech Republic	Polabec	9 preworks of hoe- or axe head- like tools	Quitta 1955, 45 no. 45; Vencl 1975, 38 – 39
23	Czech Republic	Troubsko	4 adze heads (shoe-last celts), 1 hoe-like tool	Quitta 1955, 45–46 no. 46; Vencl 1975, 50; SALAŠ 1986, 31 – 34
24	Czech Republic	Liteň	3 adze heads (shoe-last celts)	Vencl 1975, 31 – 32
25	Czech Republic	Praha-Bubeneč	3 adze heads (shoe-last celts), 1 prework	Vencl 1975, 39–40
26	Czech Republic	Bezměrov	4 preworks for adze heads (shoe-last celts) as well as ceramic sherds	Spurný 1964; Vencl 1975, 49; Salaš 1986, 20
27	Czech Republic	Bohušice	4 preworks	Vencl 1975, 49; Salaš 1986, 20
28	Czech Republic	Dolní Věstonice	2 adze heads (shoe-last celts), 1 fragmented bone awl	Vencl 1975, 50; Salaš 1986, 24
29	Czech Republic	Moravičany	3 adze heads-preworks	Vencl 1975, 50; Salaš 1986, 27
30	Czech Republic	Lovosice	5 adze heads (shoe-last celts)	Quitta 1955, 45 no. 44
31	Dänemark	Askø By	2 shaft-hole axe heads (perforated shoe-last celts)	http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/234254/ [accessed 01. December 2019]
32	Dänemark	Udstolpe	2 shaft-hole axe heads, 1 axe head	Rech 1979, 110 no. 197; http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/4271/[accessed 01. December 2019]
33	Germany	Gau-Algesheim I	1 shaft-hole axe head (perforated shoe-last celt), 2 hoe or axe head-like tools	Quitta 1955, 43 no. 34; Stein 1979, 20 no. 24
34	Germany	Tangermünde-Hämerten	1 shaft-hole axe head (perforated shoe-last celt), 1 flat axe head, 1 similar tool	Quitta 1955, 31 no. 8
35	Germany	Leipzig-Hänichen	1 shaft-hole axe head (perforated shoe-last celt), 1 adze head (shoe-last celt), 2 flat axe heads	Quitta 1955, 31 no. 9

depot no.	country	site	content	source
36	Germany	Heldrungen	2 shaft-hole axe heads (thereof 1 perforated shoe-last celt), 1 flat axe head, 1 shoe-last celt-prework	Quitta 1955, 32 no. 10
37	Germany	Holleben	1 shaft-hole axe head (perforated shoe-last celt), 3 adze heads (shoe-last celts), 1 shoe-last celt-prework, 1 flat axe head-prework, 2 celt-shaped preworks	Quitta 1955, 32–33 no. 11
38	Germany	Möckern	4 shaft-hole axe heads, 7 similar tools	Quitta 1955, 34 – 35 no. 13
39	Germany	Mose	3 shaft-hole axe heads	Quitta 1955, 35 no. 14
40	Germany	Reuden	3 shaft-hole axe heads	Quitta 1955, 36 – 37 no. 18
41	Germany	Tantow	2 shaft-hole axe heads (perforated shoe-last celts)	Berlekamp 1966, 79
42	Germany	Zwenkau	1 undetermined prework, 1 adze head-prework, 1 hoe- or axe head-prework, 1 adze head (shoe-last celt)	Quitta 1955, 39 no. 22
43	Germany	Schkeuditz-Dölzig	1 shaft-hole axe head (perforated shoe-last celt), 4 preworks of other tools	Quitta 1955, 29 – 30 no. 5
44	Germany	Gau-Algesheim II	1 shaft-hole axe head (perforated shoe-last celt), 1 adze head (shoe-last celt), 1 hoe or axe head-like tool	Quitta 1955, 43 no. 34; Stein 1979, 20 no. 25
45	Germany	Kloster Wald	1 hoe or axe head-like tool, 1 shaft hole axe head (perforated shoe-last celt)	Quitta 1955, 43 no. 36; Stein 1979, 16 no. 7
46	Germany	Neckarsulm-Oberei-senheim	2 shaft-hole axe heads	Quitta 1955, 44 no. 38; Stein 1979, 16 no. 5
47	Germany	Oedheim	2 shaft-hole axe heads (unperforated shoe-last celts), 1 adze head (shoe-last celt), 2 hoe- or axe head-like tools	Quitta 1955, 44 no. 39; Stein 1979, 16 no. 6
48	Germany	Bagemühl	3 shaft-hole axe heads; 3 axe heads, 1 chisel head	Schumann 1888, 117 – 121; Schumacher 1914, 40; Quitta 1955, 39 no. 23; Raddatz 1957, 206; Berlekamp 1966, 58; Rech 1979, 99 no. 55; Parschau 1987, 28
49	Germany	Prenzlau-Schönwerder	1 shaft-hole axe head, 1 fragment of a shaft-hole axe head, 1 adze head	Berlekamp 1966, 70
50	Germany	Wolmirstedt	1 shaft-hole axe head, 1 hoe or axe head, 2 adze heads (shoe-last celts)	Quitta 1955, 38 no. 21
51	Germany	Groß Polzin	1 shaft-hole axe head, 3 axe heads	Schoknecht 1967, 311
52	Germany	Trampe	2 shaft-hole axe heads	Schumann 1895, 330 – 332; Berlekamp 1966, 60; Rech 1979, 199 – 100 no. 56
53	Germany	Wollin I	4 shaft-hole axe heads	Schumann 1895, 328 – 330; Quitta 1955, 41 – 42 no. 31; Berlekamp 1966, 67; Rech 1979, 100 no. 57
54	Germany	Pasewalk I	4 adze heads (shoe-last celts), 1 shaft-hole axe head, 2 axe heads	Kunkel 1935, 324; Hoika 1955, 41 no. 29; Hellmundt 1964, 55 – 56; Rech 1979, 100 no. 65
55	Germany	Altentreptow I	1 shaft-hole axe head and at least 1 similar tool	Stubenrauch 1904, 111; Kunkel 1926, 34; Berlekamp 1966, 51 – 52
56	Germany	Penkun or Brüssow	1 shaft-hole axe head (and probably more items)	Stubenrauch 1904, 111
57	Germany	Luttum	3 axe heads, 1 shaft-hole axe head	Deichmüller 1968; Vencl 1975, 51
58	Germany	Ludwigsburg	3 shaft-hole axe heads	Files at Museum für Vor- und Frühgeschichte Berlin; Quitta 1955, 40 no. 27; Berlekamp 1966, 69
59	Germany	Schkeuditz-Freiroda	4 heavy stone tools, amongst them 1 shoe-last celt, 1 axe head	Quitta 1955, 31 no. 7
60	Germany	Golßen	2 axe heads	Marschalleck 1944, 248
61	Germany	Edersleben	4 shaft-hole axe heads	Quitta 1955, 30 no. 6
62	Germany	Erkner	1 axe head, 6 heavy stone tools	Files at Museum für Vor- und Frühgeschichte Berlin
63	Germany	Penkun-Friedefeld	2 axe heads, 6 shaft-hole axe heads, 1 shaft-hole axe head-prework	Müller et al. in prep.
64	Germany	"Beeskow-Storkow"	3 shaft-hole axe heads	Quitta 1955, 39 – 40 no. 24; Berlekamp 1966, 86
65	Germany	Deetz (Havel)	4 shaft-hole(?) axe heads, 1 shaft-hole axe head-pre-work	Quitta 1955, 40 no. 25
66	Germany	Werder (Havel)-Glindow	3 shaft-hole axe heads, 1 axe head (hoe)	Quitta 1955, 40 no. 26
67	Germany	Havelberg	2 shaft-hole axe heads	Quitta 1955, 41 no. 28
68	Germany	Zollchow	2 shaft-hole axe heads	Berlekamp 1966, 72
69	Germany	Waldeshöhe	2 axe heads	Hellmundt 1964, 77
70	Germany	Mühlhausen / Thüringen, Grabe	2 adze heads (shoe-last celts), 1 hoe, 2 preworks, 1 undetermined tool	Vencl 1975, 51
71	Germany	Hanau-Steinheim	1 shaft-hole axe head (perforated shoe-last celt), 3 adze heads (shoe-last celts, of which 1 is fragmented)	Stein 1979, 19 no. 19
72	Germany	Schladen	1 shaft-hole axe head, 1 shaft-hole axe head-prework, 1 adze head	Lönne 2003, 173 – 174
73	Germany	Hedersleben	4 shaft-hole axe heads, 1 prework	Vencl 1975, 51

depot no.	country	site	content	source
74	Germany	Südliches Anhalt-Scheuder	4 shaft-hole axe heads	Vencl 1975, 52
75	Germany	Mülverstedt	2 shaft-hole axe heads (perforated shoe-last celts)	Vencl 1975, 51–52
76	Germany	Gotha-Sundhausen	2 shaft-hole axe heads (perforated shoe-last celts)	Vencl 1975, 52
77	Germany	Vollersroda	2 shoe-last celt-preworks, 1 axe head	Küssner / Neumann 2008
78	Germany	Sandersdorf-Brehna-Z-scherndorf	1 adze head (shoe-last celt), 1 shaft-hole axe head (perforated shoe-last celt)	Vencl 1975, 52
79	Germany	Ducherow	2 shaft-hole axe heads (perforated shoe-last celts)	Berlekamp 1966, 52.
80	Germany	Magdeburg-Prester	2 adze heads (of which 1 shoe-last celt), 2 flat axe heads	Vencl 1975, 51
81	Germany	Wettin-Löbejün-Gimritz	1 adze head (shoe-last celt), 1 prework	Vencl 1975, 51
82	Germany	Bösdorf	1 adze head (shoe-last celt), 1 flat axe head, 1 shaft-hole axe head	Vencl 1975, 51
83	Germany	Eschenbergen	3 adze heads (shoe-last celts), 3 flat axe heads, 1 shaft-hole axe head	Vencl 1975, 51
84	Germany	Bitterfeld-Wolfen	1 shaft-hole axe head (perforated shoe-last celt), 1 adze head (shoe-last celt)	Vencl 1975, 51
85	Germany	Frankfurt (Oder)	1 copper shaft-hole axe head (type Gorica), 2 shaft-hole axe heads	Berlekamp 1966, 122
86	Germany	Seebergen	1 adze head (shoe-last celt), 1 flat axe head, 1 shaft-hole axe head (perforated shoe-last celt)	Vencl 1975, 52
87	Poland	Grzędzice (Seefeld)	2 shaft-hole axe heads	Berlekamp 1966, 103
88	Poland	Żalęcino (Sallentin)	1 shaft-hole axe head, 2 axe heads	Kunkel 1935, 324; Dorka 1939, 187; Quitta 1955, 42 no. 32; Berlekamp 1966, 102; Rech 1979, 100 no. 58; Kaflińska 2006, 15 no. 62
89	Poland	Sulechowo (Soltikow)	3 adze heads? (“hoes”)	Kaflińska 2006, 15 no. 46a
90	Poland	Plemięta	3 adze heads (“hoes”)	Wiślański 1984; Kaflińska 2006, 14 no. 39
91	Poland	Maciejowice (Matzwitz)	originally 10–15 heavy stone tools; preserved are 2 shaft-hole axe heads (of which 1 perforated shoe-last celt), 1 shaft-hole axe head-prework,1 adze head (unperforated shoe-last celt), 2 flat axe heads	Schumacher 1914, 42 no. 1; Quitta 1955, 42 no. 33; Kaflińska 2006, 14 no. 31
92	Poland	Stary Zamek	1 shaft-hole axe head (perforated shoe-last celt), 2 adze heads (shoe-last celts), 2 adze head-preworks (shoe-last celts)	Romanow 1977; Lička 1981, 619; Rech 1995, 25–26
93	Czech Republic	Štěnovice	1 adze head (shoe-last celt), 1 axe head	Vencl 1975, 40–42
94	Czech Republic	Plačice	2 shaft-hole axe heads (of which 1 perforated shoe-last celt), 2 adze heads (of which 1 shoe-last celt), 1 flint blade	Frolík 1981
95	Czech Republic	Mšeno II	ground heavy stone tools	Lička 1981
96	Czech Republic	Mšeno I	2 shaft-hole axe heads, 2 adze heads (shoe-last celts)	Lička 1981
97	Czech Republic	Troubsko	some shaft-hole axe heads	Salaš 1986, 34
98	Czech Republic	Sudice	5 shaft-hole axe heads	Quitta 1955, 55; Vencl 1975, 50; Salaš 1986, 31
99	Czech Republic	Soběchleby	2 adze heads (shoe-last celts?)	Salaš 1986, 27–31
100	Czech Republic	Brno-Žebětín	3 adze heads (2 shoe-last celts, 1 flat axe head)	Salaš 1986, 24
101	Czech Republic	Jaroměřice nad Rokytnou	6 four-sided preworks	Vencl 1975, 50; Salaš 1986, 27
102	Czech Republic	Vitiněves II	8 adze heads (shoe-last celts), 1 flat axe head-like tool	Quitta 1955, 46 no. 48
103	Czech Republic	Litoměrice	5 flint blades	Quitta 1955, 45 no. 43
104	Czech Republic	Kovanice	4 adze heads (shoe-last celts), 5 hoe-like tools	Quitta 1955, 45 no. 42; Vencl 1975, 26–30
105	Czech Republic	Jeřice	4 adze heads (shoe-last celts), 1 axe head	Vencl 1975, 24–26
106	Czech Republic	Blšany-Malá Černoc	2 adze heads (shoe-last celts), 1 prework, flint, bones	Vencl 1975, 33–37
107	Czech Republic	Vitiněves I	5 adze heads (shoe-last celts), 1 shaft-hole axe head, 1 prework	Vencl 1975, 44–46
108	Czech Republic	Křinec	1 shaft-hole axe head, 1 adze head (shoe-last celt), 1 prework	Vencl 1975, 30
109	Czech Republic	Čištěves	probably up to 50 artefacts, of which 5 shaft-hole axe heads, 2 adze heads (shoe-last celts), 3 preworks are still preserved	Vencl 1975, 13–18
110	Czech Republic	nový Bydžov-Chudonice	15 adze heads (shoe-last celts), 2 preworks	Vencl 1975, 18–24
111	Czech Republic	Lípa	unknown number of shaft-hole axe heads and adze heads	Vencl 1975, 30–31
112	Czech Republic	Břeclav	6 shaft-hole axe head-preworks	Vencl 1975, 49–50; Salaš 1986, 24
113	Czech Republic	Dřevnovice	2 shaft-hole axe heads	Salaš 1986, 27

Unexpected dimensions of a Swifterbant settlement at Medel-De Roeskamp (the Netherlands)

Theo J. ten Anscher and Sebastiaan Knippenberg

Abstract Large scale excavations at Medel-De Roeskamp near the city of Tiel in the Dutch river area have almost completely uncovered a Swifterbant settlement site dating around 4,300–4,000 calBC. This site stands apart for its large size, its extended broad-spectrum subsistence economy primarily based on domesticates, and the presence of about 25 house plans, pleading against residential mobility. The character of the find assemblage is indicative of a permanent settlement too. The emphasis on pig herding and cereal cultivation, with a grain spectrum consisting of four different species, processed and probably grown locally, is very similar to that found in some contemporaneous Bischheim and Michelsberg sites to the southeast and south. Medel stone artefact imports and the Medel ceramics also point to contacts with the Danubian tradition, Bischheim in particular. The Medel house plans bear general resemblances with the small house plans found in epi-Rössen contexts, and possess close parallels in the house plans from Bischheim sites in the German Rhineland. Medel-De Roeskamp is a clear example of a settlement fully adapted to a sedentary Neolithic way of life in the western parts of the North European Plain, where fishing, hunting and gathering continued to play a role in daily life well into the Bronze Age. In Medel-De Roeskamp, in the Dutch river area, the neolithisation process had reached a mature stage, characterised by site permanency, already in the period 4,300–4,000 calBC.

Keywords Neolithisation, Swifterbant culture, houses, permanent settlement, pig herding, cereal cultivation

Zusammenfassung *In Medel-De Roeskamp ist eine Siedlung der Swifterbant-Kultur (c. 4300–4000 calBC) nahezu vollständig ausgegraben worden. Diese Siedlung ist aufgrund ihrer Ausdehnung, der Wirtschaftsweise, die neben Fischfang, Jagd und Sammeln vor allem auf Viehhaltung – besonders Schweinezucht – und Gartenbau basiert, sowie der mehr als 25 nachgewiesenen Hausgrundrisse einzigartig. Neben der Dimension der Siedlung sprechen auch die Funde für eine sesshafte Lebensweise. Einige Steingeräte und die Keramik weisen auf Kontakte mit den Nachfolgern der Linearbandkeramik hin. Die Hausgrundrisse von Medel ähneln epi-Rössener Beispielen und besonders einigen Bischheimer Häusern aus dem Rheinland. Der Fundplatz Medel ist ein wichtiges Beispiel für eine Siedlung mit einer sesshaften Lebensweise im westlichen Bereich der nordwesteuropäischen Tiefebene, wo Fischfang, Jagd und Sammeln bis in die Bronzezeit eine bedeutende Rolle für die Subsistenz spielten. In Medel-De Roeskamp im holländischen Rhein-Maas-Gebiet zeigt sich so in der Zeit von 4300–4000 calBC schon eine fortgeschrittene Phase der Neolithisierung mit permanent bewohnten Siedlungen.*

Introduction: a broad outline of the Swifterbant culture

Swifterbant is an indigenous early Neolithic culture occurring between the Scheldt area in Flanders and at least the Weser area in Lower Saxony. Its territory may have reached as far as the river Elbe near Hamburg. Its Mesolithic roots are attested in the reliance on hunting, gathering and fishing, in its lithic industry and in the manner of burying the dead: extended on their back. The neolithisation of the Swifterbant culture is pictured as a slow (incomplete) 'step by step' process that took a long time, evolving from contacts with the descendants of the Linear Band Pottery culture (Linearbandkeramik, or LBK) in adjacent southern and eastern areas (Raemaekers 1999). It started with the introduction of ceramics (c. 5000 calBC), followed by the adaption of domestic animals/husbandry (c. 4,700–4,450 calBC) and later by the adaption of cereal cultivation (c. 4,300–4,000 calBC), leading to an extended broad spectrum economy, in which the domestic element only gradually gained more importance, but before c. 4,000 calBC never seemed to become predominant (Raemaekers 1999; 2019). Around 4,000 calBC or somewhat later cattle bones increasingly outnumber pig/wild boar bones, point-

ing to a structural shift in the subsistence economy (Gehasse 1995). There is an echo of this development in the ritual depositions. Already in the earliest phase of the Swifterbant culture pot offerings are attested, as are offerings of red deer antlers and aurochs skulls from bulls, whereas the oldest ^{14}C dated depositions of domestic cattle horns, again from bulls, occurred much later.[1]

Residential mobility is considered to be the prevailing settlement system, with hardly any exception (Raemaekers 1999). Swifterbant sites are usually situated in gradient rich wetland zones near (small) streams. The duration of the habitation varied, depending on the possibilities of the location in question. Some sites like Bergschenhoek, on a flat shore, are thought to have been inhabited very shortly: just a few days or a week at most (Louwe Kooijmans 1985). The majority of Swifterbant sites, however, are located on elevated grounds, and seem to have been periodically used for tens of years to a few centuries, such as for instance the river dune sites Hardinxveld-Giesendam-Polderweg, Hardinxveld-Giesendam-De Bruin and Hoge Vaart-A27 (all belonging to phase Swifterbant 1 [SW1] which is dated between c. 5,000–4,400 calBC), the levee site Swifterbant-S3/S5 and other sites on levees and sand dunes around Swifterbant, and the river dune site Hazendonk-1 (all dating to phase SW2: c. 4,400–3,900 cal BC).[2] The discovery of adze marks pointing to an arable field on a clayey levee at Swifterbant-S4, and subsequently the identification of tilled soils in thin sections arguing for arable fields at other nearby sites as well, ended the discussion about grain being imported or cultivated locally at wetland sites in favour of the latter option.[3]

A few sites were situated on locations that continued to be easily accessible and inhabitable for a very long time. They span the complete duration of the Swifterbant culture and beyond. Hüde I (Lower Saxony, Germany), a palimpsest with a problematic stratigraphy on a higher ground bordering lake Dümmer, is a well known example. At the time the Hüde ceramics and features were published in full, its Swifterbant component was heavily underestimated (Kampffmeyer 1991).[4] This is quite understandable since back then publications on the Swifterbant culture were scarce, preliminary and based on just a few sites, all dating to SW2 (e.g. De Roever 1979). It took another two decades to reach a better understanding of the width and depth of this culture. Hüde I has a close western counterpart in Schokland-P14, located on a large sand ridge on a substrate of boulder clay bordering the Overijsselse Vecht (Ten Anscher 2012; 2015). In particular, the ceramics are very similar.[5] Schokland-P14 has a more reliable chronostratigraphy though its dating is based on ^{14}C-dates from charred food crusts on pottery sherds. If the crusts contained fish remains (whether this is the case is unknown), the dates might be too old due to the reservoir effect.[6]

Schokland-P14 at least provides an impression of the characteristics of the ceramics and worked flints in subsequent stages that could offer a typological key for a new interpretation of the Hüde I phasing. Schokland-P14 has yielded several house plans, arguing for logistic mobility rather than residential mobility.[7] However, it is not clear whether they belong to SW2 or to the next phase, the Pre-Drouwen phase of the West group of the Funnelbeaker culture (Trichterbecherkultur, or TRB). In the Pre-Drouwen phase (c. 3,900–3,400 calBC), the Swifterbant (ceramic) tradition lived on, alongside new elements that are typical for the early TRB, partly derived from the Michelsberg culture, partly indigenous developments (Ten Anscher 2012; 2015). The view that the Swifterbant culture could have ignited the TRB North group as

1 Kroezenga et al. 1991; Prummel / Van der Sanden 1995; Ufkes 1997; Raemaekers 2019.

2 Louwe Kooijmans 2001a; 2001b; Hogestijn / Peeters 2001; Peeters 2007; De Roever 2004; Raemaekers 1999. – Phasing based on ceramic characteristics according to Ten Anscher 2012, 127–129.

3 Cappers / Raemaekers 2008; Huisman et al. 2009; Huisman / Raemaekers 2014; Schepers 2014.

4 Kampffmeyer's interpretations and suggested periodisation, relying heavily on the developments within the TRB North Group, are no longer tenable, also because his periodisation was not only hampered by the inadequate knowledge of the Swifterbant culture at the time, but was also affected by his assigning the same sherds to different phases. See Ten Anscher 2012, 585–589 for an extensive comment on the developmental model presented in Kampffmeyer 1991. See also Ten Anscher 2015, 349–353. Still, Kampffmeyer's 'Anhang B: Tafeln', containing hundreds of drawings of sherds, many so similar to the sherds from for instance Schokland-P14, is a treasure of lasting value.

5 Compare Ten Anscher 2012 fig. 5.1, 5.16, 5.19 and 7.4 with Kampffmeyer 1991, 'Anhang B: Tafeln'.

6 It should be noted that the ^{14}C-dates of the Swifterbant occupation of Medel-De Roeskamp, which on the basis of the typological characteristics of both its ceramics and its worked flint must have been by and large contemporaneous with Layer B from P14-Schokland, tally with the dates from Schokland-P14 and confirm the global validity of the dates proposed for Layers A–C at Schokland-P14 (Ten Anscher 2012, 58–62).

7 The Overijsselse Vecht (German: Vechte) originates in German Rhine-Westphalia.

well is rebutted.[8] Nevertheless, from c. 3,900 calBC onwards, an increase in contacts between the Swifterbant/Pre-Drouwen region and TRB North group communities is probable, as similarities in pot decoration suggest, eventually leading to the incorporation of, among other things, the megalithic tradition in the classic phases of the TRB West group. Schokland-P14 and Hüde I are the main sites representing the Pre-Douwen phase of the TRB West group, both sites being used during the classic phases of the TRB West group as well. In the Scheldt area, the Swifterbant culture ended abruptly around 4,000 calBC, being replaced by, or integrated into the Michelsberg culture (e.g. Vanmontfort 2004; Crombé et al. 2011; Teetaert et al. 2020).

Around 3,800 calBC, the Michelsberg influence manifested itself more strongly in the Dutch river area too, leading to a seemingly swift development into the Hazendonk group (c. 3,800–3,400 calBC).[9] Just as Pre-Drouwen, the Hazendonk group is regarded as an offshoot of the Swifterbant culture (Raemaekers 1999; Louwe Kooijmans 2007). Whereas Swifterbant is generally viewed as a not fully or truly Neolithic society,[10] the Hazendonk dune settlement site Schipluiden is presented as the earliest example of a fully developed broad-spectrum Neolithic way of life in the Netherlands outside the loess zone in the south (with its former LBK occupation), because at Schipluiden the evidence for animal husbandry and cereal cultivation dominates over the evidence for hunting, gathering and fishing (Louwe Kooijmans / Jongste 2006). The generally accepted, but somewhat problematic view is that the Hazendonk group eventually evolved into the Vlaardingen group, occupying more or less the same areas as Hazendonk did before.[11] Vlaardingen is contemporaneous with the classic stages of the TRB West group and beyond, thereby continuing a cultural separation between the communities in the Dutch river and dune area and the central and northeastern regions of the Netherlands, that started around 3,800 calBC.

The Swifterbant culture has long been seen as closely related to, or even as a Dutch variety of the Ertebølle culture (De Roever 1979). The alleged affinities have been fueled by the occasional occurrence of knob-type bases in Swifterbant ceramics. In fact, the similarities are far outweighed by the differences (Ten Anscher 2012, 132–134; 2015, 346). For instance, the basic concept of what a pot should look like differed considerably between the two groups. Ertebølle pots have their maximum diameter very low on the pot. SW-pots, on the contrary, certainly from c. 4,300 calBC onwards, have their maximum diameter much higher on the pot. The differences are not restricted to pottery either. Contacts between these adjacent cultures are not unlikely, but they certainly are not pivotal for the crucial developments within the Swifterbant culture. Unlike in Ertebølle, the key notion in the Swifterbant culture is neolithisation, and the basic underlying mechanism is the continuous contact with the southern and eastern regions and its subsequent offshoots, the Danubian tradition from Großgartach, Planig-Friedberg, Rössen and Bischheim to Michelsberg. The Swifterbant pots mirror to some degree the subsequent southern fashions in forms and techniques. They could be viewed as local copies of a selection of the ceramic repertoire of the Danubian tradition, in particular the Rössen/Bischheim 'Vorratsgefäße', 'Vorratstöpfe' and 'Kugel-' and 'Ösenbecher', though keeping their distinct own Swifterbant signature. The Michelsberg influence occurs late, first perhaps discernable in the occurrence of pots with a roughened surface, more angular pot profiles, flat and pointed bases and, slightly later, attested by 'Arkadenränder'.

8 See Ten Anscher 2012 and 2015 for the alleged role of Swifterbant in the formation of the TRB North Group, by now refuted, see e.g. Sørensen 2015.

9 E.g. Louwe Kooijmans 1980; Raemaekers 1999; Louwe Kooijmans 2007; Koot et al. 2008. Some pottery sherds and the Hazendonk flint assemblages do show Michelsberg influences. The Hazendonk burial practices are at variance with the Swifterbant burial tradition. Though the flexed positions of the Hazendonk dead certainly betray allegiance to the southern 'old Neolithic', similar flat grave cemeteries are not found in Michelsberg either.

10 E.g. Amkreutz 2013; Out 2009. Raemaekers 2003, however, using the availability model (Zvelebil 1986) as a methodical framework, has expressed his reservations about the validity of the underlying concept of a long transition model, stating that the Dutch data do not rule out the possibility of a (relatively) short transition model, thereby implying that already in Swifterbant the neolithisation might have reached the consolidation phase instead of the substitution phase. See also Raemaekers 2019.

11 Transitional sites are unknown. It should be noted that the Vlaardingen pottery (S-shaped pots with a row of perforations below the rim, baking plates and collared flasks) has more in common with the Pre-Drouwen ceramic tradition than with the carinated bowls and barrel shaped vessels typical of Hazendonk. Neither does the Vlaardingen burial practice relate well to the Hazendonk cemeteries (or to the graves of Pre-Drouwen or classic TRB for that matter). Quite a few Vlaardingen sites have been excavated, but no graves have been discovered yet, except for a single cremation pointing to a possibly crouched position, and apart from a suggestive reconstruction of an excarnation platform (Louwe Kooijmans 1985; Verhart 2010; Louwe Kooijmans et al. 2016).

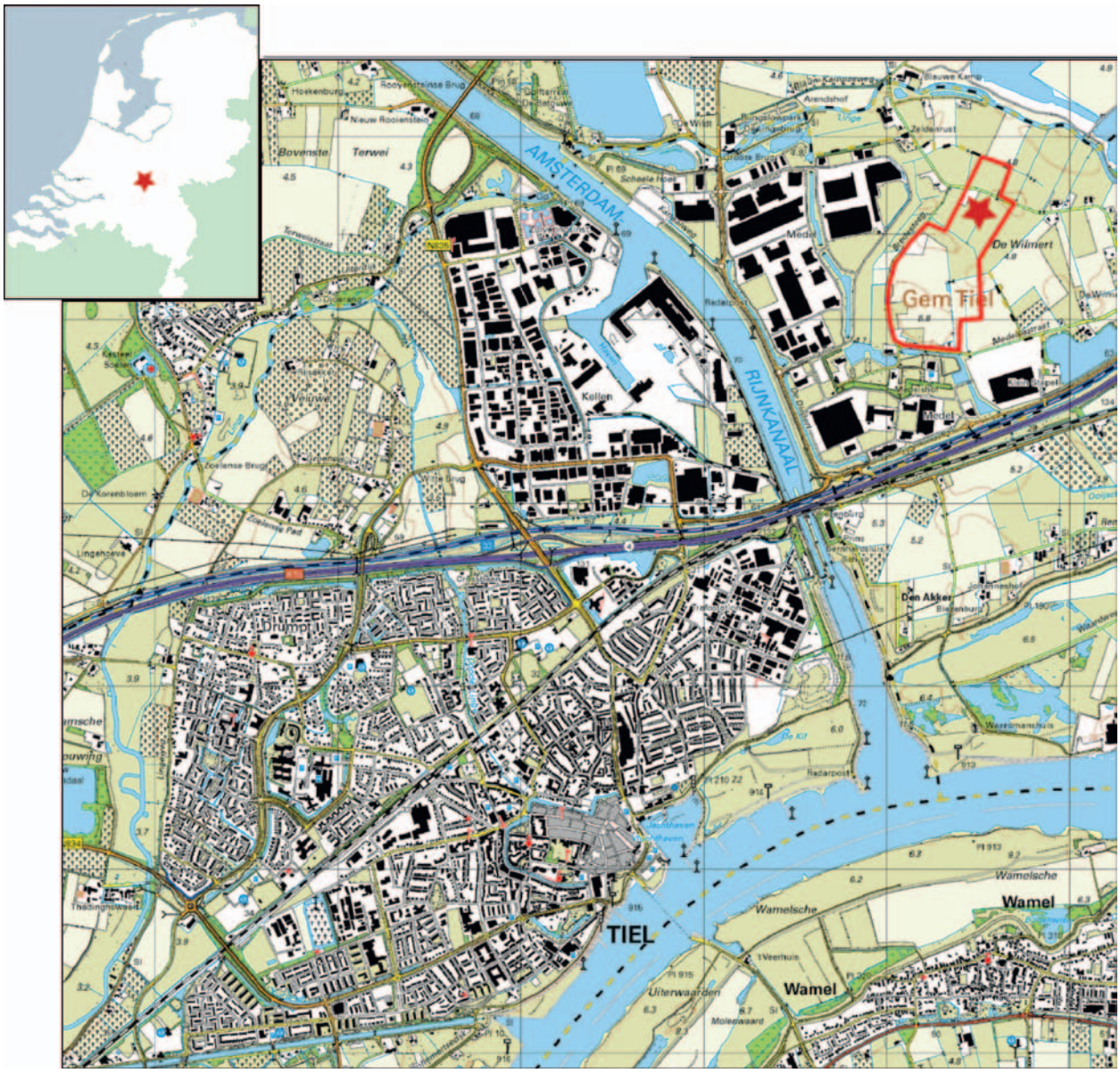

Fig. 1 Location of Medel-De Roeskamp (red star).

Of course, all the other Neolithic elements that subsequently entered the Swifterbant culture derived from the Danubian tradition too, simply because there is no alternative source: the perforated shoe-last adzes ('hohe durchlochte Schuhleistenkeile'), the perforated broad wedges ('durchlochte Breitkeile'), the cattle, sheep and goats, the cereal species, leaf-shaped arrowheads, 'Walzenbeile', and the polished axes.[12] In the Dutch river area, already from the very beginning, Swifterbant people obtained part of their flint from sources well within the territory of the Danubian tradition (Van Gijn et al. 2001a; 2001b). All this attests to long term relationships between the Swifterbant culture and its farmer neighbours in the south and the south-east. Medel-De Roeskamp illustrates this again and in even more aspects than already pointed out above.

The Medel sites

Medel is a hamlet near the city of Tiel in the Dutch river area (Fig. 1). Preceding the construction of a large business park, extensive archaeological investigations were carried out over the last 15 years. They resulted in the discovery of many sites dating from the Early Neolithic to the Middle Ages. The prehistoric sites of Medel-De Roeskamp (named after a de-

12 See Ten Anscher 2012 for references. English translations for 'hohe durchlochte Schuhleistenkeile' and (Rössener) 'durchlochte Breitkeile' according to Raemaekers et al. 2011.

molished local farmyard) were detected by coring in 2012 by the archaeological firm RAAP (Boshoven 2012). Subsequent test-trenches excavated in 2014 by a combined team of RAAP and ACVU-HBS yielded additional information: a site of the Swifterbant culture covering about 1 ha, situated below an extensive Bronze Age settlement associated with at least two burial mounds. In between both archaeological strata there were scattered finds of a then unknown age (Norde / Van Renswoude 2014).

The developer of the business park, Industrieschap Medel, an organisation established by the municipalities of Tiel and Neder-Betuwe, decided on a time span of at most one year for these sites to be excavated.[13] Between November 2016 and September 2017 employees of four Dutch archaeological firms (RAAP, Archol, ADC and BAAC), working together in a joint venture, excavated the sites of Medel-De Roeskamp almost completely. The Bronze Age settlement includes several successive house plans, dating to the youngest phase of the Early Bronze Age in the Dutch river area (early WKD3, c. 1,900–1,800 calBC).[14] The largest and youngest Early Bronze Age multi-phase house plan is also the most complete one; it is accompanied by several small granary-type structures with four or six posts. The house site was covered by a particularly rich find layer with more than 150,000 finds (including a lot of loam weights which are among the oldest found in the Netherlands). The burial mounds, two large monuments and one small one, contained almost fifty graves, both inhumations and cremations, dating from the Early Bronze Age until well into the Middle Bronze Age and possibly even the Iron Age. This settlement was preceded by late Bell Beaker (c. 2,200–2,000 calBC) and Early Bronze Age inhabitation (phases WKD1–2, c. 2,000–1,900 calBC), of which mostly eroded sherds were recognised as well as a few features, of which a flat grave cemetery with inhumations is most striking. It contains some single interments, a double grave and a remarkable collective burial with the remains of more than ten adults and children. A small Middle Neolithic settlement belonging to the Hazendonk group (with ^{14}C-dates around 3,700–3,500 calBC) was uncovered too. These sites were stratigraphically separated from each other and from the large Swifterbant site, the subject of the remainder of this paper.

Due to the huge number of finds (c. 950,000) from the combined Medel sites, the site report is not finished yet. Although all finds that were selected for further research (about half a million) have been analysed by now, at this moment only a preliminary impression of the results of Medel-De Roeskamp, the most significant Swifterbant residential site excavated yet, can be presented.

Excavation strategy

The considerable depth of the Swifterbant occupation levels at 1.0–1.5 m below the present-day surface and the high groundwater table provided a challenge. Fortunately it proved possible to excavate the Swifterbant site without having to rely on costly drainage by filter wells. This was accomplished by not opening up more than the area that could be fully documented during a single day. Typically, the day after each excavation unit was inundated. However, in order to obtain long and deeper cross sections, and for the investigation of some archaeological layers in the channel adjacent to the site, for a limited period a well point system was indispensable.[15]

Given these limitations, and also keeping in mind the maximum field-work period of twelve months for a large site, one had to compromise. Extensive excavation, for instance by sieving or trowelling the complete archeological layer, would imply that only a small part of the settlement area could have been investigated fully. Instead, the goal was to get a general overview of the 'entire' Swifterbant settlement, making use of the rare opportunity offered at Medel. The standard excavation procedure was to sieve about one of every eight square meters of the settlement layer (sandy clay) using a 5 mm and sometimes a 2 mm mesh-screen, while many 10 liter samples of the settlement layer were taken for future sieving using finer meshes. The finds from the other 87.5 % of the settlement layer were collected during opening up using a mechanical shovel, thereby losing an estimated 97 % of the finds. Even so the number of recovered finds is staggering.

13 The main element of the tender was a design and construct brief largely drawn up by the excavating companies. Contrary to common practice in Dutch contract archeology, the contract was won on the basis of quality rather than lowest price.

14 Early Bronze Age phasing according to Ten Anscher 2012, 239–271. WKD is the abbreviation of 'Wikkeldraad' = barbed wire = 'Stacheldraht', named after the dominant type of decoration on the ceramics.

15 In a clayey environment filter wells hardly ensure dry working circumstances. The main reason for the installation of filter wells was that by lowering the high groundwater level the upward force of the ground water and therefore the risk of abrupt flooding (piping) of a trench was reduced. At Medel the drainage had the unexpected negative effect of reducing the visibility of features like postholes.

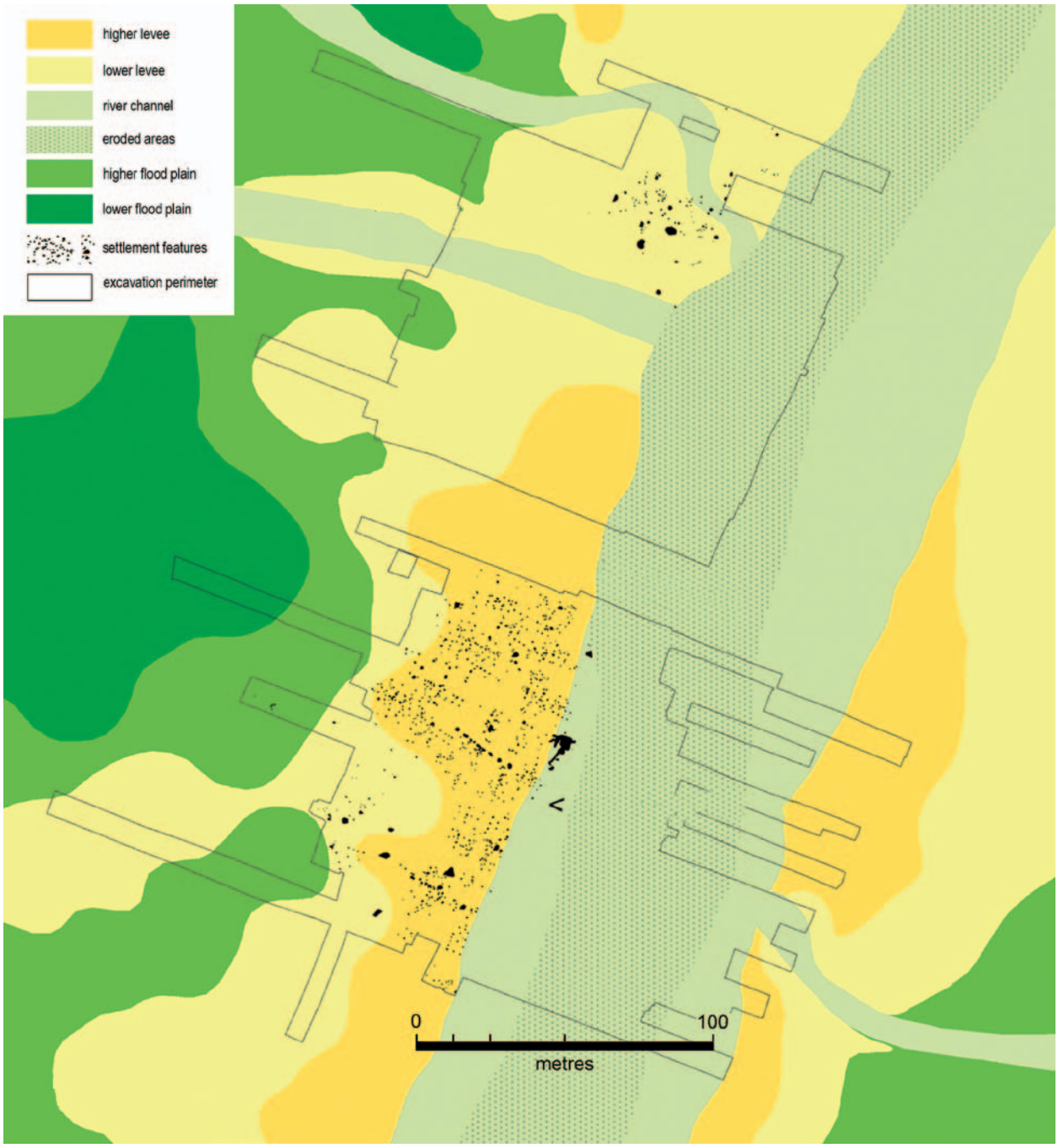

Fig. 2 Natural setting of the Swifterbant site Medel-De Roeskamp.

Natural setting

Sandy outcrops, river dunes and levees are the familiar landscape elements on which Swifterbant sites are usually found. The Medel settlement is situated on a 50 m wide sandy clay levee along one of the branches of a channel network belonging to the Rhine system (Fig. 2).[16] The levee may have had a height of just 0.75–1.0 m or even less. Near Medel the alluvial valley of the Rhine-Meuse system is several kilometers wide, pressed between ice-pushed ridges in the north and the extensive higher grounds of the coversand area of Noord-Brabant in the south, reaching well into Belgium.

Based on two ^{14}C-dates the levee was formed after c. 4,700–4,500 calBC.[17] Though regularly flooded, the surrounding flood plain, characterised by small channels (crevasses) and marshy pockets, with tree stands

16 Information on the natural environment has been provided by our physical geographer Nico Willemse (RAAP).

17 ^{14}C samples taken from wood fragments/twigs; 2 sigma range.

consisting mainly of alder and oak, in general provided a rather dry environment, accessible by foot and by canoe. The Swifterbant occupation started when the channel was already silted up to a considerable degree, though still connected to the active river system. By then, the prevailing calm conditions made the levee a convenient location for a settlement, at least for a considerable time. However, regular flooding led to the silting up of the surrounding flood plain, ultimately covering the levee. This meant that in the long run the levee ceased to be a relatively high and mostly dry element, thereby losing its suitability for use as a dwelling place.

Duration of habitation and settlement size

Eleven ^{14}C dates (from burnt bone, charred hazel nutshell, charred and uncharred seeds, charred grain kernels and charcoal) belong to the period 4,325/4,225–4,000 calBC, and two more (from burnt bone and charred hazel nutshell) attest to a relatively late use during 4,065–3,965 calBC. So Medel is firmly dated in phase SW2, its occupation spanning presumably around 200–300 years and some 350 years at most.

Situated outside the provisional boundaries of the business park, the eastern counterpart of the excavated levee remains unknown. There is a chance that it has been largely eroded already, perhaps even before the Swifterbant inhabitation of the western levee started. On the other hand, the eastern levee potentially could have played an important role in the Medel settlement system, for example as a nearby arable field, a grazing/feeding ground for cattle and pigs, or as a burial ground – contrary to expectations no graves were found on the western levee. So it should be realised that part of the puzzle is missing. Although a large tract of the settlement area was excavated and the find abundance was dwindling towards the south and the north where the levee was sloping down, it cannot be excluded that it continued beyond the excavated area, again on higher parts of the western levee, perhaps constituting a chain of sites.

The southern concentration of finds and features covers about 11,000 m^2, the northern concentration measures around 1,500 m^2. For easy reference, they are called the southern and the northern site though they belong to the same settlement, subdivided by a natural depression in the surface of the levee. The northern site lies several decimeters lower than the southern site. Presumably, both sites were largely contemporaneous, though the occupation of the much larger and higher southern site may have lasted a century or so longer.

For a Swifterbant settlement the size of Medel-De Roeskamp is astonishing. It is twice the size of all the excavated Swifterbant sites in the Netherlands combined (except for Nieuwegein that is made up of several much smaller sites; see Molthof / Baetsen, this volume).

Finds

The overwhelming majority of finds – some 600,000 belong to the Swifterbant period – comes from the settlement layer in the top of the levee. In the channel, several thin layers with refuse were discovered. These

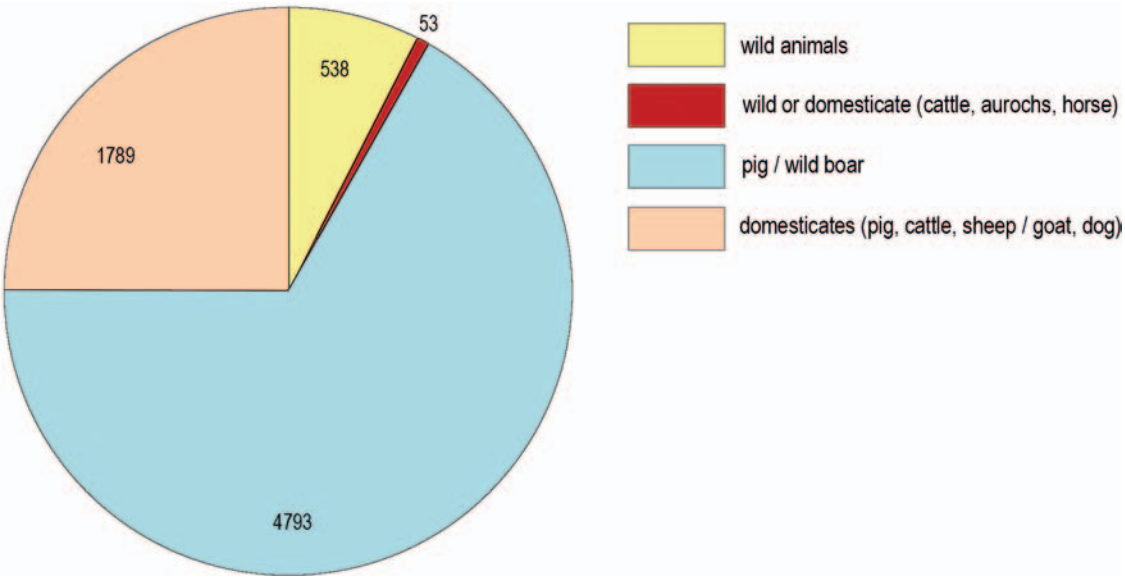

Fig. 3a Identified animal species: all mammals subdived into different groups (for numbers see Fig. 3b).

class	species	NISP
mammals	pig	11
	wild boar	18
	pig / wild boar	4,793
	cattle	1,552
	aurochs	25
	cattle / aurochs	24
	sheep / goat	126
	dog	100
	horse	29
	deer (antler excl)	433
	beaver	28
	fur animals	34
birds		102
fish		4,571
reptiles	European pond turtle	1
total		**11,847**

Fig. 3b Identified animal species (NISP: Number of Identified Specimen).

layers had a limited extension of about 10–30 m² each, and didn't yield many finds. The same holds true for two subsequent refuse layers to the south of the northern site.

Animal bones constitute the most abundant find category. The 340,000 pieces of mammal bone typically are poorly preserved, showing a high degree of fragmentation also caused by extensive sieving. From only 2 % of the mammal bones the species could be determined (Fig. 3a–b).[18] The proportion of wild animals (wild boar/pigs excluded), mainly deer, is strikingly low compared to other Swifterbant sites. Noteworthy too is the paucity of beaver bones, elsewhere ubiquitous. In addition to a dominance of swine (wild boar/pigs) bones, a high percentage of domesticated animals, predominantly cattle, is seen. On the basis of the dimensions of their molars (M2), it seems that a large majority of the swine bones belongs to pigs instead of wild boars. In that case the Swifterbant people from Medel have been swineherds first and foremost, with cattle farming taking second place. Animal husbandry seems to have been much more important than hunting at Medel, and more so than at any other known Swifterbant site.

Due to the sampling method, fish bones are underrepresented and biased in favour of larger species. Still, fish bones are found in high numbers. Similar to many Swifterbant sites, pike fishing was a major activity. Anadromous species such as twait shad and allis shad were caught too.

Hundreds of charred kernels from naked barley, einkorn and emmer wheat were found. Especially noteworthy are charred rachis remains of durum wheat, a novelty in Swifterbant context. The charred grains of naked wheat found in Medel most likely belong also to the durum wheat. Chaff remains of naked barley and durum wheat indicate that threshing of both cereals would have taken place at the site. Chaff remains of einkorn and emmer – spikelet forks and glume bases – suggest that dehusking (but likely also threshing) of these hulled wheats took place at Medel too. Nearby arable fields are to be expected. So cereal cultivation probably played a significant role in the local subsistence economy. There is no evidence for growing oil plants or pulses from the Swifterbant context in Medel. Antler adzes and flint sickle blades may be associated with these agricultural activities.

There is ample evidence of activities related to the gathering of food plants, such as loads of charred hazelnut shells and some charred remains of sloe plum, hawthorn and crab apple, as well as water chestnut.[19]

Ceramics constitute the second most abundant find category. From over 85,000 fragments of pottery the 18,500 sherds larger than 2 cm² were selected for analysis. As is indicative of SW2 ceramics in general, the predominant temper type at Medel is a combination of plant material, presumably moss, and crushed stone, in particular quartz. The Medel pottery is unusually well made, the joints of the clay rolls (U-joints as well as Hb-joints) being seldom recognisable. On the whole the Medel pottery is rather thin walled (mean: 8 mm, one third is thinner than 7 mm). Neck sherds with a thickness of 3–4 mm are not uncommon. Typical is the two-staged construction of quite a lot of relatively thick walled pots (Fig. 4: 17549). After being set aside to dry for a while, a fresh clay layer of 2–6 mm thickness was applied on the outer surface of the pot. The applied layer is often easily recognisable in the pot profile and prone to erosion. The pots usually are S-shaped, like the Rössen or Bischheim 'Vorratsgefäße' (16151). Sometimes the shape is somewhat angular (17497) or globular, resembling 'Kugelbecher' (6620) or 'Kugeltöpfe' (17009). A few bowls have been recognised. Pointed and rounded bases were common. Bases with modest knobs and flat bases are rarely encountered. Occasionally lugs ('Ösen') are found

18 The information concerning the mammal bones has been provided by archaeozoological specialists, Kinie Esser and Joyce van Dijk (Archeoplan Eco), the information on fish bones is based on the analysis of Wim Van Neer (Royal Belgian Institute of Natural Sciences, Brussels).

19 All the archaeobotanical information has been provided by archaeobotanical specialist Lucy Kubiak-Martens (BIAX Consult).

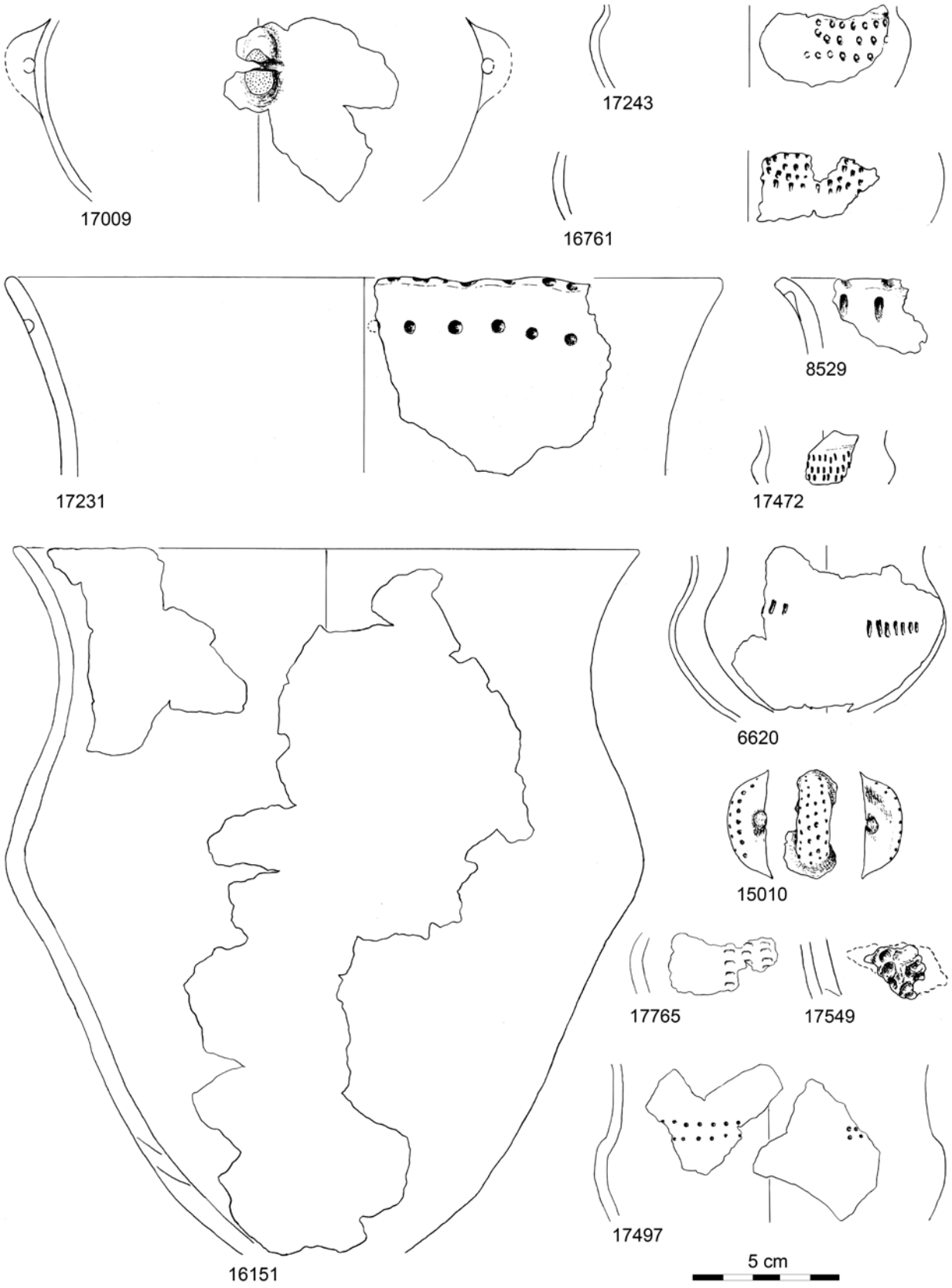

Fig. 4 A selection of pottery sherds, see text.

Fig. 5 A selection of lithic artefacts: a) edge flake from a jadeitite axe; b) fragment of an amphibolite perforated broad wedge; c) active grinder made from quartzite; d) quern fragments made from gabbro (left) and sandstone (right).

(17009). One of them has been turned into a longitudinal knob by inserting a plug in the perforation (15010). It has an asymmetrical section with a convex and a concave long side, and it is covered with rows of round impressions on top and on the convex side, but not on the concave side, suggesting that it has been one of a pair, placed closely to each other.

The usual SW decoration types like a row of vertical elongated, oval or round impressions below the rim are present, sometimes with 'Lochbuckel' on the inside of the rim. This type of decoration is mainly found on larger pots (8529; 17231). Especially characteristic for Medel are impressions, round or otherwise, arranged in fields on the shoulder or near the maximum diameter (6620; 16761; 17243; 17497; 17765). This type of decoration is typical for smaller pots (17472). Some larger pots possessed a roughened surface covered with fingertip impressions (17549) similar to pots found in late Bischheim and Michelsberg. Half of the rim sherds have 'Randkerbung' or a less conspicuous type of rim impressions (8529; 17231).

The characteristics of the Medel ceramics seem to indicate regional variation in SW2, the emphasis on decoration in fields and the two-staged construction being characteristic for the Swifterbant communities in the Dutch river area.[20] Several sherd concentrations belong to just one pot each and may represent buried pot offerings (16151).

The lithic assemblage, comprising about 8,000 pieces of worked and utilised stone, for the large majority consists of river cobbles and pebbles in addition to a smaller portion of moraine rocks.[21] These probably had been collected from nearby outcrops of coarse river sediments being part of the ice-pushed ridges and slopes near Rhenen, where perifluvioglacial activity also brought in moraine stones.

A few individual artefacs attest to external contacts. The most definite examples are a re-worked fragment of a perforated broad wedge made from am-

20 The ceramics have been analysed by Theo ten Anscher (RAAP).

21 The stone artefacts have been analysed by Sebastiaan Knippenberg (Archol).

phibolite[22] and an edge flake as well as a very small fragment of a ground axe, both made from jadeite, preferably named jadeitite (Fig. 5a–b).[23] The amphibolite may have originated from northern Bohemia in the Czech Republic,[24] whereas the rare jadeitite most probably came from the Italian Alps around Mount Viso and Mount Beigua (Pétréquin et al. 2012). Most likely, these objects were obtained through inter-community exchange with neighbouring sites in the Neolithic hinterland.

The stone tool assemblage provides additional evidence for (grain) food processing and permanent settlement. A predominance of hand-held stones actively used for food grinding (Fig. 5c) is noticed, with only a few flat quern counterparts, mostly fragmented and worn down (Fig. 5d). The presence of these tools is taken as an indication of the processing of cereals and/or other food plants.[25]

A recurrent feature of many tools is their multifunctional usage, particularly among the hand-held tools, being used as active hammers, grinders, and pounding stones, as well as anvils, and sometimes even querns. This has been attested at other Swifterbant sites as well (Devriendt 2014; see also Peeters / Devriendt 2016), and it suggests an integrated part of the Swifterbant stone industry.

Another recurrent tool type is the hammer stone. Ground stone in the form of axes occur in very small numbers and are without exception fragmented, with often only (edge) flakes remaining. The Medel inhabitants also used stone to adorn themselves, exemplified by the finding of a small number of pendants and a single bead. The pendants generally consist of flat small water-worn pebbles with a biconical perforation at one end, although an artificially ground and shaped example possessing two perforations has also been recognised. The presence of a number of pre-forms suggests that these items had been manufactured locally.

Among the 20,000 pieces of flint, the large majority consists of nearby obtained flints. A small portion, however, is brought in from southern regions: from southern Dutch Limburg and possibly the Hesbaye region in Belgium. The number of arrowheads is remarkably low. The toolkit predominantly consists of scrapers. Together with the presence of sickle blades and the abundant evidence of tool re-use, they all are aspects one would expect in a permanent settlement site, with an emphasis on agricultural and domestic activities.[26]

Features

The notion of a domestic settlement site at Medel is further supported by the spatial analysis of the features.[27] Postholes are by far the predominant feature type. Over a thousand postholes, many of considerable depth of up to 0.8–1.0 m and with diameters around 0.25–0.3 m have been uncovered. Exceptional cases in which the actual post-fill could be distinguished within the larger posthole suggest postdiameters of c. 0.15–0.20 m, pointing to firmly built structures. Most postholes had very light-coloured fills, making them hard to distinguish from the natural subsoil. It is likely that therefore some went unnoticed, as the interrupted patterns in several adjacent trenches illustrate.

The careful study of the posthole clusters enabled the identification of house plans at the southern site. So far about 25 house plans have been reconstructed (Fig. 6). More houses must have been present, given the considerable number of postholes that could not be assigned to any plans.

Despite the variation in size, the plans show a remarkable consistency in post configurations. Based on the most complete plans, the following general observations can be made (Fig. 7). All are two-aisled structures. It is noteworthy that the postholes within each row are in almost perfect alignment, suggesting the main constructing axis had been along the longitudal direction. The central postholes are the deepest and are placed at more or less regular intervals. They constituted the longest posts.

Wall postholes exhibit more variation in their dephs and intervals. The variation in the latter aspect may be partly due to a bias in visibility, as the wall

22 It is rock rich in amphibole and high-Ca plagioclase, based on non-destructive analysis by Hanco Zwaan, Museum of Natural History (Naturalis), Leiden, using micro-Raman spectroscopy and X-ray fluorescence (ED-XRF).

23 Based on high Na contents, these are relatively pure jadeite rocks with low omphacite presence. The artefact has been analysed non-destructively by Hanco Zwaan, Museum of Natural History (Naturalis), Leiden, using micro-Raman spectroscopy and X-ray fluorescence (ED-XRF); see Harlow et al. 2014 for terminology.

24 Bernardini et al. 2012; Christensen et al. 2006; Schwarz-Mackensen / Schneider 1986; Šída / Kachlík 2009.

25 Use-wear analysis is currently being performed.

26 The information on the flints has been provided by Paul van der Kroft (RAAP) who together with Jeroen Mendelts MA (RAAP) carried out the analysis of the flint material.

27 All features from the Neolithic period have been analysed by Sebastiaan Knippenberg (Archol).

Fig. 6 The southern site showing the features with the location of identified house plans (H) and rows of posts plotted on the density (in g) of animal bone remains, with RPN = northern row of posts; RPS = southern row of posts.

postholes are generally lighter in colour, and therefore could have been missed more easily. The house size varies, but exhibits a continuum between the smallest one being around 9 m long and almost 5 m wide and the longest one having a length of 18.5 m, whereas the widest house, which is not the longest, measures 7 m. The general plan form is rectangular, with a number of house plans slightly tapering toward the western end.

Some of the larger houses suggest they had been divided into different compartments, as certain parts of the plan exhibit slightly different post configurations, which is also associated with a difference in posthole size and depth (Fig. 8). In some, these compartments can be viewed as being part of the house, suggesting it was divided into different segments or rooms. In exceptional cases, for example house 6 (Fig. 8), it may

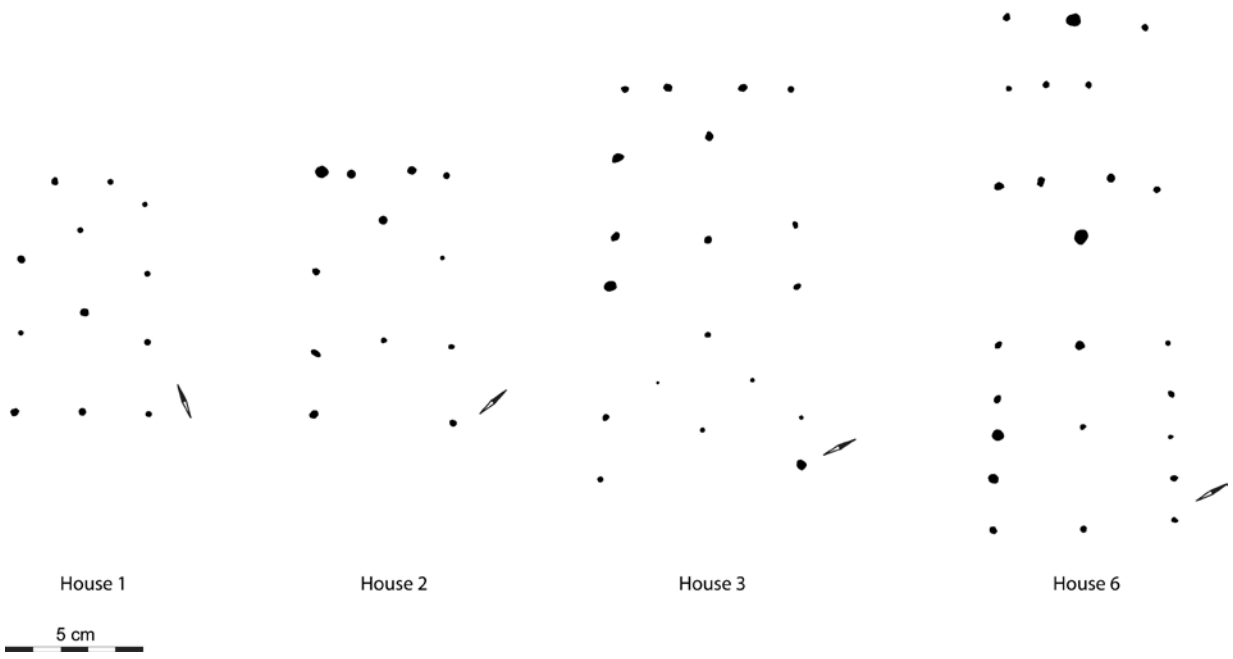

Fig. 7 A selection of the most complete house plans at Medel-De Roeskamp.

be argued that it relates to a later addition, although this will be difficult to prove.

A structural internal element found in almost all house plans is the presence of a pair of deeply dug posts situated at regular distances at each side of the central axis. Many of these pairs are situated at the western end of the house, but more centrally located ones also occur. These pairs always form regular triangles with one of the central posts. Both equilateral as well as isosceles triangles have been identified, with post distances of circa 1.5 to 2.4 m. A clue for their interpretation may be provided by their postfills. All three generally contain much more charcoal. This may indicate they had been situated adjacent to hearths.

The high number of identified house plans reflects a long lived permanent settlement. In some cases, houses have been rebuilt at the same location

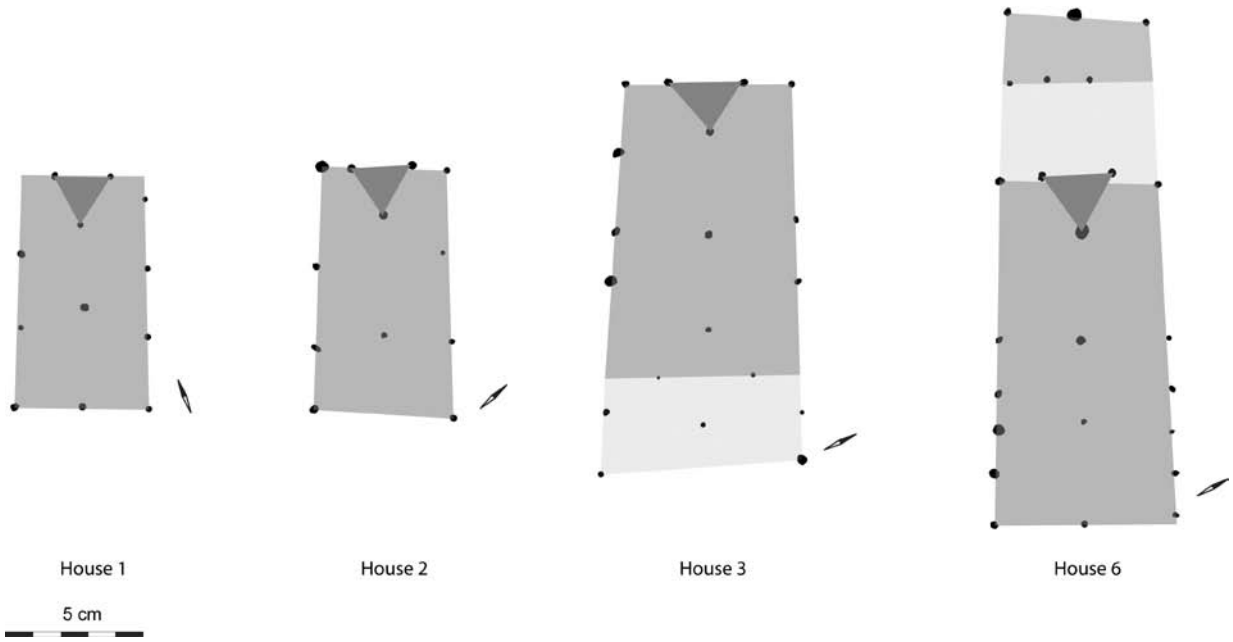

Fig. 8 The same house plans as in Figure 7, showing the division into different compartments and the location of the triangle configurations of deep postholes.

or were slightly moved, supporting continuous use of the southern site. The larger number of structures in its northern part indicates that this part must have been occupied the longest. The slightly different orientation of some southern plans, including the outlier house 1 with a perpendicular orientation, may point to a slight shifting of the settlement to the south. The overlap in house plans and differences in orientation indicate that the house plans represent several phases, each accounting for perhaps three to five houses. Getting to grips with the phasing will be a challenging task, considering the problems connected with a palimpsest situation and a notorious plateau in the ^{14}C calibration curve.

The other types of features at Medel are much less frequent. They include shallow pits and hearths. Pits have been identified on the basis of their larger diameter and flat to slightly bowl-shaped bottom. They often had not been dug in much deeper than the topsoil layer, so originally they must have had a depth of around 0.3–0.4 m. Pits are both situated inside as well as outside the house plans. Within house 2 or 3 a pit was found containing a large part of a 'Vorratsgefäß' (Fig. 4: 16151). It is hard to prove whether these are the remains of an intentional house offering (as found in for instance Funnelbeaker [TRB] houses). They might relate to some functional use as well. It is noteworthy that the overall number of pits at the site is small and that deep ones (> 0.6 m) are absent, indicating that pits were not used for food storage.

A conspicious element is formed by a row of very large postholes centrally located in the settlement perpendicular to the gully. The postholes were around 0.5–0.6 m wide and up to 2.0 m deep. They contained the remaining lower parts of seven massive oak posts and one made of alder, all showing cutting marks of stone axes. In alignment with these posts the upright trunks of two alder trees were uncovered. The fact that these trees were rooted in a layer below the levee signifies that they already existed before the formation of the levee, and their alignment with the oak posts suggests that they were still visible when the latter were erected. It must have been an impressive structure, presumably with a substantial height. The oak posts did produce tree ring series of considerable length (about 120 years), but they could not be matched to the regional dendrochronological curve. Another row had been placed around 50 m to the south. Its length and orientation, as well as its distance to the gully, are very similar to that of the northern one, though the southern row consists of paired postholes, less deep and wide, and not deep enough for the posts to be preserved.

How to interpret these rows? They do not surround the site, their length is too short and the post intervals are too wide for a protective fence or wall. So a defensive function seems unlikely. It couldn't have served as a protection against the wind, considering that west/northwest is the prevailing wind direction. Since the northern row seems to have incorporated trees that had survived the formation of the levee, it is likely that it belonged to the earliest habitation. Unsuitable as a defensive structure, the exceptional post sizes suggest a ritual role rather than a practical one, perhaps associated with the founding or structuring of the initial settlement. The parallel orientation to the houses would be in agreement with this idea. Whether the southern row of paired postholes is associated with the assumed younger southern shift of the settlement mentioned before, is a tempting thought but again difficult to prove.

The northern site is much smaller and does not have the high density of posthole features. Their presence, however, attests to the erection of one or more structures there too. Unfortunately this cannot be supported by the identification of a clear house plan. The preservation in this site is a lot better, probably due to less intensive and shorter use, resulting in less trampling. This is exemplified by the presence of two shallow hearths yielding a wealth of macrobotanical remains and other finds.

Settlement structure and houseplans in context

Though lacking the defensive palisades, Medel-De Roeskamp has a village structure that recalls the arrangements encountered a few centuries earlier in settlements of the Rössen culture of the Niederrheinische Bucht.[28] This resemblance could very well be the accidental outcome of repeatedly rebuilding and moving of the house location within a confined area. A difference, however, is seen in the choice of a new location when re-building a house. Within Rössen sites, houses were almost always moved to another location, whereas houses at Medel were sometimes re-build on the same spot.

The village arrangement at Medel is probably not unique for Swifterbant. Whilst at Medel many more houses could be identified than the two or four houses at Schokland-P14, large tracts of Schokland-P14 that

28 Rössen sites near Hambach, Inden and Aldenhoven, see for instance Dohrn-Ihmig 1983.

might yield many more house plans have not been excavated yet. In size and post configurations the house plans found at Schokland-P14 exhibit similarity with the small house plans of Medel. At P14 the additional pair of posts that subdivides the stuctures is present too (Ten Anscher 2012, 373–383). The P14 house plans might be slightly younger, perhaps arguing for a tendency towards smaller houses in Swifterbant.

Though the Medel houses are clearly not related to the Rössen longhouses, the partitioned two-aisled, slightly tapering plans do somewhat resemble the smaller Rössen houses with lenghts around 20 m. By contrast, small rectangular and sometimes tapering two-aisled houses that have a general resemblance to the plans found at Medel-De Roeskamp and Schokland P14 are the norm in Epi-Rössen offshoots.[29] Good parallels, however, have been excavated not too far away in several sites near Jüchen-Garzweiler in the German Rhineland, spanning an occupation period from around 4,500–4,200 calBC.[30] The oldest house plan FR 98/28 still resembles Rössen types, although it already represents a transition toward the more simple two-aisled forms found at Medel. Nevertheless, its small rows each consisting of three internal posts perpendicular to the long sides are lacking in the Swifterbant houses. The two tapering house plans associated with the Bischheim middle phase, FR 98/251 and FR 2001/103, consist of a central row and two side rows, each made up of four or five postholes at regular intervals. Although conspiciously wide, they have more in common with the P14 houses than with the Medel house plans which only seldom show side posts perpendicular to the central posts. The youngest house plan, FR 138, however, with its rectangular, and two-aisled plan is very similar to the larger Medel houses. The presence of a configuration of posts at its northern short end, quite comparable with the triangular configuration found in the Medel house plans is also striking. The proximity in time and space as well as the close similarities in house plans make it therefore quite likely that the Swifterbant house tradition harks back to Bischheim sources.[31] The Swifterbant houses, in turn, could have served as a link to Hazendonk and TRB house types.[32]

Conclusion

Large scale excavations at Medel-De Roeskamp near the city of Tiel in the Dutch river area have almost completely uncovered a Swifterbant settlement site dating around 4,300–4,000 calBC. This site is exceptional due to its large size, its extended broad-spectrum subsistence economy primarily based on domesticates as well as a large number of house plans, pleading against residential mobility. The character of the find assemblage is indicative of a permanent settlement too. Presumably, Medel was the long lived permanently inhabitated core of a territory that was exploited also by means of numerous short lived special purpose camps scattered in the surrounding areas.

The emphasis at Medel on pig herding and cereal cultivation, with a grain spectrum consisting of four different species, processed and probably grown locally, is very similar to that found in some contemporaneous sites to the southeast and south, notably the Rhineland Bischheim sites near Jüchen-Garzweiler and the Flemish Michelsberg site Spiere-De Hel (Arora / Zerl 2003; Vanmontfort 2004). Medel imports such as the two fragments of jadeitite axes and a perforated broad wedge, and the Medel ceramics also point to contacts with the Danubian tradition, in particular Rössen/Bischheim. The Medel house plans bear general resemblances with the house plans found in Epi-Rössen contexts, and possess close parallels in the house plans from Bischheim sites in the German Rhineland.

29 For the term Epi-Rössen see Gleser 1992; 2012. See for instance the Goldberg-house plans published by Bersu 1936. See Ten Anscher 2012, 383 for a discussion of the cultural context of the Swifterbant or Pre-Drouwen house plans from Schokland-P14, which applies to the house plans of Medel-De Roeskamp as well. The house plans from Jüchen-Garzweiler were not known to Ten Anscher at that time.

30 Arora 2000; 2001; 2004; Arora / Zerl 2003; 2004. House plan FR 98/28 (19 × 4–8 m; tapering), charred grain from a posthole ^{14}C-dated 4,455 ± 85 calBC; house plan FR 98/251 (19 × 10–12,5 m; tapering); house plan FR 2001/103 (15 × 6–9 m; tapering), charred grain form a nearby pit 14C-dated 4,290 ± 45 calBC; house plan FR 138 (18 × 5,5–6 m; rectangular), no associated ^{14}C-dates. Arora 2004 linked FR 98/28 to early Bischheim, FR 98/251 and FR 2001/103 to its middle phase and FR 138 to late Bischheim, also taking the characteristics of the associated ceramics into account. Interestingly, about 12 m to the northeast, parallel to house plan FR 138, an 8 m long palisade was found, consisting of ten postholes with diameters around 0.25 m. Though less sturdy, it recalls the palisades found at Medel.

31 A Michelsberg source is unlikely since permanent dwelling structures are hardly found in Michelsberg contexts.

32 Hazendonk group: see the house plan from Wateringen 4 (Raemaekers 1997) and Ypenburg-Locatie 4 house plans 2 and 3 (Houkes / Bruning 2008); TRB: see e. g. Müller 2017, 22–23: house type Dagstorp (TRB North group), for instance the house from Rastorf, and house type Flögeln (TRB West group), for instance Pennigbüttel house B. See also Drenth et al. 2014: the TRB West group hut from Slootdorp-Bouwlust, quite similar to the Swifterbant hut plan found at Swifterbant-S3 (De Roever 2004, appendix 1).

Medel-De Roeskamp sheds new light on the neolithisation of the western part of the North European Plain, with site permanency in SW2 being arguably the final outcome of the neolithisation process. Medel-De Roeskamp is a clear example of a settlement fully adapted to a sedentary Neolithic way of life in the western parts of the North European Plain, where fishing, hunting and gathering continued to play a role in daily life well into the Bronze Age. In the Dutch river area, the neolithisation process had thus reached a mature stage already in the period 4,300–4,000 calBC.

Acknowledgements

We are much obliged to the Industrieschap Medel for financing the archaeological investigations at Medel-De Roeskamp and in particular to Ilse Schuuring (Municipality of Tiel) who with great tenacity put the archaeology of Medel on the map. We thank the organisation board of the workshop 'Stone Age borderland experience – Neolithic and Mesolithic parallel societies in the North European Plain' (20 to 22 May 2019, Landesmuseum Hannover) for the opportunity to attend and to present our paper. Many thanks to Erik Drenth for his critical remarks on the text.

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Swifterbant and the Late Mesolithic in Westphalia

Bernhard Stapel

Abstract While the Westphalian loess belt was already settled by farmers of the Linear Pottery culture by the 6th millennium calBC, the introduction of a Neolithic way of living in the area north of the river Lippe was significantly delayed. First Final Mesolithic sites indicate the presence of contemporaneous hunter-gatherers. In the 5th and 4th millennia calBC a few isolated finds from the Muenster Embayment show contacts to cultures of the adjacent northern lowlands.

Keywords Final Mesolithic of northern Westphalia, neolithisation of the Muenster Embayment

Zusammenfassung *Ab dem 6. Jahrtausend calBC wurden die westfälischen Lössbörden bereits von den Bauern der Linearbandkeramik besiedelt. Dagegen erfolgte nördlich der Lippe die Einführung der neolithischen Lebensweise deutlich verzögert. Zunächst zeigen endmesolithische Fundplätze in diesem Raum ein Weiterleben von Jäger-/Sammler-Gruppen an. Im 5. und 4. Jahrtausend calBC deuten einige wenige Einzelfunde aus der Münsterländer Tieflandbucht Verbindungen zu Kulturen des nördlich anschließenden Flachlandgebiets an.*

Introduction

Westphalia is situated at the southern fringe of the north European plain. Large areas in the south and east are part of the German central upland. Only the Muenster Embayment in the northwest and the foothills of the Wiehengebirge are to be attributed to the northern lowlands.

Since the 6th millennium calBC the loess belt in the Hellweg region and east Westphalia had been settled by farmers of the Linear Pottery culture (LBK) and later of Middle Neolithic cultures of Danubian tradition. At first glance, the presence of contemporaneous Final Mesolithic hunter-gatherers in Westphalia seems to be doubtful. However, there are a handful of hints pointing to the presence of such groups in the northern Münsterland region. This scanty evidence is represented by a few stray finds from sandpits and older excavations, which reveal connections to the northern lowlands.

Late and Final Mesolithic sites in northwestern Westphalia (7,100– 5,300/4,750 BC)

In the northwestern part of Westphalia there are about 90 Late Mesolithic sites represented by the presence of trapeze microliths (Stapel 2013a, 219 Abb. 279). The majority of our information comes from surface collections. Excavations on Westphalian Mesolithic sites have been rather the exception so far. The main areas of distribution are in the southwest of the area and along the river Ems. But the picture is surely determined by activities of amateur archaeologists and might not correspond to prehistoric reality. A decline in the number of Late Mesolithic sites compared with that of the earlier Mesolithic period cannot be observed.

One of the few excavations has been conducted in Vreden-Stadtlohner Straße (Kreis Borken), in the west of the Münsterland, near the Dutch-German border (Fig. 1; Stapel 2013a, 220–221). A small test trench excavated in 2001 and 2002 yielded a layer containing Mesolithic artefacts at the base of a Plaggen soil. The assemblage consists of approximately 1,100 pieces of flint (Fig. 2). The artefacts are usually of limited size. Significant components of the assemblage are regular blades and blade cores. Modified tools are rare, and include a few retouched and utilized blades and flakes, a scraper, and three microliths of which one is a symmetrical trapeze.[1]

At first glance it seems to be a quite ‘normal’ Late Mesolithic material. Surprisingly, the AMS-dating of two charred hazelnut shells found together with the

1 In general, there are similarities to the Swifterbant assemblage of Hüde I, Dümmer, Lower Saxony (Stapel 1991, 153–155). The micro point is an exception to this.

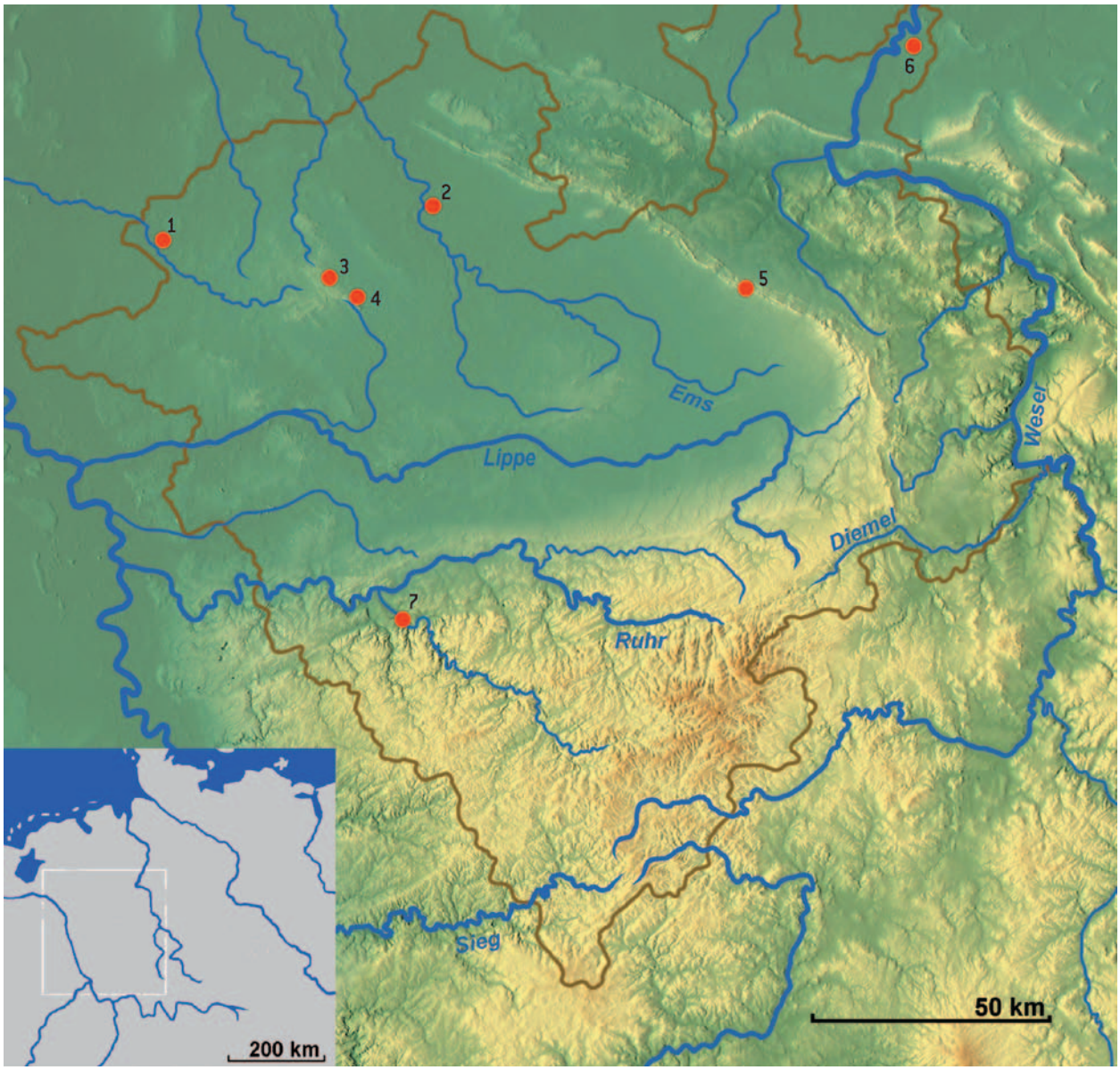

Fig. 1 Map of main sites discussed in the text. **1** Vreden-Stadtlohner Straße; **2** Greven-Sandgrube Schencking; **3** Rosendahl-Osterwick; **4** Nottuln-Uphoven; **5** Oerlinghausen-Lipperreihe Heisterbrink; **6** Petershagen-Hävern; **7** Hagen Blätterhöhle (graphics: M. Kloss, draft B. Stapel).

artefacts revealed unexpectedly late results, pointing to an occupation of the site at about 4,900 calBC (GrA 21396: 6000 ± 50 BP, 4897 ± 62 calBC), some 400 years after the start of the Neolithic in Westphalia.

But Vreden is not the only Late Mesolithic site of such an age. Birgit Gehlen has been examining materials from east Westphalia as part of her research project on Mesolithic sites in North Rhine-Westphalia. One of the surveyed sites is Oerlinghausen-Lipperreihe Heisterbrink (Kreis Lippe; Gehlen et al. 2017, 16–29). In October 1927 this location had been excavated by amateur archaeologists. Their report described two artefact scatters or concentrations surrounding a pit with charcoal filling, possibly a hearth.

The assemblage consists of over 860 silex artefacts of small dimension. The silex industry is based on blades. Microliths are represented by trapezes, micro points, and micro burins. A few blades with oblique retouched end and some scrapers should also be mentioned (Gehlen et al. 2017, 20–21 Abb. 7–8). Similarities to Vreden can be noted above all in the microliths, in the manufacturing technique, and in the small dimensions of the artefacts (Gehlen et al. 2017, 26). An AMS dating of charcoal confirmed a Final Mesolithic age of about 5,000 BC (Col 2190.1: 6080 ± 47 BP, 5005 ± 67 calBC).[2]

2 In east Westphalia there are a few Mesolithic sites with even later radiocarbon dates (Banghard / Gehlen 2013, 211). The reliability of these dates is under discussion.

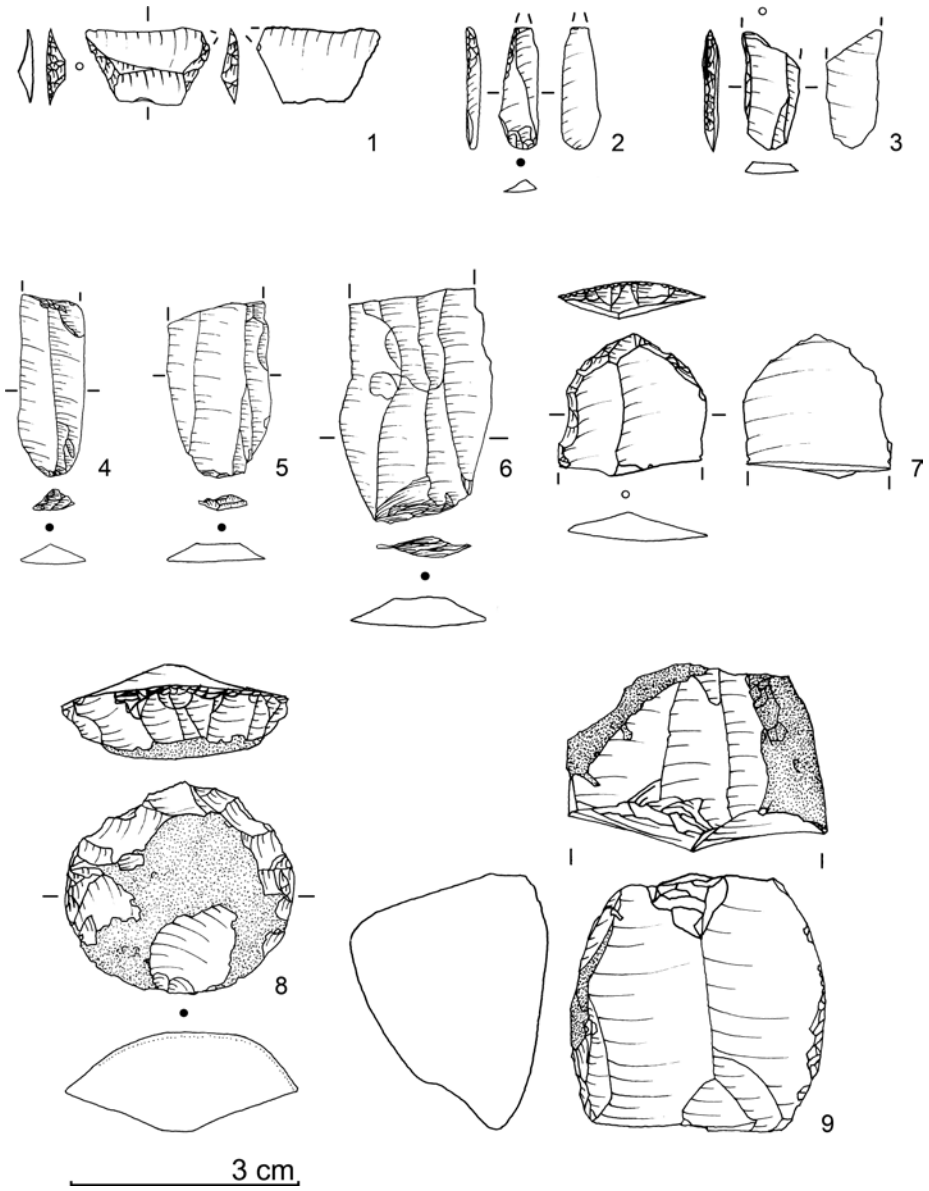

Fig. 2 Vreden-Stadtlohner Straße. Flint artefacts: **1–3** microliths; **4–6** blade fragments; **7–8** scapers; **9** core (drawings: J. Piesniewski and P. Altevers).

The two sites probably reveal a Final Mesolithic cluster in the Muenster Embayment. These hunter-gatherers lived in northern Westphalia at a time when agricultural communities of the LBK and early Rössen cultures were settled in the loess zone of the Hellweg region and east Westphalia, which is situated 80–100 km further south (Pollmann et al. in prep.). During the later Middle Neolithic (4,750–4,400 calBC) the settlement area of the cultures of Danubian tradition was extended to the north, with Nottuln-Uphoven (Kreis Coesfeld) forming the first Neolithic outpost in the lowlands of northwestern Germany (Groer 2010; 2013).

T-shaped antler axes in Westphalia

T-shaped antler axes represent an artefact category often discussed concerning the transition from Final Mesolithic to Neolithic in northwestern Europe. Over 20 specimens from twelve sites are known from Westphalia (Stapel 2013b, 228–231 Abb. 290). These all are single finds dredged from river sediments of the Ems, Lippe, and Weser rivers. Radiocarbon dates for Westphalian specimens show a range from 5,000 to 3,500 calBC. This corresponds to previous dating results, e.g. from Belgium (Crombé et al. 1999, 116 table 2).

Because T-shaped antler axes were used both by Final Mesolithic hunter-gatherers and Neolithic farmers, an unambiguous cultural assignment is only exceptionally possible.[3] This is perhaps true for an antler axe from Greven-Sandgrube Schencking (Kreis Steinfurt; Stapel 2013b, 229 Abb. 291). The sand pit exploiting Holocene and Pleistocene sand is located in the Ems floodplain. Since the 1970s, a bulk of archaeological finds dating from the Middle Palaeolithic to the late Middle Ages has been recovered there by amateur archaeologists, including this object. The dating of the T-shaped antler-axe from Greven (MAMS 11799: 6027 ± 30 BP, 4898 ± 42 calBC) is very similar to the results from Vreden and Heisterbrink. Since the item is older than the beginning of the Rössen settlement in Nottuln-Uphoven, it should probably be attributed to Final Mesolithic groups.

Swifterbant in Westphalia?

The northwestern European lowlands seem to have been settled by cultures of hunter-gatherer descent until the end of the 5th millennium calBC or even later; represented by the Swifterbant culture west of the river Elbe (Louwe Kooijmans 2007, 306), and the Ertebølle culture north and east (Hartz et al. 2007, 574 fig. 4). With late radiocarbon dates for Westphalian Mesolithic assemblages it may be possible to detect influences from the north or west in this region. Two recently found artefacts from Greven-Sandgrube Schencking have initiated a new discussion on this issue.

In 2013, the operator of the sand pit handed over an unexpected piece of worked bone to the amateur archaeologist Gregor Laufer. It is a 47.5 cm long and 24 cm wide scapula of an aurochs (Fig. 3). Two circular discs with a diameter of 7.3 cm and 8.8 cm have been cut out of the bone. At the damaged end there are signs that a third disc has been obtained, too (Stapel / Schlösser 2014, 46–49). A ^{14}C-dating yielded an age of 4,345 ± 9 calBC (MAMS 18466: 5488 ± 24 BP). Comparable scapulae with circular cuts were not known from Westphalia before.

However, there are good parallels from the distribution area of the north German and Danish Ertebølle culture, e.g. a scapula with three cutouts from the site Ringkloster in Jutland, DK (Andersen 1994/1995, 36–38 fig. 20a/b). There it was possible to prove that these scapulae are waste products of bone ring production. Further roughouts for disc or rings and waste pieces have also been published for sites with Swifterbant material, e.g. Hüde I, Dümmer (Landkreis Diepholz; Deichmüller 1969, 32–33 Abb. 2,1.5).

Fig. 3 Greven-Sandgrube Schencking. Scapula with circular cutouts (photo: S. Brentführer).

We owe the study by Lutz Klassen on the transition from the Mesolithic to the Neolithic in southern Scandinavia a distribution map of this artefact group, which is based on preliminary work by Danish colleagues (Klassen 2004, 126–128 Abb. 96; cf. Vang Petersen 1984, fig. 13). This type of bone ring production, which can be seen in the scapulae with circular cuts, seems to be closely linked to Final Mesolithic groups, whose subsistence was based on hunting, fishing, and gathering. In contrast, no comparable finds are known from contemporaneous west and south German Neolithic farming cultures. The Greven specimen is the most southern find of its type so far (Fig. 4).

3 It is perhaps possible to distinguish between Mesolithic and Neolithic T-shaped antler axes on the basis of aspects of the manufacturing process (David 2019, 479).

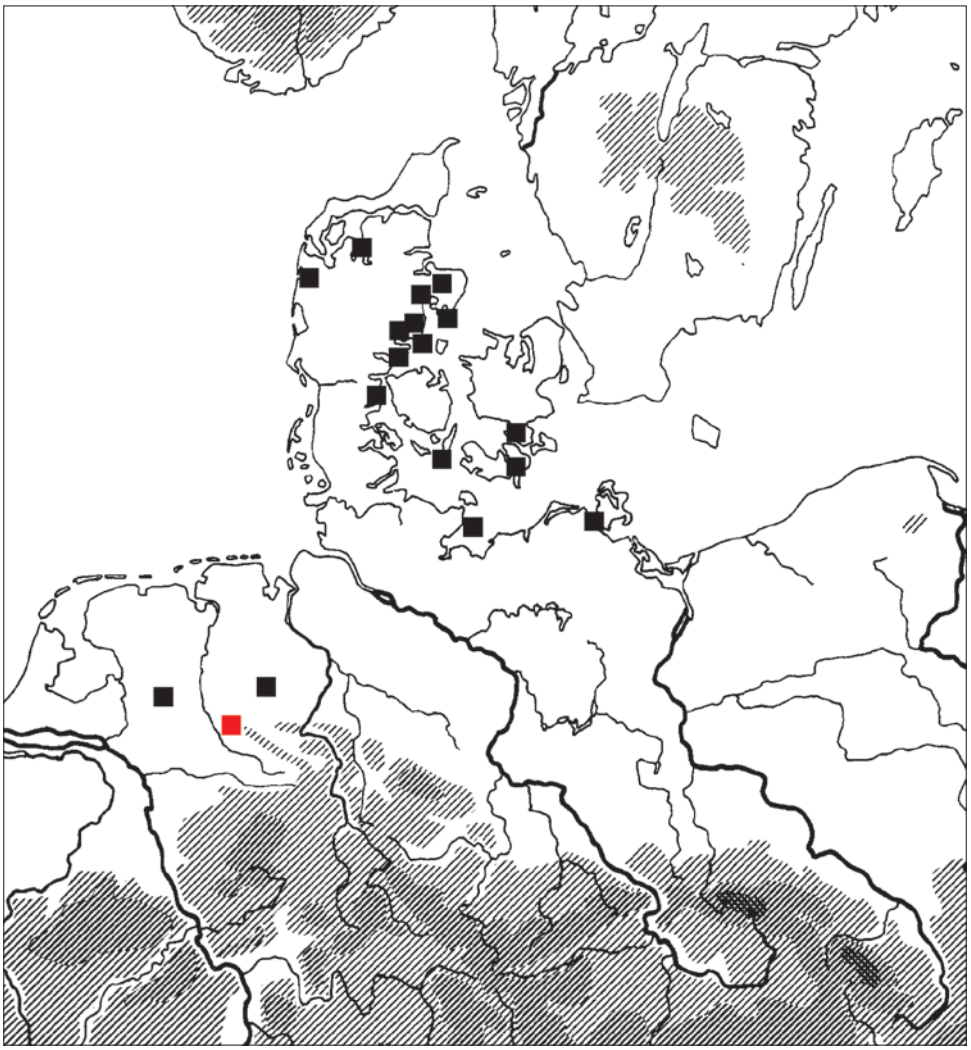

Fig. 4 Distribution map of scapulae with cutouts. Greven-Sandgrube Schencking is marked in red (graphics M. Kloss, after Klassen 2004, Abb. 96).

Fig. 5 Greven-Sandgrube Schencking. Decorated rim sherd (photo: P. Altevers).

The shoulder blade is a waste product and can therefore hardly be interpreted as an import find from the north in a region otherwise dominated by Neolithic cultures such as the Rössen culture. There seems to be much to suggest that Final Mesolithic hunters of the Swifterbant culture lived here along the river Ems.

Furthermore, a ceramic fragment in the collection of archaeological remains discovered in the sand pit over the past decades might belong to a similar cultural context. It had already been picked up a few years ago by another amateur archaeologist, Manfred Schlösser. The characteristics of this sherd differ markedly from those of the Iron Age ceramics otherwise found there. The rim sherd has a decoration with fingertip and fingernail impressions on both the outside and the interior of the rim (Fig. 5). A food crust offered the possibility of radiocarbon dating. The result pointed to the 43rd century calBC (Col 2679,1,2: 5,395 ± 40 BP).[4] Therefore it seems quite possible to look for parallels in the Swifterbant culture.

4 Radiocarbon dating in cooperation with B. Gehlen and J. Rethemeyer, University of Cologne. We are still waiting for the results of an isotopic evaluation concerning the reliability of the date. A correction for reservoir effects is possible.

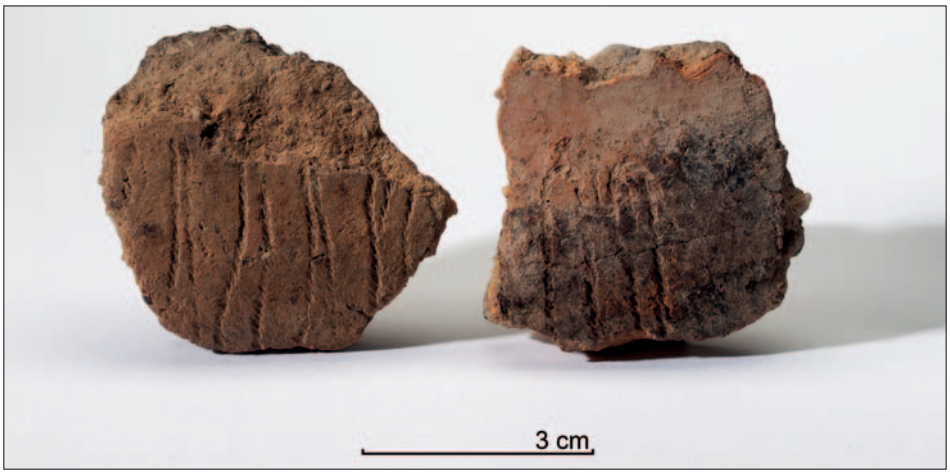

Fig. 6 Rosendahl-Osterwick. Sherds with cord impressions (photo: S. Brentführer).

In the assemblage of Hüde I there are pottery vessels with a decoration on the inside and outside of the rim (Kampffmeyer 1991, Taf. 7,691; 22,3810; 36,9114; 57,27238; 64,30147). Position and technique of the decoration vary, so that these are similar, but not identically decorated potsherds. Nevertheless, it seems possible to connect the Greven rim sherd with this material.

On the sites Swifterbant S3 and S61 (De Roever 2004, 90 fig. 19a; 95 fig. 24i) as well as Schokland-P14 (Ten Anscher 2012, 71 fig. 5.1,149) we can see pottery similar to the Westphalian ceramic fragment. Decoration on the interior of the rim is certainly to be noted for the Swifterbant culture. Not least because of the radiometric dating an assignment to the Swifterbant culture seems plausible.

However, it should not be concealed that decoration of the outer and inner rim also occurs at Rössen sites, such as Soest-Deiringsen/Ruploh (Kreis Soest; Günther 1976, Taf. 11,19).

A second site with affinities to population groups in the north European plain has certainly been known for quite some time: Rosendahl-Osterwick (Kreis Coesfeld). Rescue excavations were carried out there from 1968 to 1972. During this time remains of a Michelsberg III phase settlement site were documented. Christoph Willms published the material (Willms 1982). However, a small number of ceramics present at this site did not fit into the Michelsberg III spectrum due to their texture; these he assigned to the Early Funnel Beaker culture (Willms 1982, 21).

Concerning our question, the important part of the assemblage is a number of sherds with cord impressions, which were recovered as stray finds (Fig. 6). This material has been discussed earlier, e.g. by Daan Raemaekers in his analysis of the late Swifterbant remains of Wetsingermaar (Raemaekers et al. 2011/2012, 9–10 fig. 8) or by Theo ten Anscher (Ten Anscher 2012, 123) for Schokland-P14. Of course, some examples from Hüde I (Kampffmeyer 1991, Taf. 58,27412) and Schokland-P14 (Ten Anscher 2012, 117 fig. 5.19,2–4) show a great similarity to the Osterwick pottery.

For his publication of the causewayed camps of Soest and Nottuln, Benedikt Knoche prepared a map showing the distribution of this pottery with cord impressions (Knoche 2008, 148–149 Abb. 5.20). He discussed this material in the wider frame of the Early Neolithic of the north European plain.

However, I consider it justified to assign it to the late Swifterbant culture or, according to the terminology for Schokland-P14 by Theo ten Anscher, the Pre-Drouwen phase (Ten Anscher 2012, 121). Thus, at a second site, indications of contact with groups from the northwestern lowlands, or perhaps even the presence of such groups in the Münsterland, might be suggested.

Moreover, in Osterwick relationships are also visible that point further northeast. One such item is a vessel that Willms (1982, 10–11 Taf. 18 F.253) assigned to the Michelsberg settlement. Klassen (2004, 186–187 Abb. 119 A) interprets it as a funnel necked beaker of his Siggeneben Süd/Stengade II group. This would suggest connections to the Early Funnel Beaker culture in Schleswig-Holstein and Denmark. Klassen proposed a similar interpretation for a fragment from a sandpit in Petershagen-Hävern (Kreis Minden-Lübbecke), near the River Weser (Klassen 2004, 186–187 Abb. 119D).

If one maps the few hints for contact with the Swifterbant culture in northern Westphalia together

with the also documented settlements of the Rössen, Bischheim, and Michelsberg cultures of the 5th and 4th millennia calBC, a picture emerges that suggests a close coexistence of the different groups (Stapel / Schlösser 2014, 48 Abb. 5). For example, the sand pit in Greven-Sandgrube Schencking is barely 30 km away from the settlement site of Neolithic farmers in Nottuln-Uphoven. However, evidence is very limited. In this respect, a second possibility may be conceivable. If the chronology of the Nottuln-Uphoven site based on 19 ^{14}C-dates is examined in detail, a hiatus can be observed between the Rössen-Bischheim and the Michelberg III phases (Groer 2013, 145 Abb. 21). The dated Swifterbant finds of Greven-Sandgrube Schencking fall into this period.

It is also possible that the frontier between the descendants of the Mesolithic hunter-gatherers and the Neolithic farmers might have shifted again and again. So, at one time representatives of the Rössen and later the Michelsberg culture moved into the Muenster Embayment, but after the abandonment of these settlements, descendants of Mesolithic hunters returned to this area.

Concerning Mesolithic/Neolithic parallel societies in Westphalia, recently the Blätterhöhle near Hagen has been brought to the fore. During the Late Neolithic the cave was used for funerals. Based on isotope and palaeogenetic analyses, it was possible to differentiate two groups within this population, which buried their dead there together: one group that used agricultural products and can be genetically assigned to Neolithic farmers, and a second group that lived mainly by fishing and can be addressed as descendants of Mesolithic hunter-gatherers (Orschiedt et al. 2014, 44). The latter population is so far archaeologically completely invisible. Currently it cannot be clarified whether these people are the descendants of local hunter-gatherers, or whether this group had immigrated from the north European plain (Orschiedt et al. in prep., 206). Maybe they were the descendants of the hunter-gatherers who left their bone artefacts on the river Ems.

Conclusions

There is so far no excavated site of the Swifterbant culture in Westphalia. However, there are indications for contacts with the north European plain, even for the presence of descendants of Mesolithic hunter-gatherers in the northern part of this region. Northern Westphalia might have been a contact zone for the exchange of information between the descendants of hunter-gatherers of the north European plain and the Neolithic farmers established in the loess belt.

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Foraging in a changing landscape – the Late Mesolithic in the coastal area of Lower Saxony

Svea Mahlstedt, Martina Karle and Jan F. Kegler

Abstract In the coastal area of Lower Saxony, Germany, archaeological research on the late Mesolithic is closely interrelated with a detailed landscape reconstruction, due to the major changes the area has undergone since the early Holocene.
In this paper the coastal and landscape development of the 7th to 5th millennium calBC is introduced with a special focus on inundation, sedimentation, and peat growth concerning the region of the East Frisian Peninsula, situated between the estuaries of the rivers Weser and Ems. The state of research on Mesolithic sites is quite fragmentary due to large areas being covered by marine clay or peat. Most finds are stray finds from the sandy uplands and therefore difficult to date directly, and as there is a lack of organic remains, there is no detailed typochronology. Some finds were made on the beaches, where they were washed ashore, having been uncovered by erosion in tidal channels. Some new finds of human bones from late Mesolithic and early Neolithic times are presented here as well as an antler axe that was expected to be of Mesolithic age. Now, recent radiocarbon dating has shown that it dates into the transitional horizon between the Late Neolithic Single Grave culture and the Early Bronze Age. Finally, a range of recent projects on early Holocene landscape reconstruction and archaeological survey on- and off-shore is presented.

Keywords Holocene sea level rise, Mesolithic, Neolithic, East Frisia, human mandibles, antler axe

Zusammenfassung *Aufgrund der starken Landschaftsveränderungen seit dem frühen Holozän ist die archäologische Forschung zum späten Mesolithikum in der Küstenregion Niedersachsens besonders stark mit einer detaillierten Landschaftsrekonstruktion verbunden.*
In diesem Artikel liegt daher ein besonderer Focus auf der Küstenentwicklung der Ostfriesischen Halbinsel zwischen den Mündungsbereichen von Weser und Ems im siebten bis fünften Jahrtausends cal. BC im Hinblick auf Meeresspiegelanstieg, Sedimentation und Moorwachstum. Der Forschungsstand zum Mesolithikum der Region ist noch sehr lückenhaft. Die meisten Funde stammen von Oberflächenfundplätzen der küstennahen Geestregion. Sie sind innerhalb des Mesolithikums kaum genauer chronologisch einzuordnen, da datierbare organische Funde ebenso fehlen wie eine detaillierte Typochronologie.
Einige Funde stammen direkt von der Küste. Sie wurden in tiefen Prielen erodiert und an Land gespült. Hier werden zwei neue Funde menschlicher Knochen aus dem späten Mesolithikum und dem Neolithikum vorgestellt sowie eine Geweihaxt, die lange Zeit als mesolithisch angesprochen worden war. Nun konnte eine Radiokarbondatierung zeigen, dass sie zeitlich aus dem Übergangshorizont zwischen der spätneolithischen Einzelgrabkultur und der frühen Bronzezeit stammt.
Der Forschungsprozess zur mesolithischen und neolithischen Besiedlung der heutigen Küstenregion Ostfriesland ist noch längst nicht abgeschlossen; dies zeigen auch verschiedene Projekte, die sich mit Landschaftsrekonstruktion, predictive modelling und archäologischem Survey zur fraglichen Epoche beschäftigen und hier abschließend kurz vorgestellt werden.

Introduction

The transition to a fully Neolithic economy seems to have happened later in northern central Europe than elsewhere on the continent. A better understanding of this period in the region has developed during the last decades, with some hotspots of research along the Baltic Sea coast, in the Dutch lowlands and the Rhine estuary. We know about contacts between late hunter-gatherers in the north and farmers to the south (Klassen 2004), and there are ideas about early farmers or horticulturists in the area of the modern Netherlands influencing developments along the Baltic coast (Ten Anscher 2015). Meanwhile, the area of northwestern Germany remains surprisingly empty on archaeological maps of the period, only illuminated by the somewhat enigmatic site of Hüde 1 at the former shore of Lake Dümmer, where

there seems to be a more direct connection to early farmers in the south (Raemaekers 1999).

This paper focusses on the area between Lake Dümmer and the North Sea coast, especially the East Frisian peninsula. Preservation and visibility of sites in this area are highly influenced by Holocene landscape development driven by the postglacial sea level rise, resulting in sediment accumulation and peat formation.

In coastal areas human occupation is closely tied to changes in regional water levels, the locations of waterways resulting from this, and the active coastal zone. Therefore, landscape evolution and human occupation of coastal zones are closely related, and evidence of the latter may provide information on regional coastline displacement. The tidal range and the extent of tidal inundation as well as the shaping force of storm events are the most relevant factors in coastal landscape transformation, the preservation of past cultural traces and landscape archaeology.

Thus we will give an introduction to landscape development first before an overview on the current state of research on the Mesolithic in the area is presented. Finally, some recent projects and new data are introduced and discussed.

The coastal area – landscape development during Mesolithic times

The coastal plain of Lower Saxony is part of the lowlands bordering the coast of the southern North Sea. The low-lying area (below +3 m a.s.l. [NHN in German]) is bordered to the south by shallow uplands of Pleistocene deposits. During and after the last glacial maximum, when the sea level was up to 130 m lower than today, large tracts of presently submerged areas in the North Sea basin were dry land and used by humans. The pre-Holocene land surface along the east Frisian peninsula was shaped by drainage patterns of numerous natural watercourses. These palaeovalleys were incised up to 20 m deep into the glacial deposits by surface discharge during times of low sea level. They created a landscape relief that was much more lively during the early Holocene than today. The melting of the continental ice sheets since the end of the last glaciation caused a global sea level rise and consequently a continuous coastline displacement within the North Sea basin (Streif 1990; 2004; Behre 2007), covering former terrestrial areas with marine deposits. These Holocene deposits covering the Pleistocene basement are up to 20 m thick and are evidence of a complex environmental history during the last 7,000 years. The Holocene sediments are composed of siliciclastic intertidal and saltmarsh deposits as well as freshwater peat, the latter's growth being induced by a rising groundwater level due to sea level rise. This so-called basal peat was radiocarbon dated to max. 6,000 calBC, giving evidence for the position of the former coastline close to that of the present-day barrier islands during that time.

Fen peat and raised bog peat locally occur at the base of the clastic sediments as well as intercalated within or on top of them indicating the formation of fenland in the coastal flats and therefore a repeated lateral shift of the coastline. On the landward part of the Holocene deposits the individual layers of basal, intercalated and overlying peat merge into thicker units or into a continuous peat sequence close to the Pleistocene hinterland. On this adjacent moraine area raised bog peat started growing due to a more humid climate in the first half of the Holocene (Petzelberger et al. 1999). Tree stubs on the bottom of the peat bogs as well as the basal peat show that this development led to a massive deforestation through time, which must have influenced the life of the late hunter-gatherers in the area. From an archaeological perspective the peat cover has sealed large areas of the former surface, burying all remains of human activity beneath.

Marine sedimentation around 5,000 calBC is limited to the channel structures of the palaeovalleys (Fig. 1). Thus, former river-dominated valleys were transformed into estuaries and narrow tidal basins (Karle / Goldhammer 2017). Until approx. 4,000 calBC channel infill took place with local peat erosion on channel flanks. With an ongoing rise in sea level, sheltered tidal flats developed in the coastal plain above -9 m below sea level (bsl). Lateral erosion of tidal channels with an erosion depth of only a few decimetres in the landward part, but up to several metres close to the tidal inlets between the barrier islands resulted in erosional loss of former mainland areas. Therefore, artefacts may have been eroded and relocated within the tidal system, so that find sites often do not relate to the original find context, depending on transport distance and energy.

Current state of research

The coastal marshes and adjacent areas have undergone massive changes since Mesolithic times due to the accumulation of marine deposits and peat formation as well as natural erosional processes, both induced by Holocene coastline displacement. In addition, there is a massive human impact on landscape development in later times due to land reclamation and peat extraction on the moraine area during the last 800 years. Therefore, Mesolithic sites were cover-

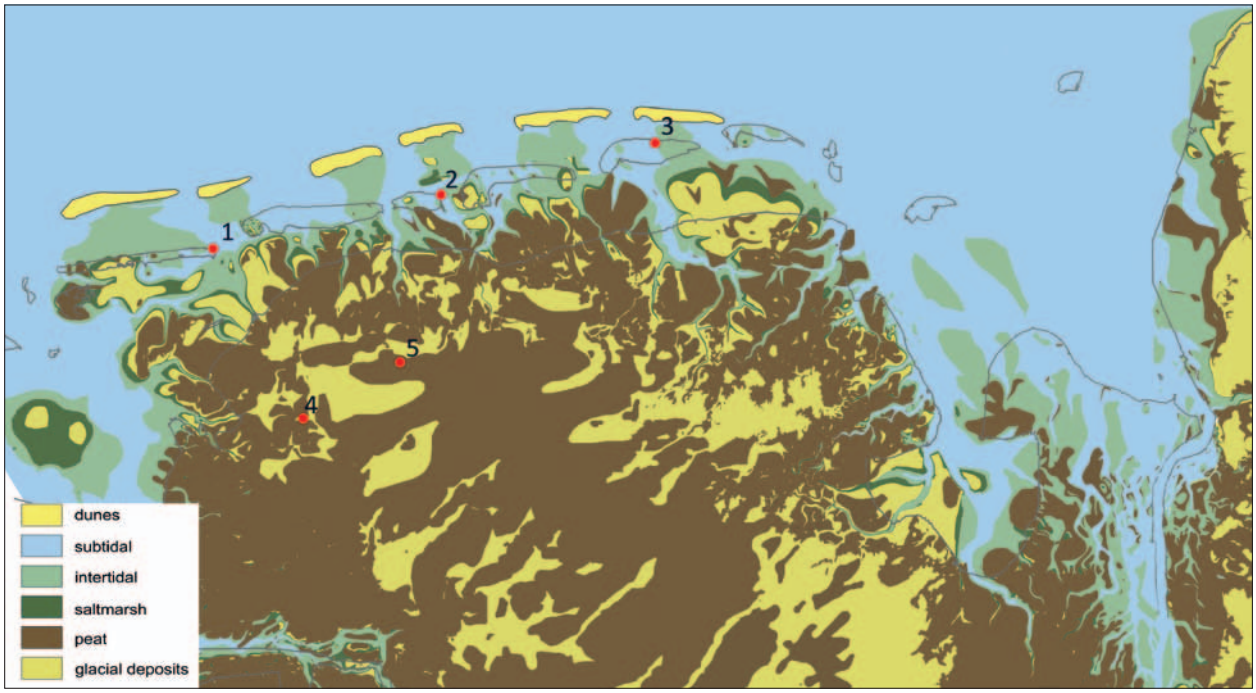

Fig. 1 East Frisia – reconstruction of landscape and sea-level between 6,000 and 5,000 calBC. Grey line: present day coast line; red dots: sites mentioned in the paper. **1** Juist; **2** Baltrum; **3** Spiekeroog; **4** Osteel; **5** Coldinne (map: M. Karle).

ed and recovered again by both natural and anthropogenic influences.

On the East Frisian peninsula Mesolithic settlement sites have not so far been the object of focused archaeological research or excavation. On the contrary, most sites were discovered by accident or during long-term surveys by volunteers (Kitz 1988, 25). Clusters of sites often correspond to the research areas of volunteers. Additionally, all surface sites are situated on the sandy uplands of East Frisia. In the coastal marshes, Mesolithic finds are rare, due to the covering with late Holocene deposits. Consequently, they are only discovered during construction activities. Mesolithic objects from the Wadden Sea have so far always been relocated stray finds (see below).

Within the last thirty years, two main publications have summarised the state of research, using two different approaches. W. Schwarz presented a more technical description of lithic assemblages (Schwarz 1990), whereas one of the authors of this paper discussed chronological and functional aspects as well as aspects of landscape use by Mesolithic people in several sample areas of Lower Saxony (Mahlstedt 2015).

Apart from single finds from the Wadden Sea area – the original find spots of which are unknown, except that their original layers are located near an erosion channel recently created in the Wadden Sea area (and thereby destroyed by it) – Mesolithic sites in East Frisia can be separated into two to three different types of sites. First, there are surface sites that have been surveyed more or less intensively. Here only lithic material has been found. The second main type of sites may be described as pit sites, where several pits filled with charcoal and partly burned cobblestones (cooking stones) have been discovered in each case. There is an ongoing debate on the anthropogenic origin of such Mesolithic pits especially in the Netherlands and Belgium (see Huismann et al. 2020). Quite similar to comparable structures in the Netherlands and Belgium, lithic material was rarely observed in the pits in East Frisia, but radiocarbon dates allow assigning the sites to the Mesolithic period.[1]

Finally, a small number of sites have not only provided lithic material but also features like fireplaces, sometimes with charcoal preserved. They form a possible third type of sites. Considering what happened in East Frisia during the time of settlement of the Hüde 1 site at Lake Dümmer, all three types of sites from the East Frisian dry lands provide some hints to synchronous late Mesolithic activity in the area. Nine of the pit sites are radiocarbon dated; most of them show activities during the Boreal period, prior to 6,600 calBC. Only two sites docu-

1 Bärenfänger 1997, 37; Fries et al. 2013; Helms / Schwarz 2008, 40–41.

ment a later Mesolithic habitation. One of them is a single pit with charcoal discovered during the building of a pipeline close to the village of Osteel (commune Brookmerland / district Aurich; Heun 1994; see Fig. 1,4). It was dug into the Pleistocene sands and later covered by basal peat and marine sediments. The surrounding area was not investigated by excavations. The other site with a late Mesolithic structure is situated close to the village of Coldinne (commune Großheide / district Aurich; Fig. 1,5) and was excavated in the 1980s by a group of amateur archaeologists (Kitz 1986). The find layer was damaged by modern ploughing. Only a single fire pit was preserved together with a quantity of flint artefacts and charcoal remains found in mixed sediments. It cannot be distinguished whether the site residues are the result of one or more settlement events. A single radiocarbon date has provided an age between 5,625 and 5,480 calBC (Table 1).

The most difficult task is to obtain chronological references for the surface sites. They can be recognised as Mesolithic by the appearance of microliths as well as small blade cores and sometimes flaked core axes. As in the neighbouring areas, there is a tendency among the stone tools from East Frisia for micropoints and triangular microliths to already appear during the first half of the Mesolithic (Boreal), thus prior to approximately 6,600 calBC (Newell 1973; Niekus 2006). They stay in use, while trapeze-shaped microliths appear during the Atlantic, which in East Frisia is contemporary with the second half of the Mesolithic. Up to now it is not clear what happened in East Frisia at the end of the Mesolithic, whether there was a transitional period to the Neolithic like in the later phases of the Swifterbant culture in the Netherlands and possibly in the Dümmer area. There seems to be an ongoing flint tradition in the late Mesolithic around the time when the Swifterbant culture develops. The best example is the typical microlith type of the late Mesolithic, the trapeze-shaped microlith. Trapezes can be found in the context of late Mesolithic / Swifterbant sites in the Netherlands (Raemaekers / Niekus 2009, 719). The situation was likely quite similar in East Frisia, where surface sites cannot be distinguished to belong to one or the other period. It is only in the course of the Swifterbant period that trapezes seem to become broader and are thus recognisable as Swifterbant culture items, as shown for the Netherlands (Niekus 2008, 59–60).

In her evaluation of surface sites from northwestern Germany one of the authors has been able to identify some characteristics of the Mesolithic use of the landscape (Mahlstedt 2015). 35 East Frisian sites were considered in her study. They differ in size, age and topographical situation. In other sampling areas of western Lower Saxony, sites from the second half of the Mesolithic after 6,600 calBC containing trapezes are quite often situated in lower and wetter positions than the earlier ones. For East Frisia, the overall impression is that most of the lower situated and possibly younger sites along the coast may have been covered by swamp sediments, or as a result of flood events, or by peat growth.

Valuable stray finds and some new dating results

While Mesolithic sites from the East Frisian peninsula show an enormous overweight in flint surface scatters compared to all other site types, there are nearly no Mesolithic flint objects among the stray finds from the Wadden Sea. Not least, this can be traced back to material properties. Finds are eroded from deeper findlayers offshore and washed onto the beaches, where they can be collected from the surface at low tide. To undergo such a process successfully a find must have a certain low specific weight. That might explain at least partly why most Mesolithic finds from the Wadden Sea are of bone and antler.

In 2016 the Archaeological Heritage Management of the ‘Ostfriesische Landschaft’ received a human mandible which was found at the northern shore of the island of Spiekeroog (Figs. 1,3; 3). It had a dark to black colour, due to a covering of iron sulphate. Surprisingly, in 2018 a second human mandible was discovered at the island of Baltrum (Figs. 1,2; 3). Both objects showed similar anthropological characteristics and were classified as ‘archaic’ (Kegler / Grefen-Peters 2019a; b).

The Spiekeroog mandible was not complete: The arched lower jaw is preserved, but not the lower jaw branches. The molars are strongly abraded. The laterally bulging corpus and V-shaped dental arch, as well as the low profile of the chin, suggest archaic features. The mandible must have belonged to a very sturdy male (branch angle approx. 140°). The advanced abrasion of the dentition makes an age of the individual of at least 40 years very likely.

The Baltrum mandible can probably also be attributed to a male individual because of its robustness. However, we do not exclude a female attribution because of the large branch angle. The abrasion of the teeth makes a time of death between 20 and 50 years of age likely. The AMS-dates of both mandibles point to a Stone Age context. The Spiekeroog man-

site	material	lab.no.	age BP	+/-	age cal BC	probability	$\Delta^{13}C$ in ‰	$\Delta^{15}N$ in ‰
Baltrum	mandible	Poz-103000	4905	30	3761-3640	95.40	14,7	15,7
Spiekeroog	mandible	Poz-103001	6510	40	5546-5374	95.40	13,4	16,1
Juist	antler axe	MAMS-43969	3751	24	2278-2042	95.40	–	–
Osteel	charcoal	Hv-19605	6560	280	6025-4852	95.39	–	–
Coldinne	charcoal	Hv-12322	6605	55	5625-5480	95.40	–	–
Zwischenahn	T-Axe, new find	Poz-82825	4880	35	3759-3541	95.39	–	–
Zwischenahn	T-Axe, old find	Poz-73450	5570	40	4486-4342	95.40	–	–
Zwischenahn	base axe	Poz-73451	7300	50	6251-6050	95.40	–	–

Table 1 Radiocarbon dates of sites and finds mentioned in this paper.

dible dates to c. 5,400 calBC (Table 1), while the Baltrum mandible dates to c. 3,700 calBC (Table 1). Stable isotopes (^{13}C and ^{15}N) were also measured (Table 1). In northwestern Europe there are no comparable values for the two stable isotope results as yet. Nevertheless, according to increased ^{13}C- and ^{15}N-values it is obvious that both humans had a very high proportion of marine food in their diet. On this background, the dating may have been affected by the marine reservoir effect (Fischer et al. 2007). Typically, affected radiocarbon dates appear up to c. 400 ^{14}C years older than they would be if unaffected (Ibid., 2142). According to the high grade of abrasion of the teeth, both individuals must have consumed terrestrial food as well.

In any case it seems justified to assume that the Spiekeroog individual lived during the time when the first farmers of the Linear Pottery culture arrived at the northern fringe of the loess belt. By that time the coastline was situated already close to its modern position. The habitat of Mesolithic hunter-gatherers would have been a heterogeneous landscape with sandy, possibly wooded areas, bogs and salt-marshes.

The Baltrum individual dated to 3700 calBC lived in the transitional time period between the late Swifterbant period in northwestern Europe and the beginning of the Funnel Beaker culture or – taking into account the influence of the reservoir effect – even in the fully Neolithic Funnelbeaker period

Fig. 2 Antler axe from Juist-Kalfamertgat (photo: R. Kiepe)

Fig. 3 Mandibles from Spiekeroog and Baltrum (photo: I. Reese / Ostfriesische Landschaft)

Brindley 1/2 about 200 to 400 years later. In the later case it would either give another example of early farmers living on marine diet as already shown for other parts of northern central Europe by Terberger et al. (2018). Or this individuum belonged to the last hunter-gatherers, who maintained the old way of life in the salt marshes, which were not of interest for the first farmers. Taking into account the environment that can be reconstructed for that period of time in the area of the recent Wadden Sea the later interpretation might be preferred: saltmarshes and tidal creeks reaching deep into the country behind the present day shoreline and a few areas where the bogs kept growing close to the shore. There, farming might not have been easy if possible at all.

One of the earliest finds that has for a long time been attributed to the Mesolithic is an antler axe found in 1980. It was collected from the surface c. 100 m east of the shoreline of the island of Juist. The object was discovered on the western border of the so-called Kalfamergat, a straight between the islands of Juist and Norderney (Fig. 1,1). The approximatley 20 cm long axe was worked from an antler branch. It is obviously not a T-shaped antler axe. The cutting edge is damaged, and the butt is rounded, possibly due to surface damage by reworking in the sea, so

that its former shape cannot be reconstructed. Thus, a clear typological distinction is not possible. A recent ^{14}C-dating gave a result of c. 2,278–2,042 calBC (Fig. 2; Table 1), which would be contemporary with the transitional horizon between the Late Neolithic Single Grave culture and the Early Bronze Age on the North Sea coast. This goes well together with the dates of antler axes with a rounded base from the Scheld area in Belgium (Crombé et al. 2018), and shows that this is no Mesolithic find at all. But at least it is a witness of human inhabitation also at times when most of the dry land in the area of the recent Wadden Sea had likely vanished already.

Unfortunately, analogies in form of further antler axes are rare in East Frisia. There is only a single undated find that was dug up by a dredge in the river Ems in the western corner of the peninsula.

In the southern neighbourhood of East Frisia an accumulation of antler axes is known from the area of the Zwischenahner Meer, a freshwater lake. Here, swimmers occasionally found antler axes (Zoller 1958). Most of these finds can be described as T-shaped antler axes, but there is at least one axe made of the basal section of a red deer antler, dating to the time between 6,251 and 6,050 calBC. This axe as well as one of the T-axes of the stray finds and a new find from recent underwater excavations on the site were directly dated (Mahlstedt et al. 2018a). The T-shaped piece of the old finds dates to the middle of the 5th millennium calBC, the new find is dated to the first half of the 4th millenium calBC (Table 1). These objects appear to have been in use for longer in this area than in Scandinavia, as mentioned earlier (Dellbrügge 2002, 44–45). In the Netherlands, Belgium, and at Hüde I, antler axes appear in Swifterbant and contemporary contexts very regularly (Crombé et al. 1999, Deichmüller 1969; Werning 1983).

Ongoing research

The current state of research in the Wadden Sea suggests a potential of finding Mesolithic sites.[2] The research project 'Settlement and cultural history of the Lower Saxony Wadden Sea Area', however, discovered only medieval to modern surface sites close to the recent dyke; the oldest burials and settlement remains are dated to the Roman Iron Age (Niederhöfer 2016).

2 Jöns et al. 2012/2013; Goldhammer / Karle 2015; Niederhöfer 2016; Karle / Goldhammer 2017.

In order to expand the knowledge of the Holocene landscape history along the German North Sea coast, the WASA research project (The **Wa**dden **S**ea as an **a**rchive of landscape evolution, climate change and settlement history) was established in 2015. During a four–year research period the intertidal and shallow subtidal zones of the barrier islands Spiekeroog and Norderney were investigated to reconstruct the dynamic state of palaeolandscapes in the Wadden Sea region as a basis for predictive modelling of human settlement patterns and their possible impact on the environment since the last glacial period. This complex set of relevant data is necessary for predictive modelling, using natural proxies as well as archaeological features to determine the archaeological perspectives of unsurveyed areas.

Concerning the dry land area of East Frisia, one of the problems with the Mesolithic sites there is that we are either dealing with more or less destroyed surface sites, or sites hidden by peat and marsh layers. For this reason a survey strategy to identify well-preserved sites more systematically is the topic of a project that started in 2019. An important discovery in this context is the fact that a good number of known surface sites in East Frisia are situated on the edge of so-called pingo scars (Mahlstedt et al. 2018b), landscape features that had been small lakes in the early Holocene. Today most such lakes have become small kettle bogs. The position of some sites on their ramparts affords a good opportunity to detect find layers on the inner slope that were partly covered and thus protected by peat. In a first survey eleven sites were tested for preservation conditions by field survey and coring. Other sites are situated on the edge of the sandy uplands, close to an area with basal peat under marine sediments. Both positions in the landscape therefore have the potential for a preserved paleo-surface below the peat. In some cases, stone tools, charcoal samples and even hazelnut shells were found by sampling with hand corers that bring up a larger amount of sediment, which is sieved and sampled directly in the field. Small test trenches have been investigated recently (Mahlstedt et al. 2021). For the next years a second survey area is planned in the Elbe-Weser area to detect Mesolithic sites with organic preservation.

Final remarks

Bringing together the reconstruction of the coastal landscape development with dated finds of human bones has given a first glimpse of possible insights into the late Mesolithic and early Neolithic periods

in East Frisia. Do the isotope values of the Baltrum mandible indicate a late hunter-gatherer way of life at the edge of the European mainland? And can we expect the Mesolithic-Neolithic transition to have happened in the same mode in East Frisia as in the neighbouring Netherlands, just because we have the same kind of flint stray finds and quite similar datings for a few antler axes?

Mesolithic sites are assumedly hidden below thick layers of marine sediments on the shoreline and below peat on the sandy uplands. A range of projects on landscape reconstruction, survey and predictive modelling have started research to answer the questions outlined above; now it depends on how they are going to develop in the near future.

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The late Mesolithic in Hamburg-Boberg: inter-cultural interactions and impacts

Laura Thielen

Abstract The sites Boberg 15, 15 East, and 20 were settled by people from the Ertebølle culture during the final Mesolithic and by people from the Funnel Beaker culture during the early Neolithic. Vessel finds illustrate contacts to Neolithic as well as final Mesolithic groups during the final Mesolithic and thus an intra- und inter-cultural network. According to archaeometrical analysis it is confirmed that culturally 'foreign' pottery was imported as well as produced at the Boberg sites, indicating a mutual interaction as well as a transfer of knowledge. Different impulses and influences on the local production are recognisable. Rössen and Stroke-ornamented ware pottery were produced at the sites, but did not influence the local vessel tradition significantly. In contrast, the establishment of vessels with overall fingernail impressions on the surface and flat bottom at Boberg can be connected to interactions between Boberg settlers and people from the Swifterbant as well as Gatersleben groups; it illustrates impulses and the adaptation of specific elements from different cultures, resulting in the formation of the so-called Friesack-Boberg group located in the inland of northern Germany. The fusion of inter-cultural elements, supported by the dating results of the Friesack-Boberg pottery to the transition between final Mesolithic and Neolithic, might also imply the beginning of the neolithisation in northern Germany.

Keywords Hamburg-Boberg, Ertebølle culture, early pottery, cultural interactions

Zusammenfassung *Die von der endmesolithischen Ertebølle- und frühneolithischen Trichterbecherkultur besiedelten Fundplätze Hamburg-Boberg 15, 15 Ost und 20 zeigen durch Gefäße, die als Kontaktanzeiger zu endmesolithischen und neolithischen Gruppen zu werten sind, ein intra- und interkulturelles Netzwerk im Endmesolithikum an. Durch archäometrische Analysen konnte nachgewiesen werden, dass die kontaktanzeigenden Gefäße nicht nur importiert, sondern teils auch in der Boberger Niederung hergestellt worden sind. Dies deutet gleichsam ein gemeinsames Interagieren unter den Beteiligten und eine Vermittlung des kultureigenen Keramikhandwerks an, wenn sich auch unterschiedliche Einflussebenen erkennen lassen. Demnach wirkten sich Kontakte zwischen der auf den Boberger Plätzen siedelnden Gruppe der Ertebølle-Kultur und Gemeinschaften der neolithischen Rössener Kultur und Stichbandkeramik nicht maßgeblich auf das lokale Töpferhandwerk aus. Im Gegensatz dazu haben nachgewiesene Kontakte zu Gruppen der Swifterbant- und Gaterslebener Kultur maßgeblich an der Entstehung von flachbodigen Gefäßen mit flächigem Fingernageldekor mitgewirkt, die der im norddeutschen Binnenland siedelnden Friesack-Boberger Gruppe zugeschrieben werden können. Letztlich können die Fusion interkultureller Einflüsse sowie die Datierung der Friesack-Boberg Keramik in den Übergangshorizont zwischen dem Endmesolithikum und Neolithikum den Beginn der Neolithisierung in Norddeutschland anzeigen.*

Introduction

The sites Boberg 15, 15 East and 20 have been well known since their excavations in the 1950s and 1960s and have caused a discussion regarding the pottery found there that was interpreted as imported (see below); they are seen as key sites for the origin of the Funnel Beaker culture in northern Germany (Schwabedissen 1994, 378). During and after the excavations no comprehensive documentation and analysis of the archaeological remains were conducted[1], and thus the project 'The Neolithisation process of northernmost Germany: with particular reference to the final Mesolithic and Neolithic sites of Hamburg-Boberg', funded by the German Research Foundation

1 With the exception of the Boberg 15 East flint artefacts: see Lübke 2000, 326–340.

(DFG)[2], aimed at putting the entire assemblage of the excavated pottery into perspective. Archaeological recording was supplemented by archaeometric analysis, which also contributes a deeper insight into the technological production of the pottery.

This paper assumes that the Boberg pottery can shed light on communication processes and the way of interactions and relationships between intra- and inter-cultural groups. In this context it is supposed that communication goes beyond unilateral transportation of information between emitter and recipient. It is rather suggested that people talking to each other in face-to-face interactions transport knowledge, ideas, and much more into a communicative space, and thereby each participant has the opportunity to react and respond to the topics of conversation. In consequence, it is assumed that communication contributions are based on one another, resulting in constructive communication and active dialogue, where each participant has the opportunity to adapt this transported information in full or in part. It is also suspected that social values and lifestyle might influence the amount of adaptation of information, which depends on mental or social connections between participants and groups.

Contacts between the Boberg settlers and intra- and inter cultural groups are illustrated through pottery and raise the question of interaction processes resulting in the adaptation of communicated information. Thus typological as well as technological pottery manufacturing traditions of the Boberg settlers as well as communication processes with intra- and inter-cultural groups are of special interest. Furthermore, the amount of adaptation of specific typological and technological attributes might illustrate different exertions of influences of intra- and inter-cultural groups on the Boberg settlers and show different levels of impacts and rejections.

Excavations and chronological setting of the sites

The archaeological sites of Hamburg-Boberg 15, 15 East, and 20 are located southeast of the city of Hamburg, in northern Germany (Fig. 1). During the final Mesolithic and Neolithic the settlement sites were situated on small sandy elevations in the Elbe palaeovalley in front of large ancient inland dunes. The accumulation of supra-littoral sediments indicates that during settlement, the landscape was characterised by a branched river system consisting of many small rivers and brooks running through the depressions between the sites. On the other side of the inland dunes the higher elevation of the geest extends from southeast to northwest alongside the glacial valley of the river Elbe (Miehlich 1986, 100–102; 1999, 199–201; see also Ehlers 1990, 138–14; 1991, 46–60; 2011, 48–53, 136; Schröder 1988, 42–74), and springs drained from the ground moraine, resulting in the formation of lakes and ponds (Köpke et al. 1999, 129; Miehlich 1986, 100; Ulmer 2002, 197). Here a permeable layer overlies a waterproof layer (for example loam and clay), and the water drained off in between the inclining layers (Murawski / Meyer 1998, 174 fig. 53a). Today, the landscape of the foreland of the dunes is characterised by the Elbe wetlands.

The site of Boberg 15 was first investigated in 1951 by opening a test trench. As Neolithic finds came to light, further excavations were carried out in 1952, 1953, 1954 and 1960. An additional investigation in 1959 aimed to define the extent of the site and resulted in the discovery of the separate prehistoric site of Boberg 15 East. Further investigations were carried out at Boberg 20. A first trench opened in 1956 led to follow-up excavations in 1959 and 1964[3]. A recent excavation was conducted at site 20 in 1991[4].

After the excavations in the 1950s and 1960s various articles about the chronological setting of the Boberg sites with respect to a selection of pottery were presented. While R. Schindler discussed a continuous settlement of Boberg 15 from Ertebølle-Ellerbek times to the early Neolithic and late early Neolithic after H. Schwabedissen (Schwabedissen 1957/1958), he supposed an occupation of Boberg 20 from the Ertebølle-Ellerbek phase to the early Neolithic. A re-evaluation was carried out by F. Laux in accordance with J. Lichardus' chronology (Lichardus 1976). Although Laux based his typo-chronological classification mainly on the archaeological artefacts illustrated by Schindler, he postulated a larger timespan of settlement of Boberg 15 and also did not agree with a continuous settlement view. Although he also connected the site to the final Mesolithic Ertebølle culture, he argued for a reoccupation in the late early Neolithic. In addition, a settlement of the late Neolithic Single Grave culture, influenced by the Bell Beaker culture, is mentioned,

2 Project leader: B. Ramminger, University of Hamburg.

3 Documentation and reports on Boberg 15, 15 East, 20, Archaeological Museum of Hamburg.

4 The excavation was part of the DFG-funded project 'The Neolithisation of Schleswig-Holstein'; cf. Lübke 1992, 49; 2000, 326f.

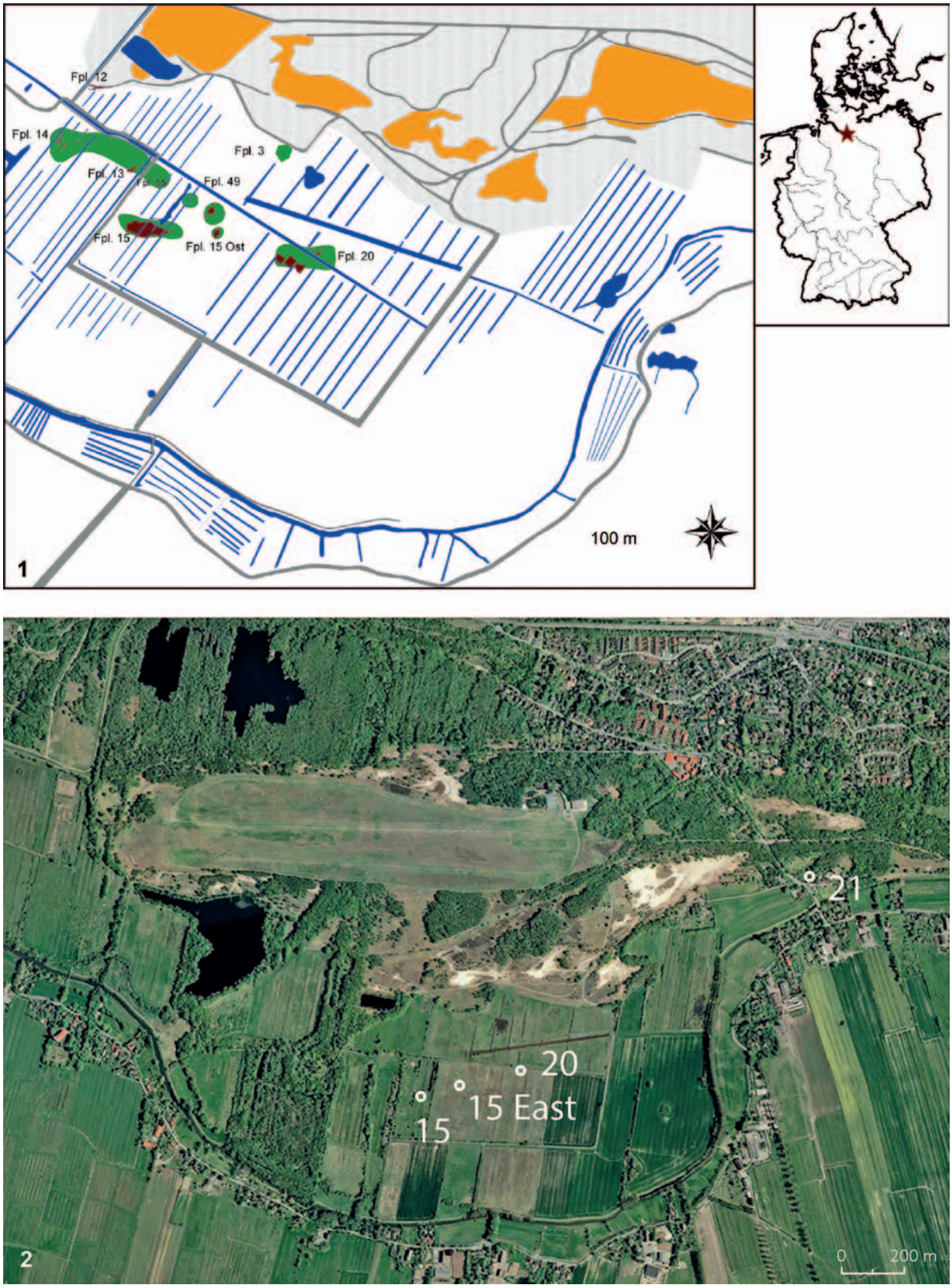

Fig. 1 Excavations of the Hamburg-Boberg sites. **1** yellow: inland dunes; blue: water; green: sandy elevations; red: excavation areas (drawing: B. Ramminger); **2** Location of the sites Boberg 15, 15 East, and 20 as well as Boberg 21 on the recent Elbe wetlands (photo: Google Earth; sites added).

Fig. 2 Boberg. **1–9** pointed bases; **10** pointed base with impressions; **11–13** rim sherds with impressions on top of the rim; **14–15** lamps. Scale 1:4.

but without any further comment. Also his interpretation of Boberg 20 differs, as Laux connected both Boberg 20 and 15 East to the Ertebølle culture, settled for just one single summer. In contrast, according to an analysis of the flint artefacts from Boberg 15 East, H. Lübke expected an occupation of the site by the final Mesolithic Ertebølle and early Neolithic Funnel Beaker culture (Lübke 2000, 326–340) after Schwabedissen (1966).

In contrast, the evaluation of the complete ensemble of excavated pottery demonstrates for Boberg 15, 15 East, and 20 a settlement of the sites during the final Mesolithic, indicated by both pointed bases in different types, such as bases with a pronounced pointed end, pointed bottoms with a triangular and conical shape as well as rounded bottoms (Fig. 2.1–9), and vessels built in U-technique[5]. Most ceramics built in U-technique (Hulthén 1977, 35 fig. 15; Stilborg / Bergenstråhle 2000, 31–33 fig. 5) show no decoration at all, and the decoration is mainly limited to impressions on top of the rim (Fig. 2.11–13), with affinity to pottery of the final Mesolithic Ertebølle culture in northern Germany (cf. Glykou 2010, 181, 183 fig. 6, 12; Grohmann 2010, 415 pl. 4,7; Lübke 2009, fig. 83.8,1.3). Also, the excavated lamps imply a settlement of the Boberg sites by persons of the Ertebølle culture[6] (Fig. 2.14–15). Two vessels built in U-technique decorated with impressions on the exterior, interior and on top of the rim (Fig. 5.1–2), as well as a decorated pointed base from Boberg 20, are exceptions (Fig. 2.10). An occupation of the Boberg sites in the early Neolithic by the Funnel Beaker culture is demonstrated by rim sherds decorated with arcades or punctures from the outside, which result in a bossel on the inside ('Lochbuckel'). A significant difference to the final Mesolithic pottery is indicated by the general use of N-technique for manufacturing the Neolithic vessels. A continuous settlement of the sites within the early Neolithic (EN II) is shown by collared flasks and sherds ornamented with vertical incisions, including scratched lines, twisted cord impressions, and plastic ridges, implying a settlement of the Boberg sites until the middle Neolithic Funnel Beaker culture. In addition, rim sherds decorated with horizontal lines and cord impressions bear resemblance to pottery of the Single Grave culture[7].

Of special note are the S-shaped vessels from Boberg, built in N-technique with small flat bases and decoration with overall fingernail impressions allover (Fig. 5.4–6). These vessels are only present at site Boberg 15, and the debate about the chronology and creation of this pottery started immediately after the excavations. For example, Schindler suggested a

5 Due to the high fragmentation of the Boberg vessels it was not possible to connect sherds built in N-technique to the final Mesolithic. However, some pointed bases from Boberg demonstrate that N-technique was used. For the difference of building a vessel in N-technique in the final Mesolithic and Neolithic see Koch-Nielsen 1986, 111f. fig. 6; Koch 1998, 125f. fig. 96.

6 See for example Glykou 2010,185 fig. 17; 2016, 134–137 fig. 110, pl. 10–11; Goldhammer 2008, 62 pl. 8,7–12; Schwabedissen 1994, pl. 17,5–8. It should be noted that in northern Germany lamps are also present from the early Neolithic Funnel Beaker site Siggeneben-Süd LA 12, dist. Ostholstein; see Meurers-Balke 1983, pl. 38, 6–10. Regarding lamps from Boberg (n = 11), a dating to the final Mesolithic as well as early Neolithic seems possible.

7 It should be noted that the frequency of typo-chronologically relevant pottery differs between the Boberg sites, which might be affected by the areas excavated in the 1950 s and 1960s. Whereas at Boberg 15 (1,490 m^2) and Boberg 20 (964 m^2) larger trenches were opened, the excavation area of site 15 East was limited to 156 m^2. Moreover, according to the documented profiles obviously just the upper surface of the elevations of the Boberg sites was excavated, and not the whole occupation layers. Regarding the distribution of typo-chronologically relevant pottery, different settlement areas of both sites Boberg 15 and 20 are recognisable, and in consequence the different frequencies cannot be interpreted impartially as indicators for site abandonment.

development from pointed-bottomed Ertebølle pots and dated the pottery to the Neolithic transition (Schindler 1953, 11–15). Laux also mentioned a typological evolution from pointed-bottomed vessels, but also a relation to the Pitted Ware culture. In addition, impulses for the decoration technique are also identifiable in the Ertebølle culture, initially influenced by the Rössen culture, while the ornamentation all over the surface of the vessels is connected to the Stroke-ornamented ware culture (Laux 1986, 23–29). On the other hand, J. Lichardus suggested a chronological relationship with his Rössen III phase, or Funnel Beaker A after Becker (Becker 1947; modified by Lichardus 1976) and proposed impulses originating from Poland, resulting in an adaptation of the decoration pattern (Lichardus 1976, 173 com. 335). On the basis of the decorated pottery from Friesack 4, dist. Havelland, and Boberg, G. Wetzel defined the 'Friesack-Boberg group' as a local facies. Similar ornamentations also appear on ceramics from Rhinow 30, dist. Havelland, and it is thought that the Friesack-Boberg group represents an inland community established during the transitional horizon between final Mesolithic and early Neolithic (Wetzel 2015, 516–522 fig. 6,1; 11,1.4; cf. Beran 2012, 511–513, 523). Analogies in a northwestern direction were identified between Boberg pottery and Swifterbant culture (De Roever 1979, 23; Ten Anscher 2012, 591; van der Waals 1972, 167), as well as Hazendonk-I (Louwe-Kooijmans 1976, 269) vessels. In addition, the pottery with overall fingernail impressions is seen as an indicator that the Swifterbant culture contributed to the neolithisation process between the rivers Rhine and Oder in northern Germany (Kotula et al. 2015, 502 f.).

To study the establishment of the flat-bottomed pottery covered with fingernail impressions from site Boberg 15 it is important to shed light on the local handcraft tradition of both final Mesolithic pottery and vessels with fingernail impression. On this basis, pottery indicating communication and interaction between Boberg settlers and other final Mesolithic as well as Neolithic societies is of special interest in identifying similarities and differences as well as possible influences.

Boberg: Pottery tradition

To identify inter-cultural contacts and interactions at the Boberg sites which might have influenced the establishment and development of pottery with horizontal rows of fingernail impressions that cover the whole vessel body, the local handcraft tradition, including technology, as well as analyses of the clays used in manufacturing the pottery, play a significant part.

A local production of pottery at the sites is confirmed by archaeometrical analysis. Diatoms (*Meridion circulare*, *Aulacoseira crenulata*; determination after Hofmann et al. 2011) were identified that can be linked to clay deposits in the littoral zone of lakes and ponds fed by contact springs, matching the local landscape[8]. In addition, a comparative petrographic thin-section analysis[9] recognised a set of dark minerals in the pottery from Boberg 15, 15 East and 20 as well as in the locally produced grey ware of the 13th/14th century from the neighbouring kiln site Boberg 21 (Spallek 2015, 65–78; cf. Kellermann 1950/1951, 34–42; see Fig. 1). Across the whole pottery history of the Boberg sites, including final Mesolithic and flat-bottomed vessels with fingernail impressions covering the whole surface, both types of clay were used regularly for manufacturing, and this indicates a repeated exploitation of local resources. Regarding the distance between the sites, located on small sandy islands and surrounded by the river Elbe, there is about 100 m between the sites Boberg 15 and 15 East and about 200 m between sites 15 East and 20, so the sites are immediately adjacent and intervisible. A 'social relationship' between the sites thus seems plausible, especially because the rights to exploit local resources would have had to be equal. Otherwise, competition and situations of conflict might be expected, which might have provoked the abandonment of one or more sites.

The technological handcraft of Ertebølle pottery built in U-technique shows granite temper in medium and high quantities[10], with mean grain sizes of 2.93 mm (standard deviation: 0.79 mm); mean wall thickness is 9.6 mm (standard deviation: 1.58 mm). The flat-bottomed pottery, decorated with fingernail impressions built in N-technique, also contains granite temper. High quantities are more common than medium quantities, with mean grain sizes of 2.64 mm (standard deviation: 0.56 mm). Mean wall thickness is 9.4 mm (standard deviation: 1.93 mm). The technology of both vessels built in U-technique and pottery with fingernail impressions

8 Analysis conducted by Th. Hübener, Institut für Biowissenschaften, University of Rostock.

9 Analysis conducted by O. Stilborg, SKEA Keramikanalys, Schweden.

10 Quantities were defined as low ≤10 %, medium ≥10 % ≤20 %, high >20 %. This differs from generally used values after Hulthén 1974, 36: low < 15 %, medium ≥15 % ≤25 %, high >25 %.

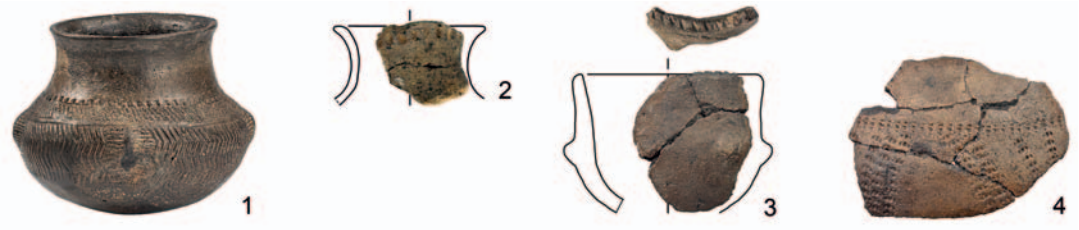

Fig. 3 Boberg. **1–2** Globular beaker; **3** vessel with rounded knob handle; **4** sherd with rectangular impressions (photos: T. Weise, Archaeological Museum of Hamburg). Scale 1:4.

seems comparable, especially the temper, grain size and wall thickness[11].

The confirmed pottery traditions of the Boberg sites and the use of local clays also enable the identification of imported vessels, which illustrate contacts between Boberg settlers and other cultural groups. These diverse interactions also affected local production, an aspect which can be studied through a comparison of manufacturing processes. Thereby, the imports' similarities and dissimilarities to the local handcraft tradition of pottery were determined.

Contacts and interactions

At Boberg, pottery showing intra- and inter-cultural interactions and communications during the final Mesolithic is present. With respect to the specific manufacturing of ceramics, possible influences on the local handcraft tradition are of special interest, and the petrographic thin-section analysis contributes a deeper insight into the technological production.

Contact within the Ertebølle culture is indicated by a lamp (Fig. 2.14) built with non-local clay and tempered with granite. Bearing in mind that in northern Germany lamps are more common at coastal sites (cf. Glykou 2010,185 fig. 17; 2016, 134–137 fig. 110, pl. 10–11; Goldhammer 2008, 62 pl. 8.7–12; Schwabedissen 1994, pl. 17.5–8), this might illustrate contacts between coastal and inland groups. Equally notable is another lamp which, according to its thin-section, was produced with local clay and tempered with granite-tempered grog (Fig. 2.15; 4.3). The grog temper differs from the mainly used granite temper in final Mesolithic pottery from Boberg, and interaction with persons knowledgeable about the manufacturing of grog temper seems possible (see below). Further intra-cultural contacts are indicated by a pointed base decorated with rounded impressions (Fig. 2.10). There are no analogies to Ertebølle pots in northern Germany, but complete decorated vessels are present, for example, at Löddesborg (Jennbert 1984, 53f., 58 fig. 41,48,8; 1994, 158f., 162 fig. 8) and Soldattorpet (Stilborg / Holm 2009, 335 fig. 11.6) in southern Sweden. Although their decorations are not exactly the same, they provide the closest match.

Pottery indicating contacts to Neolithic cultures is illustrated by the well-known globular beaker from Boberg 20, with similar beakers appearing during the middle and late Rössen culture in southern Lower Saxony (see Lönne 2003, 211, 218f.; Fig. 3.1). An additional rim sherd decorated with oval impressions can be associated with globular beakers, but the absence of a specific decoration does not allow the determination of a geographical origin (Fig. 3.2). The archaeometrical analysis of the rim sherd detected two different types of grog temper. Thus, for tempering this grog-tempered vessel, previous generations of grog tempered ware as well as (remains of) a vessel tempered with granite were crushed (Fig. 4.1). The temper amount is 16 %; the grain size is 1.1 mm. The raw clay used for manufacturing this vessel clearly differs from the local clays and illustrates that the globular beaker was imported to the Boberg sites.

Interactions with the Rössen culture are also represented by a small pot with a rounded knob handle (Fig. 3.3; see also Laux 1986, 1 fig. 9,6; Schindler 1961, 15 fig. 4,1). Schindler (1961, 14; 1962, 253) already drew an analogy to Rössen pottery, which was also supported by Laux (1986, 15 com. 18)[12]. Regarding the technology with 17 % temper amount, and 1.5 mm grain size, the small vessel shows similarities to the globular beaker and its grog temper as well as the composition

11 The technological tradition is also consisent with continuity in clay preparations within the typological turnaround of the early Neolithic Funnel Beaker pottery from the Boberg sites. The middle Neolithic Funnel Beaker pottery with vertical incisions also indicates a trajectory of successive change, while the pottery of the Single Grave culture demonstrates, in contrast, a significant and pronounced change in technology.

12 Laux highlighted a typological parallel with a vessel from Wahlitz, dist. Burg (Behrens 1973, 57 fig. 19c), but the bowl shape of the vessel from Wahlitz is not conclusive; see also Klassen 2004, 77.

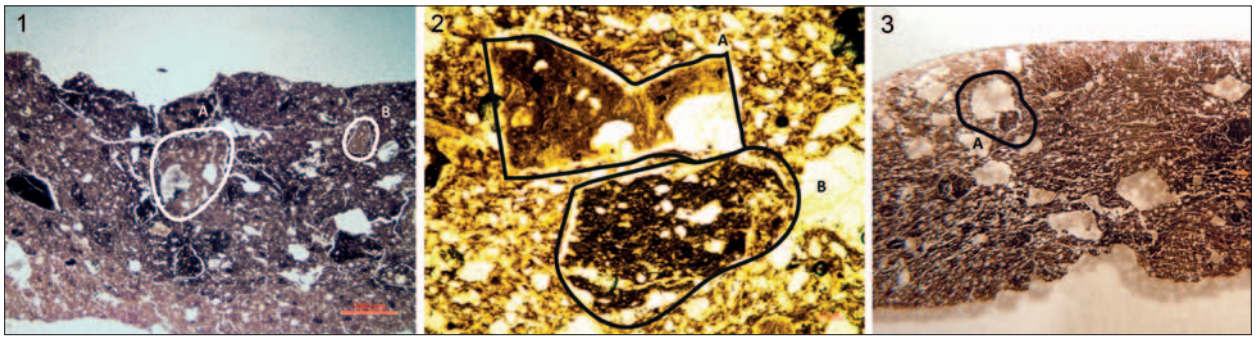

Fig. 4 Boberg. Grog temper. **1** globular beaker; **2** vessel with rounded knob handle; **3** lamp. A grog and granite; B grog (photos: O. Stilborg, SKEA Keramikanalys).

of grog and granite, indicating that two different types of vessels were crushed for tempering (Fig. 4.2). In contrast, the archaeometrical analysis makes clear that in this case local clay was used and that the vessel with the rounded knob handle was produced at the Boberg sites. The manufacturing processes of both are very similar, as demonstrated by different types of grog temper. Yet for both samples, the production techniques as revealed by the grain sizes and, in particular, the grog temper tradition, differ from the contemporary final Mesolithic pottery as well as from the flat-bottomed vessels with fingernail impressions from the Boberg sites. Thus it seems possible that persons from the Rössen culture manufactured pottery at Boberg.

Interaction with the Stroke-ornamented ware culture at Boberg is indicated by one piece ornamented with rectangular impressions (Fig. 3.4). Similar decoration occurs during the middle Neolithic Stroke-ornamented ware culture of the middle Elbe-Saale region, Saxony, Bavaria, and Bohemia (Czech Republic) (e.g. Kaufmann 1976, pl. 25,4, 26,4.9.11–12; Klassen 2004, 81). The Stroke-ornamented vessel from Boberg differs from local wares in its low amount of temper (7 %) and its small grain size of 1.3 mm, whereas the granite temper was also frequently used for the production of local vessels at Boberg. The analysed raw clay demonstrates that the vessel with rectangular impressions was made with local clay. The difference of the technological tradition, especially concerning temper amount and grain size, exemplifies that the vessel was not produced as a copy by locals, but rather manufactured by a potter who had the special knowledge of manufacturing Stroke-ornamented ware pottery.

Inter-cultural interaction between Boberg settlers and Gatersleben people is indicated by a flat-bottomed vessel decorated with rounded impressions covering the shoulder (Fig. 5.3). According to L. Klassen a connection of the vessel to the Gatersleben culture is illustrated

Fig. 5 Boberg. **1–2** rim sherds with impressions on the exterior, interior and on top of the rim; **3** flat bottomed vessel with rounded impressions covering the shoulder; **4–6** vessels with fingernail impressions (3–6 photos: T. Weise, Archaeological Museum of Hamburg). 1–2; 4–6 scale 1:6; 3 scale 1:4.

by comparable vessels from the site Schenkenberg, dist. Delitzsch (Kroitzsch 1973, pl. 14f.). In addition, it is suggested that this ornamentation succeeded the decoration of the Rössen culture and, consequently, the Boberg vessel could be dated to the early Gatersleben culture (4,400–4,200 BC) of the middle Elbe-Saale region (Klassen 2004, 79f.; see also Laux 1986, 27f. fig. 19,4). The clay of the vessel has a general similarity to the local clay, so that it is not possible to decide if the vessel was locally produced or imported. However, the technology differs from the final Mesolithic pottery as well as the vessels covered with fingernail impressions. This vessel is tempered with a crushed rock containing only quartz and feldspar, and the common local granite could not be determined with certainty. In addition, especially the grain size (1.1 mm) and quantity of temper (15 %) seem comparable to the Rössen technology from pottery of the Boberg sites. Therefore, even this vessel may have been produced by a person of the Gatersleben culture, instead of a local individual copying a Gatersleben vessel.

Two vessels from Boberg built in U-technique are decorated with impressions on the inside, top and outside on the rim (Fig. 5.1–2). Even though Ertebølle pointed-based vessels with rim decoration, including impressions on top of the rim as well as rounded impressions on the outside, are present in northern Germany at the sites Timmendorf Nordmole I, dist. northwest Mecklenburg (Lübke 2003, 637 fig. 79,5:1; 2009, fig. 38.8,2), Rosenhof, dist. Ostholstein (Schwabedissen 1994, pl. 17.1) and Schlamersdorf LA 05, dist. Stormarn (Hartz 1996, 376f. fig. 4.7), the decoration on the inside of the rim is absent there. Decoration on the inside of the rim occurs occasionally in Ertebølle pottery, e.g. at Löddesborg in southern Sweden (Jennbert 2011, 93; see also Brinch Petersen 2011, 223). In contrast, impressions on the inside of the rim are a significant element of decoration of pottery of the Swifterbant culture (Northern Group) in its Middle Phase (4,600–3,900/3,800 calBC; cf. Raemaekers 1999, 108–112, 165; Raemaekers / De Roever 2010, 135), and the two pieces of Boberg might therefore illustrate contacts with the Northern Group of the Swifterbant culture, Middle Phase. The manufacturing of both vessels indicates similarities to the local pottery, as there is granite temper as well as grain sizes of 2–3 mm. The archaeometrically examined vessel (Fig. 5.1) shows the use of local clay[13]. A difference exists in the low amount of temper (9 %), which is not common in the local pots, implying that the vessel was produced by a person of the Swifterbant culture (Northern Group). The decorations of the vessels with fingernail impressions also indicate a connection to the Swifterbant culture. The archaeometric analysis mainly identified the use of local clay for manufacturing (Fig. 5.5–6), except one sample with non-local clay, illustrating contacts to Swifterbant communities (Fig. 5.4). However, regarding the high amount of granite temper (29 %) and the grain size (3.2 mm), the technology does not really differ from the local tradition. Contacts and interactions with the Swifterbant culture are obvious for both vessels with combined impressions at different positions, as well as the pottery with overall fingernail impression from Boberg. Taking the geographical distribution of ornamentation types into account, it becomes apparent that the rim decoration is more often present in the Swifterbant Northern Group (Netherlands and northwest Germany), whereas overall fingertip impressions are more frequent in the Swifterbant Southern Group, close to the river Scheldt in Belgium (Raemaekers 1999, 111f.). Also, the use of temper indicates a differentiation. Whereas both groups used organic temper, crushed quartz/granite occurs more often in the Northern Group. On the other hand, grog temper seems to be more frequent in pottery of the Southern Group[14]. Given the current stage of research, it is not possible to decide if the beaker made with non-local clay illustrates inter-cultural contacts to the Northern or Southern Group of the Swifterbant culture, but inter-cultural influences by the Swifterbant culture resulting in the development of the Boberg pottery decorated overall with fingernail impressions seems obvious. Furthermore, the pottery built in U-technique with decoration on the inside of the rim indicates contacts which might have influenced the final Mesolithic local handcraft.

Contact zones and relationships

The analyses results indicate inter-cultural contacts with final Mesolithic and Neolithic groups and highlight that these relationships went beyond a simple ‘give and take’ of specific goods. Pottery can have been manufactured during mutual interactions when communication and knowledge transfer took place, and diverse effects on the local productions are recognisable.

13 In that case, a comparison of the clays used for the two possible Swifterbant vessels is necessary to determine if both have been produced at the Boberg sites.

14 See Constantin 2010, 132f.; Crombé 2009, 486–489; Crombé et al. 2008, 466–470; Raemaekers 1999, 109, 111 table 3.46; 2008, 495f. table 2; Raemaekers / De Roever 2010, 141–143; Ten Anscher 2012, 91f. fig. 5.3; 2015, 340f. fig. 7.

The manufacturing of the Rössen and Stroke-ornamented ware pottery at Boberg deviates from the final Mesolithic tradition in terms of typology and technology. Especially the grog temper of both the globular beaker and the small vessel with knob handle differ from Ertebølle pottery and vessels covered with fingernail impressions from the Boberg sites. The small vessel with grog and grog-granite temper, manufactured with local clay, exemplifies that the potter had to know about Rössen manufacturing traditions. Also, the difference concerning grain size and the low amount of temper of the Stroke-ornamented ware vessel supports the idea that the vessel was created by a culturally foreign potter at the Boberg sites, and this opens up the possibility of a communication of manufacturing techniques to the locals. Furthermore, both vessels made with local clay imply a production by Rössen and Stroke-ornamented ware potters and indicate an integration of Neolithic people into the society settled at the Boberg sites. Although the contacts to Neolithic groups did not influence the final Mesolithic typology significantly, influences by way of knowledge transfer by Rössen potters could be illustrated, as seen by the use of grog temper, specifically in the lamp produced with local clay and tempered with grog-granite[15]. Contacts between final Mesolithic locals and the Rössen and Stroke-ornamented ware cultures exemplify that societies with different economies and cultural traditions interacted, but the continuation of Mesolithic pottery traditions indicates no demonstrable major impacts by the Neolithic cultures. This also implies that people of both Rössen and Stroke-ornamented ware culture were not fixedly settled down, and (at times) established themselves at the Boberg sites.

The two vessels from Boberg built in U-technique and decorated on the inside, top and outside of the rim correspond with decorated pottery from the Northern Group of the Swifterbant culture. The closest parallels are found in the Middle Phase (4,600–3,900/3,800 calBC; Raemaekers 1999, 108–112, 165; Raemaekers / De Roever 2010, 135), particularly with regard to the impressions on the inside of the rim. The archaeometrical analysis on one sample indicates that the vessel was produced with local clay, but the ornamentation on the inside was not manufactured repeatedly by Boberg potters. Therefore, the decoration does not represent a feature of final Mesolithic pottery at the Boberg sites and rather indicates that the vessels were manufactured by people of the Swifterbant culture. Although no clear influence on the decoration patterns is recognisable, the interactions between Boberg and Swifterbant might have had a lasting effect on the local tradition. First of all, it is remarkable that the Boberg pottery is built in U-technique which is familiar from Ertebølle and Swifterbant manufacturing. One difference between both cultures is the H-technique in pottery production, which is only known from the Ertebølle culture[16]. H- and U-technique both use coils, but differ as coils in the H-technique are fixed by pressing vertically down with the fingertips. For vessels built in U-technique, coils were smoothed down on the inside and outside (Hulthén 1977, 35 fig. 15; Koch-Nielsen 1986, 109–112; Stilborg / Bergenstråhle 2000, 31–33 fig. 5). As a result, the H-technique produces thicker vessel walls compared to the U-technique (Stilborg / Bergenståhle 2000, 30 f.; see also Andersen 2011, 199 f.). Regarding heat resistance (cf. Rice 1987, 229; 2015; Tite 1999, 220) in particular, the reduction of wall thickness improves the quality of the vessel and can imply skill development. According to the excavation findings at Ringkloster, Denmark, the coiling techniques succeeded each other. At the beginning both H- and U-technique are present, then there are only the U-technique and an oblique version of the U-technique, to be eventually complemented by the N-technique[17]. However, as pottery build in the H-technique is not present at Boberg, a cultural proximity to the Swifterbant culture seems possible. Furthermore, the coiling technique can have had an effect on the shape of vessels, bottoms included. For example, H-technique and solid pointed bases are predominant in the eastern part of southern Scandinavia, whereas bases with pronounced pointed ends occur frequently in the western part (Hulthén 1977, 39 fig. 19; Stilborg / Bergenståhle 2000, 31). Moreover, there are regional differences within the Danish Ertebølle culture. Pottery in northern Jutland has cylindrical vessel shapes with thick walls, built in H-technique, and the bases have precisely shaped points, while in the west-southwest region U- and oblique U-technique occur more often, and vessels are S-shaped, with more conical bases (Andersen 2011, 196–199, 203 figs. 4; 8; 10).

15 Thin-sections indicating lamps tempered with grog, quartz and feldspar are also present for example at site Rosenhof in northern Germany: Hulthén 1977, 43, 45 fig. 24.

16 See Andersen 2011, 199, 202 Fig. 9,a; 2010, 170; De Roever 2004, 46 f.; Hulthén 1977, 35 Fig. 15; Koch-Nielsen 1986, 110; Raemaekers 1999, 195; Stilborg / Bergenstråhle 2000, 30 f.

17 Andersen 2011, 199, 202 fig. 9a. – In contrast, radiocarbon dates on pottery from Neustadt LA 156, dist. Ostholstein, indicate that H-, U- and N-technique were in use at the same time: Glykou 2016, 48–57, 164 f.

Site	Lab.-no.	C14 age BP	C14 age calBC 1s	C14 age calBC 2s	δ13C
Friesack 4	AAR-15046	5419±27	4289±30	4336–4241	-34.51±0.05
Rhinow 30	AAR-18757	5250±30	4073±72	4229–3977	-28.95±0.05
Rhinow 30	AAR-18758	5138±36	3923±65	4038–3804	-28.83±0.05
Boberg 15	LuS 11578	5820±55	4767–4600	4799–4539	—
Boberg 15	LuS 11658	5300±60	4231–4046	4317–3985	—
Boberg 15	LuS 11577	5000±60	3932–3706	3984–3661	—

Table 1 Radiocarbon dates of pottery from sites Friesack 4 and Rhinow 30, dist. Haveland (after Kotula et al. 2015, 495, table 1).

Various distributions of specific bottom shapes are also mentioned in the context of the Swifterbant culture (Raemaekers 1999, 112). In comparison, Ertebølle and Swifterbant ceramics show similarities especially concerning bases with a pronounced pointed end, but the pointed bottoms with triangular and conical shape of Ertebølle vessels differ. It is worth noting that all types of bottoms are preserved at Boberg (see Fig. 2.1–9). In sum, the final Mesolithic pottery from Boberg resembles both Ertebølle and Swifterbant manufacturing in terms of building technique and bottom shapes. Therefore, interactions with groups of the Swifterbant culture might have influenced local pottery production. Concerning the potential chronological succession of the building techniques, the predominant use of U-technique at the Boberg sites might also depend on the chronological setting. The various types of bottoms might also reflect functional dimensions instead of cultural backgrounds. However, lamps are a clear exception, because they are only represented in the Ertebølle culture, and the imported sample indicates intra-cultural contact, as does the pointed base decorated with rounded impressions. In sum, the resemblance to both Ertebølle and Swifterbant pottery makes it possible that impacts from Ertebølle and Swifterbant groups resulted in the fusion of techniques at the Boberg sites and therefore both influenced the local pottery tradition. In this context, a permanent stay of persons of the Swifterbant culture at the Boberg sites can also be discussed. The interaction between the Ertebølle settlers from Boberg with Swifterbant groups and their influence might indicate a fundamental difference from the interactions with persons of the Neolithic Rössen and Stroke-ornamented ware culture, perhaps due to a higher sense of association and proximity between Mesolithic communities.

Such a higher sense of association and proximity can also have had an effect on the development of the Boberg pottery with horizontal rows of fingernail impressions that cover the whole vessel body. As mentioned above, potential influences of the Swifterbant culture are obvious, as ornamentation covering the whole or a large part of the vessel is common, even though more frequent in the Southern Group. If the Swifterbant culture, distributed in the southern region, influenced the development of the pottery with fingernail impressions covering the whole surface, a knowledge transfer of grog temper can also be discussed. Nonetheless, it must be noted that grog temper has not been identified in pottery with fingernail impressions from Boberg. In contrast, the vessel shape, particularly the flat bottom, shows that Neolithic cultures also played an active part during the development of the local pottery. Inter-cultural interaction between Boberg settlers and Gatersleben people is indicated by the flat-bottomed vessel decorated with rounded impressions covering the shoulder. In sum, the pottery with overall fingernail impression from Boberg illustrates inter-cultural interactions and impulses from final Mesolithic and Neolithic societies, resulting in an adaptation and combination of specific elements, including shape and ornamentation. Indeed the technology of both vessels built in U-technique and pottery with overall fingernail impressions seems comparable, especially the temper, grain size and wall thickness. The perpetuation of the final Mesolithic technological tradition as well as the use of local clay indicates that the Boberg settlers were involved and, in consequence, an expulsion of the locals seems improbable.

In this context it is notable that pointed bases and lamps from Friesack 4 also indicate a settlement of this site during the final Mesolithic and moreover represent material of the southernmost archaeological site of the Ertebølle culture in inland eastern Germany (Kotula et al. 2015, 494, 499–501; Wetzel 2015, 518, 523). The settlement of Boberg and Friesack by final Mesolithic groups of the Ertebølle culture, together with the radiocarbon dates of the decorated pottery, imply that both vessel types were produced at the same time (Table 1). A completely decorated vessel from Friesack 4 yielded a final Mesolithic date (Tab. 1; AAR-15046). Similar dates are associated with two samples from Rhinow 30 (Tab. 1; AAR-18757; AAR-18758; cf. Kotula et al. 2015, 495 table 1; Wetzel 2015, 516). The range of the radiocarbon dates of pottery from Friesack 4 and Rhinow 30 indicates a dating of the pottery with fingernail impressions that cover the vessel body to the final

Fig. 6 Boberg. Interaction network. No scale.

Mesolithic. Keeping in mind that the early Neolithic Funnel Beaker culture starts around 4,100/4,000 BC, especially the Rhinow 30 dates also support a position in the transition horizon between final Mesolithic and early Neolithic (cf. Kotula et al. 2015, 500–503; Wetzel 2015, 519). Concerning the chronological setting of the pottery, the radiocarbon dates of completely decorated vessels from Boberg 15 also seem to support a dating in the final Mesolithic as well as in the transition horizon (Table 1; LuS 11578, 11658, LuS 11577[18]). Regarding a possible reservoir-effect, the settlements are situated near water and thus the use of aquatic resources might have adversely affected the radiocarbon dating results. In this context, the missing carbon values of the Boberg pottery as well as the low carbon values of the Friesack and Rhinow dates urge caution (cf. Kotula et al. 2015, 500–502; Wetzel 2015, 523), and further radiocarbon dates are necessary to confirm the dating in the transition from final Mesolithic to early Neolithic.

In sum, the geographical distribution of flat-bottomed pottery with fingernail impressions and the restricted settlement region in northern Germany alongside the river Elbe are conspicuous, as is the dating. Both seem to support the term 'Friesack-Boberg group', defined after Wetzel (2015). However, it should be emphasised that inter-cultural interaction and impacts, which can be connected to the Swifterbant culture as well as the Gatersleben culture, played a significant part for the establishment of the overall decorated pottery at the Boberg sites. In addition, regarding the adaptation of flat bottoms, influence by the Brześć Kujawski-/Lengyel culture can be discussed for the sites Friesack 4 and Rhinow 30 (Wetzel 2015, 528 fig. 17), which might indicate that different Neolithic cultures influenced the development of the flat-bottomed pottery in the north.

Furthermore, the pottery with overall fingernail impressions stands out due to its distribution at the Boberg sites. Final Mesolithic pottery and early Neolithic vessels decorated with arcades and punctures from the outside, resulting in a bossel on the inside ('Lochbuckel'), occur at Boberg 15, 15 East, and 20, and indicate that all sites were settled by groups of the Ertebølle and early Funnel Beaker culture. In contrast, the pottery with overall fingernail impressions is only present at Boberg 15. As mentioned above, a social relationship between the sites is presumed, and the limited incidence of vessels might indicate that the Friesack-Boberg pottery had a special function as

18 The analysis was conducted by Anders Lindahl, The Laboratory of ceramic research, Lund University, Schweden.

well as social significance, and was thus symbolically charged.

Furthermore, the predominant use of N-technique for manufacturing the vessels with fingernail impressions as well as the flat bottoms indicate a proximity to Neolithic pottery, and the interconnection of cultural impulses and influences might also show that the Friesack-Boberg group was crucial for the process of neolithisation in the north. The adaptation might illustrate the beginning of (social) conformity, which further increased until the formation of early Neolithic Funnel beaker pottery around 4,100 BC. Bearing in mind that the development of Funnel beakers also indicates the fusion of impulses from different cultures (cf. Klassen 2004, 166f., 288–290; Müller 2011, 293–296 fig. 7), the Friesack-Boberg group perhaps highlights an intensified network of different cultures which played a significant part in the neolithisation process.

Conclusion: network and mobility

The various intra- and inter-cultural contacts at the Boberg sites highlight the contact network of archaeological cultures and, therefore, a high level of mobility to interact with different groups. Furthermore, influences might also illustrate migrations of culturally foreign persons to the Boberg sites (Fig. 6). It is thus clear that during the final Mesolithic long distances were travelled to keep in contact. In particular, the location of sites along the river Elbe implies that river courses were an advantageous means for making contact and interacting, and will have played a crucial role. Moreover, using waterways enables people to cover long distances in a rather short time, and thus the river Elbe likely was an artery for contacts in the final Mesolithic. The locally produced 'foreign' pottery illustrates the integration of inter-cultural persons in the local society, with different levels of impact and rejection. While the local technology remained basically unchanged, there were interactions with Rössen and Stroke-ornamented ware groups, and the development of the Friesack-Boberg group demonstrates culturally diverse impacts. It seems that foreigners visited the Boberg sites intentionally, and for social meetings instead of displacing the original inhabitants. Clearly, people from the Boberg sites were open to inter- and intra-cultural interactions. With regard to the imported vessels, it is emphasised that they can likely have been brought to the Boberg sites by foreigners as well as locals who had visited faraway regions. However, the Boberg sites are not a single phenomenon in the final Mesolithic. For example, in northwestern Germany, pottery from site Hüde 1, dist. Diepholz, settled by the Swifterbant people, shows connections to the Rössen as well as the Ertebølle culture. Also, site Dąbki 9 in northern Poland should not go unmentioned, where pottery illustrates contacts to the Linear Pottery culture, Stroke-ornamented ware culture, Brześć Kujawski group, and Lengyel, Bodrogkeresztúr as well as Ertebølle culture (Czekaj-Zastawny 2015). In the end, the great significance of special places and 'meeting points' in the final Mesolithic becomes apparent and underscores that groups were not isolated, but rather open to contacts and interactions. In such a setting, increased tolerance towards different sociocultural as well as economic practices is required, and therefore it should also be discussed whether inter-cultural contacts were performed by a specialised subset of the population which consequently played a key role. Assuming that contacts took place repeatedly, it might be possible that these people had easier access to each other and more knowledge of cultural diversity, helping to dissolve boundaries and limitations between other actors.

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Hunter-gatherer pottery from the Baltic Sea coast – some regional examples from Schleswig-Holstein

Sönke Hartz

Abstract The present study deals with Ertebølle pottery from the modern districts of Schleswig-Holstein, including sherds from three submerged coastal sites. In Schleswig-Holstein, sherds from pointed-bottomed vessels were found in the 1880s in Kiel harbor, but excavated and stratified material did not appear before 1970. Since early pottery was associated from the start with the terminal Mesolithic Ertebølle culture (ERT) and the neolithisation process, new investigations were conducted between 1985 and 2006 both on inland and coastal sites of the ERT. The finds presented here come from coastal sites on the Baltic Sea coast, since the variety and number of sherds from submerged sites with good preservation is obvious. The finds should to some extend contribute to the understanding of the emergence, dispersal and disappearance of terminal Mesolithic pottery in the western Baltic.

Keywords Schleswig-Holstein, Ertebølle culture, coastal sites, early pottery tradition

Zusammenfassung *In Schleswig-Holstein wurden seit Beginn der 1980er Jahre Ausgrabungen auf Küstensiedlungsplätzen der endmesolithischen Ertebølle- und frühesten Trichterbecherkultur durchgeführt. Drei überregional bedeutende Fundstellen liegen im östlichen Holstein in der Niederung des Oldenburger Grabens (Grube-Rosenhof LA 58, Wangels LA 505) und in der Neustädter Bucht (Neustadt LA 156). Die auf diesen Fundplätzen geborgenen stratifizierten Tonscherben geben Einblicke in die frühen Keramiktraditionen des Nordens.*

Zahlreiche gut erhaltene spitzbodige Gefäßfragmente und Tonscherben von ovalen Lampen aus der späten Ertebølle-Kultur stellen die Grundlage für Analysen zur Entstehung, Nutzung und Herstellungstechnik der ältesten Keramikproduktion dar. Darüber hinaus lässt sich erforschen, wann die Ablösung der spitzbodigen Ware durch die Bechergefäße der frühneolithischen Trichterbecherkultur stattfand.

Introduction

Early ceramic traditions have been given a central role in understanding cultural contacts and technological transfer among terminal Mesolithic hunter-gatherer societies of the western Baltic region. These traditions are characterised by a pointed-bottomed pottery connected to an economy based primarily on hunting, gathering and fishing. Settlements are predominantly found on the Baltic Sea coast, whereas sites in the inland and on the North Sea coast are very rare. Pottery is a common constituent of those coastal settlements especially on sites in the modern districts of Schleswig-Holstein, and on Jutland and Fyn.

In this article ceramics from three of the oldest pottery-bearing coastal sites in Schleswig-Holstein are discussed. In this region, ceramics associated with the Ertebølle culture pre-date the first evidence for agriculture by at least 500 radiocarbon years. The material is presented here to illuminate ceramic technology and the use of pottery in late hunter-gatherer societies. It will be discussed what types of vessels were produced, when pottery emerged, and when it was replaced by funnel-shaped beakers at the onset of the early Neolithic Funnel Beaker culture (Trichterbecherkultur, TRB). The aim is to contribute to a better understanding of the emergence and dispersal of late Mesolithic ceramic traditions and their connection to the southern Scandinavian and eastern Baltic regions.

Appearance of early ceramics in the north

To present-day it is generally accepted in Schleswig-Holstein that according to radiocarbon dates pottery production started at the Baltic Sea coast in

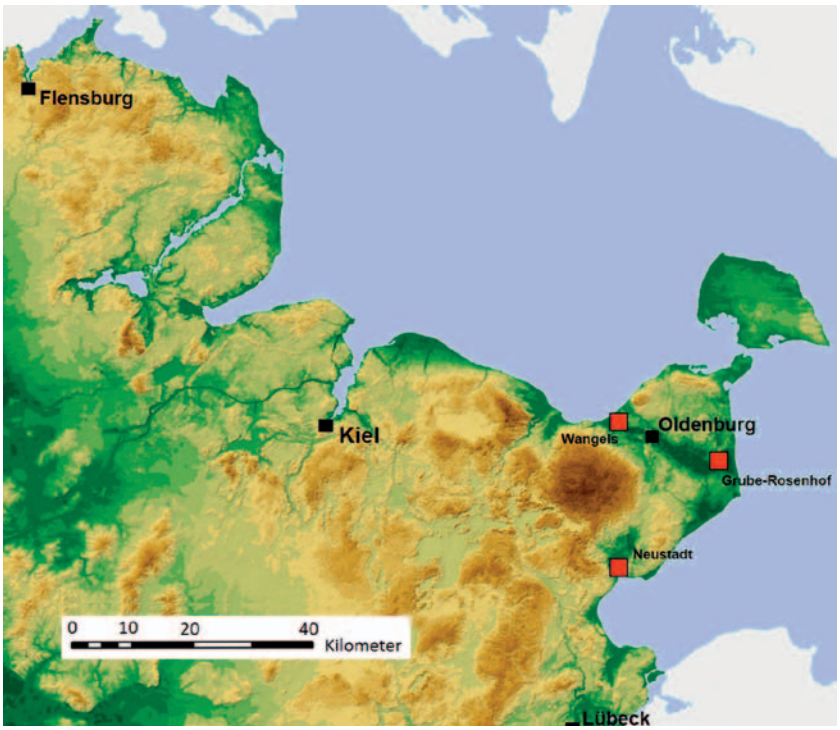

Fig. 1 Ertebølle sites mentioned in the text.

eastern Holstein c. 4,700 to 4,600 calBC on sites like Grube-Rosenhof LA 58, Wangels LA 505 and Neustadt LA 156 (Fig. 1). However, ceramics appear more or less contemporaneously in the geographical area encompassing Denmark, Scania (southern Sweden), Schleswig-Holstein and Mecklenburg-Western Pomerania in northeast Germany.[1] On the island of Rügen Terminal Mesolithic pottery has been absent so far, but only a few sites with good preservation were investigated (Hirsch et al. 2008; Lübke / Terberger 2004). Much older dates from inland sites like Schlamersdorf LA 5 and Kayhude LA 8 (Meyer 2016) seem very problematic, since they were measured from charred remains attached to the inner parts of the vessel. These samples could be contaminated by the hardwater reservoir effect in view of the contribution of fresh water fish in the diet (Philippsen 2013; Philippsen / Heinemeier 2013).

Ceramic vessels from coastal sites are associated with the younger ERT and appeared some centuries before the introduction of domesticated fauna and flora. Pottery seems of special importance in the Mesolithic record as it is one indicator of cultural contacts and developments between northern Germany and the neighbouring regions. Culturally, the first appearance of pottery marks the border between the older (Jäckelberg and Rosenfelde phase) and the younger Ertebølle culture (Jarbock and Timmendorf phase) in the region around Mecklenburg Bay.

In contrast to sites on mineral soils the preservation of potsherds in marine/brackish gyttja layers is generally excellent, and sometimes larger pieces to the size of half pots or even fully preserved vessels occur (Fig. 2). However, the sites of Wangels LA 505 and Neustadt LA 156 yielded early Neolithic (EN I) sherds as well, and these settlements are discussed as transitional sites, where Ertebølle ceramic is associated alongside a set of new pottery types from the early Funnel Beaker culture. However, observations from sherds from waterlogged sediments could elucidate the dating and use of early pottery craft in late forager societies in Schleswig-Holstein.

It seems very likely that hunter-gatherers of the early ERT already had container technology for gathering and storage, and therefore the question needs to be specified to what reason pottery was introduced into the material culture of such complex societies. Various authors prefer the idea that ceramic containers may be understood as the need for pots for new (prestige) food preparation modes, and that the vessels were associated with ritual uses (Jennbert 1984; Fischer 2002; Povlsen 2013). However, currently no clear variation in the subsistence pattern or fundamental changes in the material culture (stone, bone/antler and wooden artefacts) is observed at the shift from the older to the

1 Andersen 2010; 2011; Lübke 2004; Prangsgaard 2013; Sørensen 2015; Terberger 2006.

Fig. 2 Pointed-bottomed vessels. **1** Rüde LA 2; **2** Wangels LA 505; **3** Grube-Rosenhof LA 58; **4** Neustadt LA 156.

younger ERT in Schleswig-Holstein. The economy was constantly based on highly specialised hunting, fishing and foraging with a large marine component (Schmölcke 2004; Glykou 2016). In contrast to this, the whole of marine and terrestrial food stuff must have been prepared without the use of ceramic containers before. The ERT-inventories reveal pots from small drinking cups up to large cooking pots made in various coil building techniques from the onset. Only little technological progress emerged during the younger ERT (Glykou 2016; Tranekjer 2015). There is evidence that vessels were used for cooking marine resources (Craig et al. 2011) or plant food preparation (Saul et al. 2012) which show no leftovers in the archaeological context.

Ertebølle pottery: pointed-bottomed vessels and oblong bowls

Throughout Denmark, Scania, northwest Poland and northern Germany the early indigenous pottery consists of two predominant types: the pointed-based vessels with slightly S-shaped profile and more or less extended rim, and the oblong bowls or clay lamps.[2]

As mentioned before, in Schleswig-Holstein both types occur stratigraphically simultaneous (Hartz 2011) and display the same geographical distribution along the northern German coast. However, the radiocarbon ages of lamps in some cases are several hundred years older than expected from other kinds of evidence. This age offset may be due to the marine reservoir effect (Fischer / Heinemeier 2003) when dating extant carbonised surface residues, probably marine animal fat like seal tran, but further investigations will have to prove this for the material in question (Robson et al. in prep). Since the emerging ERT, and throughout the younger ERT, pointed-bottomed pottery in Schleswig-Holstein seems very variable regarding shape, size and coil-building technique (Glykou 2010; 2016). This observation supports the impression that the knowledge of ceramic manufacture was not a local invention but was introduced from outside into the Ertebølle province in Schleswig-Holstein as a fully developed package after a period of routine production (see chapter below).

Coastal sites with Ertebølle inventories

Site context of Grube-Rosenhof LA 58

The site Grube-Rosenhof LA 58 is located in the eastern part of the Oldenburger Graben valley and was discovered in 1969; it was partially investigated

2 Huthén 1977; Prangsgaard 1992; 2013; Andersen 2011; Van Diest 1981; Glykou 2016; Heron et al. 2012; Robson et al. in prep; Galiński 2012; Kotula 2017.

between 1970 and 1980 under the direction of H. Schwabedissen (Schwabedissen 1994). C. 330 m^2 were excavated systematically, some further 300 m^2 were opened for trial trenches to document the find layers. The find layers are very rich and more than 4,000 potsherds were recovered (Nydahl in prep.), which make Rosenhof one of the richest sites concerning pottery along the western Baltic coast.

Early conventional ^{14}C dates suggested that the settlement was inhabited from c. 5,000 until 3,800 calBC, however, in spite of the large excavation area, there were doubts whether the earliest layers already contained pottery or not. The follow-up investigations in 2001 and 2002 (Grube-Rosenhof LA 58, area A), which were to answer this open questions, were restricted to the refuse layers of the settlement on an area of c. 60 m^2. The complete inventory has been presented by J. Goldhammer (Goldhammer 2008), therefore, only a short summary of the results will be given here.

The material from area A comprises approximately 350 pottery fragments of which c. 310 belong to thick-walled, coarsely tempered pointed-based vessels, and 40 to oval lamps. The number of lithic artefacts totals c. 5,500 pieces, 2 % of which have been identified as tools (Hartz 2004; Goldhammer 2008). Soft-hammered blades with parallel edges are the dominating type, corresponding cores and reduction waste from the preparation of striking platforms appear as well. Among the 130 flint tools, axes are the most prominent group. They are represented in almost equal shares by oblong-oval ('flake-axe like') core adzes and by oblong-oval and trapezoidal, flat-trimmed flake axes. The third most common group of lithic artefacts are transverse arrowheads. These projectiles were made from blades and, in terms of size and form, do not form a uniform group. The remaining tools consist of blade scrapers with a partially asymmetric front, concave and straight-truncated blades, thick core borers, various edge-retouched pieces and hammer stones. The single occurrence of an angle burin illustrates the relative insignificance of this implement in the Ertebølle culture of East Holstein.

A group of antler and bone implements completes the tool inventory. T-shaped axes and punches with distinctive wear traces were made from red deer antlers. Slender points used for leisters and two needle-like awls along a heavy chisel were made from bones. From the re-excavations 134 wooden artefacts were recovered, among these are leister prongs, paddles, fragments of spears, net floats, fragments of a bow and pointed hazel sticks. The majority of the leister prongs were made from the core wood of pipfruit, but pieces of hazel, dog wood, ash and elm are found as well. The wooden implements further consist of four paddle fragments with blades of round to oval and elongated shapes.

By the results from the old excavation, where cultural layers to a thickness of 0.6 m were recovered, and the high frequency of lithic tools and pottery sherds, Grube-Rosenhof LA 58 is suggested as a base-camp settlement. There is evidence from the animal bone material that the site was inhabited throughout the year with both summer and winter hunting activities (D. Heinrich, pers. comm.). The adaptation of refined excavation techniques has revealed almost 4,000 fish remains, with a high proportion of marine species. From the re-excavation six radiocarbon dates are available. They indicate a habitation from 4,800 to 4,600 calBC (Goldhammer 2008).

Site context of Wangels LA 505

The site Wangels LA 505 is situated in the western part of the Oldenburg Graben valley on the northern edge of an isolated sandy peninsular. The excavation was conducted from 1996–1999, covering an area of approximately 300 m^2. Cultural layers were observed at depths of up to 1.5 m beneath the surface, which is 2.3 to 2.5 m below present sea level. They consist of grey medium to coarse-grained gravel containing numerous molluscs. The excavation demonstrated that, after an initial occupation phase between 4,300 and 3,700 calBC, the site was resettled by Neolithic farmers of the late Funnel Beaker culture (Middle Neolithic V) between 2,900 and 2,700 calBC (Hartz 1997/1998).

The terminal Mesolithic inventory from Wangels encompasses a number of find categories which are typical of waterlogged sites. These are large potsherds, implements of bone and antler (T-axes, punches, bone points) as well as wooden artefacts, mammal and bird bones, fish remains, molluscs and plant remains (Hartz 1997/1998; Heinrich 1997/1998). The flint tools inventory comprises c. 350 flat trimmed trapezoidal flake axes and c. 250 transverse arrowheads as well as borers, scrapers and flint knives (Faasch 2016). Special attention is paid to stone axes which were produced of non-local amphibolith, suggesting contacts with farming communities south and east of the river Elbe. More than 201 wooden artefacts were recovered from the settlement layers (Klooss 2010), among these are 45 leister prongs, mainly made of pipfruit and hazel. Other wooden implements are paddles, spears, pointed sticks, and there are also antler tools like T-axes, punches and polished shafts with crafted ends.

Fig. 3 *In situ*-sherds of a fragmented pointed-bottomed vessel from Wangels LA 505.

In the pottery assemblage from the initial occupation (ERT phase) phase around 4,300 calBC sherds from pointed-bottomed vessels (Fig. 3) and oval lamps occur. The material comprises approximately 200 sherds from eight thick-walled, pointed-based vessels, and 19 sherds from oblong lamps. An analysis and stratigraphic classification of the ceramics is discussed by Grohmann (2010). Some charred food remains on pottery fragments and samples from other organic artefacts were dated by radiocarbon method. The 31 dates indicate that the settlement existed between 4,300 and 3,700 calBC, but with an emphasis on the early Funnel Beaker culture (Early Neolithic I; Hartz 2004).

Site context of Neustadt LA 156

The submerged site Neustadt LA 156 is located 3.5–4.0 m below the present sea level. It was discovered in 1999 and excavated from 2000 until 2006 by divers (Hartz / Glykou 2008; Glykou 2016). Around 110 m² were investigated. However, only c. 10 m² of this area belong to the proper occupation area. In the refuse area, the find layer merges into brackish gyttja/peat with molluscs which provides excellent preservation conditions.

From the layers with high proportions of organic components, not only sharp-edged flint artefacts and ceramic finds were retrieved, but also plant remains, animal bones, antler implements, charcoal as well as worked and charred wood. The high proportion of finds and the thick find layers suggest that Neustadt LA 156 was used as a base-camp settlement, comparable to Grube-Rosenhof LA 58 some 25 km north.

Altogether more than 40,000 flint artefacts were excavated (excluding chips), 1 % of which have been defined as tools (Hartz 2004). This group is dominated by 750 transverse arrowheads, which were fabricated from blades and flakes in almost equal shares. The second group comprises c. 260 flat trimmed trapezoidal flake axes, followed by c. 100 blade scrapers. The blade implements also comprise concavely and obliquely truncated tools, borers as well as edge-retouched and denticulated pieces. Burins, however, are very rare, which is similar to other coastal sites of the terminal ERT in Schleswig-Holstein.

The non-flint stone tools comprise hammerstones of quartzite or quartzite sandstone, round-butted axes (‘Walzenbeile’) and two Danubian shaft hole axes, which underline the special role of East Holstein in the distribution of imported amphibolite axes from the south.

Among the bone implements, simple bone points, awls, a slender bone chisel, a spatula-shaped tool with a denticulated end and several ulna daggers have to be mentioned. T-shaped axes, harpoon heads, punches and a small chisel were made from antler.

Among the wooden tools are leister prongs, dug-out canoe fragments, paddles, spears, angled handle shafts for axes, fragments of a bow and arrows, a net float made of bark, textile net remains, several fragments of wicker work fish traps, pointed sticks and poles.

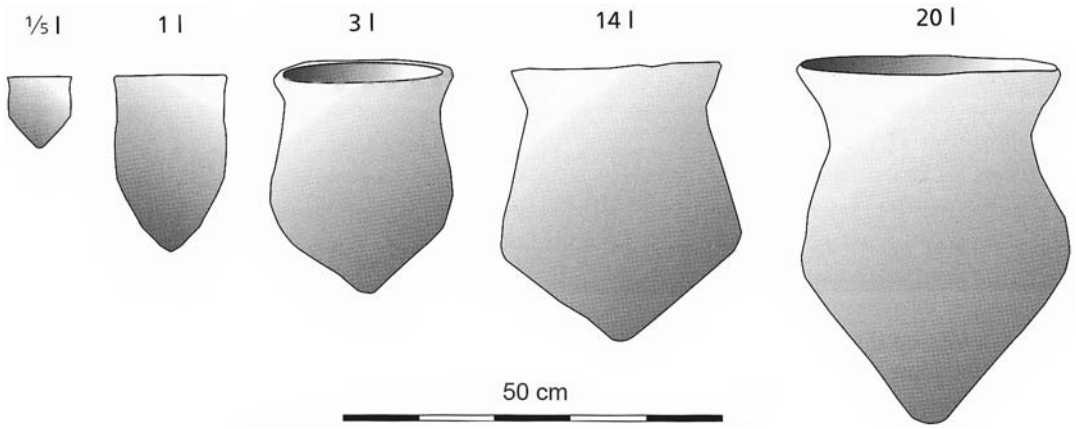

Fig. 4 Sketch of Ertebølle vessel sizes (after Andersen 2010, fig. 7).

The animal bones, bone and antler implements and pottery were analysed by Glykou (2016). Neustadt differs from the other two sites in its focus on marine resources. The fish bone assemblage with its approximately 13,000 pieces and the list of fish species are clearly dominated by marine species. Moreover, most of the mammal remains also come from marine species such as seals and dolphins (*Phocoena phocoena*, and *Delphinus)*.

Within the ceramic finds, c. 2,500 coarsely tempered, thick and thin walled sherds from pointed-bottomed vessels appear along with c. 110 remnants of oblong lamps.

The chronological frame is set by more than 35 AMS-dates, which cover the period between 4,500 and 3,800 calBC. Thus, the site belongs to the younger (ceramic) stage of the ERT (Timmendorf phase) and the earliest phase of the Funnel Beaker culture (Wangels phase), and is more or less contemporaneous with Wangels LA 505.

Terminal Mesolithic pottery

Pointed-bottomed vessels

From all three sites mentioned above the same general type of pointed-bottomed vessel with smoothed to slightly sharp concave neck and everted rims exists. Straight rims or even incurving ones have not been observed so far, and any kinds of applications like handles, lugs or knobs are lacking. There is considerable variation to be seen in the size, the profiles, the shape of the pointed bases, the wall thickness and the decoration of the pots. The most common type is the medium sized vessel (3–8 litres capacity), whilst small cups (< 3 litres) and larger pots (> 10 litres; Fig. 4) are rare. Vessel shoulders are almost conical, more cylindrical ones are found only on two smaller cups from Grube-Rosenhof LA 58 (old excavation) and Ecklak (Hartz 2011). The unpronounced low rounded belly breaks (carination) are generally located in the middle to lower part of the vessel.

The bases vary from heavy and markedly distinct forms to narrow pointed ones and more rounded ends (Fig. 5). Two main construction techniques have been observed: the most common one involves formation of the base by pressing a lump of clay into a cone. The vessel is subsequently built up by laying clay coils in rings around the opening of the cone (Koch 1998; Glykou 2010). According to another technique, the pointed base was made by one or more clay coils arranged in a small spiral. Following this process, the upper part of the pot was manufactured using clay coils. Observations on how these coils are treated in order to shape the pot has led to the recognition of three different techniques, the U-, H- and N- techniques (Hulthén 1977) which appear in variations and intermediate forms (Glykou 2016). For example, in Neustadt LA 156 and Grube-Rosenhof LA 58 (area A), the H-techniques dominates with more than 50 % of the sherds, followed by U- and N-technique (Glykou 2016; Goldhammer 2008), whereas the U-technique is the most frequent construction type in Wangels (Glykou 2010). So far there is no tendency towards a change of techniques as a chronological indicator, as it appears in Denmark (Andersen 2011). The general thickness of the Ertebølle pottery sherds from coastal sites in Schleswig-Holstein built in U- and H-technique varies from 8–12 mm with a mean value of 10 mm on all three sites, while sherds constructed in N-technique are slightly thinner (mean of 8 mm).

The raw clay for pointed-based vessels is primarily tempered by burnt and crushed granite with red feldspar and white quartz. Up to 8 mm large and

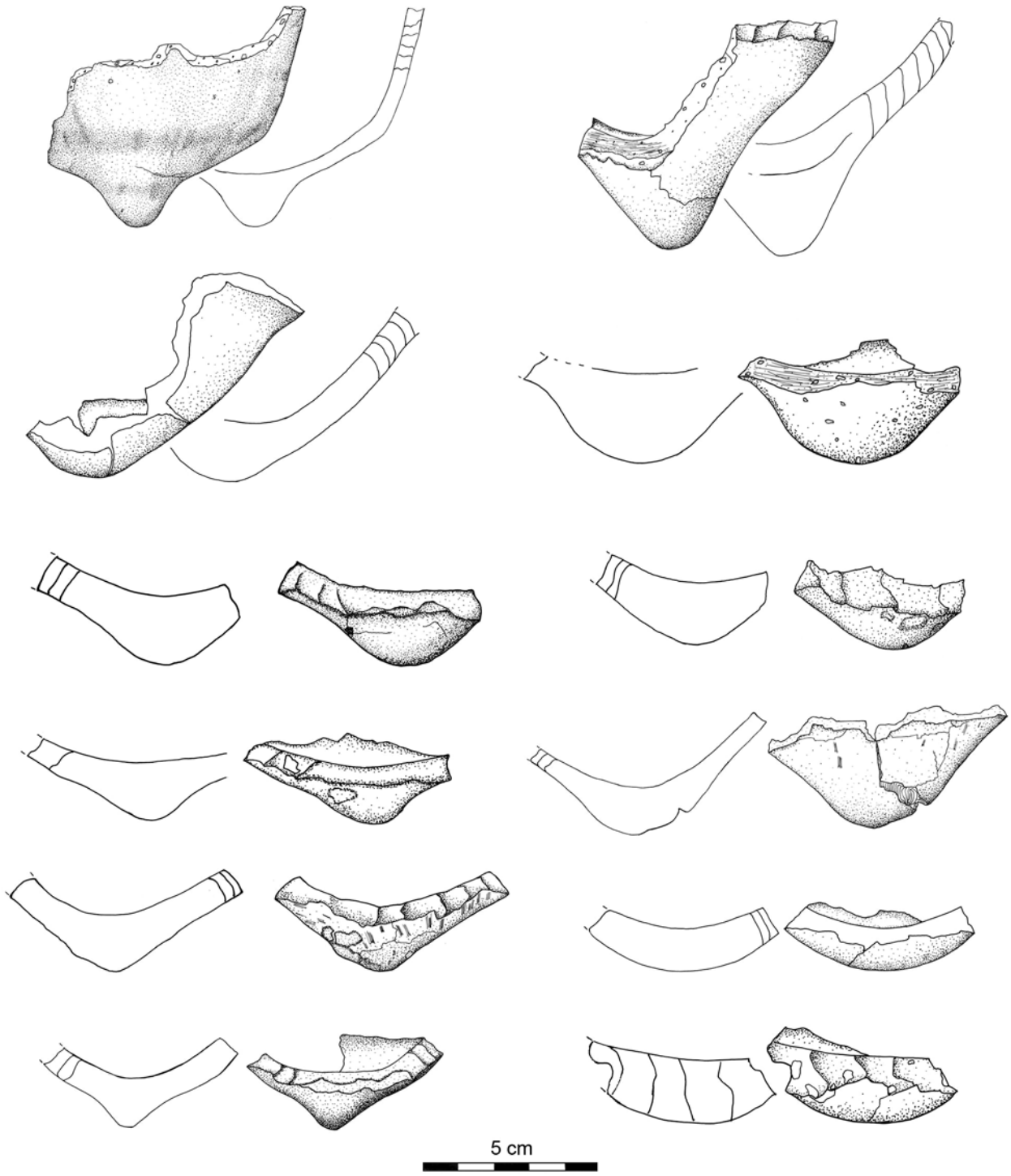

Fig. 5 Variety of pointed bottoms from Neustadt LA 156.

sharp feldspar grains are often visible in thick-walled belly sherds (Fig. 6). Granite rocks are easily accessible on the Baltic coast and were used as cooking stones throughout the whole Stone Age and later periods. In the case of thin-walled wall sherds, fine sand was mixed into the raw clay as well (Glykou 2010), while chamotte and organic temper (charred plant remains) were recorded only in thin sections from Neustadt, indicating that the Ertebølle pottery was the result of a longer ceramic manufacturing process. However, the extremely rare presence of organic temper suggests that plant remains were probably accidentally mixed in the clay.

There is only sparse decoration on pointed-based pots from northern Germany, and the typical ornamentation is mostly limited to the top of the rim. Ornamentation is restricted to finger and/or fingernail imprints, but few cases of circular impressions

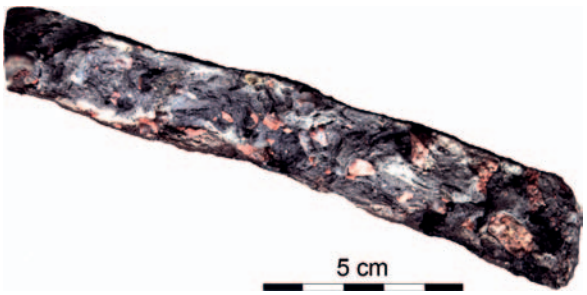

Fig. 6 Ertebølle sherd from Wangels LA 505 with large feldspat tempering particles.

made with bone stamps are known as well (Fig. 7). In contrast to some Danish sites (Prangsgaard 1992), belly decoration is extremely rare and occurs only as stab impressions on two wall sherds from Grube-Rosenhof LA 58 (old excavation; Hartz 2011) and Neustadt LA 156 (Glykou 2010).

The function of pointed-based vessels is discussed due to charred remains on the surface. No pots or larger base-fragments from coastal sites in Schleswig-Holstein were preserved *in situ* on habitation areas since these were affected by heavy erosion during transgression. Both inner and outer parts of the vessels show indications for the use of cooking or direct fire exposure in the form of charred surface deposits. While the inner part is often covered with up to 3 mm thick adherence ('food crusts'), the outer part is usually soot-blackened with a glossy surface. In Neustadt, for example, more than 50 % of the charred remains are deposited on the inner part of the potsherds, while 20 % occur outside, and 25 % on both of the inner and outer vessel parts (Glykou 2016). At the inner part the charred remains are concentrated to the belly region (61 %), while bases (3 %) and rim sherds (3 %) only rarely show surface coatings. The fact that charred remains are not limited to pots of specific size, that they are often thick and built up in thin layers, indicates that pointed-based vessels were made for domestic purposes as effective cooking pots, probably for long term use (Glykou et al. 2012). The black soot as a sign for boiling over direct heat, large spallings on bases and belly sherds, and drilled holes as evidence of repair support the assumption that Ertebølle vessels were constructed more for cooking then for storage. The cooking procedure made marine and vegetable food resources palatable that otherwise are indigestible, at the same time preserving all nutrients in the food. However, new methods of analysing starch from food crusts reveal exciting potential to discuss different uses of these vessels as well (Saul et al. 2012).

Shallow oblong clay bowls ('blubber lamps')

The second diagnostic vessel type of the Ertebølle culture in Schleswig-Holstein is an oblong bowl with slightly pointed ends and a rounded bottom (Fig. 8). Lamps may differ in size and wall thickness, but are always oval to oblong in shape. Lamp fragments are few on Ertebølle sites in northern parts of Denmark, but appear in greater numbers towards the south on the isle of Fyn and on the northern German coast of Schleswig-Holstein (Andersen 2010; Robson et al. in prep). During the Grube-Rosenhof LA 58 excavation (old excavation) more than 50 diagnostic sherds from lamps were recovered (Van Diest 1981; Nydahl in prep.), measuring between 15 to 25 cm in length and 7 to 11 cm in width, which seems to be quite large

Fig. 7 Ertebølle rim sherds from Neustadt LA 156 with nail and stab impressions.

Fig. 8 Large Ertebølle lamps. **1** Neustadt LA 156; **2** Wangels LA 505.

compared to those found on Danish sites (Prangsgaard 1992). The sherds from Neustadt add up to 85 pieces and resemble the Grube-Rosenhof LA 58 ones in size and shape; one fully reconstructed lamp measures c. 30 cm in length and 11 cm in width (Fig. 8.1; Hartz 2011; Glykou 2010). There is good agreement in the shape of the lamps between those from the northern German sites and vessels found in Ronæs Skov and Gudsø Vig (Andersen 2009), whereas the lamps from Tybrind Vig (Prangsgaard 2013) are more rounded and significantly smaller in size.

In principle, the lamps from Schleswig-Holstein were produced in two construction techniques (Van Diest 1981). The first one (coiling technique) starts with pinching a lump of clay into the desired shape to build up the rounded bottom. Subsequently the coils were put onto each other by oblique U-technique to build up the wall and finally the rim. The second

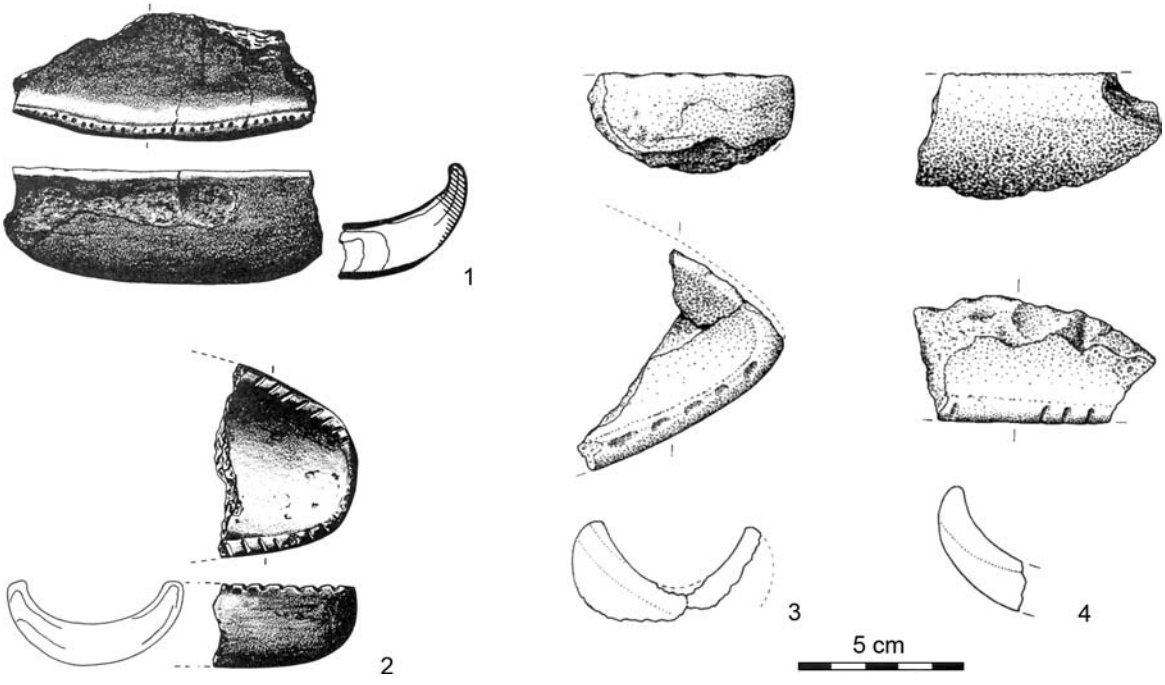

Fig. 9 Examples of ornamented lamps from Grube-Rosenhof LA 58 (**1–2**) and Wangels LA 505 (**3–4**).

technique (layer technique) consists of putting thin layers of clay on top of each other and then carefully working out the wall until the rim is finished. In Neustadt the layer technique is the most frequent one, accounting for up to 75 % of the 85 lamp fragments (Glykou 2016).

In most cases the raw clay for lamp manufacturing is finely tempered with sand, followed by a more coarse tempering with crushed granite with red feldspar, usually observed in fresh fractures as 1–2 mm small grains in the thicker walled vessels. Chamotte and quarzite was used in a few cases in Grube-Rosenhof LA 58 and Wangels LA 505 (Van Diest 1981 and personal observations), while plant remains in sherds from Grube-Rosenhof LA 58 were probably accidentally mixed into the clay and do not represent primary tempering materials.

Decoration was only occasionally applied and consists of parallel or slightly transverse fingernail imprints on the rim, although stabbing, finger(tip) imprints or simple notches (Fig. 9) are known as well (Hartz 2011). In Neustadt, c. 14 % of the lamp sherds are decorated, and approximately the same value applies for Grube-Rosenhof LA 58, whereas in Wangels LA 505 only two of the 19 pieces show rim decoration.

Judging from ethnografic parallels, the shape of the clay vessels, analyses of charred remains, and from experiments performed with replicated oblong bowls filled with marine animal fat,[3] it seems likely that the oblong bowls were used as lamps, probably for heating, lighting and fishing.

Origin of Ertebølle ceramic tradition

Since there is no knowledge of pottery production in the early Ertebølle culture (Jäckelberg and Rosenfelde phases) as shown on sites like Grube-Rosenfelde LA 83 and Strande LA 163 (Schmütz 2018; cf. Goldhammer / Hartz 2013), this technology must have been acquired from outside, most probably by cultural transmission from other ceramic-using hunter-gatherers. The oldest pointed-based sherds were recovered at Grube-Rosenhof LA 58 and Neustadt LA 156, where they are dated to c. 4,600 or 4,400 calBC, respectively. Thus, in the western Baltic, pottery appears c. 500–600 radiocarbon years before the first evidence of domesticated animals (cows and sheep/goat) and cereals (Sørensen 2014). It is an interesting fact that early ceramics on coastal sites does not consist of imported vessels, and it seems obvious that the knowledge of technology was taken over and then transferred into locally produced pointed-based containers.

The appearance and use of Ertebølle pottery was not, as has been previously thought, triggered by influences from Neolithic farming communities (Bandkeramik or post- Bandkeramik cultures) further south or southeast, neither was it an inspiration from or due to social contacts to foragers from the Swifterbant culture in the southwest, where pottery emerged c. 5,000 calBC (Raemaekers 2011). Moreover, the duplicity of pointed-based pots with oblong lamps displays great similarities in the contemporaneous late Mesolithic Narva culture of the eastern Baltic.[4] However, some differences can be observed in the shape, ornamentation and tempering between (Scanian) Ertebølle and Narva vessels (Dumpe et al. 2011). It seems convincing that social networks and contacts existed along the southern Baltic coastline which led to technological influences regarding the knowledge of pottery making in the Ertebølle province around 4,600 calBC (Andersen 2010).

Detailed stratigraphical observations on sherds from Grube-Rosenhof LA 58 indicate that from older to younger find layers a gradual reduction from a coarse, thick-walled pointed-based pottery (> 1 cm wall thickness) to a finer, thin-walled pottery (< 1 cm wall thickness) took place. A more subtile change in pottery construction techniques and vessel forms was also observed between regional groups of the Ertebølle culture (Andersen 2010; 2011; Glykou 2016). However, in Schleswig-Holstein potsherds built in N-, U- und H-techniques are always associated with lamps (Hartz 2004; 2011). Thus, for the period between 4,600 and 4,100 calBC it seems possible to distinguish Ertebølle pottery on technological grounds, but it is likely to assume that pointed-bottomed pots and oblong bowls were adopted as a package.

Disappearance of pointed-based ceramic tradition

There is a large data base of direct radiocarbon dates from sherds from Wangels and Neustadt which demonstrate that pointed-based vessels disappear c. 4,100/4,000 calBC (Glykou 2016; Hartz 2004).

3 Mathiassen 1935; Hulthén 1980; Van Diest 1981; Heron et al. 2012.

4 Timofeev 1998; Hallgren 2004; Klassen 2004; Terberger et al. 2009; Piezonka 2008.

From now on they are replaced by a wider set of vessels like narrow funnel beakers, wide bowls, lugged beakers, flasks and amphorae, which typologically characterise the early Funnel Beaker culture (Koch 1998; Grohmann 2010; Sørensen 2014). These regular thin-walled pots are produced in N-technique and have always slightly rounded to flat bottoms (Kotula et al. 2015; Sørensen 2015). At the same time domesticates, cereal pollen and grains appear in small quantities which are typical markers for the onset of the Neolithic in the north.[5]

Comparable to the formation in Denmark there is a gradual change from more coarse grained thick-walled pointed-based pots to thin-walled funnel beakers. However, the varied vessel types of the early Funnel Beaker culture have knobs and lugs and the beakers are ornamented on the outer part of the rim. In Schleswig-Holstein transitional forms like the Type 0 vessel (Koch 1998) with a S-formed profile and a slightly pointed base appear on settlements with longer duration of occupation ('transitional sites') as well (Glykou 2016). The observation from Denmark that new pottery types were adopted in a relatively short time span on coastal and inland sites around 4,100/4,000 calBC,[6] can be confirmed for the area of eastern Schleswig-Holstein as well.

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5 Kalis/Meurers-Balke 1998; Kirleis et al. 2012; Sørensen/Karg 2014; Feeser/Dörfler 2015; Gron/Sørensen 2018.

6 Fischer 2002; Klassen 2004; Johansen 2006; Andersen 2010.

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Paths of innovation – the site Dąbki, Poland, and the early forager pottery in the Baltic Sea region

Andreas Kotula

Abstract The site Dąbki, Poland, is one of the most important hunter-gatherer settlement sites to shed light on the introduction of pottery into the western Baltic Ertebølle culture in the 5th millennium calBC. This lakeshore environment site was settled from c. 5,200–3,600 calBC, and bog excavations revealed find material in excellent preservation conditions. The pottery assemblage consists of local pointed-bottom pottery and lamps as well as Funnel Beaker pottery. Additionally, numerous fragments of non-local Neolithic ware from communities to the south were uncovered. The pointed-bottom ware was analysed and compared to pottery from neighbouring hunter-gatherer complexes of the 5th millennium calBC. The results show that the pottery from Dąbki displays clear similarities to the western Baltic Ertebølle ware, but some typological traits indicate eastern connections, too. Based on this, possible scenarios for the introduction of pottery into the western Baltic sea area are discussed.

Keywords Ertebølle culture, hunter-gatherer pottery, eastern influences

Zusammenfassung *Der Fundplatz Dąbki ist einer der bedeutendsten Siedlungsplätze später Jäger-Sammler für die Diskussion der Einführung von Keramik in die Ertebøllekultur im westlichen Ostseeraum im 5. Jahrtausend v. Chr. Der Seeuferfundplatz war zwischen ca. 5200 und 3600 v. Chr. besiedelt, und die Ausgrabungen in den vermoorten Uferschichten ergaben Fundmaterial mit hervorragender Erhaltung. Die lokale Keramik besteht aus früher Spitzbodenware und Lampen sowie Trichterbecherkeramik; darüber hinaus ergab der Fundplatz eine Vielzahl nicht-lokaler Keramikfunde aus südlich gelegenen neolithischen Gemeinschaften. Die Analyse der frühen Spitzbodenware und der Vergleich mit Keramik benachbart gelegener Jäger-Sammler Kulturen im Ostseeraum ergab deutliche Ähnlichkeiten der Dąbki-Keramik mit der Ware der Ertebøllekultur; typologische ähnlich sind jedoch auch Gefäße östlicher Kulturgruppen. Die Ergebnisse der Analyse dienen als Basis für die Diskussion möglicher Szenarien der Einführung von Keramik in den westlichen Ostseeraum.*

Introduction

The invention of pottery vessels was one of the most crucial developments in prehistory, leading to massive advances in food preparation, consumption, transport and storage (Orton / Hughes 2013). The invention and production of pottery vessels was traditionally connected with Neolithic farming societies, starting in the Near East (cf. e.g. Arnold 1985). Accordingly, the introduction of pottery into the late Mesolithic Ertebølle culture (ERT) in the southern and western Baltic Sea area was traced in the influence by early Neolithic communities expanding through central Europe into the northern European lowlands in the late 6th millenium calBC (e.g. Berlekamp 1977). This was supported by technological analyses highlighting similarities between ERT and Linear Band pottery (LBK) vessels (Hulthén 1977).

In northern Germany, research at the site Rosenhof was of major importance, and on the basis of supposed early farming activities there as well as supposed cattle and pig domesticates an earliest Neolithic phase with pointed-bottom pottery was postulated (e.g. Schwabedissen 1994), but evidence of cereals and domestic animals was later rejected (Scheu et al. 2008; Krause-Kyora et al. 2013; Feeser / Dörfler 2015). H. Schwabedissen elaborated the idea of Neolithic influence on the pottery production of semi-sedentary groups in northern Germany especially with evidence from the Hamburg-Boberg sites, were early Neolithic as well as pointed-bottom pottery was uncovered (Schwabedissen 1994). His hypotheses were in general agreement with western European research postulating Neolithic influence on early pottery in forager groups (cf. Klassen 2004, 110–111).

However, in eastern Europe and Russia, forager groups with pottery had been known for a long time, and in the Russian Far East and Japan, sites with early pottery dating to the Pleistocene had been documented since the 1960s. Successively, forager sites with pottery and ^{14}C-data much older than early farming communities in the Near East were found to be widespread in Eurasia, and since the 1990s attempts have been made by western archaeologists to bring together the evidence, assuming that the innovation of forager pottery spread from East Asia moving westward ultimately into Europe (Van Berg 1990; 1997; Hommel 2009). This idea has been popularised and further developed since the 2000 s (e.g. Klassen 2004; Piezonka 2015). Modelling of early pottery ^{14}C-data indicates a diffusion of hunter-gatherer pottery from east to west in Eurasia, starting with Pleistocene dates in China, Japan, and the Russian Far East, with gaps especially in Russia (Jordan et al. 2016).

In western Russia this innovation is known from the 7th millennium calBC, reaching the area east of the Baltic Sea in the 6th millennium calBC (Piezonka 2015). The start of pottery production at coastal Ertebølle sites in the western Baltic is then dated to c. 4,600 calBC (Andersen 2008; Hartz 2008), and this fits well with the idea of this innovation spreading from east to west in northern central Europe. An important part of the discussion on the introduction of early pottery and neolithisation in the Baltic Sea area is the site Dąbki in northern Poland (Ilkiewicz 1989; Timofeev 1998; Kabaciński et al. 2015) with an occupational phase between c. 5,200–3,600 calBC and an extensive early pottery ensemble. Since its discovery in the 1970s, long-going research has been undertaken, and new analyses of the pottery ensemble provide insight into cultural affiliation of the ceramic ware (Kotula 2015; cf. Czekaj-Zastawny 2015; Czekaj-Zastawny / Kabaciński 2015). In this paper, the early local pointed-bottom pottery will be discussed in the supraregional context of the Baltic Sea area.

Site and significance

The site Dąbki is located in northern Poland in the centre of the southern Baltic Sea area between Szczecin and Gdańsk, south of the present-day Baltic Sea coast. Several Stone Age sites were detected during systematic prospections in the 1970s on a sandy elevation in a periglacial tunnel valley, nowadays surrounded by bogs (Dębowska 1978). Geographical analyses and topographical data could verify an island situation in a freshwater lake at the time of Stone Age occupation (Fig. 1; Lampe 2015). On the most promising site, Dąbki 9, excavations were first carried out between 1979 and 1985. A mixed cultural layer was uncovered at the elevated sandy settlement area, but the adjacent bog area proved to be especially rich in finds with excellent preservation conditions of organic materials. On the basis of ^{14}C-data from different layers of the bog sediments a chrono-stratigraphical sequence was postulated, providing early datings for the presence of forager pottery and domestic animals and forming a close parallel to the results from the Rosenhof site, as they were presented at that time (Ilkiewicz 1989; Schwabedissen 1994). The ceramic material comprised of a Late Mesolithic ensemble exhibiting parallels to the Ertebølle culture of the western Baltic, with additional sherds supposedly originating from or being influenced by southern Neolithic communities (Ilkiewicz 1989). The pottery as well as supposedly early domestic cattle bones were key points in the discussion of the neolithisation in the Baltic Sea area, while the decoration of the pointed-bottom vessels was discussed as influence from the eastern European Neman culture (Timofeev 1998).

New research on the site has been carried out since 2004 (Kabaciński et al. 2015). Taphonomical analyses pointed out a complex and disturbed bog stratigraphy with the intermixing of the Stone Age material by human and natural impact factors like trampling and floodings (Kotula et al. 2015; 2018). Additionally, new archaeozoological and genetic examinations of the *Bos* spp. remains rejected the presence of domestic animals at the site (Kabaciński et al. 2009; Schmölcke / Nikulina 2015). New excavations enlarged the knowledge of find material and site structure considerably and uncovered Stone Age settlement features on land c. 80 m south of the main bog excavation area (Dąbki 10), pointing out that the settlement was much larger than previously thought (Kabaciński / Terberger 2015). Numerous new ^{14}C-dates attribute the Stone Age occupation to the timespan between c. 5,200 calBC and 3,600 calBC (see below).

The artefact types exhibit general parallels to the western Baltic ERT (Kotula in press). Among organic tool types, T-axes are predominating, which are often considered a typical tool type of the ERT, but T-axes are also broadly distributed among Neolithic societies (Kabaciński et al. 2014). Other tool types like ulna-daggers and perforated shoulder blades also have parallels in the ERT (Kabaciński / Terberger 2015). The flint artefact production is based on a local Mesolithic tradition, but similarities to the ERT can be traced, too (Sobkowiak-Tabaka 2015). A large truncated blade can be connected to

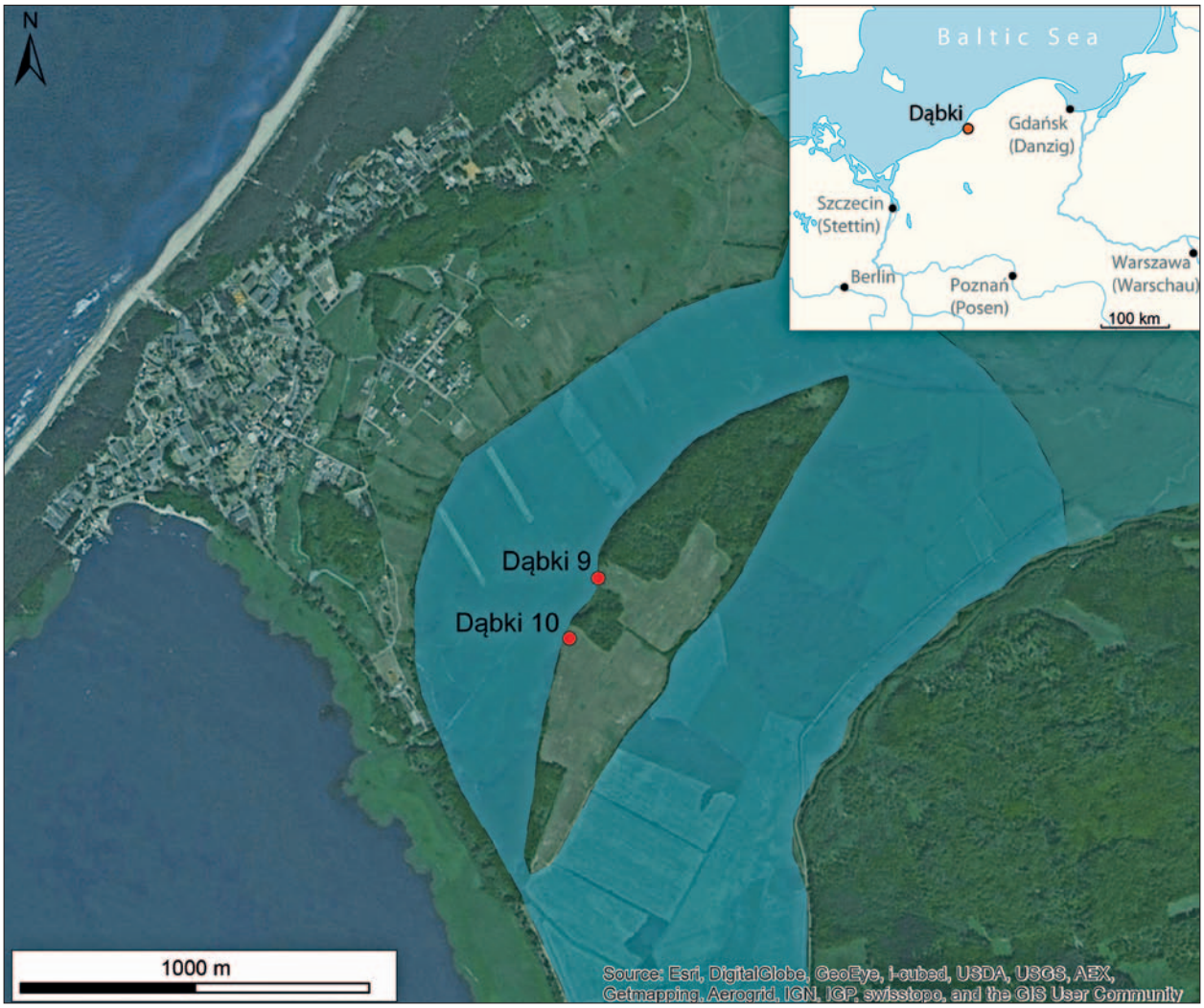

Fig. 1 Location of the site Dąbki and reconstruction of the island situation.

exchange with more western ERT groups, probably on Rügen island, and two blades of chocolate flint point to interactions with southern Neolithic LBK communities (Sobkowiak-Tabaka 2015). The pottery ensemble was especially targeted for new systematic analyses, as the variability of the assemblage and possible influences from southern Neolithic communities had been pointed out before (Ilkiewicz 1989). The early local vessel types comprise of pointed-bottom pots and oval bowls (lamps). With the new examination it was also possible to uncover round- and flat-based funnel beakers in the material. With the rejection of remains of domestic animals and plants, the introduction of Funnel Beaker culture (TRB) vessels confirmedly was not accompanied by a change in economy at the site. Additionally, many sherds could be identified as non-local ware from different Neolithic societies. Some LBK fragments show the influx of foreign ware starting during an early occupational phase c. 4,900 calBC, followed by Stroke Band pottery (SBK), and especially numerous Brześć Kujawski ware (c. 4,600–4,000 calBC; after Grygiel 2008; contra: Czerniak et al. 2016). They indicate long lasting exchange networks to Neolithic societies in the south, especially Kujawy. Some sherds of an extremely well-made and richly ornamented ware could be identified as Bodrogkeresztūr culture pottery from Hungary, dating to the late 5th millennium calBC (Czekaj-Zastawny 2015). Additionally, a perforated amphibolite axe was also found which possibly originates from a late SBK context (Terberger et al. 2009). The overall evidence of the non-local ware highlights long lasting and far reaching contact networks to farming societies, indicating that the site was an important place of Mesolithic-Neolithic exchange networks in the southern Baltic area.

Some finds from the assemblage might have acted as exchange goods. Amber pieces, which occur regularly at Dąbki, both processed and unprocessed, represent a raw material of probable importance to

Neolithic groups (e.g. Kabaciński / Terberger 2015; cf. Gronenborn 2010). The analyses of the animal remains further pointed out possible trading goods (Schmölcke / Nikulina 2015): With more than 60 % beaver bones dominate the mammal remains from the site. While this is extremely unusual in the context of the Late Mesolithic in the southern Baltic Sea area (beaver bones on Ertebølle sites generally only averaging around 0.1 %), a dominance of beaver remains can be found in Mesolithic and Neolithic sites especially in northeastern Europe (Schmölcke / Nikulina 2015). The overall number of remains from fur bearing animals distinctly surpasses the estimated local demand, and it is thus suggested that the exchange of furs was an important part of the extra-local network (Schmölcke / Nikulina 2015; Kotula in press). The overall evidence indicates that Dąbki was integrated within the exchange networks of the Baltic Sea area, with close similarities to the Ertebølle culture of the western Baltic and strong network connections with Neolithic communities to the south.

Chronology: site occupation and pottery

More than 70 ^{14}C-dates have been obtained from different materials in the bog (Table 1). They confirm settlement activities on the site between c. 5,200 calBC and 3,600 calBC. The oldest date stems from charcoal in feature 28 on the sandy settlement site (Poz-52527: 6,240±40 BP). Hazel tree trunks, some of them with cut marks, from the bottom of the bog stratigraphy confirm human activities before the water level rose in connection with the Littorina transgression (Poz-27402: 6,220±50 BP; Poz-10437: 6,140±40 BP; Gd-3127: 6,250±40 BP) and the environment became an island. A series of datings from different materials confirm regular and intensive settlement activities throughout the 5th millennium calBC and the early 4th millennium calBC, with the latest dates around 3,600/3,500 calBC (food residue on pottery Poz-27412: 4,920±40 BP; horse bone KIA-10330 A: 4,787±33 BP), before the settlement was abandoned, probably due to the development of unfavourable environmental conditions in the area (Kalis et al. 2015).

Numerous direct dates from crusts of pottery sherds have been obtained, and reservoir effect has to be taken into consideration here (cf. e.g. Fischer / Heinemeier 2003; Philippsen 2015). All datings from pointed-bottom ware and one lamp date fall within the time frame of the 5th millennium calBC. The oldest date is an outlier in the sequence with 4,937±60 calBC (Poz-41583: 6,040±40 BP; Table 1). More numerous evidence starts from c. 4,770 calBC (Poz-10436: 5,900±40 BP; Poz-18654: 5,890±50 BP; KIA-26386: 5,880±37 BP; KIA-26385: 5,831±28 BP) throughout the 5th millennium calBC. The youngest date 4,082±75 calBC (Poz-27401: 5,250±40 BP) fits well into a transitional context to the Northern group of the TRB culture (e.g. Hartz / Lübke 2004; Kotula et. al 2015; Glykou 2016). One vessel unit was dated several times, including one sherd dated twice (Poz-41580: 5,740±40 BP; Poz-18609: 5,660±40 BP) as well as another non-refitting sherd (KIA-26386: 5,880±37 BP). The results diverge, only partly overlapping in the 1 and 2 ϱ range, and a minimum reservoir effect of c. 100/250 years can be stated for this vessel. It remains unclear, if and to what extent the youngest date is also affected by reservoir effect. A recent extensive study of lipids from forager pottery crusts around the Baltic Sea area pointed out a higher component of aquatic lipid markers (APAAs) in the Dąbki sample compared to Ertebølle, Narva and other sampled sites, making reservoir effect in food crust dates generally likely here (Courel et al. 2020). However, the existing data from pointed-bottom pottery does agree with the general time frame of the introduction of hunter-gatherer ceramics in the central and western Baltic area c. 4,600 calBC (Hartz 2008).

^{14}C-data were also obtained from Funnel Beaker pottery in Dąbki, and results show remarkable differences between typo-chronology and ^{14}C-ages (Kotula et al. 2015). Dates start as early as 5,039±88 calBC (Table 1; Poz-41578: 6,100±50 BP), c. 1,000 years earlier than usually expected for an early funnel beaker in northern Europe (Hartz / Lübke 2004; Glykou 2016), and most TRB dates from Dąbki are older than expected. The huge age discrepancy is in accordance with observations from other sites (e.g. Hartz et al. 2012; Philippsen / Meadows 2014; Philippsen 2015). At the northern German Ertebølle site Schlamersdorf, dating results of inner and outer crust of an Ertebølle sherd differ by 1,500 years. ^{14}C-datings of TRB pottery from Bebensee also resulted in ages c. 1,000 older than expected (Philippsen / Meadows 2014). For the northern German inland site Friesack freshwater reservoir age was estimated at c. 1,200 years (Meadows et al. 2018). Unfortunately, isotopes were only measured for few sherds from Dąbki (Fig. 2). Most of the TRB sherds fall into the isotope range of inland Ertebølle and TRB pottery, and this suggests a mixture of terres-

Identification-no.	Lab-no.	C14 age BP	C14 calBC (2σ)	C14 calBC (μ)	δ13C (‰)	δ15N (‰)	Material	Description
70–2/2011	Poz-52527	6240±40	5311-5066	5209±72			charcoal	charcoal (feat. 28)
tree stump-1/2008	Poz-27402	6220±50	5308-5048	5174±77			wood	tree stump, probably hasel-nut
99–2/2004	Poz-10437	6140±40	5215-4981	5099±70			plant remains	large tree trunk, probably cutted
163–1/2007	Poz-41578	6100±50	5210-4856	5039±88			pottery residue	Funnel Beaker pottery
426–1/2008	AAR-17986	6065±35	5057-4848	4973±59	-27,61 ± 0,22	7,75 ± 0,18	pottery residue	Funnel Beaker pottery
530–1/2005	Poz-41583	6040±40	5047-4836	4937±60			pottery residue	pointed-bottom pottery
509–1/2009	Poz-41582	6000±40	4995-4792	4891±53			pottery residue	Funnel Beaker pottery
22–2/2004	KiA-26388	5960±32	4939-4743	4843±47	-19,52 ± 0,29		animal remains	wild boar, burnt bone
527–1/2009	AAR-17981	5916±35	4896-4711	4788±44	-27,48 ± 0,14	7,53 ± 0,17	pottery residue	Funnel Beaker pottery
176–1/2004	Poz-41579	5915±35	4895-4711	4786±44			pottery residue	Funnel Beaker pottery
249–II/83	KIA-10331	5999 ± 34	4989-4796	4890±50	-22,04 ± 0,11		animal remains	horse bone
352–1/2005	Poz-18654	5890±50	4901-4615	4764±61			pottery residue	pointed-bottom pottery
109–1/2004	KiA-26386	5880±37	4842-4685	4753±42	-27,55 ± 0,64		pottery residue	pointed-bottom pottery
129–1/2004	KiA-26385	5831±28	4781-4610	4693±45	-28,51 ± 0,13		pottery residue	pointed-bottom pottery
110–III/81	KiA-26389	5816±30	4769-4557	4670±46	-18,9 ± 0,17		animal remains	T-shaped antler axe
241–1/2008	Poz-27400	5780±40	4722-4534	4630±52			animal remains	T-shaped antler axe
191–1/2010	AAR-17983	5760±50	4721-4491	4611±62	-25,95 ± 0,14	8,2 ± 0,29	pottery residue	Funnel Beaker pottery
18–2/2004	Poz-10438	5750±40	4701-4501	4603±55			pottery residue	lamp fragment
192–1/2004	Poz-41580	5740±40	4696-4491	4592±56			pottery residue	pointed-bottom pottery
102–II/81	AAR-17982	5707±35	4678-4459	4548±52	-27,72 ± 0,13	6,33 ± 0,1	pottery residue	Funnel Beaker pottery
192–1/2004	Poz-18609	5660±40	4592-4370	4492±50			pottery residue	pointed-bottom pottery
460–1/2008	AAR-17984	5638±30	4541-4371	4466±41	-27,95 ± 0,22	7,47 ± 0,18	pottery residue	Funnel Beaker pottery
401–II/81	KIA-10332	5632 ± 34	4541-4362	4460±50	-21,64 ± 0,23		animal remains	horse bone
98–I/79	Poz-41584	5630±40	4538-4365	4455±49			pottery residue	pointed-bottom pottery
190–1/2005	Poz-18610	5610±35	4516-4357	4431±42			pottery residue	imported pottery (Ertebølle)
719–1/2008	Poz-27397	5600±40	4504-4351	4425±42			animal remains	metapodial bone chisel
408–II/81	Poz-18607	5550±40	4458-4338	4398±36			pottery residue	Funnel Beaker pottery
91–1/2009	AAR-17125	5567±29	4407	4404±31	-26,84 ± 0,12		pottery residue	Funnel Beaker pottery
118–1/2004	KiA-26384	5477±28	4366-4261	4325±32	-24,68 ± 0,85		pottery residue	pointed-bottom pottery
265–II/83	Poz-18608	5440±35	4349-4241	4295±34			pottery residue	Funnel Beaker pottery
71–2/2011	Poz-52528	5410±40	4348-4076	4269±57			charcoal	charcoal (feat. 38)
170–2/2007	Poz-27396	5380±40	4335-4060	4228±76			animal remains	T-shaped antler axe
6–2/2004	KiA-26387	5339±29	4313-4052	4163±65	-21,78 ± 0,09		animal remains	wild boar tooth
546–1/2008	Poz-27401	5250±40	4230-3973	4082±75			pottery residue	pointed-bottom pottery
55–2/2011	Poz-49886	5250±40	4230-3973	4082±75			charcoal	charcoal„glued" to piece of pottery (feat. 38)
407–1/2006	Poz-18612	5195±35	4147-3951	4007±42			animal remains	T-shaped antler axe
199–1/2004	Poz-10434	5160±40	4046-3806	3962±63			animal remains	large antler
520–2/2005	Poz-18613	4955±35	3798-3652	3733±48			pottery residue	Funnel Beaker pottery
10–2/2004	Poz-27412	4920±40	3779-3642	3703±42			pottery residue	Funnel Beaker pottery
95–II/81	KIA-10330 A	4787 ± 33	3642-3519	3580±40	-23,8 ± 0,12		animal remains	horse bone

Table 1 ^{14}C-data from Dąbki: food residue dates from local pottery ware and selected plant and faunal data.

trial and freshwater sources prepared in the vessels (Philippsen 2015). High ^{15}N- and low ^{13}C-values are considered to be connected with high ^{14}C-ages, and the dates from Dąbki may thus well be influenced by reservoir effect. However, the small sample size inhibits further conclusions, and isotope variability has been pointed out for different samples from the same vessel (Philippsen 2015). ^{13}C-values were also measured for vessels: here, too, it is suggested to be cautious with the data. We consider only few TRB dates from Dąbki reliable and to be in accordance with the later occupation at the site (Kotula et al. 2015). Feature 38 provided indirect evidence to date the transition from pointed-bottom to Funnel Beaker ware in Dąbki. In this pit early Funnel Beaker sherds as well as pointed-bottom pottery were uncovered, and a charcoal from a non-diagnostic sherd dating to 4,082±75 calBC (Poz-49886: 5,250±40) provides

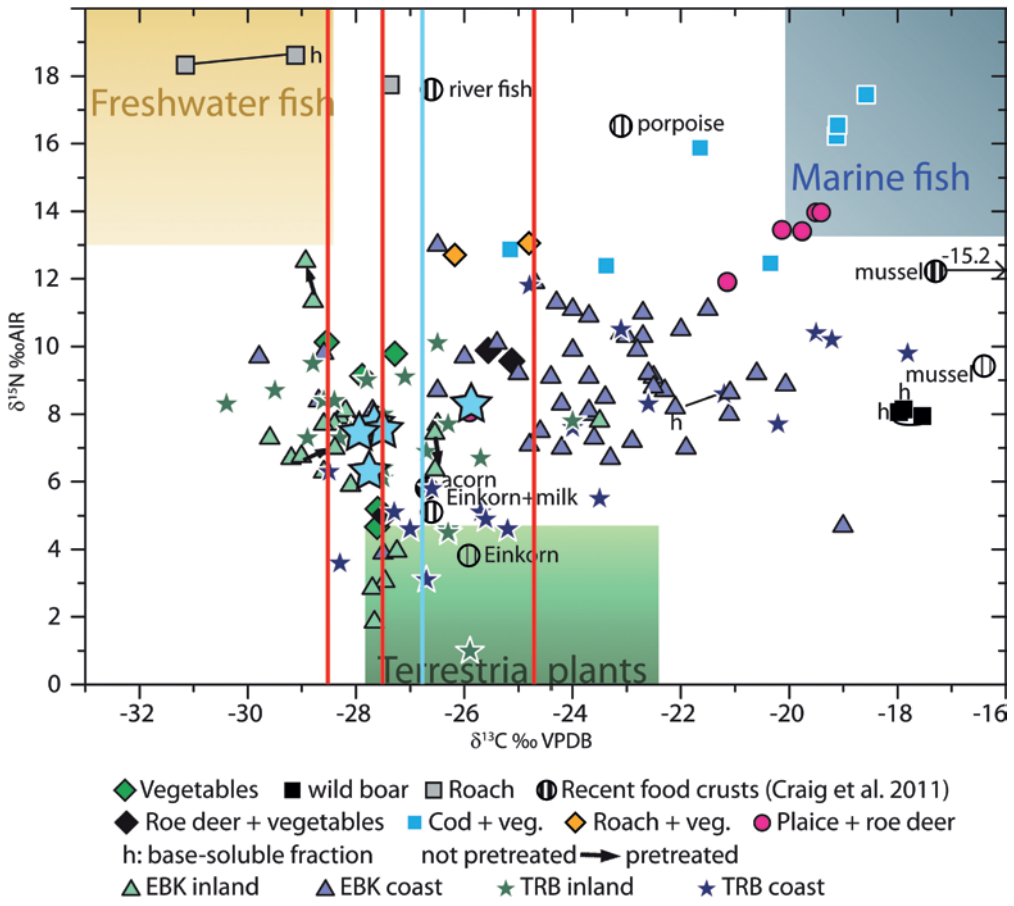

Fig. 2 Stable isotope values of Dąbki pottery food crusts against the background of experimental and archaeological food crusts (supplemented after Philippsen 2015). Big blue stars: TRB food crusts; vertical lines: only ^{13}C-values measured (blue = TRB ware; red = pointed-bottom ware).

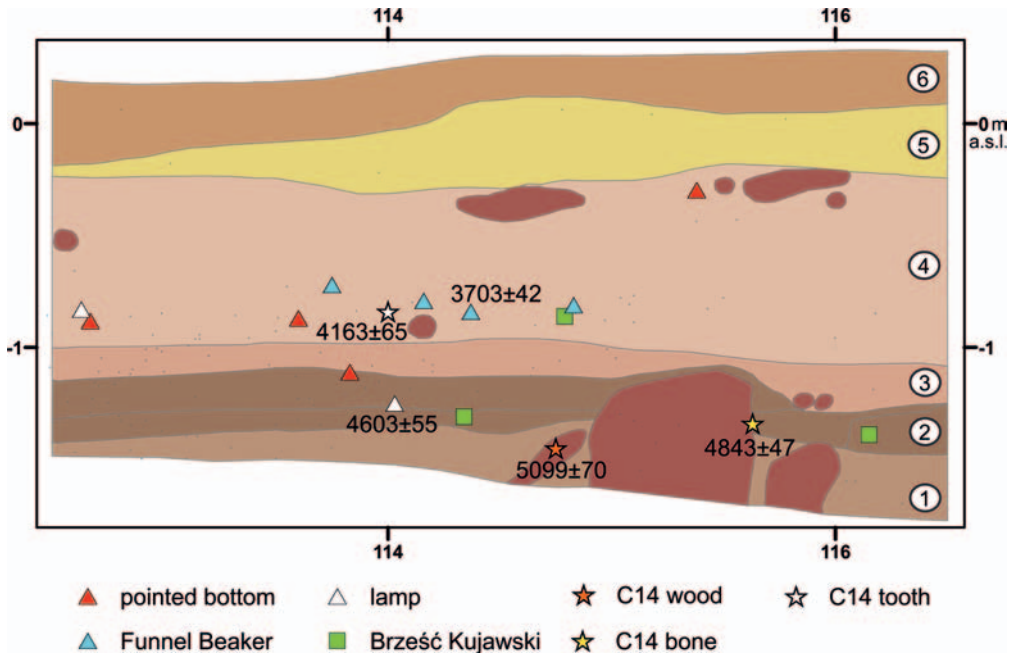

Fig. 3 Projection of pottery types and ^{14}C-data calBC (distance <1 m) on the southern profile Trench I/80 square X 113–116. ^{14}C-dates from left to right: KIA-26387: 5,339±29 BP; Poz-10438: 5,750±40 BP; Poz-27412: 4,920±40 BP; Poz-10437: 6,140±40 BP; KIA-26388: 5,960±32 BP. Stratigraphy: **1** detritus gyttja, **2** shell gyttja, **3** detritus gyttja, **4** decomposed reed peat with wood, **5** alluvial sands, **6** moss peat with wood detritus.

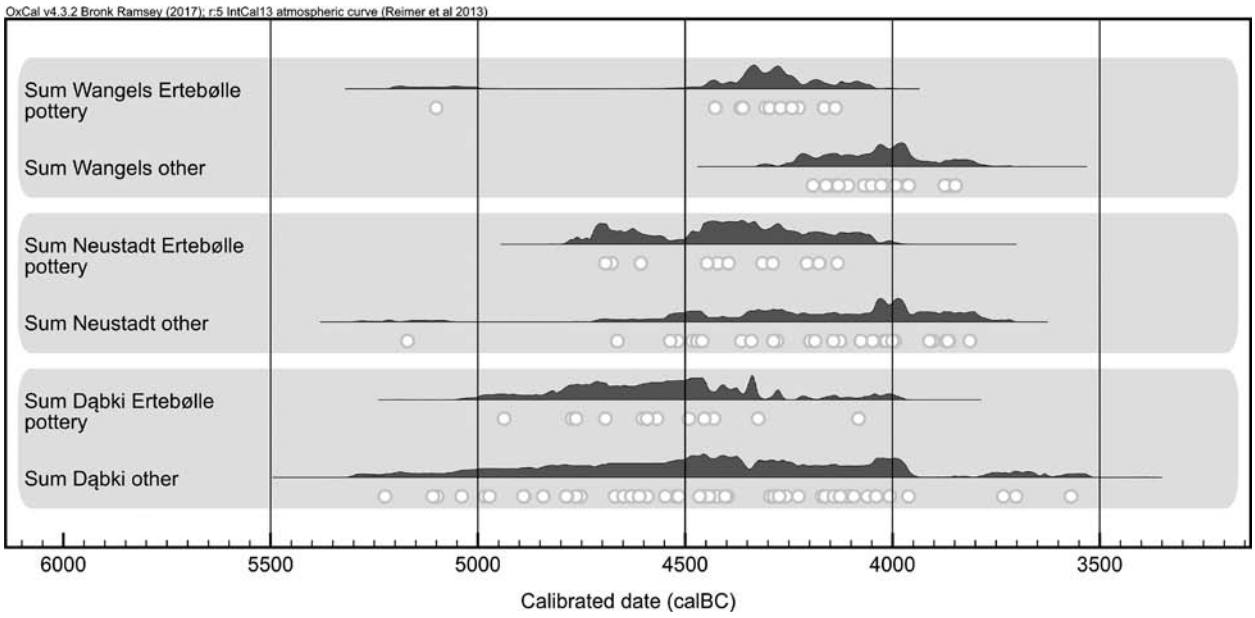

Fig. 4 ^{14}C-data of pottery food residue against ^{14}C-data from other organic non-pottery sources from the sites Dąbki and two northern German ERT sites (Wangels, Neustadt) with especially numerous available ^{14}C-data.

a background for the transition between the types. It also has a similar age as the youngest date from a pointed-bottom vessel (see above). This is in overall accordance with the earliest datings of the Northern TRB group from around 4,200/4,100 calBC (Kotula et al. 2015; cf. Hartz/Lübke 2004; Glykou 2016).

The stratigraphy of the bog area provides only limited additional information, as large parts of the former shore zone were exposed to anthropogenic and natural disturbances, resulting in a mixed cultural layer (Kotula et al. 2015; 2018). While most parts of the bog trenches cannot provide reliable chrono-stratigraphical evidence, the deepest part of the trenches show a better stratigraphical resolution with few finds and correct chrono-stratigraphical order (Fig. 3). In the lowest part of the gyttja and peat layer sequence a tree stump was dated to c. 5,100 calBC. In the overlying gyttja layer pointed-bottom pottery and lamps accompanied by non-local Brześć Kujawski pottery are situated. A residue from a lamp sherd (Poz-10438: 5,750±40 BP) and a wild boar bone (KIA-26388: 5,960±32 BP) from this sediment layer date to between c. 4,860 and 4,600 calBC. TRB pottery is then found markedly higher in the overlying peat sediment, together with pointed-bottom pottery as well as Brześć Kujawski pottery, ^{14}C-dated to between c. 4,300 (wild boar bone KIA-26387: 5,339±29 BP) and 3,600 calBC (TRB food crust KIA-27412: 4,920±40 BP), which indicates a compact sedimentation or slight disturbance in the upper part of the stratigraphy.

The ^{14}C-dates from pointed-bottom pottery suggest a start of local pottery production around 4,850/4,700 calBC, thus dating slightly earlier than in the Western Baltic coastal area at c. 4,600 calBC (e.g. Hartz 2008). While the pottery data advise caution due to a possibly high reservoir effect, as displayed in the TRB dates, some indications support an early pointed-bottom pottery production in Dąbki:

(1) No systematic shift towards older ages is observable in the pointed-bottom pottery data against the other ^{14}C-data, and both categories are represented by numerous dates (Fig. 4). An intensive occupation evidently starts already in the first half of the 5th millennium calBC, and in general, the assemblage is characterised by a high similarity and connection to the Ertebølle culture in morphology and technology (see below). It is thus likely that pottery production in Dąbki was part of a broadly contemporary introduction of pottery at the southern Baltic coastal sites in the first half of the 5th millennium calBC.
(2) The concept of pottery vessels was known in Dąbki even before local production through non-local Neolithic ceramic ware, starting in late LBK times in the earliest 5th millennium calBC, and upheld contacts are confirmed by many Neolithic vessels from different cultures throughout the 5th millennium calBC. Insight into the convenience of pottery vessels was thus present early at the site, and has possibly facilitated an early local ceramic production.

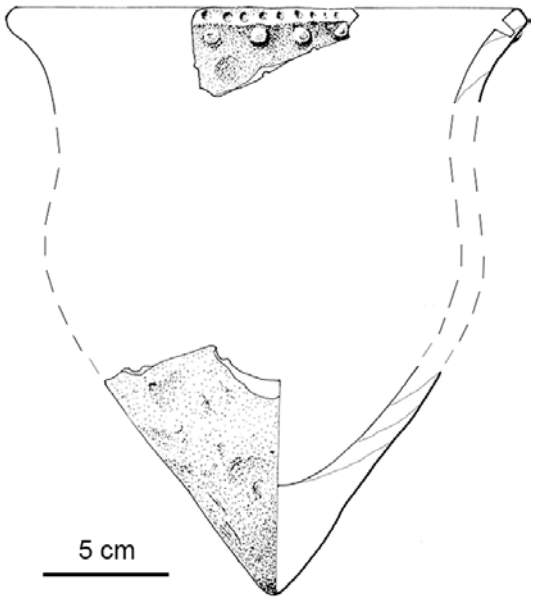

Fig. 5 Schematic drawing of pointed-bottom vessel from Dąbki (drawing: J. Ożóg).

(3) The reliable stratigraphical evidence shows a marked vertical gap between the lowest found pointed-bottom pottery/lamps and TRB pottery in the stratigraphy, indicating a clear time difference between the appearance of both types.

Summing up evidence, we assume it likely that around the mid of the 5th millennium calBC local ceramic production was fully established in Dąbki, approximately contemporaneous with the introduction of pottery production in the western Baltic Ertebølle culture. The ^{14}C-data suggest an earlier start of pottery production in Dąbki, but this cannot be reliably confirmed due to an uncertain amount of reservoir effect in the pointed-bottom pottery food residues.

The early local pottery from Dąbki: a summary of characteristics

A detailed analysis was undertaken for the pointed-bottom pottery and lamps from the excavation campaigns 1979–2010. The pointed-bottom ware consists of 146 sherds, from which 64 vessel units were combined. Unfortunately, small fragment sizes and very limited decorations made the combination of full profiles almost impossible, thus vessel units are separated into 51 rim units, 11 bottom units and one belly unit (with decoration) plus one reconstructed small vessel with full profile. This results in the estimation of a MNI of 52 pointed-bottom vessels. Despite problematic profile reconstruction, the vessels can be generally characterised as S-shaped with round inflections and a presumably conical lower body form (Fig. 5). The pointed-bottom ware was admixed with mineral components, mostly crushed granite. If more than one material was observed, the second admixture was predominantly sand. The local clay, which was used for the production of pottery (pers. comm. A. Czekaj-Zastawny), contains in parts sand, and it can thus not be differentiated between artificially added or natural sand components. The wall thickness of the vessels averages at 11 mm, and the coil joins could be mostly identified as N- and rarely U-joins. The surface was smoothed or simply flattened, and the outside surface was prepared more carefully than the inside. The vessel openings vary between 10 and 33 cm, averaging at around 19 cm. The rim section is short (averaging at 19 mm height), and almost 90 % of the rims are bent outwards with rounded inflection points. Most of the vessels (96 %) exhibit decorations, although almost exclusively in the rim section. Typically, the rim is decorated with 'Randkerben' (rim cuts) and a horizontal row of round impressions/perforations below the end of the rim, with perforations predominating (Fig. 6.1–4). The impressions/perforations were carried out from the outside as well as from the inside with no apparent predominance. One vessel unit shows a belly decoration with vertical impressions, and another vessel was decorated with vertical rows of small impressions from the rim to the shoulder. The bottoms are massive and drop-shaped or conical (Fig. 6.5–6).

Overall 87 fragments could be assigned to lamps, of which 44 were combined to 29 vessel units. They represent a more finely made ware than the pointed-bottom vessels, but exhibit similar technical traits. While wall thickness is at average around 9 mm, the bottoms are more massive with 11 mm. The clay is better mixed than in the pointed-bottom ware, and while the same mineralic admixture was added, particles were more finely grained. The lamps were formed out of lumps of clay, but in some cases only the bottom was formed in this way and the walls were then added with N-joined coils. While rims were carefully smoothed, much less effort was given to the majority of bottoms. Typically, rims are very dark grey coloured, while bottoms are much brighter, which points to the use of these vessels as containers to burn substances containing fat (cf. Van Diest 1981). The overall forms are oval with rounded or pointed ends. The length varies mostly between 12 and 15 cm, but

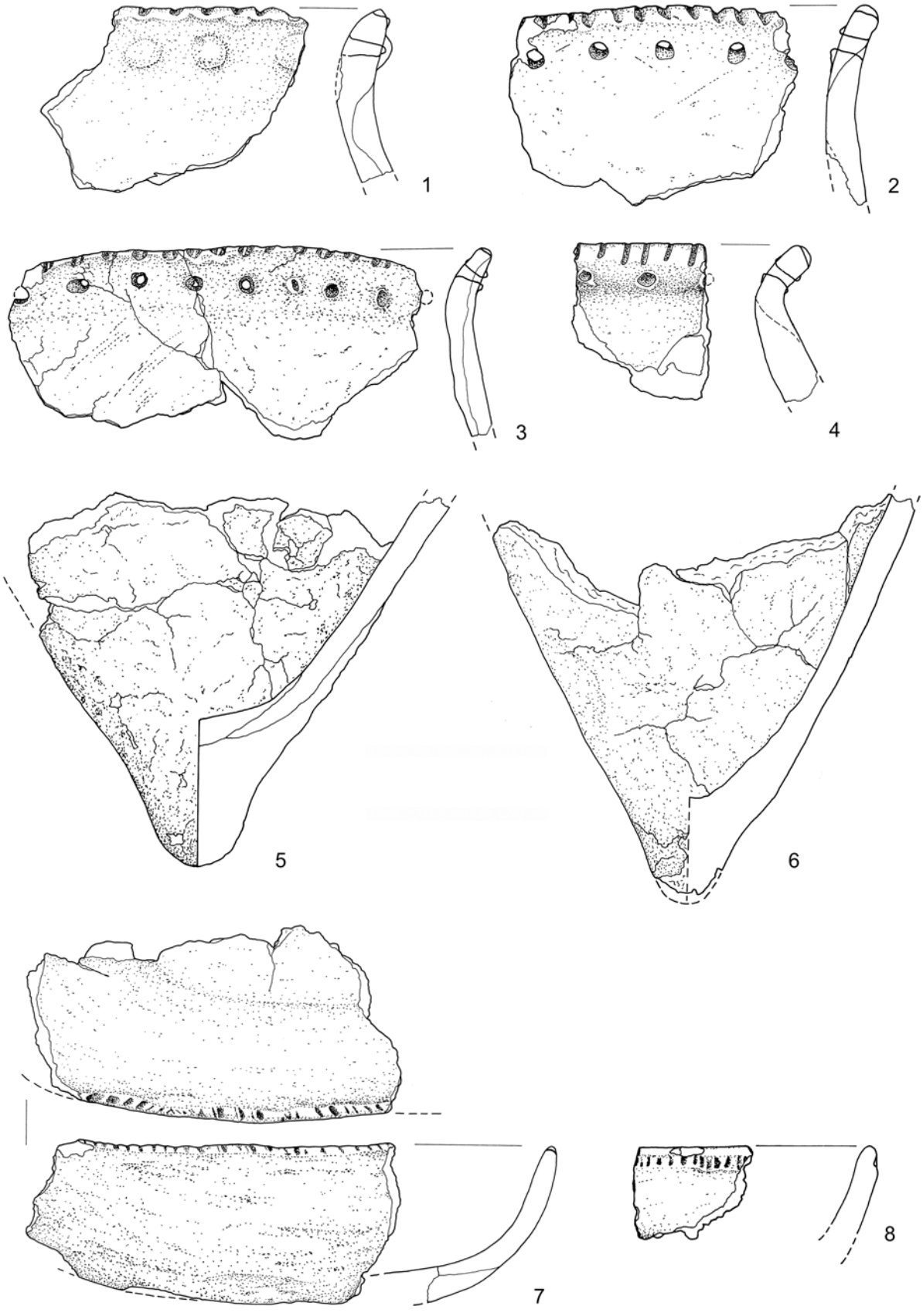

Fig. 6 Dąbki. Pointed-bottom pottery. **1–4** rims, **5–6** pointed bottoms, **7–8** lamps. Scale 1:2 (drawing: J. Ożóg).

fragments of one extremely large specimen indicate a possible size > 30 cm long. The height could be measured on two lamps with 3 and 5.2 cm, respectively. Approximately 50 % of the lamps are decorated, mostly with cuts on the rim (Fig. 6.7), but some also exhibit a horizontal row of impressions or perforations, similar to pointed-bottom vessels. Two lamps have a different decoration with a horizontal row of small vertical impressions below the end of the rim (Fig. 6.8); in one case this ornament is repeated on the vessel inside. The best parallels for this ornament can be found in the eastern Baltic Narva culture, e. g. at the Šventoji site (e. g. Rimantienė 2005).

Early forager pottery in the northern Polish lowland

The Polish lowland is a crucial area to study contact and networks of the 5th millennium calBC between large cultural complexes of the western (Ertebølle culture) and eastern Baltic (Narva culture) and eastern Europe (Dubičiai type). Only few sites in northern Poland provide evidence of forager groups with early pottery. C. 23 km south of Dąbki the site Koszalin-Dzierżęcino is situated, with a find spectrum covering a time span from the Mesolithic to the Middle Ages (Ilkiewicz 1998). The forager pottery there consists of mostly small fragments, with similar characteristics to that of Dąbki, with rim sherds displaying the same decorational features (rim cuts and a horizontal row of impressions/perforations). Sherds from lamps were also uncovered. A particular interesting find is a pointed-bottom vessel with a sharp double-conical profile and decoration on rim and shoulder. It differs technically from the Dąbki pottery and the local ware, and typological parallels can be found in the Dnepr-Donec circle (Piezonka 2015). C. 150 km east of Dąbki, the site of Rzucewo is situated. Besides finds of the Rzucewo culture (a local branch of the Corded Ware complex), a late Mesolithic pottery phase and TRB pottery were also detected (Król 1997; Kabaciński et al. 2008). The late Mesolithic pottery closely resembles the Dąbki ware, with technical and typological similarities (Czekaj-Zastawny / Kabaciński 2018). It can be mentioned, however, that impressions/perforations below the rim end have a rectangular shape and the decorations are more variable than in Dąbki. Three direct datings have been carried out on food crusts from some of the sherds (Kabaciński et al. 2008). The dates between c. 4,400 calBC and 4,150 calBC confirm a Late Mesolithic forager ware in the second half of the 5th millennium calBC.

Close to the Oder estuary the Tanowo sites are situated on a moraine hill at a palaeolake, resembling the environmental situation of Dąbki (e. g. Galiński 2016). The settlement duration is estimated between c. 5,000 calBC and 3,800 calBC (Galiński 2016), and, according to the excavator, early local pointed-bottom pottery is present at the site from the beginning. The sites Tanowo 2 and 3 provided a large collection of forager pottery with c. 4,000 fragments, combined to c. 300 reconstructed vessel units by the excavator, including pointed-bottom vessels, lamps and Funnel Beaker vessels. While pointed-bottom pottery is technologically mostly quite similar to the Dąbki ware, the coiling technique is dominated by U-joins and therewith leaning more towards the western Baltic Ertebølle culture, where U-technique is very common (e. g. Prangsgaard 1992). The decoration on the other hand shows rows of impressions/perforations and rim cuts closely resembling Dąbki and other early forager pottery from the Polish plain.

Lastly, at the inland site Chobienice close to Poznań, few fragments of pottery with Late Mesolithic characteristics were uncovered (Kobusiewicz / Kabaciński 1998). Rim fragments closely resemble Dąbki and Rzucewo ware with impressions below the rim and rim cuts. The impressions were carried out with a rectangular tool. The site also yielded Brześć Kujawski pottery, and it is still a matter of discussion whether occupational phases of groups with different economies or a Neolithic group receiving forager vessels by contact are to be postulated (Kobusiewicz / Kabaciński 1998; Kabaciński 2016).

Overall, the early forager pottery in the 5th millennium calBC from the different sites in northern Poland displays significant similarities, with parallels in technical characteristics and especially decorational features. Except Chobienice, all sites were situated in close vicinity of the southern Baltic Sea, and the similar typo-technology implies a regional interaction and knowledge exchange network, probably connected via waterways.

Comparative pottery analyses in supraregional perspective: sites and cultures

In the western and eastern Baltic Sea environments, large hunter-gatherer techno-complexes with early pottery existed in the 5th millennium calBC. To examine the cultural affiliations of the ceramics of northern Poland a supraregional comparison was

Fig. 7 Sites included into pottery analysis.

carried out for the pointed-bottom pottery from Dąbki with roughly contemporaneous wares from sites of the Ertebølle culture (site Neustadt LA 156, Schleswig-Holstein, Germany), Narva culture (sites Žemaitiške 3 and Žeimenio ežero 1, Lithuania, and Kääpa, Estonia) and Dubičiai type of the Neman culture (Dubičiai 2 and Varėnė 2, Lithuania).[1] Additionally, one vessel unit from the Polish inland site Chobienice was included (Fig. 7). Further early pottery in hunter-gatherer contexts in the 5th millennium calBC is known from sites of the Zedmar culture in eastern Poland and Kaliningrad district, and the Friesack-Boberg group in northern Germany. These pottery types are however considered later than the aforementioned wares and are thus not discussed here (Gumiński 2020; Kotula et al. 2015).

1 I am grateful to Aikaterini Glykou and Henny Piezonka for providing me with text and data of their then unpublished PhD-theses.

Ertebølle culture

The Late Mesolithic Ertebølle culture of the western Baltic is one of the best-studied Stone Age cultures in northern Europe. Sites are mainly known from Denmark, northern Germany and southern Sweden. The Polish forager sites with early pottery are sometimes generally included into the Ertebølle culture (Czerniak / Kabaciński 1997; cf. Hartz et al. 2007, fig. 2), but regularly discussed separately (e.g. Courel et al. 2020). In the Ertebølle culture pointed-bottom pots and oval bowls (lamps) are known. The introduction of early pottery in Denmark and northern Germany is dated to c. 4,600 calBC by ^{14}C-evidence (Andersen 2008; Hartz 2011). However, the oldest pottery food crust dates with ages between 5,500 and 4,950 calBC originate from the inland sites Kayhude and Schlamersdorf in northern Germany (Hartz 2011), but reservoir effect has been pointed out for these sites (e.g. Philippsen 2015). However, a single plant date from the ceramic matrix of a sherd from Schlamersdorf

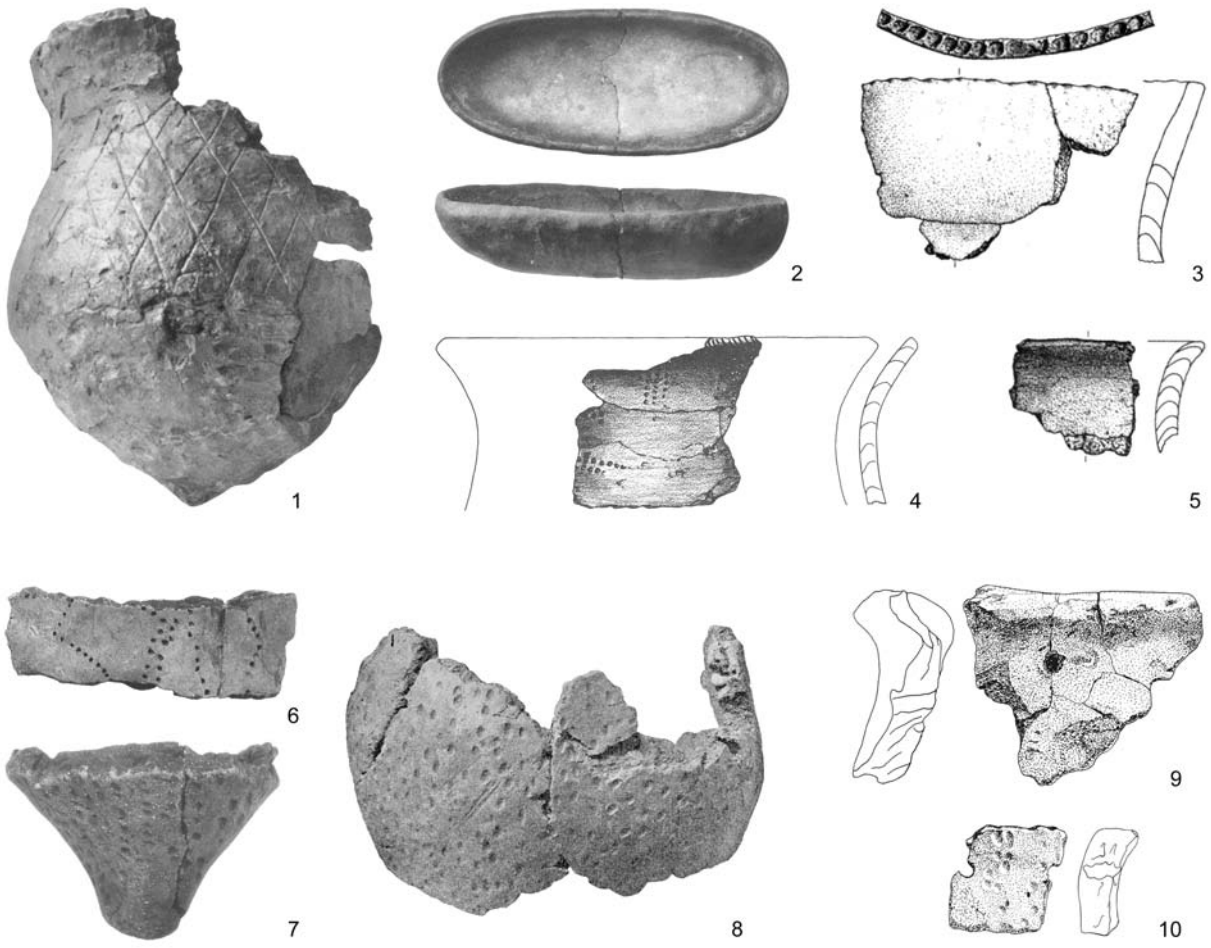

Fig. 8 Pottery of the western (**1–5**) and eastern (**6–10**) Ertebølle culture. **1** Braband, Denmark; **2** Gudsø Vig, Denmark; **3**, **5** Ringkloster, Denmark; **4** Timmendorf-Nordmole, Germany; **6–7**, **9–10** Löddesborg, Sweden; **8** Soldattorpet, Sweden. 1 scale 1:3, 2–8 scale 1:4; 9–10 scale 1:2 (after Andersen 2008; Brinch Petersen 2011; Glykou 2010; Jennbert 2008).

dates to 4,875±65 calBC (AAR-11483: 5,985±50 BP; Philippsen 2012; Philippsen / Heinemeier 2013), highlighting a possible older age of pottery from this site. As yet, this date has not been supported by other data. Ertebølle pottery rarely carries decoration more complex than rim cuts, but in the eastern Ertebølle culture in southern Sweden more elaborate decoration is common (Fig. 8; Prangsgaard 1992). From around 4,200/4,100 calBC Funnel Beaker pottery replaces the Ertebølle ware in northern Germany and the northern European plain, slightly later also in Scandinavia around 4,000 calBC.[2] Pottery from the submerged Ertebølle site Neustadt LA 156, Schleswig-Holstein, was integrated into the comparative analysis. The site was recently targeted for an extensive pottery analysis (Glykou 2016). Situated in the Lübeck bay, the site was a coastal settlement at the time of Stone Age occupation from the late Ertebølle to the early TRB, confirmed by ^{14}C-data between c. 4,550 and 3,720 calBC. 105 pointed-bottom vessel units from Neustadt were included in the comparative pottery analysis.

Narva culture

In the eastern Baltic, sites of the Narva culture are distributed widely over a large area in the present day countries Lithuania, Latvia, Estonia, and Belarus as well as western Russia (Rimantienė 2005). The earliest ^{14}C-datings from this hunter-gatherer culture with pottery date to the older half of the 6th millennium calBC and originate from sites in the northeastern part of the area. In the inland of Lithuania, the oldest dates are confirmed before the middle of the 5th millennium calBC, and sites from the eastern Baltic Sea area date around c. 4,000 calBC (Piezonka 2015). The pottery set consists of pointed-bottom pots and lamps. While the oldest vessels are rarely decorated, ornamentation increases in

2 Hartz 2011; Sørensen 2014; Kotula et al. 2015; Glykou 2016.

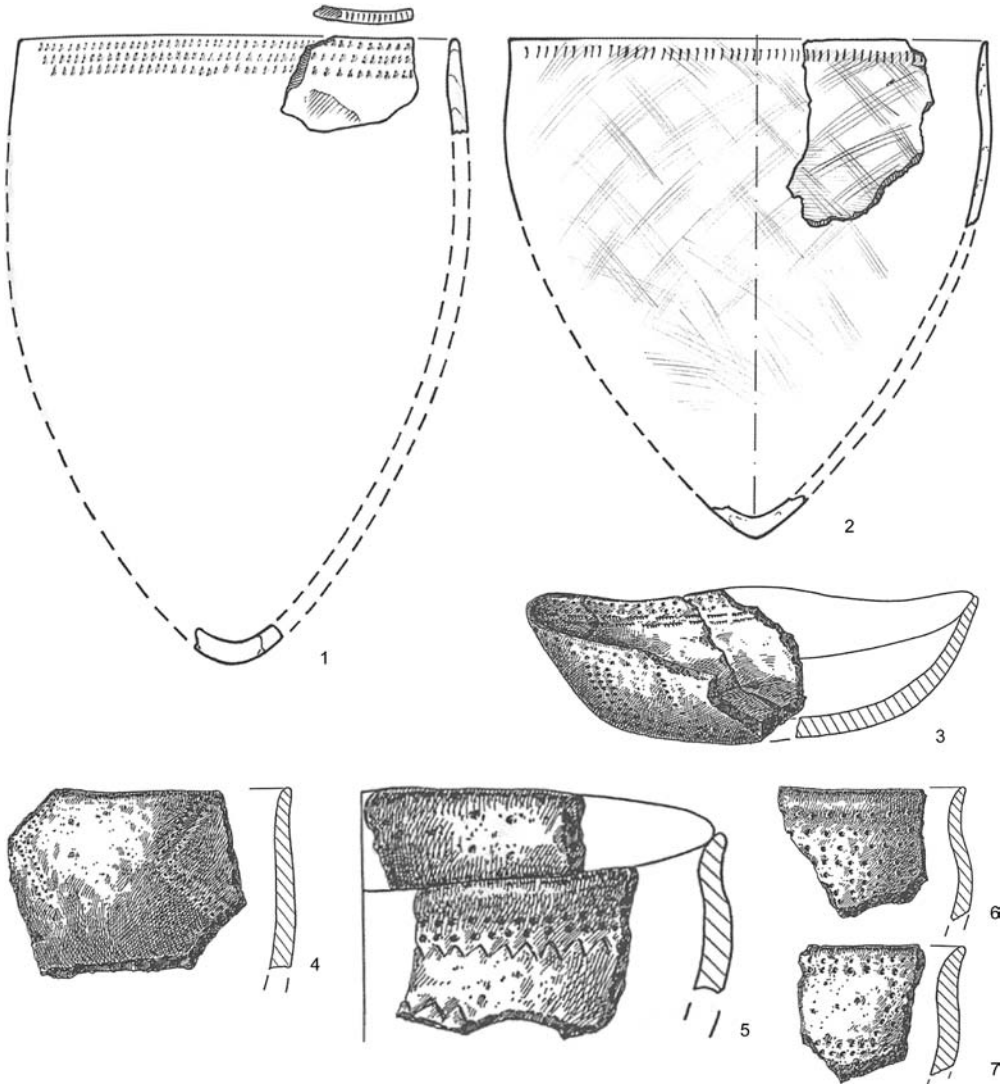

Fig. 9 Pottery of the early Narva culture. **1–2** Osa, Latvia; **3–7** Zvidze, Latvia. 1–2 scale 1:5; 3–7 not to scale (after Dumpe et al. 2008; Loze 1992).

later phases (Fig. 9). From Narva context three sites were included in the comparative analysis (Piezonka 2015). The site Žemaitiške 3, Lithuania, is one of many Stone Age sites situated at lake Kretuonas in a bog environment. Horizon B from this site is connected with an early Narva phase dating c. 4,650 to 3,950 calBC, and pointed-bottom pottery from this layer was included (25 vessel units). Another ensemble originates from the site Žeimenio ežero 1, situated at lake Žeimenis, only 2 km west of lake Kretuonas, with material typologically dated to the middle Narva culture (12 vessel units included). An important Narva site in Estonia is Kääpa, providing ^{14}C-data starting from the middle of the 6th millennium calBC. The find layer can be connected to the oldest phase of the Narva culture (69 vessel units included).

Dubičiai type of Neman culture

In the area south of the Narva cultural complex, sites of the Dubičiai type (recently regularly denoted as Prypjat-Neman culture; cf. Tkachou 2018) are located. This complex is interpreted as the earliest phase of the Neman culture or as a preceding separate cultural unit, respectively. Sites are found in southeastern Lithuania, Belarus, Ukraine and northeastern Poland. Due to preservation issues and mixed stratigraphies on sandy settlement sites, information is limited (Piezonka 2015). The existing data indicate that this ware represents an established tradition around the mid of the 6th millennium calBC (Piezonka 2015; Tkachou 2018). The only known vessel type is the pointed-bottom pot. A decoration with a horizontal row of impressions below the

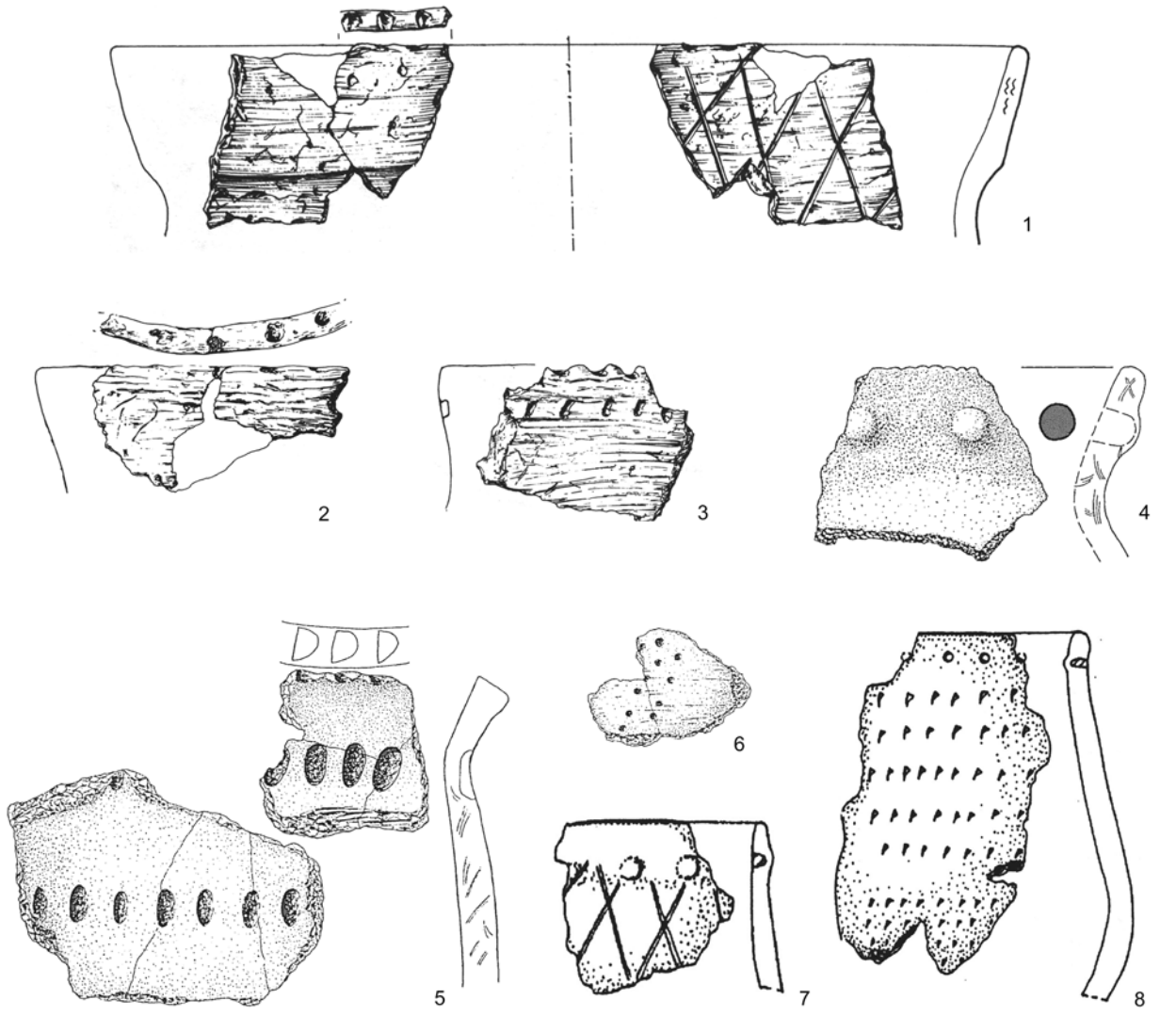

Fig. 10 Pottery of the Dubičiai type of the Neman culture. **1–3** Woźna Wieś, Poland; **4** Dręstwo, Poland; **5** Kašėtos, Lithuania; **6** Varėnė, Lithuania; **7–8** Rusakovo, Belarus. 1 scale 1:3; 2–6 scale 1:2; 7–8 scale 1:3 (after Kempisty / Sulgostowska 1991; Piličiauskas 2002; Józwiak 2003).

rim can be considered typical, but the vessel body is also frequently decorated (Fig. 10). The type site Dubičiai, Lithuania, yielded material mostly considered to be type Dubičiai, but some sherds were also interpreted as belonging to a younger Neman phase due to unsecure stratigraphical context (15 vessel units included). At another Lithuanian site, Varėnė 2, there are several occupational phases without clear stratigraphical division, but some vessels could clearly be connected with the Dubičiai type (4 vessel units included).

Late forager pottery from the Polish lowland

In addition to the Dąbki ware it was possible to examine one vessel unit from Chobienice. This site west of Poznań yielded c. 100 pottery fragments from two cultural phases connected with different zones on the site (Kobusiewicz / Kabaciński 1998). The older inventory comprises of Late Mesolithic flint artefacts and some sherds as well as fragments of Brześć Kujawski ware. A few fragments belong to a Late Mesolithic ware with impressions below the rim, and parallels are drawn to the coastal Mesolithic pottery (Fig. 11; Kabaciński 2016).

Method of analysis

All in all, three systems of pottery analysis were adapted to each other, technological and typological characteristics were compared and a multivariate correspondence analysis was carried out for the pointed-bottom vessels (Piezonka 2015; Glykou 2016; Kotula 2017). In the correspondence analysis (CA), only vessel units with rim preservation were included, as

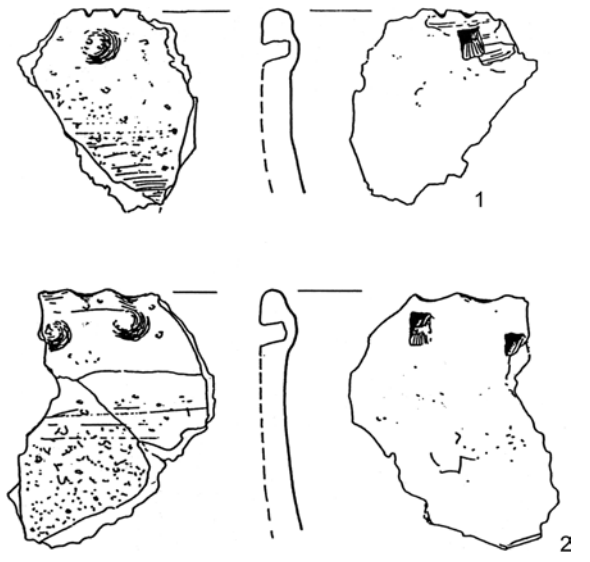

Fig. 11 Chobienice. Pointed-bottom pottery. Rim sherds (after Czerniak / Kabaciński 1997). Scale 1:2.

the very differing preservation states did not allow an informative comparison of vessel bodies. The technological characteristics integrated into the CA were wall thickness, admixture, (outer) surface treatment and wall-building technique. Typologically, rim diameter and shape of rim were included; decorational features were separated into decoration of the end of the rim, rim decoration and rim-body decoration (Fig. 12). While nominal characteristics like admixture could easily be included, a separational value was chosen for metrical variables on the basis of typical characteristics observed in the Dąbki pointed-bottom material. These features were separated into 24 characteristics for the occurrence matrix to display in the 1. and 2. principal axes. All in all, 160 vessel units of the eight different sites were analysed in the CA.

Results

The main result of the analysis by techno-typological characteristics is a clear separation between an eastern group with Narva and Dubičiai on the one hand and a western group of Ertebølle vessels and the material from the Polish sites on the other hand (Fig. 13). It becomes clear that the eastern and western types are especially distinctive in their technology. The average wall thickness of Dąbki (11.1 mm) and Neustadt (11.8 mm) vessels as well as that of the vessel from Chobienice (12 mm) is distinctively higher than that of the Dubičiai (9 mm) and especially Narva vessels (8.4 mm). In most vessels from Neustadt, Dąbki,and the Narva culture just one type of admixture was added to the clay, but 90 % of Dubičiai vessels contained more than one admixture. The western and central Baltic pottery was almost exclusively admixed with mineralic additions, especially crushed granite and to a lesser extent sand and quartz. Narva and Dubičiai vessels show admixture in much higher quantities and different components. Dubičiai pottery is characterised by a combination of plant and mineralic admixture, while plant or shell admixture without other additives is typical for Narva ware. The surface treatment also exhibits a clear distinction between eastern and more western types. The outer and inner surface of Neustadt, Dąbki and Chobienice vessels is smoothed, but less carefully on the inside. Brushed surfaces are especially typical for Dubičiai vessels, but also appear on Narva ware. Narva vessels on the other hand are often scraped on the outer and inner surface, and slip was added on the outside in many cases. The wall-building technique is rather indifferent among the respective cultures. N- and U-technique are common in the whole study area. N-technique is especially typical for Dąbki, while Neustadt Ertebølle vessels were built with H- and U-technique. Examination of wall technique was more problematic on Dubičiai and Narva vessels, but N-technique is confirmed for both types, and in the Narva culture also U-technique is rather common. The shape of Neustadt, Dąbki, and Chobienice vessels is very similar, exhibiting an

Variable CA	Pottery characteristic
wall > = 10	wall thickness 10 mm or higher
wall < 10	wall thickness lower than 10 mm
admMine	mineralic admixture
admPlant	plant admixture
admShell	shell admixture
admLow	low-middle amount of admixture
admHigh	high amount of admixture
surfSmoRaw	simple smoothing of surface
surfSmoFine	fine smoothing of surface
surfBrush	brushed surface
surfScrape	scraped surface
surfSlip	slipped surface
wallN	wall coiling technique with N-joins
wallU	wall coiling technique with U-joins
wallH	wall coiling technique with H-joins
wallOth	wall technique other
rimDm > = 25	rim diameter 25 cm or larger
rimDm < 25	rim diameter below 25 cm
rimInw	inward curved rim
rimOutw	outward curved rim
rimStraig	straight rim
decoRimE	decoration on end of rim (e.g. rim cuts)
decoRim	decoration of rim area
decoRBody	decoration of rim and body

Fig. 12 Variables of the correspondence analysis.

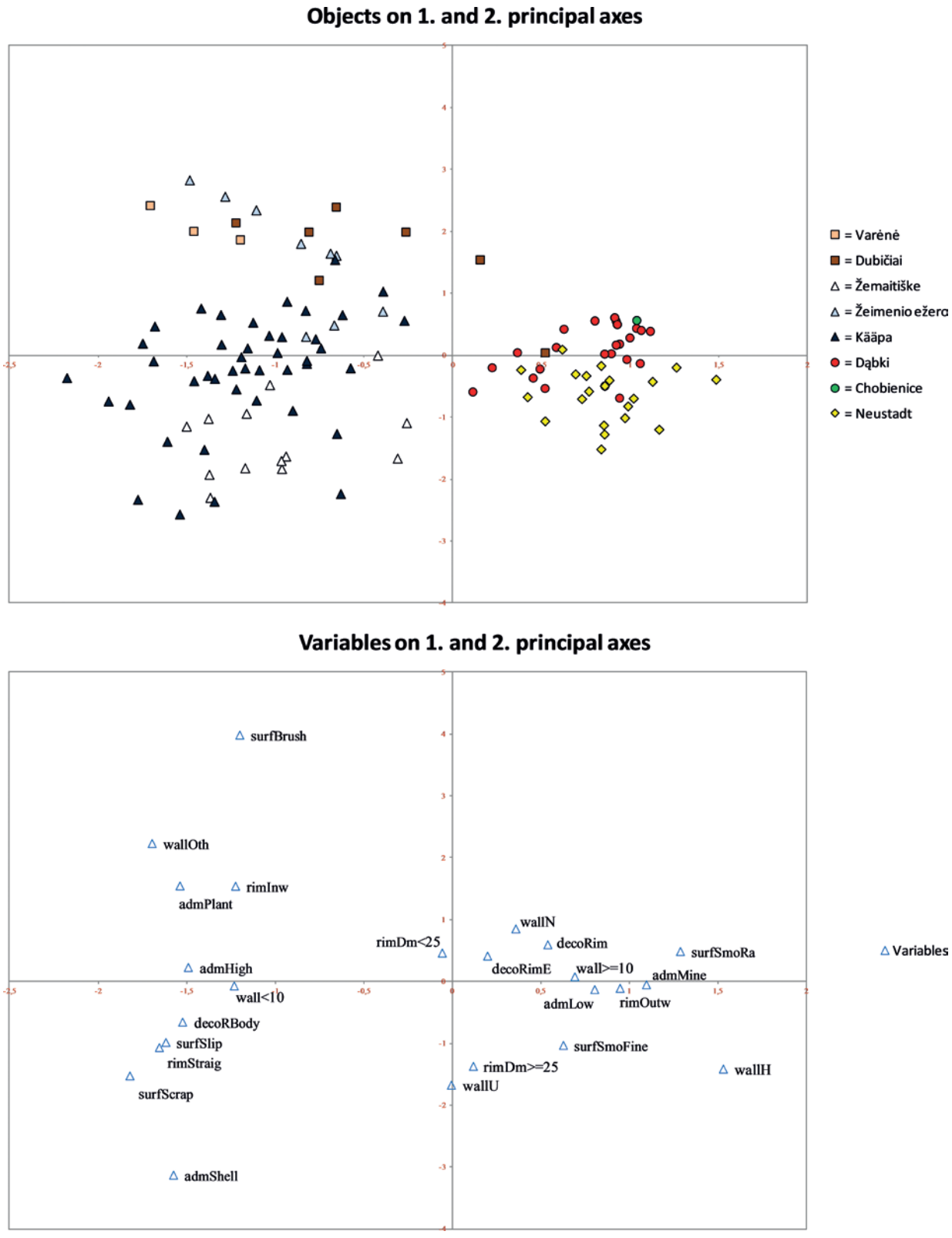

Fig. 13 Correspondence analysis of technical and typological pottery characteristics from the different sites. 1. against 2. principal axis (inertia 22,4 % and 10,1 %). Top: objects, bottom: variables.

s-shaped profile with rounded inflection points and rims curved mostly outwards. Narva and Dubičiai vessels on the other hand are more often bulbous, cylindrical or conical in overall shape, and their rim forms are less standardised, featuring rims curved inwards and outwards as well as straight ones. The pointed bottoms from Ertebølle ware differ by region, and Neustadt pots exhibit rather thin, rounded bot-

toms, while in Dąbki the shape is massive pointed or conical. They display similarities to the tap-shaped bottoms of the eastern Ertebølle circle in southern Sweden and on Bornholm (cf. e.g. Jennbert 1984; Vang Petersen 2015). Simple rounded or pointed bottoms are common amongst Narva and Dubičiai vessels, sometimes slightly tap-shaped, but not as massive as the Dąbki bottoms. Most of the vessels from all sites were decorated, with the exception of Neustadt where almost half of the pots are undecorated (47 %), and decoration on pottery is restricted to the rim area here. In Dąbki, vessel decoration is very standardised, and almost all rims display decoration with a combination of rim cuts and a horizontal row of impressions/perforations on the rim. While Neustadt pottery is only decorated on the end of the rim, mostly with cuts, Dąbki ware exhibits rim cuts and a row of impressions/perforations around the rim, and in single cases, decoration was also observed on the body. The Chobienice vessel has decoration similar to the Dąbki material. The Neustadt pottery corresponds to the sparsely decorated ware of the western Ertebølle culture, while eastern Ertebølle vessels are more varied in decoration, and a Narva culture influence has been pointed out for southern Sweden (e.g. Hallgren 2004). Dubičiai and Narva vessels have more varied decoration in general and can be adorned in the rim area and all over the body. Dubičiai vessels are decorated mostly on the rim and in the upper body section. A single horizontal row of impressions on the rim is very characteristic for this type, exhibiting a parallel to Dąbki ware (cf. e.g. Józwiak 2003). Narva and Dubičiai vessel ornamentation is more often arranged in simple geometric patterns and thus more complex than that on the Polish and German ware.

While the vessels from the Ertebølle site Neustadt and the Polish sites form a rather dense cluster in the CA, the ones from the eastern cultures are broadly distributed, indicating heterogenous characteristics. This is especially true for Narva sites: the wares from Žeimenio ežero and Žemaitiške are clearly separated, and the Kääpa material is broadly distributed, mainly separated by the variable shell admixture. Brushed surfaces and plant admixture on the other hand are typical for Dubičiai type sites and for the Narva site Žeimenio ežero (cf. Piezonka 2015). The big complexes Narva/Dubičiai and Ertebølle/Polish sites show almost no intersection, but some Dubičiai vessels are more separated from the eastern circle and closer to the western types. They show some typological similarities to Dąbki and Chobienice, especially rim decoration and outward curved rim form as well as some technological corresponding features like thicker walls and mineralic admixture. While the affiliation to the Dubičiai type has been questioned in one case due to the technical features (Piezonka 2015), these vessels show a correlation in typo-technology to Ertebølle and Polish sites.

The Polish sites and Neustadt show some separation, too. While wall thickness of > 10 mm, mineralic admixture, small quantities of admixed particles and rims curved outward are indifferent characteristics common in all wares, N-technique and rim decoration in particular are typical only for the material from the Polish sites and act as especially separating variables. Additionally, smaller rim diameters and less carefully smoothed surfaces can also be accounted for these sites. Typical characteristics in the Neustadt inventory on the other hand are U- and H-technique, large rim diameters and overall more carefully smoothed surfaces. However, it becomes clear in the supraregional perspective that the Polish sites and Neustadt follow a similar technological tradition.

Discussion

The typo-technological analysis shows that the pottery from Dąbki and Chobienice is very similar to that from the Ertebølle site Neustadt in Holstein, northern Germany. In the correspondence analysis, these sites from the western and central southern Baltic area form a cluster opposite the eastern wares of the Dubičiai and Narva types, which display a wide range of characteristics resulting in a broad distribution. On the other hand, rim decoration exhibits some parallels between Dubičiai type vessels and pottery from the Polish sites. However, it becomes clear that the pottery from Dąbki is very closely connected with Ertebølle ware. This is in accordance with the other find material from the site, which can mostly be paralleled with artefact types common in Ertebølle context. On the other hand the abundance of beaver remains in the faunal assemblage is unique in central Europe but finds parallels in northeastern Europe.

The Ertebølle culture can be understood as a phenomenon of synchronous Late Mesolithic settlements in the western and central Baltic Sea area with a more or less similar material culture, neighbouring early farming communities to the south and eventually undergoing the process of neolithisation towards the Funnel Beaker culture (cf. Czerniak / Kabaciński 1997). This large cultural complex is not a homog-

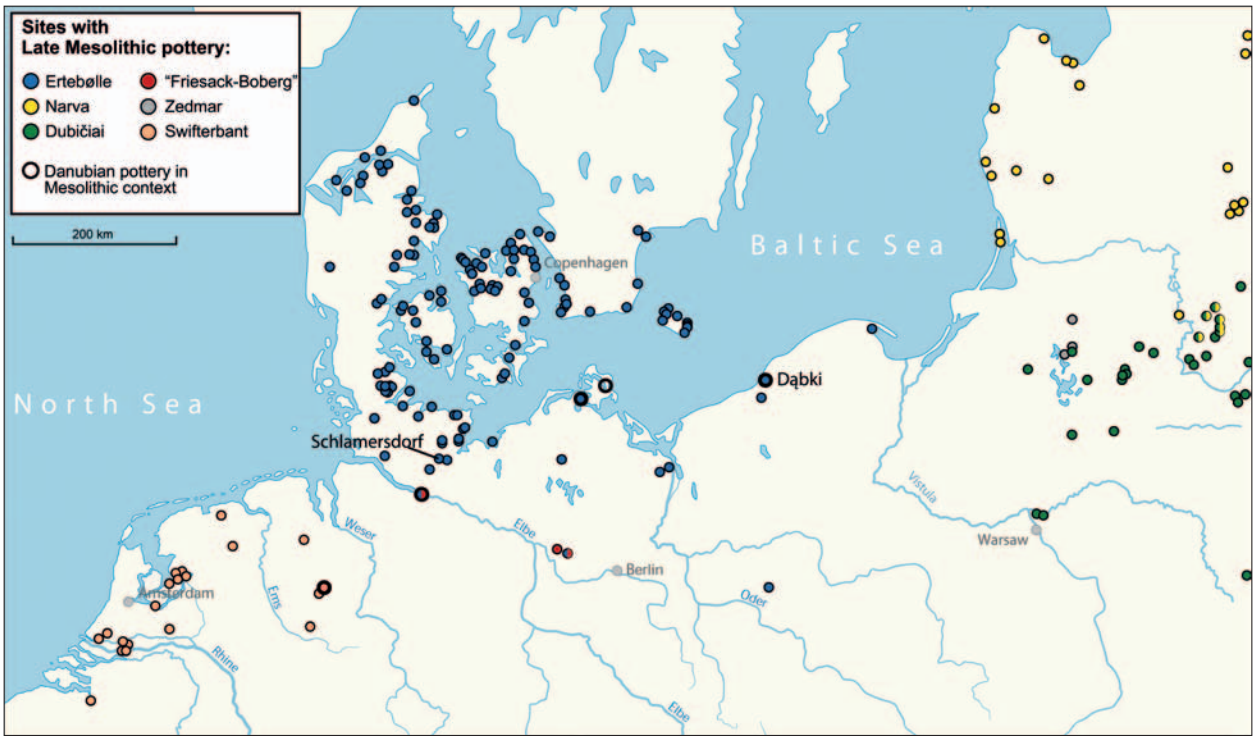

Fig. 14 Late Mesolithic sites with pottery in northern central Europe. The sites Schlamersdorf and Dąbki with potential early evidence discussed in the text are highlighted.

enous entity, and regional differences exist e. g. on the basis of local flint technology substrates. Based on the pottery analysis and overall similarities in the find material, the site Dąbki can be described as part of the Ertebølle culture with some regional characteristics. The early pottery in the Polish lowlands in general shows high degrees of similarity, and this is especially displayed in comparable decorations. On the basis of their economy, geographical location and pottery characteristics these sites can be attributed to an eastern regional variation of the Ertebølle culture.

East and west of the Ertebølle area, hunter-gatherer communities with pottery may have acted as inspirational agents for the emergence of pottery in the Ertebølle culture (Fig. 14). To the south, farming communities were also integrated in contact networks with Mesolithic groups, as illustrated by Neolithic pottery from some Mesolithic settlement sites, with Dąbki as the most outstanding example, exhibiting long-lasting networks between hunter-gatherer groups and Neolithic farmers. Different scenarios for the introduction of pointed-bottom pots into the area of the western Baltic Ertebølle culture can thus be discussed.

The earliest direct ^{14}C-evidence from Ertebølle pottery originates from Schlamersdorf and Kayhude, northwestern Germany. For these dates reservoir effect could be confirmed (Hartz 2011; Philippsen / Heinemeier 2013), but a plant sample, however, dates to c. 4,875 calBC (see above). Nethertheless, there is no conclusive indication that Ertebølle pottery at the Schleswig-Holstein inland sites appeared earlier than mid 5th millennium calBC and thus predates coastal Ertebølle pottery (Philippsen / Meadows 2014). Rather undisputed early evidence comes from a food crust date from Rosenhof with c. 4,600 calBC (Hartz 2011) from a consistent stratigraphical context (Goldhammer 2008). Looking for influences on the early pottery evidence in Schleswig-Holstein, the Swifterbant culture in the western lowlands might have provided inspiration here. Starting from 5,000 calBC, the emergence of this culture was influenced by a zone south of the western lowlands in the 6th millennium calBC, where pottery finds besides LBK ware indicate the presence of other groups with pottery, possibly with forager background (La Hoguette, Limburg, 'Begleitkeramik'), and some finds indicate the presence of these groups north of the loess belt (Louwe Kooijmans 2008). Impulses from this area most probably led to the emergence of some characteristics of the Swifterbant culture, with pottery amongst them (e. g. Ten Anscher 2015). Pointed- and rounded-bottom vessels are known in the Swifterbant culture, but no lamps. While this type is otherwise widely distributed in the Ertebølle area, lamps are also missing at the northern German inland sites like Kayhude and Schlamersdorf (Hartz 2011). Functional aspects of inland sites were

put forward for that (e.g. Hartz 2011), but new evidence points out the use of lamps in the inland in other regions (Kotula et al. 2015). The absence of this vessel type in the Swifterbant culture and at the northern German inland Ertebølle sites indicates a possible connection and may point to influence coming from the west into the Ertebølle culture. Additionally, new research could verify some technological differences between Ertebølle coastal and inland pointed-bottom ware in Schleswig-Holstein (Meyer 2017), while some parallel developments in the pottery of Swifterbant and Ertebølle are suggested (Glykou 2016). However, a recent lipid study was able to point out that Swifterbant vessels were used in more specialised ways than Ertebølle ware (Demirci et al. 2020). There is no conclusive evidence for a western inspiration on Ertebølle pottery yet, and the northwestern German inland remains a crucial region for the further study of possible influences (e.g. Ten Anscher 2015).

Dąbki is an important site for the discussion of the introduction of pottery into the Ertebølle culture by influence from the east (e.g. Povlsen 2013). It has been discussed that the early pottery in the southern Baltic was inspired by eastern European groups with earlier pottery traditions (e.g. Van Berg 1997; Timofeev 1998; Klassen 2004), and ^{14}C-data provide general support for this (Jordan / Zvelebil 2009; Piezonka 2015; Jordan et al. 2016). For the southern Swedish Ertebølle culture, typological parallels to Narva pottery have been pointed out (Hallgren 2004). The pointed-bottom ware from the Polish central southern Baltic displays typological similarities to Dubičiai type pottery. The beginning of the Dubičiai type is estimated around the second half of the 6th millennium calBC (Tkachou 2018). ^{14}C-dates from Dąbki pointed-bottom ware around 4,850/4,700 calBC point to a slightly earlier introduction of ceramic technology than in the western Baltic Ertebølle culture, but due to uncertain reservoir effect, the data is not conclusive. The idea of eastern influence is supported, though, by the appearance of lamps, which are unknown to western lowland foragers, and thus most likely were brought into the western Baltic from the eastern Narva culture. This is underlined by typological parallels between lamps from Dąbki and Narva culture. It is well possible that the general inspiration for the pointed-bottom vessel type and the usability of ceramic containers in forager context came from the east into the central Baltic. The comparison of pottery characteristics, however, highlights technological differences. While it may be possible that an eastern inspiration was accompanied by an autochthonous technological development, numerous non-local Neolithic vessels in Dąbki, in parts predating the local production, provide another possible explanation: Especially sherds from SBK and Brześć Kujawski ware display technological similarities to the local pointed-bottom pottery, like mineralic admixture, smoothed surface and N-coil technique, and the foreign Neolithic ware may have acted as a technological blueprint for local production. It is thus possible that the emergence of Ertebølle pointed-bottom pottery was a 'creolisation' of eastern influences and Neolithic impact in the Polish lowland (cf. Povlsen 2013).

The Ertebølle groups were based on local substrate in each different area, and it has to be considered that they responded differently to external influences respective to their geographical location and network situation. It cannot be ruled out that successive waves of influence from the west and east, respectively, inspired pottery production in the different Ertebølle regions. Dąbki was a well-integrated and innovative part of the Baltic Sea Ertebølle networks, and the Polish sites can be described as an eastern branch of the Ertebølle phenomenon. While ^{14}C-data are not conclusive, there are clear indications for eastern European influences on the innovation of Ertebølle ceramics.

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Long distance contacts in the area of the north European plain: The Late Mesolithic and Early Neolithic in Poland and its relations to neighbouring cultures

Jacek Kabaciński and Agnieszka Czekaj-Zastawny

Abstract This paper discusses the relatively scarce evidence of contacts between last hunter-gatherer-fisher groups and different farming societies known from the Polish lowlands. It points out different forms and scales of their relations. Two possible ways of interactions between the two so different cultural systems are suggested. The first one is a gradual transformation from a hunter-gatherer to a farming way of life. As the Mesolithic economic system at that time was optimal and very effective, it can be supposed that non-economic reasons played a substantial role in that transition. An example of such a transformation is visible in the aggregation of sites at Dąbki in Polish Pomerania. The second way of interaction resulted in an integration of both systems. Bilateral exchange contacts led to closer inter-human relations that also resulted in physical incorporation of hunter-gatherer individuals or groups into the Neolithic society. They brought with them strong beliefs and customs that were for some reasons and to some extent accepted by Danubian farmers, and the phenomenon resulted in the emergence of a unique entity in the lowlands: the Brześć Kujawski group of the Lengyel culture that included and integrated different traditions.

Keywords Late hunter-gatherers, early farmers, contacts, system transformation

Zusammenfassung *Der Beitrag diskutiert die Kontakte zwischen den späten Jäger-Sammler-Fischern und verschiedenen bäuerlichen Gemeinschaften in der polnischen Tiefebene, die unterschiedliche Intensitäten solcher Beziehungen widerspiegeln. Es werden zwei Formen der Interaktion zwischen den so unterschiedlichen kulturellen Systemen diskutiert. Die erste ist ein gradueller Übergang von einer Lebensweise als Jäger-Sammler-Fischer hin zur bäuerlichen Wirtschaftsweise. Aufgrund des effektiven mesolithischen Ökonomiesystems zu dieser Zeit können wir annehmen, dass ökonomische Gründe für den Übergang keine entscheidende Rolle spielten. Der zweite Weg der Interaktion führte zu einer Integration beider Systeme: Bilaterale Tauschkontakte hatten engere menschliche Beziehungen und die Eingliederung erster Jäger-Sammler-Individuen in die neolithischen Gemeinschaften zur Folge. Sie brachten ihren Glauben und ihre Gewohnheiten mit, die in gewissem Maß von den donauländischen Bauerngemeinschaften akzeptiert wurden. Dieser Vorgang führte zu einem einzigartigen Phänomen in der Tiefebene: der Brześć–Kujawski-Gruppe der Lengyel Kultur, die verschiedene Traditionen integrierte.*

Introduction

The middle of the 6th millennium calBC was a crucial time for the hunter-gatherer societies who had inhabited the territory of today's Poland for the preceding half a million years of human occupation (Kabaciński 2016c). The first farmers who had crossed the mountain ridges of the Carpathians and Sudetes from the south brought a whole set of innovations, not only in the sphere of economy (like agriculture and husbandry), but also in ideology. This is sometimes called the 'Neolithic package' (Gronenborn 1997). The neolithisation of Poland was a part of a much wider process documented all over Europe from c. 7,000 calBC; this process – which certainly had different faces in different areas – was and still is a subject of discussions and different concepts,[1] concerning also the role played by Mesolithic groups.[2]

1 Childe 1925; 1951; Ammerman / Cavalli-Sforza 1971; 1984; Zvelebil 1986; 1998; Kozłowski 1994; 1998; 1999; Gronenborn / Petrasch 2010; Kozłowski / Nowak 2019.

2 Bánffy 2000; 2003; Whittle 1996; Gronenborn 1997; Jeunesse 1997; Pavúk 2002; 2004; Lenneis 2007; Czekaj-Zastawny / Przybyła 2012; Terberger et al. 2018.

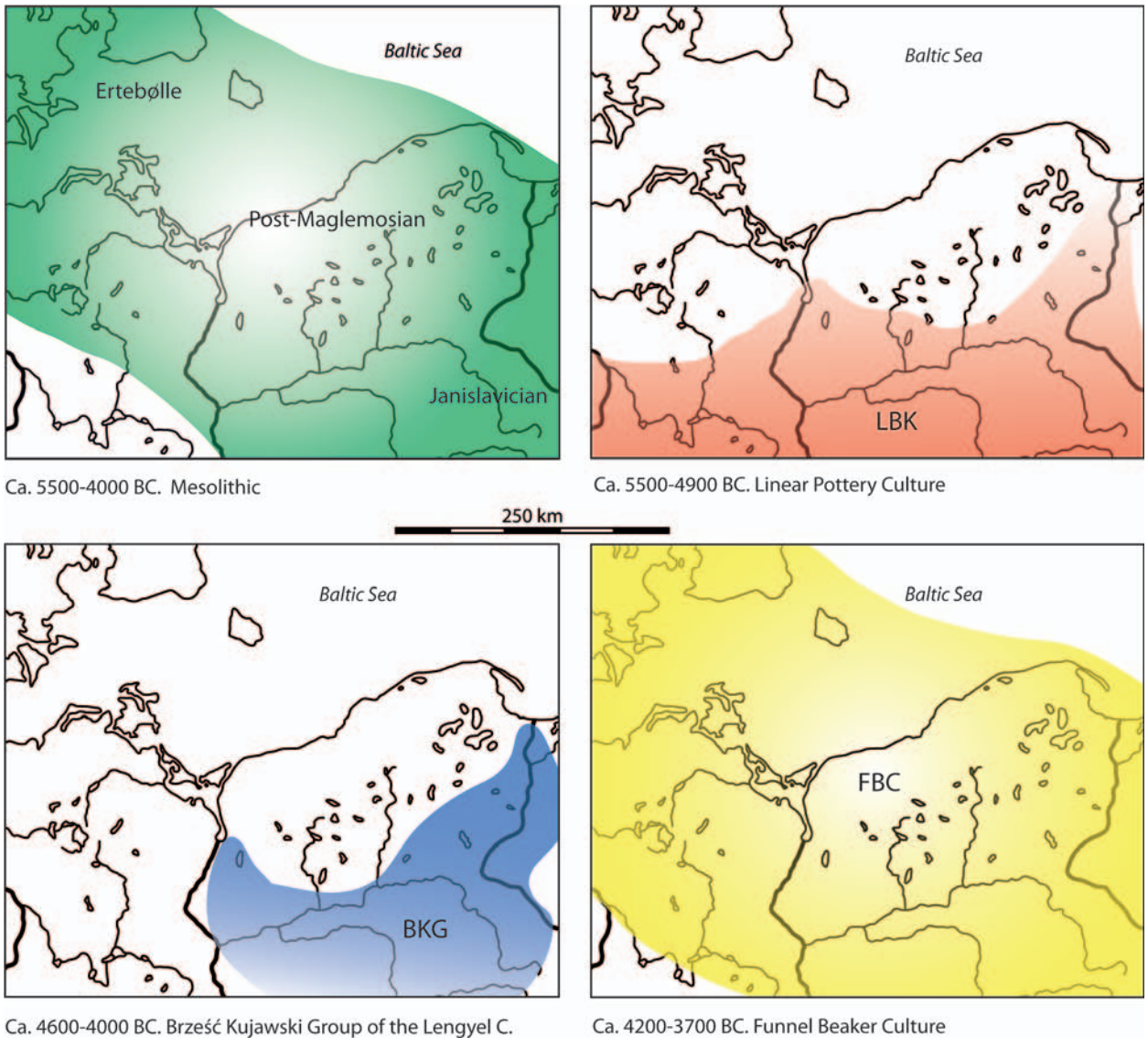

Fig. 1 The cultural situation in Poland from the middle of the 6th to the middle of the 4th millennium calBC (drawing: J. Kabaciński).

The spread of the earliest Neolithic groups in Poland – Linear Band Pottery culture (Linearbandkeramik: LBK) – was gradual, but, according to radiocarbon dates, relatively fast, and between c. 5,500 and 5,300/ 5,200 calBC LBK settlements appeared within the majority of the most fertile areas of Poland from Lesser Poland and Silesia to the south, through central Polish Kuyavia up to the northern fringes (Fig. 1; Czekaj-Zastawny / Kabaciński 2016). Even if from a large-scale perspective the dispersal of the earliest Neolithic occupations had 'island' character, it was certainly an important moment, as for the first time ever intercultural relations between hunter-gatherers and farmers were possible on Polish territory.

The Neolithic settlement in Poland, initially spatially limited, expanded in the course of time, fed by population growth and supplied by further waves of immigrants from the south, of so-called late Danubian cultures, during the 5th millennium calBC (Kadrow 2016). Finally, Funnel Beaker culture groups, considered as the first native farmers, settled most of the Polish territory during the 4th and 3rd millennia calBC (Nowak 2016). The continuously growing presence of farmers in the originally hunter-gatherers' world led to different forms of contacts, which are interpreted as results of exchange, but which in some cases had also wider socio-cultural implications.

The evidence of contacts

Observing the general dispersion of the Mesolithic and early Neolithic settlements (Fig. 1) and taking into account at least 1,500 years of spatial coexistence in a more distant or closer vicinity, the scale of contacts should have been substantial. However, it is not

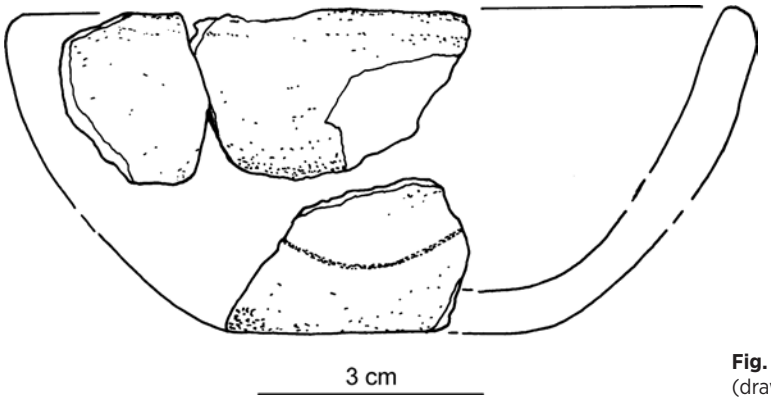

Fig. 2 Dąbki. Pottery of the Linear Band Pottery culture (drawings: J. Ożóg).

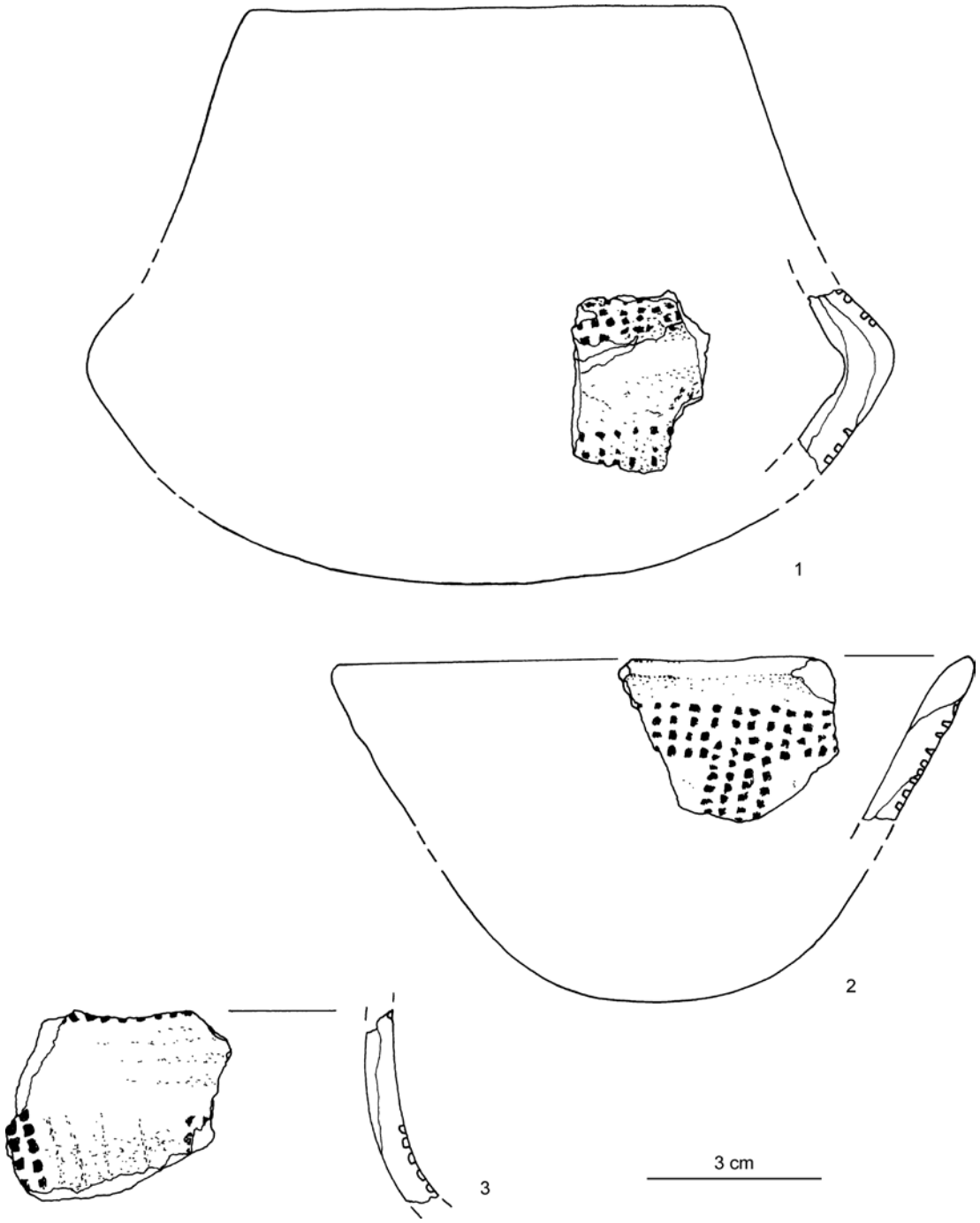

Fig. 3 Dąbki. Pottery of the Stroke Band Pottery culture (drawings: J. Ożóg).

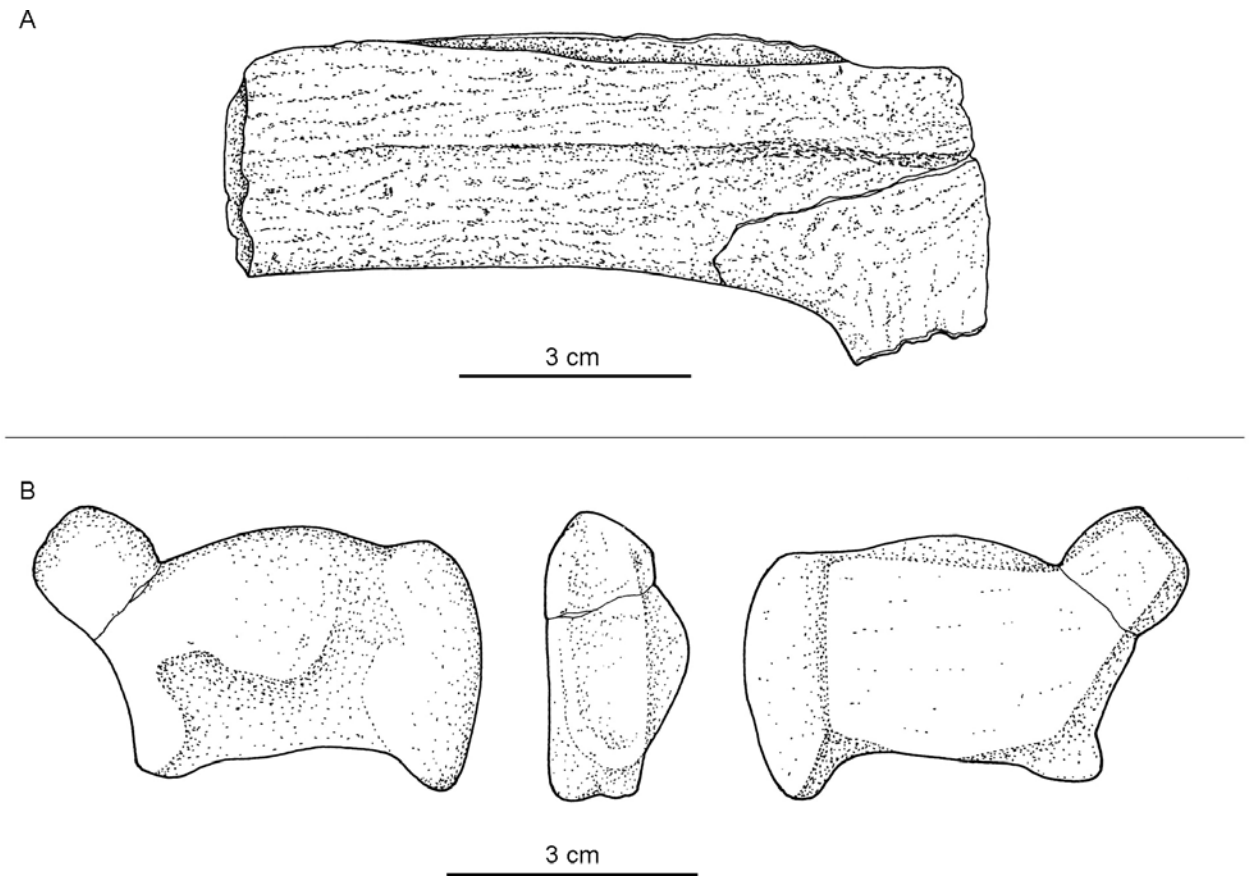

Fig. 4 **A** Poznań-Dębiec, fragment of red deer antler T-axe; **B** Brześć Kujawski, amber figurine (drawings: J. Ożóg).

reflected by an amount of direct evidence in the form of easily identifiable objects exchanged in the course of such contacts (Klassen 2004). On the Polish territory a direct record of relations is encountered both in Neolithic and Mesolithic contexts, and it increases over the course of time.

Extremely scarce are finds from the period of potential first contacts between Mesolithic and LBK groups. On LBK settlements in Ludwinowo (Kuyavia, central Poland) and in Modlnica (Lesser Poland) single objects of amber were found (Czekaj-Zastawny 2011; Czerniak 2010), most probably of Baltic area origin, and exchanged from foragers. On the other side, fragments of LBK ceramic vessels were discovered at the Mesolithic settlement in Dąbki (Fig. 2; Czekaj-Zastawny 2015). That long-lasting aggregation of settlements on the island in Dąbki lake might have served as a trading post where different goods like beaver furs, amber, ceramic vessels, bone and antler tools, and food were exchanged between foragers and farmers (Kabaciński et al. 2015a; 2015b; Schmölcke / Nikulina 2015).

It seems the intensity of contacts increased as new populations of Danubian origin appeared in Poland in the 1st half of the 5th millennium calBC, especially in the Polish lowlands. These groups represent the Stroke Pottery culture (SPC). What characterised these people, as well as their successors – the so called Brześć Kujawski group of the Lengyel culture (BKG) in the 2nd half of the 5th millennium calBC – was a much more flexible economic system, allowing them to penetrate and settle sandy areas of the plain never occupied by the LBK (Czerniak 1980; 1994). In a natural way they were exploring territories that were a primary ecumene for hunter-gatherers. In the case of the SPC such evidence is known from Dąbki (pottery vessels, Fig. 3; Czekaj-Zastawny 2015) and from the site Poznań-Dębiec, where a T-shaped axe made of red deer antler was found in one of the features (Smoczyńska 1953; Fig. 4A). This kind of tool was most popular within Mesolithic populations inhabiting the coastal zone of the Baltic (Kabaciński et al. 2014).

The most mobile of all the Danubian societies were BKG groups, who, for instance, entered as the first Neolithic groups deep into Pomerania, a territory densely inhabited by Mesolithic people. This is proven by numerous BKG stone tools found out of settlement context (Siuchiński 1972). Dozens of BKG clay vessels found in Dąbki (Fig. 5; Czekaj-Zastawny 2015) and Szczepanki in northeast Poland (Gumiński 2011) show the growing intensity of interactions between

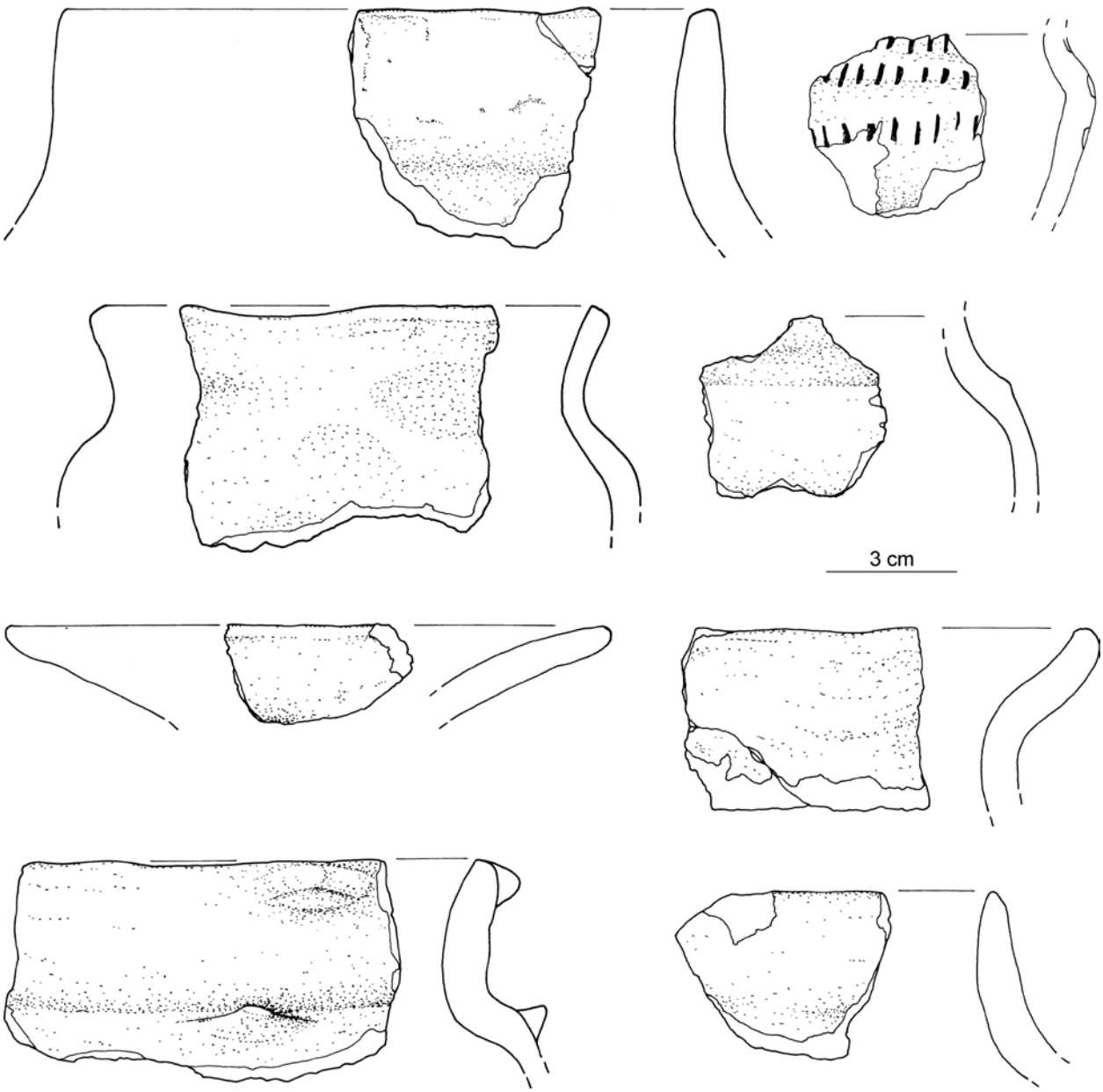

Fig. 5 Dąbki. Pottery of the Brześć Kujawski group (drawings: J. Ożóg).

the Mesolithic world and farming communities at that time. For the first time ever we have also the evidence of Mesolithic pottery discovered in the context of a Neolithic settlement. One such site is Chobienice 8 (Fig. 6; cf. Czerniak / Kabaciński 1997; Kobusiewicz / Kabaciński 1998; Kabaciński 2016b), the other one is Brześć Kujawski, site 3, where besides pottery also an amber figurine (bear?) was found (Fig. 4B; cf. Cyrek et al. 1983; Grygiel 2008).

In our opinion a clear influence or at least an inspiration of Mesolithic groups is also visible in the production of red deer antler T-shaped axes – tools commonly produced in the northern Mesolithic as well as in the BKG (Fig. 7; Kabaciński et al. 2014) – as well as adzes made of metapodial bones found on the BGK sites (Bogucki 2008). These last mentioned tools had already been produced by Maglemosian communities since the beginning of the 8th millennium calBC, and numerous adzes of this type were recorded at an early Mesolithic site in Krzyż Wielkopolski (Kabaciński 2009) and also in Dąbki, where they are dated to the middle of the 5th millennium calBC (Fig. 8; Kabaciński et al. 2014; 2015a).

The above-mentioned evidence of relations between hunter-gatherers and early farmers is generally very rare and does not reflect a potential scale of interaction. The finds also don't answer a basic question: what happened to the hunter-gatherers in the

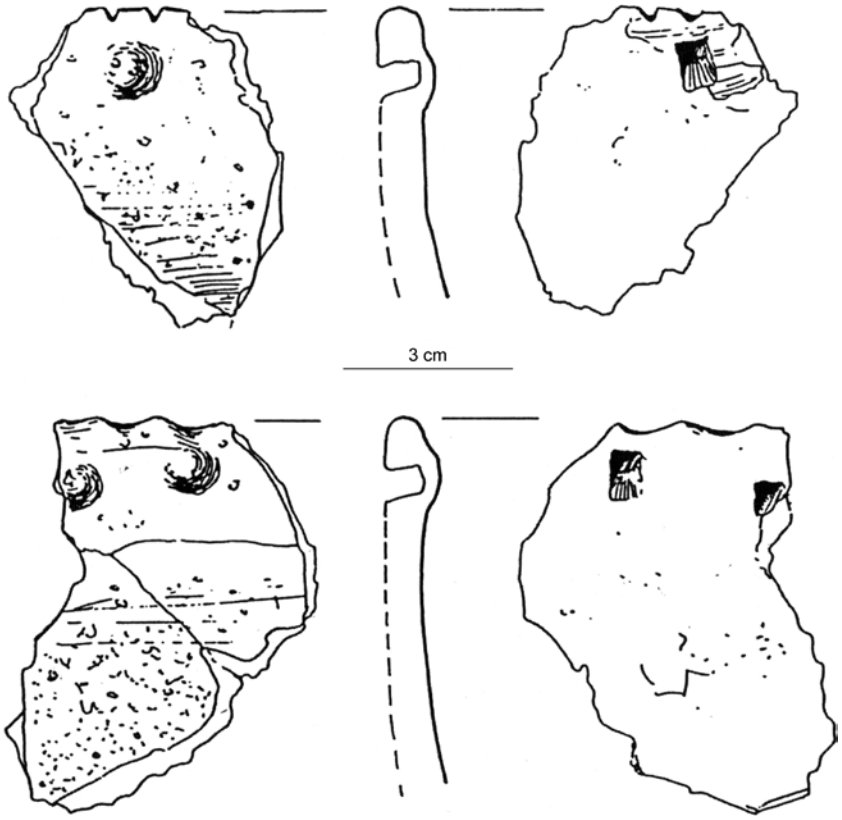

Fig. 6 Chobienice. Mesolithic pottery (drawings: J. Sawicka).

Fig. 7 Red deer antler T-axes: **A** Dąbki; **B** Bodzia (BGK) (photo: A – J.Kabaciński, B – E. David).

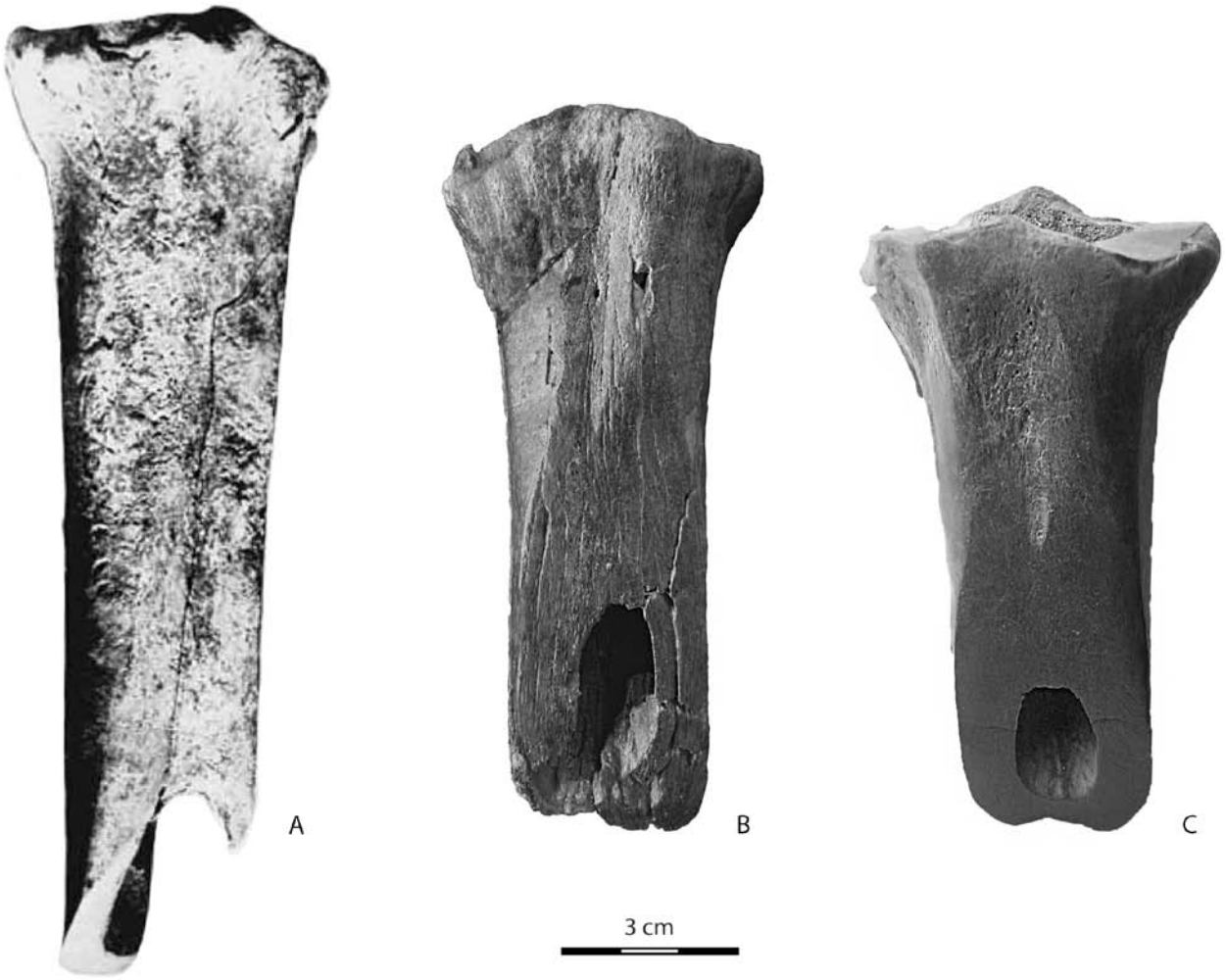

Fig. 8 Adzes from metapodial bones: **A** Osłonki; **B** Krzyż Wielkopolski; **C** Dąbki (A – after Bogucki 2008, B-C – photo: J. Kabaciński).

course of the Neolithic expansion? What was the fate of the advanced Mesolithic populations, as there is almost no evidence for their existence on the Polish plain during the late 4th and 3rd millennia calBC?[3] The archaeological record is especially lacking any kind of evidence of aggression or trauma (Sulgostowska 2016). Below we present two cases that may be considered as exemplifications of different interactions that took place at the edges of these two worlds.

Dąbki and the North Group of the Funnel Beaker culture: transformation of the system

During the 5th millennium calBC the coastal zone of Pomerania, the very northern part of today's Poland, was inhabited by technologically advanced hunter-gatherer-fisher societies who optimally exploited the rich terrestrial and freshwater environment. On one side they were rooted in the local Late Mesolithic of the so called post-Maglemosian tradition, on the other one they belonged to the circum-Baltic cultural zone (Kabaciński 2001). Two such sites have been excavated so far in Poland, Dąbki and Rzucewo,[4] of these, the first one is much better recognised.

An aggregation of sites, including the main site Dąbki 9/10, was situated on an island of today's silted up Dąbki lake, a few kilometers away from the former Baltic coast. More than twenty years of excavations have exposed the remains of a long-lasting Late Mesolithic occupation dated between the end of the 6th and the end of the 5th millennium calBC, including numerous settlement pits and huts,

3 Bagniewski 1987; Kobusiewicz / Kabaciński 1993; Kabaciński 2016a; Kozłowski / Nowak 2019.

4 Kabaciński / Terberger 2009; Terberger et al. 2009; Kabaciński et al. 2011; Czekaj-Zastawny / Kabaciński 2018; Król 2018.

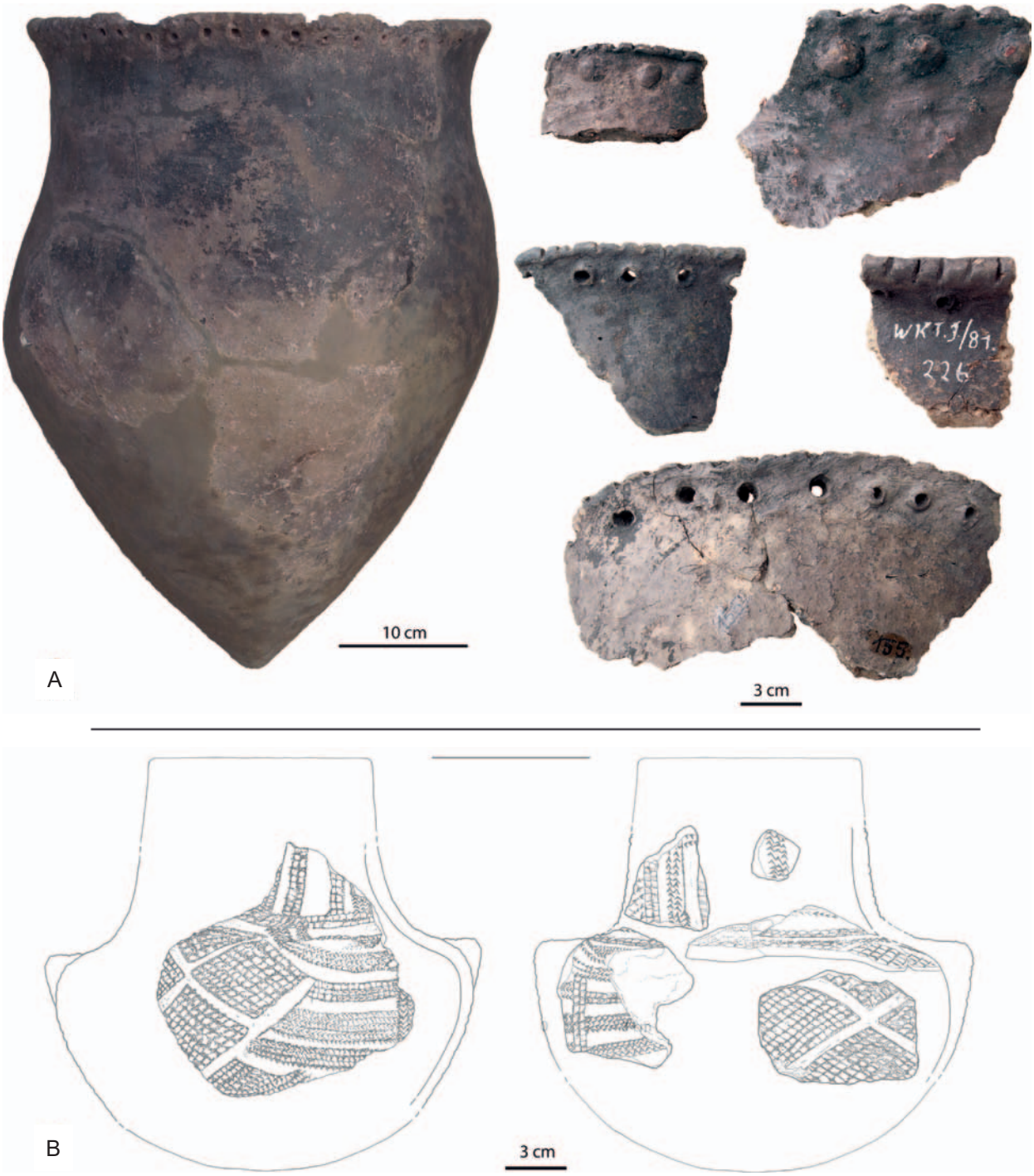

Fig. 9 Dąbki. **A** Mesolithic pointed-bottom pottery; **B** imported Bodrogkeresztur vessel (A – photo: A. Czekaj-Zastawny, J. Kabaciński; B – drawings: J. Ożóg).

an amber workshop, and rich collections of faunal remains, flint artefacts, locally produced pointed-bottom clay vessels as well as imported Neolithic pottery (Fig. 9; Czekaj-Zastawny et al. 2011; 2013; Kabaciński et al. 2015b).

Around 4,200–4,000 calBC an important change in pottery production is recorded, namely the appearance of the earliest Funnel Beaker culture (FBC) pottery, typical of the North group of that culture. There are technological and stylistic arguments that this new pottery is rooted in the proceeding pointed-bottom ware, including some typical forms of Mesolithic vessels decorated with ornamentation known from the FBC (Fig. 10; Czekaj-Zastawny / Kabaciński 2015). Due to problems with dating and reservoir effect it is not completely clear whether pointed-bottom vessels were still produced at the turn from the 5th to the 4th millennium calBC parallel to

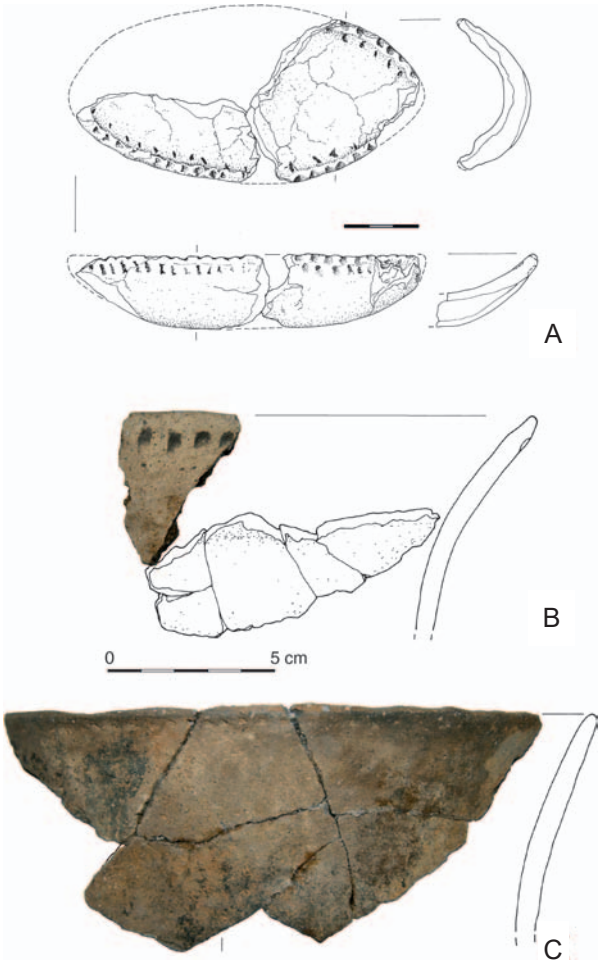

Fig. 10 Dąbki. **A** Mesolithic lamp decorated with Funnel Beaker culture ornamentation; **B–C** Early funnel beakers (drawings: J. Ożóg, photo: J. Kabaciński).

stylistically new pots, or whether they were replaced by funnel beakers. But certainly, according to results of paleoenvironmental studies (Kalis et al. 2015) the societies inhabiting the Dąbki island until around 3,700 calBC were hunter-gatherers, and only after that date the first signs of agriculture are recognisable in this area. Therefore the change from Mesolithic to early FBC at its initial stage was nothing but a stylistic change in pottery production. Summing up, what we observed in the case of Dąbki is a gradual transformation of hunter-gatherers resulting finally in the adoption of some elements of farming economy.

The Brześć Kujawski group of the Lengyel culture: integration of systems

The Brześć Kujawski group of the Lengyel culture (LC) displays a fully developed agricultural system based on cultivation of wheat and barley, accompanied by cattle husbandry and less frequently sheep / goats and pigs (Czerniak 1980; Grygiel 2008). Hunting played a minor role in the economy. This cultural group is also known for building long wooden houses and using copper. The BKG, dated to the 5th millennium calBC, is the youngest group of the LC, and, contrary to other groups recognised in southern Poland, it occupied almost exclusively the lowlands; there is no doubt that as far as subsistence is concerned it was a society characterised by an advanced and stable Neolithic economy. However, a surprising number of elements characteristic for this culture can be directly linked with a Mesolithic heritage (Czerniak 1994; Czerniak / Kabaciński 1997).

Typically for the BKG, like all cultures of Danubian origin, the deceased were buried in pits within the settlements in a flexed position on the side. Before burial, dead individuals were adorned with richly ornamented armlets and bracelets made of animal ribs, with hip-belts with hundreds of beads made of small shells, necklaces of animal teeth, and equipped with T-shaped axes made of red deer antler (Fig. 11). Either domesticated or wild animal bones could be used for manufacturing armlets and bracelets, but the ornamentation has close analogies in the Maglemosian world (Czerniak / Kabaciński 1997; Płonka 2003; Bogucki 2008). Also necklaces and pendants made of teeth of wild animals or beads produced of fish bones may be accounted as reflections of hunter-gatherer roots.

T-axes, made of red deer antlers, were popular tools manufactured by BKG people, and in our opinion the idea of their production derived from the circum-Baltic Mesolithic area (Kabaciński et al. 2014). Such tools are only rarely discovered in the context of other LC groups, representing contacts between different societies of the same origin. The most intriguing fact is that numerous T-shaped axes were recorded as grave goods.

Burial customs belong to the sacred zone and reflect traditions deeply rooted in the society, repesenting an integral component of each cultural system, the BKG in this case. The evidently Mesolithic roots of the BKG burial tradition present within a fully developed agricultural society might point to a syncretic nature of the BKG – a result of a specific integration of the Danubian population inhabiting the Polish lowlands with local foragers. Those Mesolithic elements that are visible in the burial rites are particularly important, given their overall role in the entire social life. And from that perspective the widespread and intensive social contacts of the BKG with the Mesolithic world should not come as a surprise.

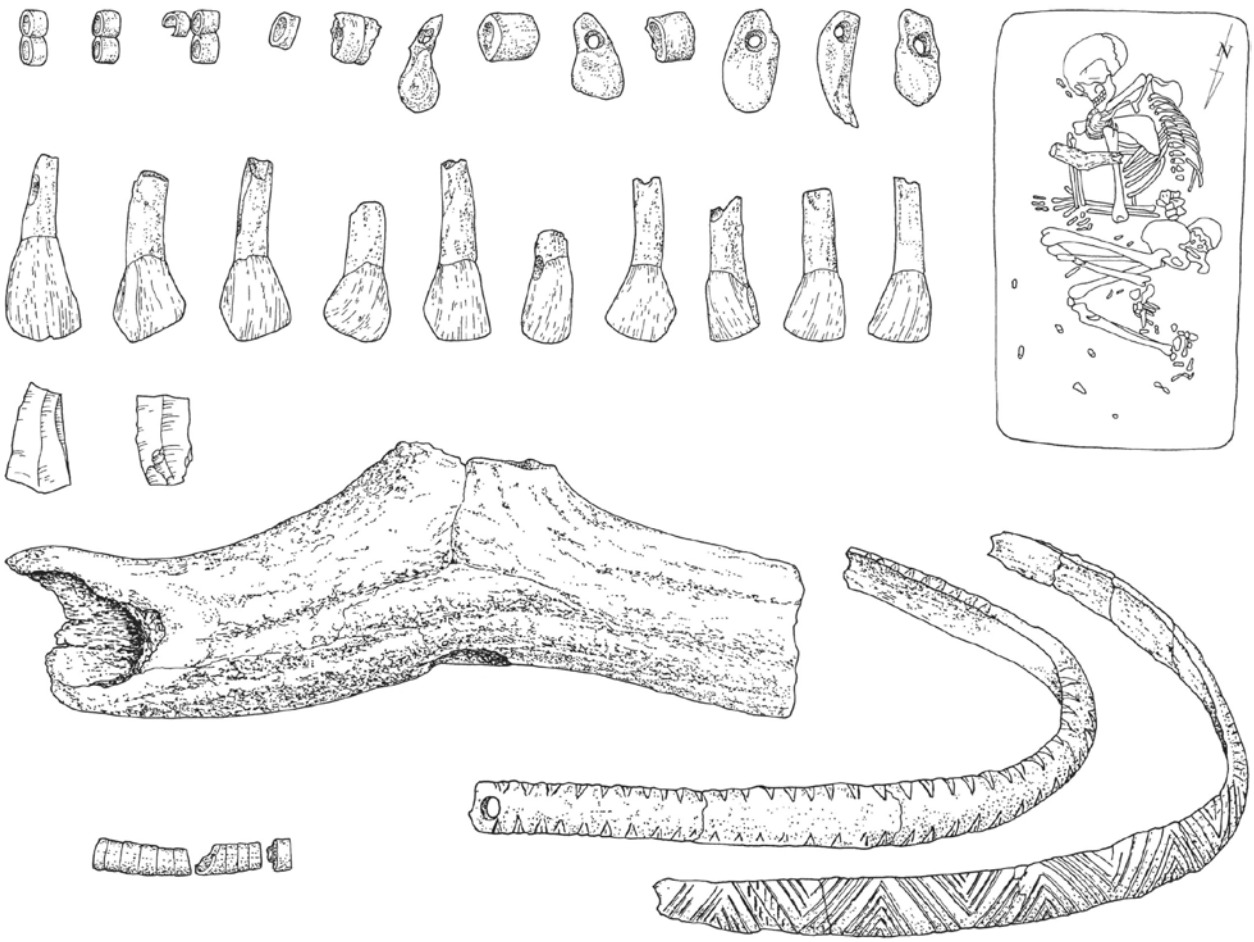

Fig. 11 Burial of the Brześć Kujawski group from Brześć Kujawski (after Jażdżewski 1938).

In Dąbki the approximate number of imported BKG vessels is as high as the number of locally produced pointed-bottom Mesolithic pots (Czekaj-Zastawny 2015). Thick food crusts on the walls of these vessels suggest they were used for everyday activities, contrary to SPC or Bodrogkeresztur culture pots. This means that the BKG pottery lost the uniqueness of the former Neolithic pottery and became an integral part of everyday house equipment.

There is also a palaeogenetic set of data supporting the thesis of the integration of hunter-gatherers' and early farmers' systems. According to palaeogenetic studies there is a distinct genetic difference between Danubian farmers and local Mesolithic societies. For European Late Palaeolithic and Mesolithic groups U-clades (especially U5a, U5b, and U4 subclades) are typical, while for the first farmers the N1a-clade predominates, followed by other less frequent ones. What is of crucial importance, there are no U5- or U4-clades recorded in LBK samples, and, *vice versa*, neither N1a- nor H-types were found in hunter-gatherer samples (Bramanti et al. 2009). Results achieved from a research on mtDNA of several skeletons from the Kujavian BKG sites Osłonki 1, Konary 1, and Konary 1a exhibit a clear 9 % share of the U5a haplogroup, distinctive for indigenous hunter-gatherers (Lorkiewicz et al. 2015). Studies of mtDNA carried out for younger farming populations rooted in the Danubian world and living in central Germany also confirmed increased values of hunter-gatherer genetic components in the second half of the 5th millennium calBC (Brandt et al. 2013).

The above-mentioned paleogenetic data combined with clearly Mesolithic elements in burial rites suggest a substantial degree of integration on population as well as cultural level. We may only suppose that the beginning of that process, the mechanism of which is difficult to recognise, occurred around 4,600 calBC, when the first appearance of the BKG on the lowlands is recorded.

Conclusions

The paper presents an overview of the evidence concerning contacts between hunter-gatherers and

early farmers on Polish territory. Direct evidence of exchange relations is scarce and archaeologically difficult to record.

Two possible ways of interactions between the two so different cultural systems are suggested. The first one is a gradual transformation from a hunter-gatherer to a farming way of life. As the Mesolithic economic system at that time was optimally established and very effective, it can be supposed that non-economic factors 'played a substantial role in that transition.

The second way possible was an integration of both systems. Bilateral exchange contacts led to closer inter-human relations that resulted in physical incorporation of hunter-gatherer individuals or groups into the Neolithic society. They brought with them strong beliefs and customs that were for some reasons and to some extent accepted by Danubian farmers, and this phenomenon resulted in the emergence of a unique entity on the lowlands that included and integrated different traditions.

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Crosstown traffic: contemplating mobility, interaction and migration among foragers and early farmers

Daniela Hofmann, Hans Peeters and Ann-Katrin Meyer

Abstract Migration is definitely back on the agenda, but so far archaeological contextualisations have lagged behind the accumulation of archaeogenetic data, leading to relatively simple 'either/or'-scenarios. From the perspective of diversity in social interaction between 'receiving' and 'incoming' (groups of) individuals, we explore three different situations in which migration played a role in the uptake of the Neolithic in order to tease out the social processes and complexities hidden under the blanket term 'migration'. In the case of the Linearbandkeramik (LBK), potentials for forager-farmer interaction differed strongly between earlier and later phases and across regions, a pattern connected to changing landscape use and mobility regimes within the LBK, as well as the changing utilisation of material culture in identity creation. In the Low Countries, it is much harder to draw a definite line between foragers and farmers based on mobility or environmental impact, and foragers had been used to dealing with population movements. There is thus far less difference between the actors, and a concomitantly greater involvement of both in shaping the Neolithic. In contrast, in southern Scandinavia and northern Germany there is the perennial question of whether the 'complex' Ertebølle hunter-gatherers eventually fell for the lures of Neolithic luxury goods, or should be credited in resisting long enough to drive a Neolithisation on their own terms. However, societies here are more internally diverse than is generally appreciated, pointing to different interaction mechanisms inland and on the coast. Overall, several interaction scenarios succeed each other in time and/or space, in each of our regions. This paper hence also calls for maintaining an archaeological style of enquiry that allows for indeterminacy and open-endedness in the study of human interactions.

Keywords Hunter-gatherers, early farmers, mobility, migration, social interaction, acculturation, Linearbandkeramik, northwest European lowlands, southern Scandinavia

Zusammenfassung *Migrationsmodelle konnten sich in der jüngsten archäologischen Forschung (erneut) etablieren, jedoch bleibt die archäologische Kontextualisierung bisher hinter den verfügbaren Daten der Archäogenetik zurück, sodass häufig recht simple und einseitig geprägte Szenarien und Erklärungsmuster die Diskussion prägen. Vor dem Hintergrund der vielfältigen sozialen Interaktionsmöglichkeiten zwischen „aufnehmenden" und „ankommenden" (Gruppen von) Individuen untersuchen wir drei verschiedene Szenarien, in denen Migration eine Rolle im Neolithisierungsprozess spielte, um so soziale Prozesse und Zusammenhänge herauszustellen, die sich unter dem Oberbegriff „Migration" verbergen können. Im Falle der Linearbandkeramik (LBK) unterscheiden sich die Interaktionsmöglichkeiten von Jäger-Sammler- und Bauerngruppen in den frühen und späten Phasen sowie zwischen verschiedenen Regionen. Dies hängt mit Veränderungen in der Landschaftsnutzung und variierenden Mobilitätsstrategien innerhalb der LBK zusammen, ebenso wie mit der sich verändernden Rolle materieller Kultur in der Herausbildung von Identitäten. In den Niederlanden ist es dagegen viel schwieriger, Wildbeutergruppen und frühe Bauern anhand der Kriterien Mobilität oder Einflussnahme auf die Umwelt zu unterscheiden. Zudem waren den Jägern und Sammlern größere Bevölkerungsverschiebungen nicht fremd. In diesem Fall gibt es daher deutlich geringere Unterschiede zwischen verschiedenen Akteuren und damit einhergehend eine stärkere Beteiligung beider Gruppen an der Gestaltung des Neolithikums. Gegensätzlich dazu stellt sich für Südskandinavien und Norddeutschland die Frage, ob die „komplexen" Jäger-Sammler-Gruppen der Ertebølle-Kultur (EBK) letztendlich der Versuchung neolithischer (Luxus-)Güter erlagen oder den Neolithisierungsprozess unter anderen Bedingungen vorantrieben, nachdem sich das Sozial- und Subsistenzgefüge dem neolithischen Einfluss aus dem Süden über Jahrhunderte „widersetzt" hatte. In jedem Fall waren die Gesellschaften der EBK von einer größeren internen Vielfalt geprägt als gemeinhin angenommen, was auf unterschiedliche Interaktionsmechanismen im Binnenland und im Küstenraum hinweist. Generell folgen in jeder unserer Beispielregionen mehrere Interaktionsszenarien zeitlich und/oder räumlich aufeinander. Dieser Artikel fordert daher auch eine offene Herangehensweise an archäologische Analysen, die Unbestimmtheiten und Variationen in der Untersuchung zwischenmenschlicher Interaktionen zulässt.*

Introduction

The history of research of the Mesolithic-Neolithic transition has always been plagued by the predictably dichotomous thinking that tends to crystallise around period boundaries. In this particular case, this initially seemed warranted because an incoming (Neolithic, sedentary) population could be opposed to an indigenous (Mesolithic, at least seasonally mobile) one. These narratives were subsequently critiqued, and mobility seen as a crucial factor in both social settings (e. g. Whittle 1996, 160–162; Barker 2006, 361–363; Finlayson / Warren 2010; Watkins 2013). However, such readings were tied to theoretical positions which assumed a leading, or at least very large role of the Mesolithic population in the adoption of agriculture. This was also the interpretive framework for initial isotopic data, showing personal mobility over a lifetime (e. g. Price et al. 2001, 601; Zvelebil/ Pettitt 2008, 199). In contrast, aDNA analyses have returned the issue of migration to the fore, providing a wealth of data, with the Early Neolithic of central Europe as one of the main case studies. As a result, the many nuanced accounts on the complexities of identity formation, the selective uptake of innovations and the role of mobility in farming societies are now largely ignored in the newer literature. Consequently, migration narratives have remained undertheorised (this is also a problem for subsequent migrations, see e. g. Furholt 2018). In this paper, we focus primarily on migration, defined as the long-term or permanent change of residence of individuals or groups, whereby they must either cross a significant cultural boundary or be so far removed from their origin community as to make regular travel back too onerous. In contrast, mobility is a more general term which also covers routine (e. g. seasonal) or shorter-term changes in residence, as well as travel and exploration.

The gap between the (pre-)historic importance of migration events and archaeologists' reluctance to systematically think about how migrations actually worked was already noted in the 1990s, most famously by David Anthony (Anthony 1990). He did, for instance, point out that archaeologists tended to think of migrations as involving one-off movement in one direction only, when in fact there was significant cross-cultural evidence for return migration, and groups who had migrated once were also more likely to do so again. Yet this is not the only way in which our narratives have lagged behind the theoretical and interpretative advances already made in the 1990s and early 2000s. For instance, the way in which we conceptualise female mobility in the Neolithic remains highly restricted – women move for the sake of male politics, i. e. in 'marriage' or as captives, and seemingly without any agency of their own. This grossly oversimplifies the range of behaviours actually observed ethnographically, even in patrilocal societies (Bickle 2020; Frieman et al. 2020), quite apart from decades of work in gender archaeology. Also, where the causes of migration are alluded to, narratives often tend to fall back on stereotypical push factors, such as climate or overpopulation. In these accounts, migration only happens when the self-evidently preferred solution of staying put no longer works, rendering migration a 'crisis' behaviour – notwithstanding that this *can* be a driving factor – rather than affording it the central place it could now take in our accounts.

In this paper, however, our main issue is with another aspect that has so far barely been addressed: how the migration behaviours of different societies shaped both the trajectory and eventual outcome of interaction. This topic has been comparatively neglected in central Europe, because Early Neolithic populations have been shown to mix very little with resident hunter-gatherers, at least in the first few centuries (e. g. Lipson et al. 2017). This means that while there is evidence for the continuous possible survival of hunting and gathering groups in non-loess territories (see below), the question how contact and connections may have looked has been relatively side-lined. This also applies to interactions between Neolithic societies in central Europe and the hunting and gathering societies of the north European Plain, where at last another 1,000–1,500 years were to pass before food production came to dominate more widely. So far, the main focus has been on the evidence for 'imports' or 'contact finds' between these societies (e. g. Klassen 2004, 301–338; Gronenborn 2009; Verhart 2012), but this has barely extended to other aspects of social life. Instead, the neolithisation scenario once again works with the idea of incoming farmers and largely parallel societies for a time (e. g. Gron / Sørensen 2018).

In this article, we argue that we must move the study of migration away from a fascination with the fact that it has happened (a question often addressed at a large, continental or at least culture-wide scale), to exploring how it unfolded as a distinct historical phenomenon, enacted by particular people and at a very specific place and time. In short, if migration is to be appreciated in social terms, then identifying push and pull factors is an important first step, but hardly the end of the story. Both the modalities and consequences of migrations will also differ based on the expectations, strategies and habituated actions of those

involved. Our main aim is to show the complexities of such processes, and the range of factors that need to be taken into account in order to provide alternative interpretative starting points. For instance, if mobility and migration were embedded at several social scales in both farmer and hunter-gatherer societies, then we could attenuate our views of migration happening in 'waves', with colonisers irrevocably changing the social structures of the colonised, while remaining unaffected themselves. Instead, we could investigate more closely how the forms of mobility and migration embedded in both societies could interleave, and where in turn they provided potential for conflict. This requires us to think through migration and its potential counterpart, territoriality and boundaries. After all, both farmer and hunter-gatherer societies were dynamic. Not only were they integrated in long-distance networks which constantly provided new potentials for change, but they also developed their own internal social trajectories. The kinds of interaction possible at the beginning of forager-farmer interaction may therefore not characterise its further development.

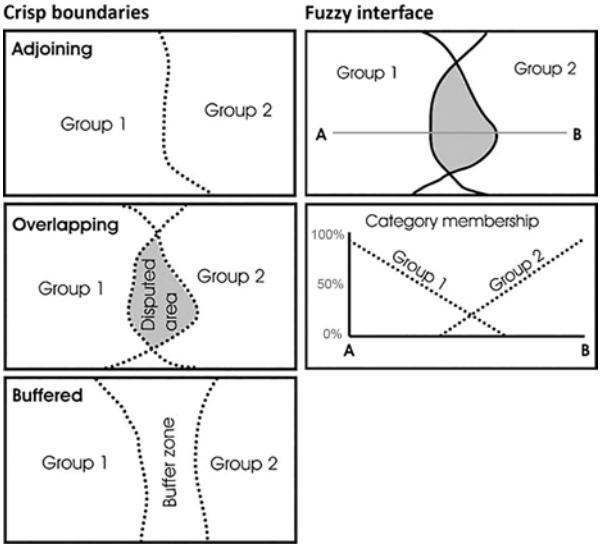

Fig. 1 Various boundary models can be defined in connection to territoriality and interaction (after Whitley 2010). Crisp boundaries refer to explicit territories, maintained and protected by various groups. The fuzzy interface model refers to a situation where territories can partially overlap, but are acknowledged by the groups. As such, the overlap area consists of 'communal' ground, and 'belongs' to both groups.

Mobility, migration and social interaction

In order to illustrate these points, we will first discuss a simple framework of how processes of acculturation are connected to social appreciation – how well does one get along with others – and related interactive attitudes. People, either as individuals or in groups, have been moving around to variable degrees and for many different reasons. In doing so, they will have repeatedly entered or crossed 'occupied' land, territories belonging to others who had already lived there for a longer time (Fig. 1), having made it their 'home(land)', just as they will have crossed 'empty' land, parts of landscapes where no people lived at all (or at least parts of landscapes bearing no traces of human presence). But how do 'insiders' react towards 'outsiders' or 'incomers'? What will be the nature of the emerging interaction? This is strongly dependent of the socio-cultural distance between the individuals involved, the intentions of incoming (groups of) individuals, as well as the openness/closedness of the resident group towards outsiders.

The literature on how interaction can unfold in contact situations is vast. In Figure 2 we have tried to summarise (in a vastly simplified way) some potential trajectories, formulating expectations of when either any incoming groups, or the local societies involved, or indeed both, may react to contact with either acceptance of mutual differences, conflict, or some form of assimilation. The power relationships involved are key here, with interactions both in a frontier situation and afterwards having a strong effect on whether ethnic distinctions are maintained or not (e.g. Hu 2013). This will also have an impact on how strongly any groups will want to mark remaining distinctions in material culture, and in what contexts we may expect to find them (see for example a short discussion of various models in Högberg 2015).

Part of the problem is also concerned with terminology – it is very difficult to talk about something we perceive to be in a constant state of change (such as 'culture') without implying essentialised categories (e.g. Sheller / Urry 2006, 212; Greenblatt 2010). Many of our terms, such as assimilation, acculturation, hybridity and so on, either make unwarranted assumptions about the possibilities of action for various participants, or quickly become so watered down that they lose any analytical sharpness (e.g. Silliman 2015). Nevertheless, in a recent contribution Matthew Liebmann (Liebmann 2013) has also argued that the consistent use of different terms can help sharpen our notions of contact situations, even though it remains hard to define in specific instances when a phase like 'contact' or 'influence' begins, and indeed, when it ends to be replaced by a new 'norm' – in itself open to challenges and change. In Liebmann's definitions for different kinds of cultural interaction (Liebmann 2013, 41), for example, 'hybridity' should be used where there is a clear power differential between the groups

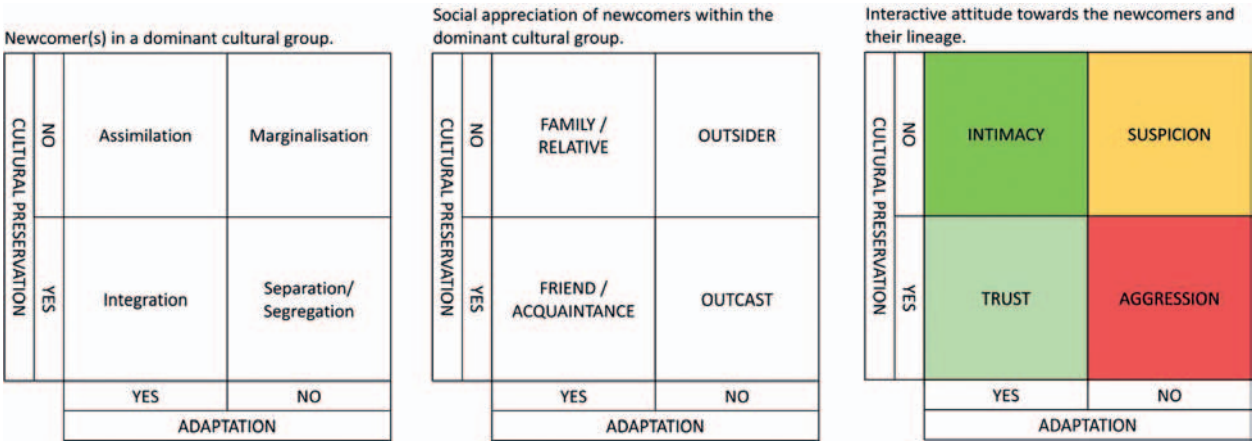

Fig. 2 Schematic representation of acculturation models (cf. Berry 1997) and related tendencies of social appreciation and interactive attitudes.

involved, and aims to stress the capacity for resistance or ambivalence in the adoption of new and perhaps dominant culture traits, for example in colonial settings. In contrast, 'mestizaje' (a term originally coined in a Spanish colonial setting of ethnic intermixing) focuses on the generative and creative aspects of encounters, and 'creolization' (a term borrowed from linguistics) should be reserved for diaspora contexts in which new forms of existence are being created from a common basis.

Bearing the above in mind, we have tried to connect frequently used terminology of acculturation (cf. Berry 1997) to social appreciation and interactive attitudes – in both directions – of the (groups of) individuals involved (Fig. 2). These are linked to the preservation of cultural traits of the incoming group (outsiders) and the adaptation (i. e. participation) of the incomers to the habits of the receiving or resident group. In a case of 'assimilation', incomers accept to abandon their own cultural values, and turn to a high degree of participation in the cultural habits of the receiving group. The incomers will be looked upon as full members ('family/relative') of the receiving group and interaction is based on intimacy; incomers' contacts with members of their own group are not based on origin/lineage. 'Integration' involves a situation where incomers maintain active contact with their own group/lineage, but show a high degree of participation in the habits of the receiving group. The incomers will be looked upon as friends/acquaintances of the receiving group, and interaction is based on trust. In contrast, when incomers maintain no/little contact with their own group/lineage, and also exhibit no/little participation in the habits of the receiving group, 'marginalisation' will occur. The incomers will be seen as strangers or outsiders, and interaction is based on suspicion. In a fourth scenario, 'separation' or 'segregation' occurs when incomers actively maintain contact with their own group/lineage and are not participating in the receiving group. Now, the incomers will be seen as outcasts, and interaction is generally aggressive, easily turning into conflict.

The above framework is, of course, very general, but just how the dynamics involved will work out in the distribution of culture traits at a population level, or indeed the further evolution of a society with multiple roots, is another question. This is a complex issue to address from a purely archaeological perspective, despite the fact that archaeology is (at least partly) concerned with the understanding of cultural dynamics. Some recent work addresses this from a computational modelling perspective (Drost / Vander Linden 2018; Erten et al. 2018), partly inspired by the pioneering work of the political scientist Robert Axelrod (Axelrod 1997). Based on their explicit model of acculturation, Erten et al. (2018) suggest that resident and immigrant cultures are more likely to stably coexist if residents are more conservative than incomers. Whilst there still is active engagement in cross-cultural interactions, these do not necessarily lead to the continuous spatial dissemination of culture traits, as the structure of the interactive environment is complex and returns non-linear dynamics (Axelrod 1997; Drost / Vander Linden 2018). It is, for instance, well possible that, within a process of increasing homogenisation of culture traits, 'pockets' of groups maintain a strong degree of cultural difference. Such pockets get isolated, which ultimately can lead to marginalisation or separation/segregation.

With the above outline of an initial reflective framework, we can start to think differently about how cross-cultural migrations and mobility may have influenced the dynamics of interaction both between hunter-gatherers and farmers, and within these coar-

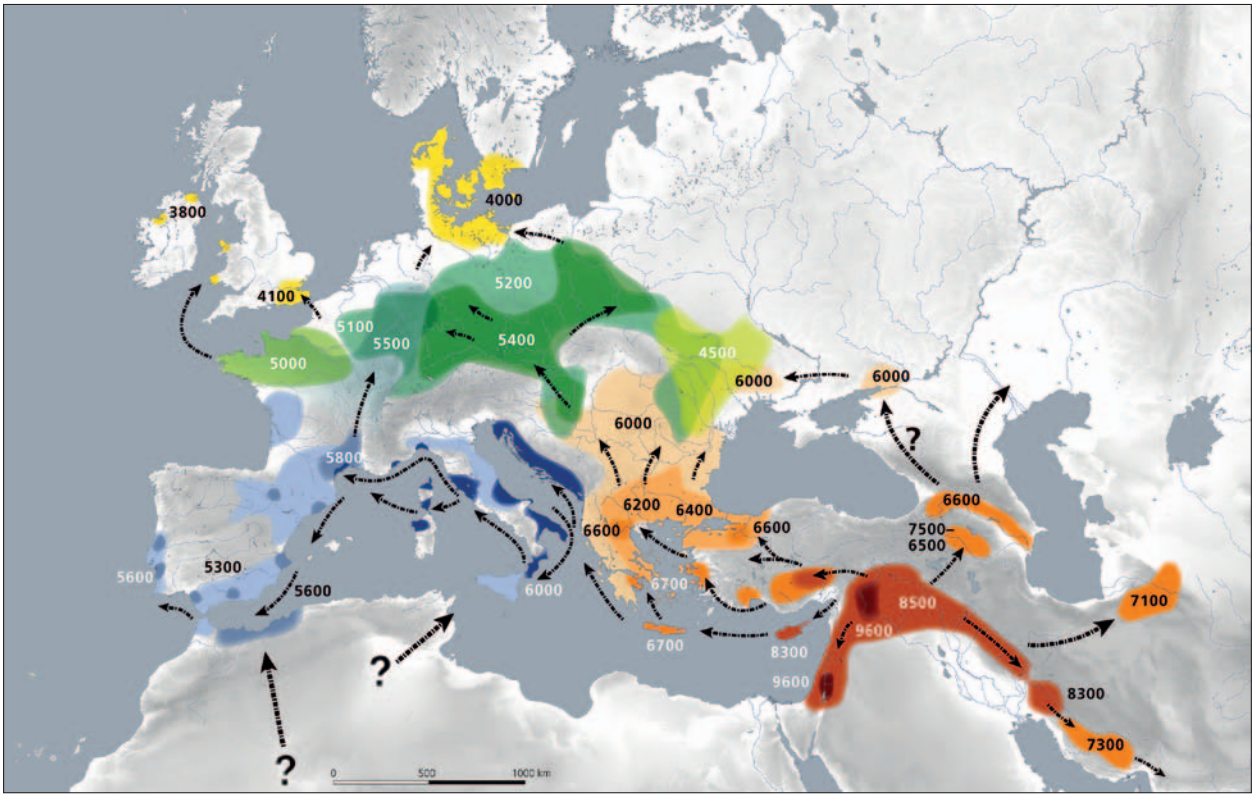

Fig. 3 Simplified map of the spread of agriculture in western Eurasia . The Linearbandkeramik is shown in green (image by D. Gronenborn / B. Horejs / M. Börner / M. Ober 2019 [RGZM/OREA], Creative Commons Attribution 4.0 International License).

sely defined categories. In the following sections we investigate the roles of mobility and migration in the 'sedentary' Neolithic communities of the LBK, and in two forager scenarios set in very different ecological and landscape settings, southern Scandinavia and the northwest European lowlands.

Migration and mobility in the LBK

As has been forcefully driven home by recent genetic evidence (e.g. Haak et al. 2010), the initial expansion of the LBK apparently did not involve substantial biological input from foragers (although there are a few individuals, see e.g. Nikitin et al. 2019). However, in the context of the present discussion, two facets of LBK society deserve to be drawn out. One is the potential for continuous mobility even in this allegedly 'sedentary' Neolithic society, more fully developed elsewhere (Hofmann 2016a; 2020). The other is how these mobility regimes and the permanent sites impacted the foragers with which LBK communities must in some way have come into contact.[1]

Movement and migration in the LBK: a constant

As we now know, the Earliest and Early LBK culture expanded rather rapidly across Europe (Fig. 3), although the precise date for its arrival in various regions remains debated (Jakucz et al. 2016; Strien 2017a; Bánffy et al. 2018). While the so-called 'Neolithic Demographic Transition' could have fuelled this expansion (Bocquet-Appel 2008; Shennan 2018), the reasons why settlers moved remain unclear. Given the large spatial gaps between Earliest LBK settlements, a largely prestige-driven migration is often argued for, in which those offspring not in line to inherit the farmstead were sent on costly and risky colonisation ventures, potentially taking place in a climate of competition between descent groups.[2] It is likely that forager populations could have persisted in the resulting large gaps, in particular if they used areas of the landscape which were not the prime targets of LBK settlers, for example river floodplains, uplands, or sandy or boggy areas. Indeed, the Late Mesolithic economy may have increasingly relied on fishing (Gehlen et al. 2017, 56–57).

1 For an excellent introduction to the forager background in central Europe, see Gronenborn 1999.

2 See e.g. Zimmermann et al. 2005; Fridrich 2005; Fiedel / Anthony 2003; Strien 2017b.

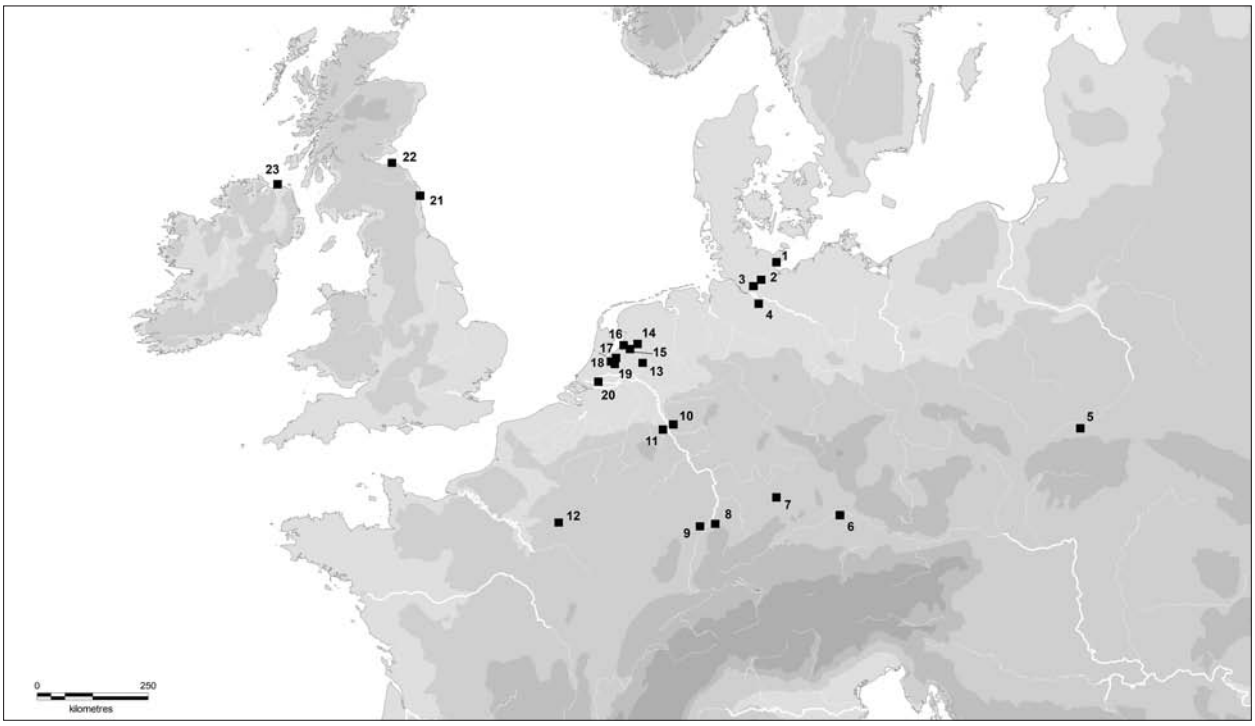

Fig. 4 Map of sites mentioned in the text. **1** Neustadt; **2** Schlamersdorf; **3** Kayhude; **4** Boberg; **5** Łoniowa; **6** Harting; **7** Marktbergel; **8** Vaihingen; **9** Herxheim; **10** Blätterhöhle; **11** Arnoldsweiler; **12** Cuiry-lès-Chaudardes; **13** Epse-Olthof; **14** Kampen-Reevediep / Hanzelijn-Hattemerbroek; **15** Dronten-N23; **16** Swifterbant; **17** Hoge Vaart-A27; **18** Baarn-Drie Eiken; **19** Soest-Staringlaan; **20** Hardinxveld-Giessendam; **21** Howick; **22** East Barns; **23** Mount Sandel.

In subsequent LBK phases, changes in domestic architecture and the appearance of cemeteries may have acted as alternative arenas for social competition (e.g. Sommer 2001; Cladders / Stäuble 2003). In addition, isotopic evidence connecting local origins and the possession of polished stone adzes in male graves across the LBK (Hedges at al. 2013), as well as differences in the intensity of care for agricultural plots at the site of Vaihingen in Baden-Württemberg (Bogaard et al. 2011; Fig. 4) have been linked into one model suggesting unequal access to land as a major factor in status competition. In other words, the importance of territoriality may have increased. Yet there are also indications that not everyone did, in fact, stay put. Relatively routine relocations of household groups could for instance be indicated by the fluctuating number of so-called 'yards' over the duration of longer-lasting and well-excavated sites (Fig. 5). Recent work at Arnoldsweiler (Balkowski 2017) has even identified a general settlement hiatus, while ups and downs in household numbers are evident across the Merzbach valley sequence and elsewhere (e.g. summarised in Hofmann 2016a). New sites continued to be established whenever the opportunity arose (see e.g. Pechtl 2011).

Such sites could even be founded in areas which did not correspond to the classically chosen loess lowlands. Instead, there is increasing isotopic evidence for what must have been entire communities settling in lower mountain ranges and sourcing a majority of their diets on non-loess soils (Nehlich et al. 2009; Turck 2019). Other LBK sites were located on small loess patches at higher altitudes (e.g. Knipper et al. 2010; summary in Zeeb-Lanz 2019, 458–460) or may have made use of upland locations for pasture (e.g. Valde-Nowak 2009; Beigl 2020). If this is shown to be a more general pattern, it could have made it more difficult for hunter-gatherers in some environments to survive alongside LBK communities. Still, there is evidence for such survival.

Forager-farmer interaction

Genetically speaking, foragers did not make up a large part of the initial Earliest LBK settlers, with a larger proportion of European hunter-gatherer DNA only reappearing later in the Neolithic (e.g. Beau et al. 2017; Lipson et al. 2017). This also applies to the isotopic non-locals at Herxheim (Blöcher et al. 2019), so that LBK upland use is not connected to Mesolithic ancestry. However, our evidence may still be biased. Large areas, particularly in the western part of the LBK (notably the Rhineland), where there are stronger archaeological reasons for presupposing hunter-farmer contacts, suffer from bad conditions

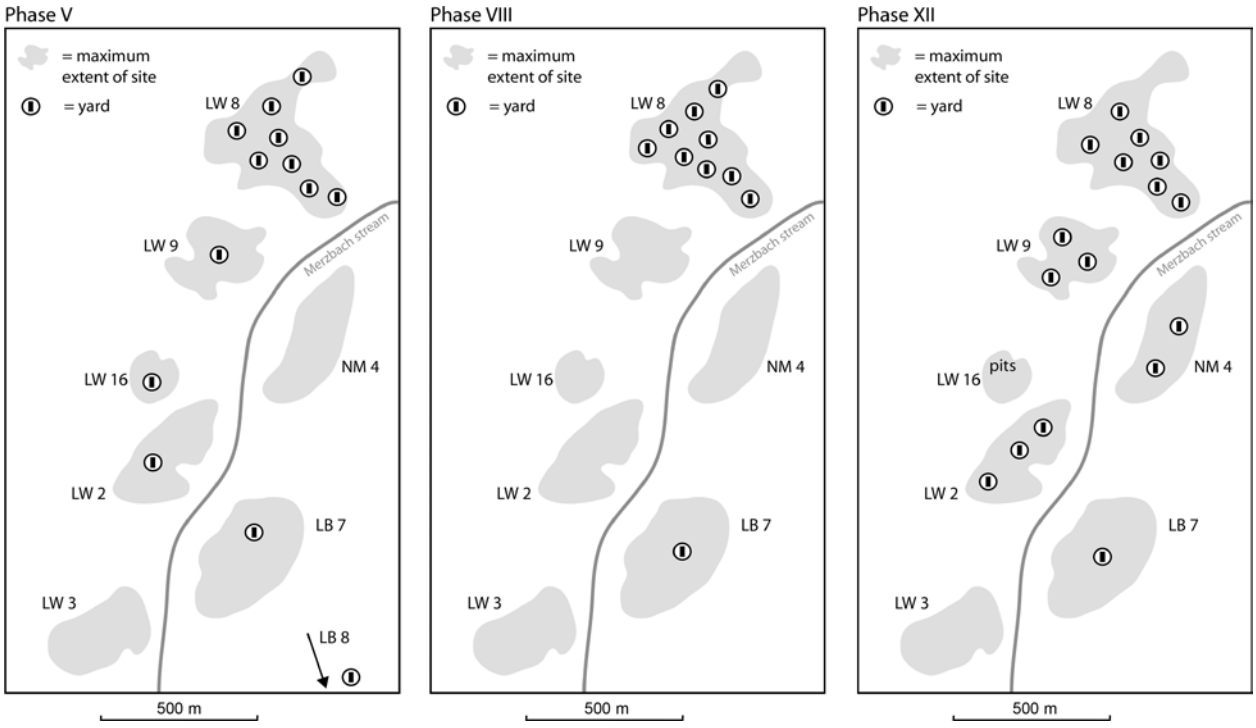

Fig. 5 Merzbach valley: Number of yards on sites in the middle Merzbach valley in phases V, VIII and XII. Location of houses is schematic. LW = Langweiler; LB = Laurenzberg; NM = Niedermerz (after data and base map in Stehli 1994, with corrections by Münch 2009).

for bone preservation, so that no genetic data are available. Identifying potential hunter-gatherer survival must thus rely on either the persistence of forager sites, or on artefactual evidence for contact.

Beginning with possible persistence, interesting data have come to light. While the isotopic indicators for a hunter-gatherer-fisher lifestyle reported for the Blätterhöhle in western Germany (Bollongino et al. 2013) post-date the LBK, and thus need not refer to the *continuous* presence of people of Mesolithic descent in the area, these findings lend new impetus to an on-going discussion centred on artefactual evidence. In the Rhineland, for instance, Mesolithic-style lithic and bone artefacts associated with 'Neolithic' absolute dates show that hunter-gatherers did persist for several generations after initial neolithisation (Banghard / Gehlen 2014). Similarly, burials in a Mesolithic tradition, but with Neolithic ^{14}C dates are known from Saxony (Stäuble / Wolfram 2013), while in the Czech Republic there are environmental indicators for continuities in landscape exploitation from Mesolithic into Neolithic times (Pokorný et al. 2010). Mesolithic societies also continued to coexist beyond the southern margins of the LBK for several centuries, and their networks were considerably impacted by the spread of the LBK (Jeunesse et al. 2019, 93–99). Yet evidence for sustained contact with LBK communities is very low. Gronenborn (2009) lists artefacts of possible hunter-gatherer origin found on LBK sites, including amber beads, harpoon heads and hunting bows. Even bearing in mind that much interaction may have involved organic 'forest products', the number of items is surprisingly low. Similarly, there is some evidence for LBK objects travelling beyond the loess into the north European Plain (e.g. Klassen 2004, 100–102, 105–108; Verhart 2012), but this increases substantially only after the LBK. Also, it is still being debated whether at least some such items may not actually represent forays by LBK people beyond the loess, rather than farmer-forager contact.

Studies of stone tool production sequences, in contrast, show that hunter-gatherer flint knapping traditions persist into the LBK in some areas (e.g. Löhr 1994; Mateiciucová 2008; Cziesla 2015, 237–260), where the lateralisation and degree of symmetry of arrowheads show consistent preferences between Late Mesolithic and Early Neolithic (although there are otherwise large changes in the toolkit, see e.g. Allard 2005, 237–239). Yet, even here it has been pointed out that the various 'Mesolithic' and 'Neolithic' indicators (lateralisation, knapping technique, raw material preferences, etc.) do not co-vary in such a way as to create two clearly defined, mutually distinct traditions (Crombé 2010; Robinson et al. 2010; 2013). Because the signal is essentially 'mixed', it has been difficult to find a coherent interpretation.

The persistence of hunting as an economic strategy, most extensively documented in the Paris Basin,

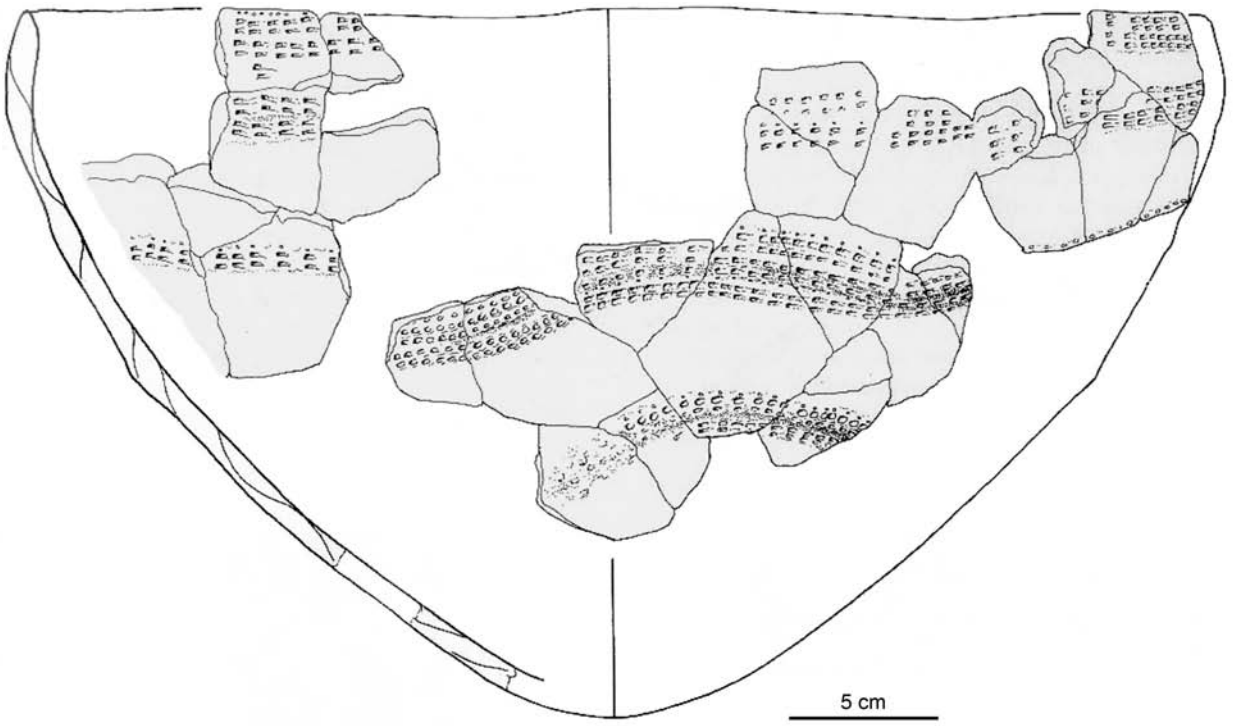

Fig. 6 The La Hoguette vessel from Choisey. This site lies outside the LBK distribution, but similar vessels have been found throughout the La Hoguette area (after Pétrequin et al. 2009, fig. 3; reproduced with kind permission of P. Pétrequin).

could be a further argument for 'Mesolithic' survivors. At Cuiry-lès-Chaudardes, shorter houses are correlated with a higher incidence of hunted animals, notably wild boar, while longer houses are associated with the herding of caprines or cattle. This distinction persists over several generations; interestingly, the shorter houses also have fewer cereal grinding stones, but a wider range of technological choices in pottery production (Gomart et al. 2015; Hachem 2018). They are thus overall somewhat less conformist. However, it is also evident that herding of domesticated animals and agriculture did play a substantial role in all houses, and the analysts explicitly reject the idea that there may be 'Mesolithic' residents at Cuiry. Instead, they point to the importance of various animal species in negotiating group, age or gender identity within the LBK itself (Gomart et al. 2015, 244–45; Hachem 2018). Again, then, it seems impossible to attach a straightforward 'Mesolithic' label to any axis of variation.

In contrast, non-LBK pottery found on LBK sites, most famously La Hoguette, Limburg and 'Begleitkeramik', is generally interpreted as being of forager origin, as it is also found outside the LBK distribution (see e.g. summaries in Manen / Mazurié de Keroualin 2003; Hofmann 2016b). The production sequence, vessel shapes and decorative motifs all differ from LBK wares (Fig. 6), further underscoring its divergent pedigree. The La Hoguette phenomenon is currently undergoing re-evaluation (Kirschneck 2020; 2021; cf. also Czieśla this volume),[3] but it already seems possible that the makers of both LBK and non-LBK pottery styles might have lived side by side in the same settlements (Fig. 7), with non-LBK wares particularly frequent around some houses (e.g. Gomart / Burnez-Lanotte 2012; Maletschek 2010). Yet the fate of non-LBK ceramics also differed over time. Initially, co-existence was short-lived: in areas east of the Rhine, such pottery is limited to Earliest LBK sites and quickly disappears. In contrast, west of the Rhine it remains present throughout the LBK sequence, diversifying over time and potentially even contributing some technological innovations to LBK pottery making, such as the use of new tempers (Hofmann 2016b; Kirschneck 2020; 2021).

Contacts across (internal) borders?

The evidence accumulated in recent years has not made it easier to understand forager-farmer interaction in the LBK area. Genetically, there was little admixture, certainly in the central and eastern areas which have so far been most extensively sampled. This means that behaviours which we classically would

3 In addition, a PhD centred on the portable XRF study of La Hoguette ceramics is under way at Ludwig-Maximilians-University Munich (Michaela Schauer).

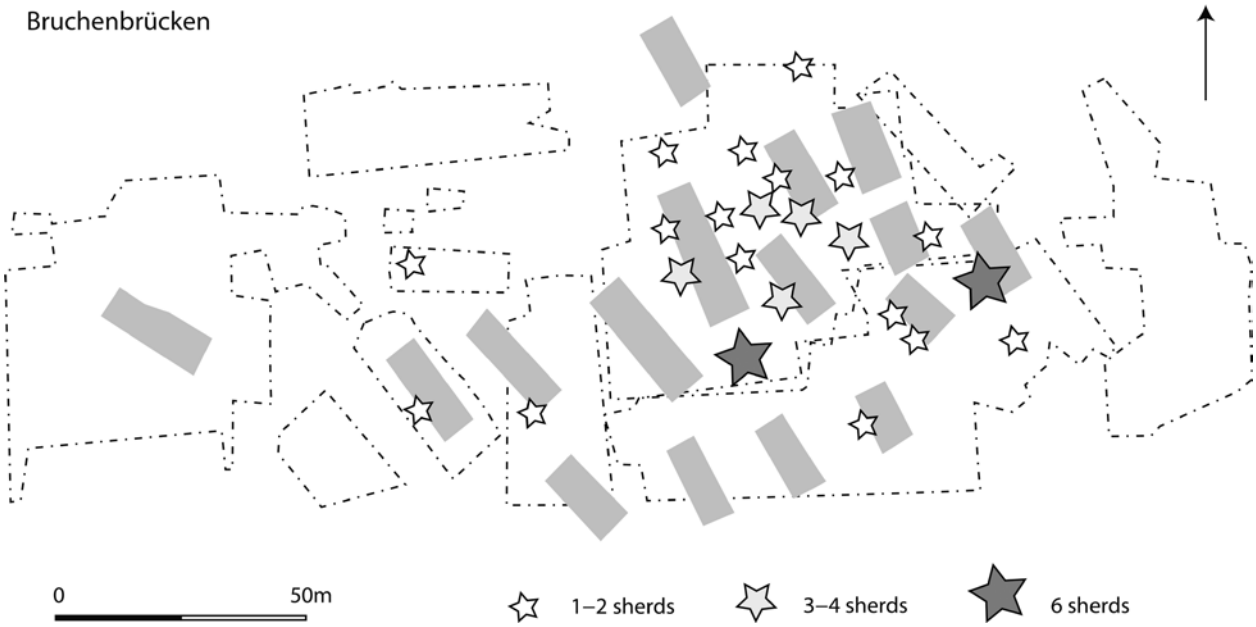

Fig. 7 Distribution of La Hoguette sherds around houses in Bruchenbrücken (after Maletschek 2010, 91 fig. 11).

have termed 'Mesolithic', and which have now been increasingly documented in LBK society – most notably considerable mobility at various social scales and a tendency to economic diversification – must be understood as related to the internal dynamics of these early farming societies in the course of expansion and consolidation. In many of these central and eastern areas, it would have been possible for hunter-gatherers to survive alongside the LBK, and the evidence is slowly being collected. However, interaction appears to have been reduced and was perhaps dominated mainly by suspicion. There may also have been more potential for conflict once LBK farmers increasingly used non-loess areas for their own needs, although this requires more concerted comparisons especially of Late Mesolithic exploitation patterns. Evidence from the LBK is also not unanimous here, with economic diversity apparently decreasing at Paris Basin sites over time (Gomart et al. 2015, 241), while the Herxheim isotopes (Turck 2019) indicate sustained use of uplands in the locally latest LBK phase. Still, if the later Neolithic resurgence of hunter-gatherer genes really is mainly fuelled by new population movements from western Europe (see Beau et al. 2017; Lipson et al. 2017), then the local central European hunter-gatherers were perhaps ultimately squeezed out.

The evidence from artefacts nuances this story. Persistent traditions in stone tool production and especially pottery manufacture indicate that there was coexistence, but that it varied chronologically. In the initial and rather more conservative expansion phases of the Earliest LBK, difference in pottery styles may have been actively suppressed to stress group cohesion (see also Sommer 2001), so that any makers of non-LBK pottery east of the Rhine soon gave up their own traditions if they settled on LBK sites. Later on, when LBK pottery was increasingly used to signal a variety of identities from personal to household and regional, there was social room for non-LBK pottery to persist, and for some limited fusion phenomena. The production sequences of Mesolithic-style arrowheads may have been less affected by these trends and are variable from the start. It is difficult to see how either of these patterns could have emerged without any direct contact between LBK and forager communities, even if this did not result in large-scale interbreeding.

In sum, the trajectories of hunter-farmer interaction in the LBK differed over time and regionally, as is to be expected in a situation in which very unlike, but dynamically evolving societies come into contact. Especially in central and eastern areas there is relatively little evidence for sustained acculturation from either side; instead, parallel societies and mutual circumspection may have been the order of the day in a context in which demographically dominant LBK communities tolerated little deviation in their own settlements. Further west, changing LBK dynamics perhaps allowed the persistence of forager ways of doing things, albeit within an economic framework dominated by farming. This similarly did not proceed on an even footing, but makes it more difficult (and indeed perhaps inappropriate) to draw up mutually exclusive and binary categories of identity, which would for example see all ceramics as emblematic

of 'Neolithic' and all hunting activities as related to 'Mesolithic' identities.

This model will need refining once more detailed studies are available for other LBK areas, and especially once chronological resolution in particular of post-neolithisation hunter-gatherer sites, within and beyond the LBK territory, is improved. But sharpening our theoretical models for interaction is undoubtedly also one of the biggest research challenges for the coming years. This in turn will require much more detailed knowledge of the historically situated ways in which hunter-gatherers inhabited and moved through landscapes, not only along the putative frontier itself, but also across and behind it on either side. This diversity is explored in the sections that follow.

Migration and mobility in the Mesolithic Low Countries

Mesolithic hunter-gatherers in northwestern Europe are still generally portrayed as 'whole-time food seekers', dependent on what the environment had to offer, and therefore organised in small and mobile groups (Zvelebil / Moore 2006). Holocene sea-level rise would have caused the loss of previously inhabitable land, followed by an increase of regionally variable population densities, increased sedentism due to a growing dependency on stable marine resources, territoriality and social complexity (Waddington 2007). Together, these factors are believed to have paved the path for the adoption of farming outside the LBK zone (but see Amkreutz 2013 for a far more nuanced model). One can, however, question whether this simplified one-directional cause-and-effect scenario fits the complexities of hunter-gatherer lifeways and their connection to the land. And as argued in the preceding section, one can question whether early farming communities were as sedentary and stuck to cultivated resources as many tend to believe.

Subsistence and wandering foragers?

Food is as critical to foragers as it is to early farmers – in fact to any living organism – and the main challenge was probably how to balance certainty and uncertainty in its supply. This will have been strongly related to the degree to which seasonal and annual availability was predictable (dependent on longer-term fluctuations), a factor foragers, as well as early farmers, had to deal with. In order to cope with uncertainty regarding food acquisition, foragers had to collect information about the distribution and presence of animal and plant resources. Clearly, animals are variably distributed in a landscape, having variable degrees of mobility and group behaviour. But also plants are variably distributed and occur in variable density, depending on a range of factors related to, for instance, climate conditions and the influence of animals, as well as humans. It is the symbiotic relationships between these 'agents' which will have characterised the qualitative and quantitative structure of the environment, and mobility is one strategy to monitor the situation which does not come as a given state of being.

As prehistoric foragers are generally portrayed to have had little influence on the environment, and as having been dependent on it, they are believed to have been living in more uncertainty than farming communities. This appears questionable, however, from several perspectives. There is ample ethnographic as well as increasing archaeological evidence for the manipulation of the environment by foragers through deliberate firing of vegetation zones.[4] It is a form of environmental management in which the manipulation of vegetation serves the purpose of managing animal and plant communities, and requires intensive cooperation between group members (Bliege Bird et al. 2016). Clearing land through burning is advantageous for the regenerative capacity of the environment, thus increasing predictability and decreasing uncertainty for its users. However, were access rights equally distributed, in other words, was there a degree of 'ownership'? And what would happen if incoming groups would want to use such land, for instance to settle and grow crops? After all, the burning of vegetation is also advantageous to improve soil fertility. Interactive attitudes may have been variable, and strongly dependent on how much room is given by resident groups to incoming groups to 'do their stuff'. Crop cultivation attracts game, and could therefore also form a basis for social integration of farmers in a forager-dominant landscape, or vice versa, integration of foragers in a farmer-dominant landscape.

The scale at which such practices occur – and might have occurred – is quite variable, however, ranging from small localised patches to vast areas. Simmons (1996) argues for an anthropogenic drive in the creation of moorland landscapes in England and Wales. However, evidence from Mesolithic northwestern Europe suggests that such 'fire ecology' was mainly of a local nature, and too short-term to support structural (i. e. measurable) changes in the vegetation on a

4 See e. g. Mellars 1976; Simmons 1996; Bos / Janssen 1996; Dark 1998; Bos / Urz 2003; Bird et al. 2016; Sevink et al. 2018.

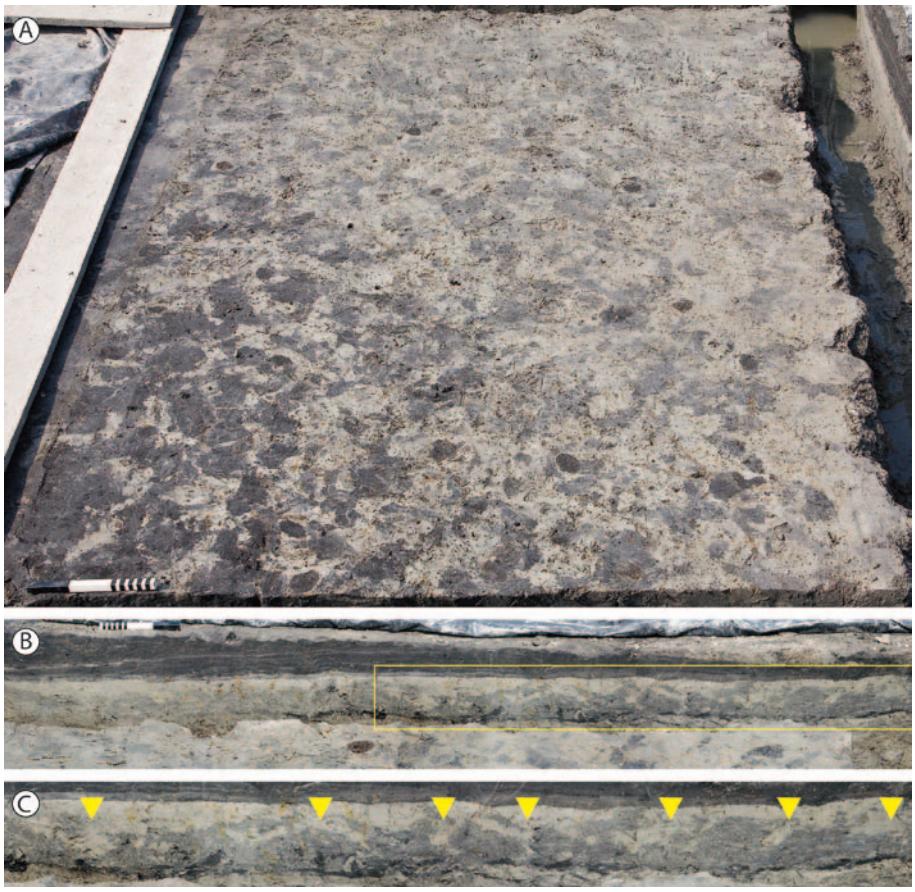

Fig. 8 **A**: Plane view of the tilled horizon at Swifterbant-S4. The patterning of dark- and light-grey patches is interpreted as tillage marks made with some sort of hand tool. **B**: Photograph showing a more or less regular pattern of tillage marks that become increasingly vague towards the left of photograph. The dark layer on top is the lower part of a midden deposit. Square indicates image C. **C**: Detail of B, with tool marks indicated by triangles (after Huisman / Raemaekers 2014).

regional scale.[5] But even when 'swapping' from one place to another, the repetitive occurrence of burning events suggests that hunter-gatherers did influence the environment on a structural basis. In fact, the small scale at which this appears to have occurred is not that different from what we see for wetland horticultural practices in the Neolithic Swifterbant culture. Palynological evidence for cereal cultivation is sparse (Bakker 2003; Out 2009; Talebi et al. 2019), despite the fact that emmer and naked barley appear to have been cultivated on a regular basis on clayey levees in the Netherlands, as shown by the presence of charred grains at the majority of Swifterbant sites (Cappers / Raemaekers 2008), and indeed the fields themselves (Fig. 8; cf. Huisman / Raemaekers 2014).[6] Apparently, the palynological signal is diffuse and localised, suggesting repetitive, but rather short-lived cultivation on small plots – 'events' on the archaeological timescale, if you like. It is therefore perfectly imaginable that firing practices by foragers, and clearing of plots by farming groups occurred simultaneously within given parts of the landscape. It might involve a context of integration, not necessarily assimilation.

As a whole, the representation of subsistence strategies among Mesolithic foragers – and early farmers – in northwestern Europe is arguably oversimplistic, and based on coarse-grained ethnographic models and assumptions with respect to the determining role of the environment. Stable isotope data from Mesolithic and Neolithic human remains from the southern North Sea and the Netherlands, for instance, demonstrate that fresh water resources (notably fish) provided a major part of the diet, and this remained the case even when dwelling sites were on or very close to the sea shore (Smits / Van der Plicht 2009; Van der Plicht et al. 2016). Indeed, zooarchaeological evidence for the exploitation and consumption of fully marine resources is sparse at best, and only really shows up in the archaeological record in the region's Late Neolithic (3rd millennium cal. BC) – agricultural practices were firmly in place by then, but paired with hunting and gathering – with evidence for the fishing of cod longer than 1 m and other large marine fish species such as haddock (Zeiler / Brinkhuizen 2013).

5 Bos / Janssen 1996; Bos / Urz 2003; Peeters et al. 2017; Sevink et al. 2018.

6 There is, however, growing evidence from micromorphological research that crop cultivation in the Swifterbant culture was common in various parts of the Dutch wetlands. Just how this should exactly be understood, also in the light of palynological evidence, is a topic of current research (pers. comm. Prof. H. J. Huisman, 13.12.2019).

This possibly reflects a rather late change in technological choices, where the tradition of trapping fish by means of funnels and weirs remained dominant. Indeed, several strategies may have been in place simultaneously. For the exploitation of staple food resources, confirmed ('Cartesian'; cf. McGlade / McGlade 1989) strategies were applied to ensure a reliable supply, whereas the exploitation of uncertain or new resources – marine? – may have required more risk-taking ('stochastic'; cf. McGlade / McGlade 1989) strategies. In sum, the sea did not play an important role in the adoption of farming here, and the contrast between lifeways is much reduced compared to the LBK. This diminished gap combined with important degrees of mobility likely had a big influence on historical trajectories here.

Mobility as a social factor

The gathering of information about food resources can be considered crucial for foragers. To achieve this, movement (mobility) is of great importance. Despite the fact that mobility is a central and traditional aspect in hunter-gatherer studies, archaeologically we know very little about this as yet. Ethnographic insights demonstrate that the spatial scale of movement and hence knowledge about the environment can be vast. Indigenous people in southern Labrador, for instance, have knowledge about terrain as big as southeastern England, the southern North Sea, the Low Countries, and northwestern Germany taken together (Fig. 9; Lovis / Donahue 2011). In northern Quebec, equally large swathes of land are viewed as their 'home' by the indigenous Cree (Carlson 2008). In fact, movement or travelling is essential to collect information and to 'be home' (Aporta 2009; 2016). Mobility forms the basis for knowledge, while at the same time it creates and maintains historical ties with the land, ties which are anchored within a community through the sharing of knowledge and story-telling (Minc 1986).

Indications for long-lasting spatial structures in the Dutch part of the Mesolithic landscape are found in the centennial to millennial time-depth of hunter-gatherer visits to particular places (Peeters 2007). At vast sites like Dronten-N23, Hanzelijn-Hattemerbroek, Kampen-Reevediep, Epse-Olthof and Hoge Vaart-A27, chronological evidence based on hundreds of AMS-dates points to hunter-gatherer activity covering time-spans of several hundred to three thousand radiocarbon years.[7] Clearly, this does not involve continuous occupation, but rather a repetitive, short-term use of such locations for various activities over many generations. The AMS record actually represents a sequence of 'events'. What is important here is that the record always shows continuity and discontinuity of activities over this long-term scale (Peeters 2009). There will be time windows when activities associated with flint knapping are 'synchronous' with the use of pit hearths – a phenomenon particularly known from the northern Netherlands and adjacent parts of Germany (Niekus 2006; Peeters/Niekus 2017; Peeters et al. 2017) – followed by a time window in which only the use of pit hearths seems to occur. There are indications that some geographical differentiation is present. In the eastern Netherlands, activity of Early and Middle Mesolithic foragers is well represented in the archaeological record, both in radiocarbon dates and flint technology. However, the Late Mesolithic and Early Neolithic in this region is only sporadically represented by flint artefacts (isolated trapeze points and punched blades), whilst radiocarbon dates of anthropogenic phenomena (pit hearths; worked wood and antler; small pits which might result from the extraction of aquatic tubers/plant roots) suggest continued presence of hunter-gatherers (Peeters et al. 2017). Elsewhere, in the Swifterbant region for instance, Late Mesolithic and Early Neolithic flint technology is far better represented. Apparently, some shifts in where in the landscape certain behaviours were carried out may have occurred at a regional and long-term scale (Peeters 2007; 2009), which may have implications for mobility patterns.

The patterning in the archaeological evidence indicates highly structured forager landscapes, in which places and landscape zones were connected through networks of trails. Their distribution was not random, although initially the emergence of spatial structures may have been driven by random self-organising processes (Mlekúz 2014). The choices made by individuals and groups of hunter-gatherers were driven by experience and shared knowledge. Hunter-gatherers did not assess landscapes from a 'helicopter' perspective, sorting out the optimal conditions for the exploitation of those landscapes. But also and maybe more importantly, mobility occurred within a particular socio-cultural setting. This does not just include the co-presence of people and animals, but also deep, mythological ties to the land. Many rules

7 Peeters 2007; Lohof et al. 2011; Hamburg et al. 2012; Hermsen et al. 2015; Geerts et al. 2019.

Fig. 9 Map of southeastern Labrador, Canada (after Lovis / Donahue 2011). The depicted area is about as big as eastern England, the southern North Sea, the Netherlands, Belgium, Luxemburg and bordering parts of western Germany together. **Top**: System of rivers and lakes drawn by native American Mathieu Medicabo. It demonstrates the mental structuring of knowledge about landscape in connection to waterborne travels. **Bottom**: Geographically corrected map of the same area.

of spatial behaviour are linked to beliefs about how the world of the living is influenced by spirits in the underworld, associated with death, and the upper world, associated with birth (see e.g. various papers in Jordan 2011).

The connection between people and land will have been strong and decisive for what socially was done and not done. The question, then, is what happens when such a connection is under stress, perturbed or disrupted? Climate-driven change, which is often referred to as a major drive behind behavioural change during the postglacial period, did have an influence on the composition and distribution of food and other resources, and this affected exploitation strategies and technology. Yet one can wonder whether this also impacted the relationships between people and the land. Great importance may particularly have pertained to those changes which occurred rapidly, within an individual's lifespan or within two to three generations. For the Mesolithic of the Low Countries, the drowning of Doggerland is a factor to bear in mind, although much of it involves slow long-term change (Sturt et al. 2013). However, the archaeological record from the Netherlands shows some patterns which might relate to more abrupt environmental impact in the 8.4–8.1 ka cal BP window, during which several events occurred within a short time. The Storegga landslide triggered a tsunami, which had some impact on the Dutch Mesolithic coast, but a rather restricted one compared to eastern Scotland and England (Weninger et al. 2008). More or less around the same time, a sea-level jump, related to the drainage of Lake Agassiz in the Hudson Bay region, led to a sudden – possibly even within a couple of months – increase of the mean sea-level in the order of 1.5 m to 2 m, on top of the structural sea-level rise of about 2 m taking place in this time window of about two centuries (Hijma / Cohen 2019). At exactly this point, a hiatus seems to be present (Peeters et al. 2015) in the body of radiocarbon dates available for the Rhine-Meuse estuary. Several sites (Dronten-N23; Kampen-Reevediep; Hanzelijn-Hattemerbroek) further inland also appear to show a corresponding 'break' in just that time window. Whether this is related to temporary migration of forager groups is not clear, but it is possible that these patterns echo some sort of disruption, e.g. with regard to historical ties between people and the land due to changing geographies, thus affecting what hunter-gatherer groups considered to be their 'home' (compare e.g. Leary 2015). After this phase, flint technology is typically dominated by large punched blades – a novelty – and broad trapeze-shaped points. Something seems to have changed in the socio-cultural sphere, possibly due to newly established relationships with the landscape and altering mobility patterns as well as interaction with other groups. Changes in interaction might have involved contacts between groups who did not have any previous relationships, or altering relationships between groups who already were in contact.

Dwellings, mobility and contacts

The drowning of Doggerland is also said to have caused a decrease in mobility and social change (Waddington 2007). This hypothesis is largely based on the absence of punched-blade technology and the occurrence of heavily built dwelling structures discovered on the British side of the North Sea, e.g. at Howick, East Barns and Mount Sandel, all pre-dating the 8.4–8.1 ka cal BP time window. In the Netherlands three comparable structures are known to date from Baarn-Drie Eiken, Soest-Staringlaan and Kampen-Reevediep, also pre-dating the 8.4–8.1 ka cal BP time window (Peeters 2007; Geerts et al. 2019). This suggests that at least for some time before the major impacts in the North Sea basin, sturdy dwelling structures were built by foragers. But whether this corresponds to a more sedentary life remains the question, also because such structures may have been common in earlier phases of the Mesolithic as well, but may be victims of the data gap in the southern North Sea area, which is hiding large swathes of the Early and Middle Mesolithic landscape (Peeters / Momber 2014).

The idea that Mesolithic hunter-gatherers were exclusively living in lightly built dwelling structures may thus be nothing more than a conceptual fallacy. Heavily built dwelling structures may well also have been common in the forager landscape, and integrated in a mobility system covering vast regions. Similar structures dating to the Neolithic are in contrast easily equated with permanency and sedentary lifeways. However, in later Neolithic times 'houses' are often quite flimsy, most certainly in the Dutch wetlands (Nobles 2016). But what do we actually know about mobility among Neolithic groups? Why do we find scattered distributions of artefacts we associate with the Neolithic without evidence for dwelling structures? Without dismissing the possibility of differential preservation, could it be that Neolithic groups were in fact more mobile than we assume? Movement, after all, is essential for the establishment and maintenance of contacts between individuals and groups.

Fig. 10 Flint artefacts from the early Swifterbant context of the site Hoge Vaart-A27. These artefacts stand out from the flint assemblage counting over 30,000 pieces >1 cm.
(**a, b**) Large flakes of banded Falster flint. Falster flint is otherwise lacking in the assemblage, and the cortex shows weathering which is untypical for occurrences in Saalian till deposits in the Netherlands.
(**c**) Medial part of an exceptionally regular and long blade (remaining length 48 mm) made out of fine-grained Scandinavian flint. The blade derives from a highly controlled process focussed on the production of long, regular blades and use is made of high-quality flint. In the Netherlands there exists no evidence for the production of such long blades, and this is the only one found in the entire assemblage.
(**d**) Broken blade (remaining length 50 mm) of banded Scandinavian flint. Although this type of flint occurs more often in the assemblage, no further pieces have been found showing the distict transparent band.

Typically, the occurrence of isolated 'Neolithic artefacts' at 'Mesolithic sites' – notably at Hardinxveld-Giessendam De Bruin, Swifterbant, and a range of Mesolithic sites with containing incidental 'Michelsberg items' – is easily interpreted in terms of contact between Neolithic farmers and hunter-gatherers (Verhart 2000; Louwe Kooijmans 2001). Isolated 'Mesolithic artefacts' at 'Neolithic sites', however, are mostly interpreted as background noise, merely representing scraps of earlier occupations. Why could such finds, both on Mesolithic *and* Neolithic sites (Fig. 10), not echo established social relationships, which might very well have developed variable forms of cultural coexistence?

Obviously, contacts between foragers and farmers did exist in the Low Countries, as elsewhere, but just how this led to new socio-cultural structures is an issue that needs to be approached from a social perspective. Hunter-gatherers and early farmers were part of a world more integrated than we (still) tend to assume. People with (partly) different lifeways knew each other, and maintained social relationships in one way or another. The nature of these relationships, and the attitudes and interactions involved, will have gradually changed, potentially leading to 'social flow' and permitted experimenting with, and acceptance or rejection of novelties in both directions. Amkreutz (2013) has expressed this process in a model of 'attunement',

which involves the implementation of new (Neolithic) elements in existing structures through acquaintance and integration. The embedding of novelties, such as cereal cultivation and animal husbandry in the Dutch wetlands, did not necessarily imply the full change of habits. In fact, the archaeological evidence strongly suggests that many aspects of 'traditional' lifeways persisted throughout the greatest part of what we call the Neolithic, and most certainly with regard to the food economy (see e. g. Louwe Kooijmans 2007; 2009). Other aspects changed, such as the abandonment of pit-hearth technology, which chronologically coincides with the appearance of ceramic vessels at the Mesolithic/Neolithic chronological boundary. Other changes involve a shift from blade-based to flake-based flint technology and corresponding shift from trapeze-shaped to transversal points in the Late Swifterbant / Pre-Drouwen / Funnel Beaker (Trichterbecher, TRB) phase, the shift from small-scale to (somewhat) larger and associated technology in the TRB/Corded Ware, as well as fishing in fully marine environments by people of the Corded Ware. But none of this will have come without a continuous flow of interaction between individuals who most probably just partly shared cultural traits and beliefs. In the end, all this depends on the extent groups want to preserve their culture, and wish (and/or are allowed) to actively participate in the practices of the other.

Migration and mobility in the Ertebølle culture

In contrast to the Low Countries, late foragers in southern Scandinavia and northern Germany are generally thought to have been much more sedentary. This development is linked to the consolidation of the Baltic coast during the last centuries of the Mesolithic, which produced varied coastal landscapes rich in stable resources (Schmölcke et al. 2006). Despite evidence for contact with LBK and later farmers, the northern hunter-gatherers did not leave a visible biological imprint within the following populations, so migration as a driving factor behind the neolithisation process has recently retaken the stage (Gron / Sørensen 2018). There are not many genetic studies directly involving Ertebølle human remains, but analyses of individuals from later periods in Scandinavia and the overall palaeogenetic picture confirm that the development of the Neolithic can be attributed at least partly to migration from the south and movement between different population groups (see e. g. Skoglund et al. 2012; Brotherton et al. 2013; Malmström et al. 2015).

In one influential model, neolithisation in northern Germany and southern Scandinavia was explained through a 3-stage-process of contact/availability, adaptation/substitution and consolidation based on the contact situation between Ertebølle and the neighbouring farming groups. These contacts are supposed to have made the diffusion of 'Neolithic' ideas and technologies possible and led to the adoption of a Neolithic mode of subsistence (Hartz et al. 2007, 587–588, adapting Zvelebil / Rowley-Conwy 1984).

The picture presented by Gron / Sørensen (2018) is also one of varying stages of contact, negotiation and homogenisation between foragers and farmers, but relies more heavily on the influx of migrating settlers. In this model, hunter-gatherers play the dominant role in taking up new practices established by incoming settlers in a process of learning how to farm. The model allows for different regional developments and alternating patterns of continuity and change, but still remains generative by focussing on process outcomes, instead of the actual mechanisms of interaction. Effectively, this is about incoming farmers 'teaching' apparently willing foragers new practices, and thus represents yet another top-down way of thinking. Despite attempting an overall explanation of the situation at the beginning of the northern Neolithic, the model argues from a distinctively southern Scandinavian perspective, whereas the first contact between hunter-gatherers and farmers might well have occurred in the southernmost areas of the Ertebølle region, in northern Germany. As will be shown below, the northern German Ertebølle differs slightly from its Danish counterparts, which is an important consideration when assessing the mechanisms behind contact and migration. Also, to better understand how Ertebølle people may have been coping with an influx of (possible) strangers, and why they may have been willing to interact, one has to take a look at the last centuries before as well as after the Neolithic turning point.

The last hunter-gatherers and the first farmers: contact, exchange, movement?

The youngest Ertebølle culture is supposed to be an exceptionally stable phenomenon, which, in the form of a 'complex' society, shares certain traits with its Neolithic neighbours. Here we supposedly have (semi-)sedentary hunter-fisher-gatherers on the Baltic coastlines, who are highly territorial and hierarchical, employ elaborate fishing and hunting technologies, produce pottery and know how to store food and

manage resources (Klassen 2004; Andersen 2010; Hartz / Schmölcke 2013; Klooss 2015). Ambiguously, these characteristics are said to have created a certain 'resistance' against 'Neolithic' influences, whilst at the same time presenting the preconditions for the development into a fully Neolithic society (Rowley-Conwy 2001, 56–58, 62; Finlayson / Warren 2010, 84–85, 94–97). In any case, Ertebølle was not an isolated phenomenon – from the start, contacts with other regions are visible (Hartz et al. 2007, 578–579, 587). These increase over time, which is suggested by the rising number of 'Neolithic' objects in Ertebølle contexts (see Klassen 2004 for a summary). Contact with the regions from which subsequent migrating settlers presumably came was therefore established well before the first incoming individuals can be traced in the archaeological record.

The question remains in how far mobility was an accepted and/or a common strategy within the Ertebølle context and what form it took, apart from (probably common, see below) seasonal movements between different resource areas. Apparently, 'foreign' objects reached northern Germany and southern Scandinavia, but did (foreign) people travel with them as well? Klassen (2004, 262–267) explains the presence of such objects as down-the-line exchange, but even then Ertebølle people must have come in contact with other, non-hunter-gatherer individuals at their immediate periphery. A similar situation may have pertained between forager groups, considering that pottery in the Late Mesolithic in the southwestern Baltic points to contacts with the eastern Baltic (Povlsen 2013; Piezonka 2015).

Overall, then, Ertebølle communities may have been generally open to innovations or exotic items, and individuals may have travelled quite far to obtain them, thereby establishing social relations beyond their own sphere. While Sørensen (2013, 12–13, 15–16) argues in favour of a cultural dualism during the earliest Neolithic and implies that some (if not most) imported objects were brought to the North by actual immigrants, it seems well possible that Mesolithic hunter-gatherers travelled longer distances into 'farming country' to establish and maintain contact and trading networks. This helps us break up the top-down approaches, which see hunter-gatherer groups as simple 'receivers' of Neolithic goods and ideas.

The increasing number of 'imported' items is interpreted as a rising demand for status display (e.g. by Klassen 2004) as well as intensified contacts. Altogether, the interpretation of foreign objects as symbols of prestige or status (see also Verhart 2000) tends to be highly influenced by our modern-day western view that things which come from afar are exotic and special, as well as selective ethnographic analogies. Considering the Ertebølle culture, most of the imports are single and/or surface finds, so their context remains unknown, but they are not, for instance, associated with particular individuals or buildings. Klassen (2004) still favours an interpretation as prestige objects, although some of the imported axes show traces of heavy wear and intensive use (Klassen 2004, 258–259). Looking at the Ertebølle culture in general, there seem to be few indicators of pronounced social inequality. The motives behind the increasing demand for Neolithic 'prestige' objects (if they are such) therefore remain somewhat in the dark, as do the reasons why apparently only Neolithic stone objects reached the North in larger quantities. It is possible, of course, that as the most durable goods were stone tools, other kinds of exchange goods are simply not preserved. As yet, we cannot judge whether the increasing numbers of foreign objects represent an already intensified influx of migrating people or simply intensified exchange on both sides. In this context it is equally possible to think of hunter-gatherers travelling south, east, or west to obtain the desired objects, either for social or practical reasons.

Another question is whether the eventual incoming settlers found a densely and permanently populated area or (seasonally) empty forests. Widely known settlement models by Andersen (1995; 1994/1995) and Fischer (2003) suggest that there were more or less permanent (sedentary) settlements along the Baltic shores, whereas the hinterland and interior regions were only exploited temporarily and seasonally in the form of short and specialised occupations. These models have recently been reworked by Johansen (2006), who argues for a cyclical rotation between different settlement areas, during which large coastal camps and smaller sites of varying functions were used repeatedly. A recent re-evaluation by Andersen (2013) also argues for a semi-sedentary lifestyle (cf. Bergsvik 2001), where hunter-gatherers stay put for several months and return to that location over the course of several years (Fig. 11). At least for Denmark, the most intensively settled areas were on the eastern shores, fjords and bays.

In contrast, for northern Germany, a high degree of sedentism seems debatable. Several large settlements are known on the eastern coast of Schleswig-Holstein (see e.g. Hartz 1999; Grohmann 2010; Glykou 2016) and Mecklenburg-Vorpommern (see Lübke 2005 for an overview). In addition, the inland areas of the Trave and Alster river valleys, as well as the Hamburg region, seem to have been much more intensively settled (Fig. 12) than the Danish interior, where we encounter

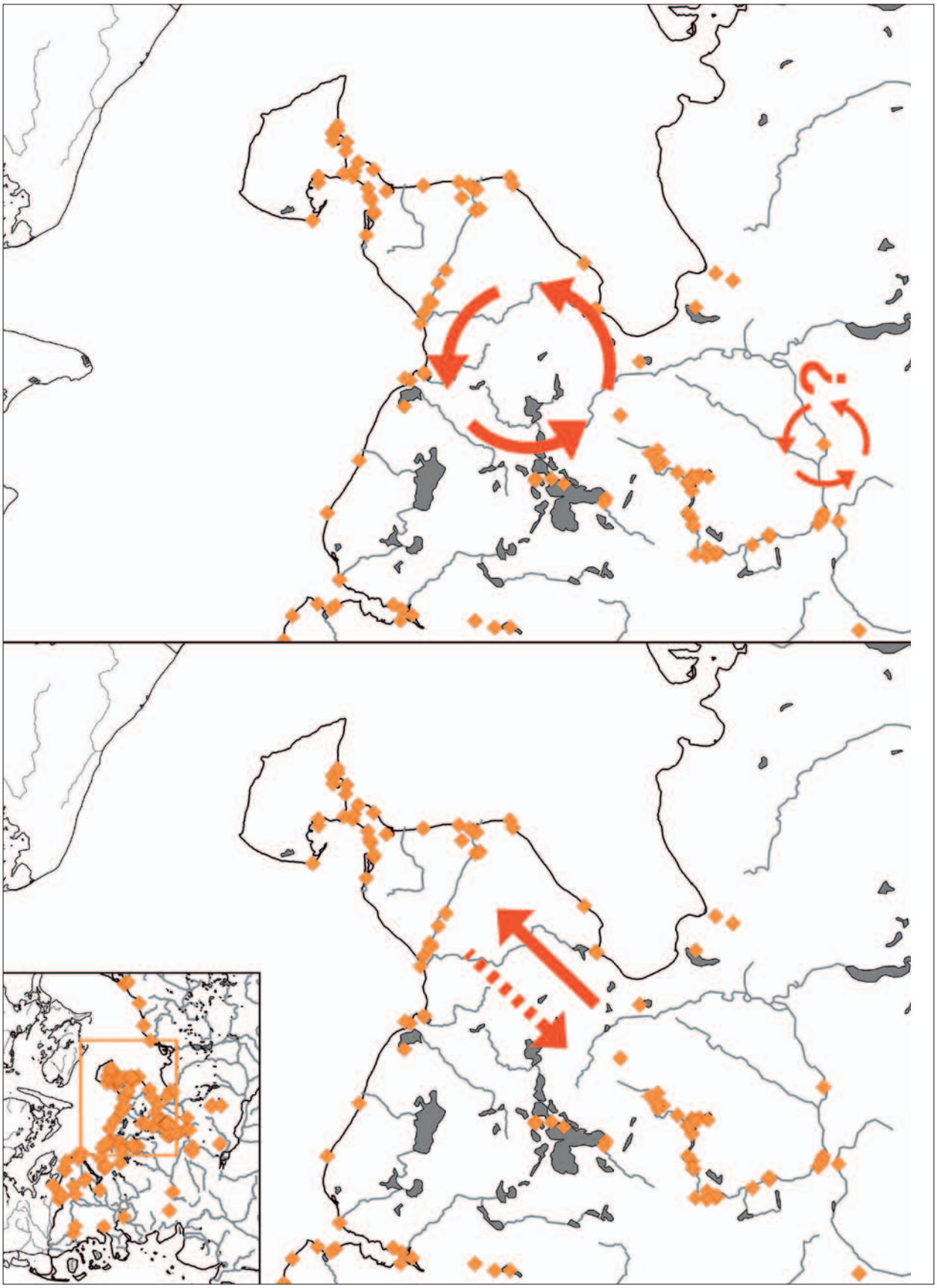

Fig. 11 Illustration of different settlement models. Andersen (1994/1995; 1995) and Fischer (2003) argue for more or less permanent settlement base camps along the coastlines which are complemented by functional (seasonal) resource extraction camps in the interior and hinterlands (illustration on the bottom). This model applies mainly to the Danish coastlines. Johansen (2006) favours a model of cyclical rotation between different settlement localities which can be used repeatedly over several years (illustration on the top). In the case of Schleswig-Holstein, this explanation seems reasonable, but it remains unclear if there were solely inland based settlement systems of this type as well.

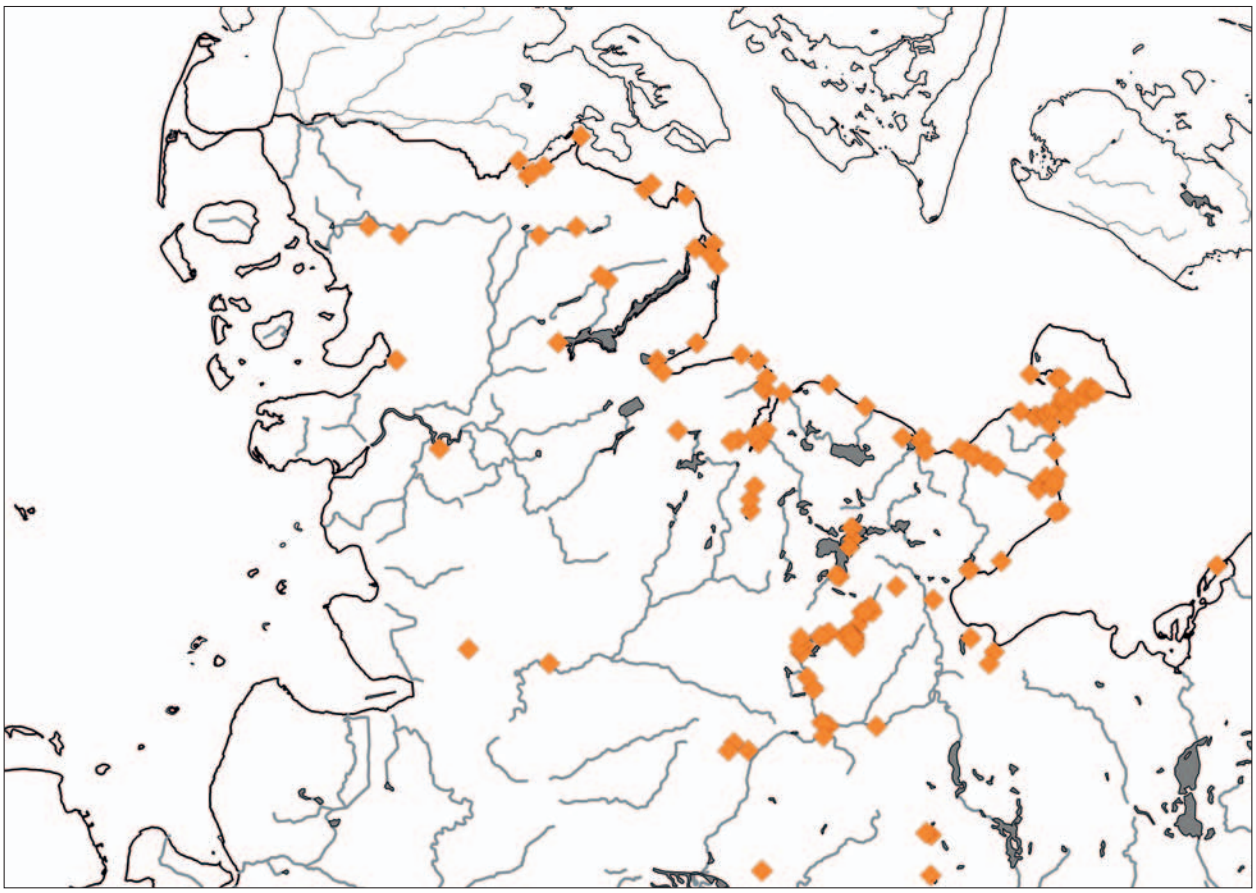

Fig. 12 This map depicts all known (and suspected) sites and single finds of Ertebølle character in Schleswig-Holstein (data provided by the Archaeological Museum of Schleswig-Holstein / Schloss Gottorf). The density of find spots in eastern Schleswig-Holstein is in stark contrast to the western regions, from which there is only little evidence for a Late Mesolithic occupation. Additionally, there are surprisingly many sites in the eastern interior and hinterland where finds cluster along the (former) lake and river systems.

mainly the small and short-lived functional camps anticipated by Andersen (1994/1995). Examples for a medium-intensity and even repeated use are provided by the sites of Schlamersdorf LA 05 (Meyer 2017), Schlamersdorf LA 15 (Meyer in prep.), Kayhude LA 08 (Clausen 2007; Meyer in prep.) and the Hamburg-Boberg complex (Thielen 2017). These sites do not reach the extent of the coastal ones, but they also have only little in common with the small flint scatters of the Jutland coastal and interior functional camps.

The evidence in Schleswig-Holstein suggests a settlement pattern in which small groups of people moved frequently along the lakes, and inhabited their shores for rather lengthy periods of time to make wide use of the available resources. As yet, it remains unclear if they travelled between the coast and the lakes (in short-distance cases this seems very likely), or retained an inland settlement cycle among the eastern lakes, or between those and the interior further south. It has to be taken into account that, unlike the situation in Denmark, the German coast was not always easily reached. In general, the main problem seems to be with the term 'permanent settlement' in itself. One has to ask how long even rich and stable coastal resources can actually support a large Mesolithic group before they become depleted.[8] If we take the existence of possible social territories into consideration as well, it is likely that groups occupying the southern 'borderlands' spent most or all of their time inland. Here, a certain 'permanent mobility' is implied, rather than fixed semi-sedentary habitation areas, also given the nature of inland resources which are usually considered less rich or stable than coastal resources (e.g. Bailey / Milner 2002/2003). In this respect the extensive research on complex hunter-gatherers and

8 These considerations naturally depend on group size. Unfortunately, information on this remains vague – Andersen (2001, 69–70) proposes a total number of 5,000 individuals for Denmark during the Final Mesolithic (with no specification for either the Early or Late Ertebølle period), while assuming increasing group sizes in the Late Ertebølle period (Andersen 1995, 48). Karsten / Knarrström (2003, 212) propose a population density of 0.2 individuals per km^2 in Final Mesolithic southern Sweden. The correlation between population growth rates and depletion of resources is an important factor when considering how long a single location can support a group of varying size.

coastal resources might have led to a generalised expectation of 'sedentariness' in these contexts. In case of the Ertebølle culture this clouds the view so that settlement dynamics as well as habitation areas away from the coast are often overlooked.

It can thus be concluded that the degree of mobility within an existing settlement and subsistence pattern varied within the Ertebølle region. And although we can trace in which way landscapes and different environments might have been exploited, we can only speculate about the significance of territories (which might be equivalent to resource control and access) and the way people moved across social or natural borders. It even remains unclear who was involved in moving (men? women? whole groups?) or if there was indeed any long-distance travel. The numbers of foreign objects do increase remarkably during the last centuries of the Ertebølle culture, and at least for Denmark this may go hand in hand with the development of semi-sedentariness, territoriality or tethered mobility patterns (see Andersen 1995; Klassen 2004). However, as the case studies above have shown, there is no such thing as a truly 'sedentary' society, so it is highly likely that the Ertebølle population was involved in trading and contact networks which reached far across the land and varied both regionally and chronologically. To see either 'sedentism' or 'foreign objects' solely as indications of an emerging Neolithic lifeway is thus unwarranted.

The arrival of the Neolithic: how did it work?

While not all foreign objects within the Ertebølle region must necessarily reflect travelling or migrating individuals, possible evidence of 'strangers' within the Ertebølle region comes from a pit near Flintbek in northern Germany, filled with pottery and flint tools which do not conform to the local technological traditions, and dated to 4,233–3,969 cal BC. Its close resemblance to material from the Michelsberg culture is taken as proof for immigrant settlers (Hartz et al. 2002, 324; Mischka et al. 2015).

In other ways, the picture for the centuries between the Final Mesolithic and the 'established Neolithic' is ambiguous. The earliest Funnel Beaker period in northern Germany and Denmark shows clear continuities to the latest Ertebølle, and subsistence practices change only slowly for at least 300 years. Within the material culture repertoire, especially in the flint industry, ongoing developments and continuities are obvious, but the ceramic assemblages change rather abruptly and new vessel forms appear. New forms of symbolic or ritual behaviour are also established, as well as new settlement types and locations, and probably a slow shift towards more terrestrial food resources (Hartz et al. 2000, 132; 2007, 585–586; Gron / Sørensen 2018, 959–963).

Even if Gron / Sørensen (2018) divide the neolithisation process into four stages (contact, introduction, negotiation, homogenisation), the question remains how people actually acted and reacted in what appears to be a more or less slow process of mutual acculturation from which a new entity eventually emerged. Since contact between possible incoming individuals and the receiving groups was established before (see above), the crucial stages must have been the 'introduction' and 'negotiation' phases. Possible strategies for coping might be classified into the overall categories of acceptance vs. rejection, leading either to assimilation and/or integration (of strangers within the receiving group), or to separation and/or aggression and confrontation (Fig. 2).

Another strategy might be avoidance or retreat. A strategy of retreat is almost impossible to prove, but it is at least possible that Ertebølle settlers might have chosen to go north or northeast within the overall Ertebølle region when confronted with larger groups of immigrants. Strong regional connection and/or territorial boundaries might have hampered such a process, and will have led to confrontation between newcomers and residents, as well as between residents. However, since the burial record of the youngest Ertebølle culture is small, we are lacking evidence for increasing physical violence. Altogether it seems unlikely that hunter-gatherers with possible resource ownership systems and well established territorial ties would simply retreat and give up their homelands.

Considering an acceptance strategy, and given the existing evidence for well-established contact, incoming settlers could instead either have been assimilated or integrated into the existing social and economic pattern, or were tolerated in a way which allowed them to practice 'their' lifestyle in formerly Ertebølle territory. In this case, the existence of trading and exchange relationships between parties in different regions might have led to the formation of social ties between individuals of different cultural contexts which can lead to the acceptance of strangers into the receiving societies. It is probably hard to prove this in terms of the archaeological evidence, but maybe the highly diverse ceramic assemblage of Hamburg-Boberg can be explained in this way. Here, Ertebølle vessels appear together with Neolithic forms, some of which were apparently produced with local clays (Thielen 2017). If those do not represent copies made by Ertebølle individuals, then it is likely they were

made by 'outsiders' within a local ceramic production sequence, as is in some cases suggested by Thielen's (2017) technological analysis.

It must remain unclear whether different settlement behaviours, e.g. seasonal or year-round sedentariness, influenced the acceptance of immigrants. Increased settlement permanency, together with fixed territories, might have facilitated the establishment of contacts – e.g. trading partners could be sought in known places –, but might also have presented an obstacle towards migration, with people defending their home areas and preventing the settlement of newcomers. Especially in the inland regions of Schleswig-Holstein and Hamburg, which possibly represented attractive land to farmers as well, people might have rejected newcomers and rather sought confrontation in order to maintain their resource areas.

As mentioned above it seems unlikely that people would retreat easily in a situation like this, unless faced with a major threat or repression by incoming settlers. It is possible, however, that a retreat strategy involved movement to the coasts and re-centring the settlement focus of smaller groups. Possibly this was underway in the Younger Ertebølle phases already, with a strong focus on Baltic marine resources. At least in Denmark the number and sizes of sites at the coast increase over time (Andersen 1995). An inland-based population persisted at sites such as Hamburg-Boberg (Thielen 2017). Yet even here, the likelihood of threats would be at least partly reduced if newcomers sought out different environments, i.e. suitable for farming rather than hunting. If 'native' residents then expressed an interest in new resources such as cattle and grain, this might have acted in favour of the newcomers as well.

Given the varied nature of the Ertebølle region(s), we must assume that all of the above-mentioned reactions towards migrating settlers might have happened. The southern Ertebølle culture differs slightly from its 'classical' better-known northern counterpart, and in addition there are different regional core areas with high concentrations of imported objects, and thus, possibly, with varying levels of contacts with Neolithic regions (Klassen 2004). It is likely that there was a similarly varied range of reactions towards new ideas and technologies, as well as people. Of course, it also made a difference in the neolithisation process if there were 'only' new objects and ideas coming in, or migrating settlers as well. If late foragers actively approached farmers to learn farming techniques from them, this is a very different (and faster?) process of introducing new technologies than the trial-and-error method carried out by hunter-gatherers alone. This is a point made by Gron / Sørensen (2018), but instead of only focusing on the role of immigrants as 'teachers' we need to expand our horizon to include the 'pupils' as driving factors (see below).

In general, the ambiguous character of sites in northern Germany (see above) and the continuity observed in the material repertoire, together with new pottery styles (which might reflect a demand for the processing of new resources), seem to illustrate some degree of mingling with incoming settlers and/or objects, innovations and trends, or at least a willingness for cooperation. The Ertebølle people's demand for foreign goods seems to reflect an open-mindedness to new things and, possibly, to other people. Their contact with Neolithic societies beyond their borders might have made migration processes easier, probably best reflected in the concentration of imported items in the area of Hamburg and southern Schleswig-Holstein. It is also possible that resource management and semi-sedentariness (sometimes seen as signs of a 'complex' society) made the 'Neolithic way' more attractive, which might explain the quick change in particular to cattle herding. In this respect, the abrupt introduction of new pottery types may be linked to the processing of new resources such as dairy.

However, if as many people came to settle the Ertebølle region as suggested by Gron / Sørensen (2018), the continuity in material culture is rather astounding. The only abrupt changes are within the ceramic assemblages (and here mainly in form and possibly function, rather than in technological aspects; see also Thielen this volume). Therefore, it is likely that incoming settlers underwent an acculturation process as well. Sites such as Neustadt LA 156, where pointed-bottom vessels and funnel beakers were in use simultaneously over at least a century (Glykou 2016, 152–165, 355–363), might point to a distinctive integration of local and foreign practices. Possible immigrants might have brought a new ceramic tradition (perhaps linked to new resources such as dairy) which was attractive enough for the Mesolithic population to quickly give up their own pottery repertoire, but otherwise practices and traditions changed much more slowly. We thus seem to witness the creation of a new, mixed identity of 'Mesolithic' and 'Neolithic' practices which eventually became established in the form of the developed Early Neolithic of northern Germany and southern Scandinavia. The processes and driving factors behind this development are far too complex to be explained by a single model, and the formation of the Funnel Beaker phenomenon itself is still undergoing extensive research (see e.g Czekaj-Zastawny et al. 2013; Furholt 2014; Hinz 2014).

Assuming the idea put forward by Gron / Sørensen (2018) is correct and the Final Mesolithic population of the Ertebølle region was motivated to take up farming and cattle herding by migrating settlers from the south, then the southern Ertebølle 'borderlands' must have played an important role as a contact or negotiation corridor through which migrating individuals must have passed. Genetic data from Ertebølle and Early Funnel Beaker contexts from northern Germany could help sharpen the picture, but so far most of the genetic evidence comes from Denmark or Sweden and stems from later periods (Skoglund et al. 2012; Brotherton et al. 2013; Malmström et al. 2015). It is interesting that the data indicate little interbreeding. In this respect the observable continuity between the Final Mesolithic and Early Neolithic (see above) hints at a more complicated scenario in which hunter-gatherers and their willingness to take up new technologies and ideas played a more important role in the diffusion of innovations than migratory processes by Neolithic settlers alone could explain.

Furthermore, the model by Gron / Sørensen (2018) leaves important questions: How many incoming settlers are we talking about in a year, or in the course of several years? Why did they come in the first place? The complexity of the neolithisation process is perhaps better understood by asking why a Neolithic mode of subsistence was attractive to well-established hunter-gatherer-fishers. What influenced their decisions to try out new technologies and subsistence practices and to welcome migrating settlers with a different cultural and economic background? Although no final conclusion is as yet possible, it is always important to consider both sides, that of the mover and that of the recipient (of either new ideas, technologies or migrating settlers), and to acknowledge that we are dealing with many different scales of perspective as well as variable inter- and intra-group dynamics. The new data for migration should certainly not tempt us to flip our narratives by 180 degrees, and to allocate all the agency to incoming farmers instead of hunter-gatherers. Instead, existing Ertebølle patterns of relatedness and of living in the landscape would have been crucial to the outcome of any Neolithic colonisation venture, and this Ertebølle background was in itself very varied.

Discussion and conclusions

Our three case studies show a range of possible interaction patterns when foragers and farmers meet. Referring back to our Figure 2, in the LBK case, there was a large cultural distance between incoming farmers and resident hunter-gatherers, and in the interior of central Europe at least this was also paired with a large demographic imbalance. How the transition worked from the hunter-gatherer perspective was thus strongly dependent on how the LBK developed. Currently, it seems likely that the Earliest LBK expansion was characterised by a relatively greater pressure towards conformity and assimilation within LBK society, making any more balanced integration rather difficult, but leaving reasonable opportunities for foragers to continue relatively undisturbed in other parts of the landscape. Yet this (perhaps uneasy) truce was not to last. As LBK settlers occupied more and more niches, remaining forager communities may have been reduced to a kind of 'home diaspora', living in increasingly circumscribed areas and with their accustomed movement patterns disrupted. At this point, we can start to discuss whether such groups should be considered marginalised, and whether they managed to survive for any length of time. At the same time, continuing westward expansion by mobile LBK groups may have involved settlers from different settlements who underwent a process of acculturation, mixing their traditions to create a new, shared one. In these settings, there was also more room for interaction with hunter-gatherers, as the pottery in particular shows. Here, a more balanced reciprocity was achieved, although creolisation may still be an appropriate term if we assume an imbalance in power relations – something that needs to be researched further. Households on LBK sites continued to produce non-LBK styles of pottery, and there are signs of mutual interaction. In time, a new, fusion identity developed, perhaps fundamental for creating some of the LBK successor cultures, such as the Villeneuve-Saint-Germain (e.g Jeunesse et al. 2019, 98–99). Overall, as LBK and forager societies changed, so did possible patterns of contact.

In contrast, both in the Low Countries and in the Ertebølle case, the differences between farmers and foragers were less marked, but have on occasion been overstated due to our own disciplinary propensity for categorisation. In the Low Countries, there has been a tendency to interpret contact finds, sturdily built houses and so on differently, depending on whether they turn up on a 'hunter' or a 'farmer' site. However, foragers and farmers both enacted their relationship to territory through practices which combined a range of economic strategies, and therefore both societies shared a degree of mobility. In addition, the forager landscape had long been dynamic and changing, both as a result of technological adaptations and environmental change. In such a context, a new and broad-

spectrum Neolithic presence may have represented more a source of innovations than an absolute and fearsome contrast. We therefore see a situation in which new economic practices and worldviews are incorporated piecemeal, and not necessarily in a linear and geographically coherent way. Scenarios of integration come closest to describing this sort of situation, with all the social groups involved operating within broadly similar social structures and comparable degrees of mobility.

Finally, in the Ertebølle case there has been a strong tendency to stress how these 'complex' foragers in essence already fulfilled most of the prerequisites for a 'Neolithic' society. Yet this may not be the best way for understanding the dynamics involved. Ertebølle communities were adapted rather variably to different landscapes, creating different preconditions for potential new settlers. In addition, innovations such as pottery or exotic goods had been circulating for centuries without causing dramatic social breakdown. The Neolithic way of life was thus not self-evidently superior; indeed, in many ways, Ertebølle communities seem in a stronger position than incoming farmers. The conundrum thus is how the Neolithic came to be introduced in the first place. Perhaps the existing connections to the south made it easier for migrating farmers to gain access to Ertebølle territory, and once there the material culture seems to provide ample evidence for technological and economic integration between the two population groups, together creating the archaeological entity now known as Funnel Beaker culture. Yet in spite of the potential openness especially of more southern Ertebølle groups, this society could have remained internally divided, with mostly people of farmer ancestry being buried in megalithic tombs.

On closer inspection, then, all of our case studies fragment – migration events and mobility patterns are chronologically dynamic and regionally diverse, and in no case was there 'the' answer of how interaction worked. Several of the scenarios we outlined at the start seem possible, or succeed each other in time, in each of our regions. The classification system in Figure 2 is primarily meant as a 'tool' to think differently about socio-cultural interactions and must hence be seen as dynamic, with communities moving between squares in the course of their varied interactions with each other. In all of our examples, the application of more fine-grained vocabulary, of 'hybridisation', 'mestizaje' and so on, will most likely be possible only at a local or at most micro-regional level. In either case, these sorts of narratives challenge the propensity to look for answers from the top down, using coarse patterns, clear dichotomous labels, unilinear trends and confident dividing lines on maps. Scenarios of admixture and integration are difficult to conceptualise with these starting points, as is the sense of indeterminacy that must have prevailed at the time. People did not know how their stories would end.

The contrast between top down and bottom up in itself has a long tradition, but with the third science revolution now being ushered in (Kristiansen 2014) we must be wary of simply reverting to big data narratives working at very large scales. These narratives are not in themselves wrong, but they lend themselves very much to just one kind of story. They are not suitable for appreciating that our confident culture maps and chronological divisions were neither static within, nor impermeable. There is inevitable seepage at the edges. To address this, we will of course have to keep accumulating more data – better chronological resolution, better genetic coverage, better environmental evidence. But new data will only tell us new stories if we explicitly allow for indeterminacy in our models.

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Changing Worlds – The Spread of the Neolithic Way of Life in the North

A singularity in continuity? The transition to farming in northwest Europe (c. 5,000–3,500 calBC) reexamined from the perspective of multiculturalism

Daan Raemaekers

Abstract Thanks to isotopic and especially aDNA analyses we now conclude that the movement of people was quite common in the prehistory of Europe, especially in relation to the spread of agriculture across the continent. The case study area of the Dutch wetlands (c. 5,000–3,500 calBC) seems to be a last stand against the renewed evidence of the role of incoming people in the transition to farming. This paper reconsiders the transition to farming in this area and discusses the evidence for incoming people and their role in the transition to farming. Throughout the 5th millennium non-local people contributed to the archaeological record, with human bones and material culture. Their influence on the indigenous groups may have been restricted, and one may interpret this as a multicultural society. In contrast, in the final centuries of this millennium, changes in material culture and the introduction of cereal cultivation and consumption seem to correlate, at least at Swifterbant S3. One might propose that the non-local people present at this time played a crucial role in the introduction of this new subsistence strategy, thanks to their cultural background in the Michelsberg culture. The role of newcomers, with new notions about burial, material culture, and subsistence, cannot be underestimated in this process of neolithisation. The outcome of this process is seen in the first half of the 4th millennium, in the Hazendonk group. This regional group can be seen as the outcome of cultural bricolage, with the Swifterbant culture and the Michelsberg culture as sources of its burial characteristics and material culture, and with a subsistence strategy in which cattle were of prime importance.

Keywords Neolithisation, Swifterbant culture, multicultural past

Zusammenfassung *Dank Isotopen- und vor allem aDNA-Analysen wissen wir heute, dass Mobilität von Menschen in der Vorgeschichte Europas tatsächlich häufig vorkam, insbesondere im Zusammenhang mit der Ausbreitung der Landwirtschaft. Die Fallstudie der niederländischen Feuchtgebiete (ca. 5000–3500 v. Chr.) scheint eine letzte Bastion gegen die wiederholten Belege für die Rolle einwandernder Menschen beim Übergang zur Landwirtschaft darzustellen. In diesem Beitrag wird die Neolithisierung dieses Gebietes neu betrachtet, und die Belege für die Einwanderung von Menschen und ihre Rolle beim Übergang zur Landwirtschaft werden diskutiert. Während des fünften Jahrtausends trugen nicht-einheimische Menschen mit ihren Überresten und ihrer materiellen Kultur zu den heute bekannten archäologischen Nachweisen bei. Ihr Einfluss auf die lokalen Gruppen scheint begrenzt gewesen sein, und man kann die Situation als eine multikulturelle Gesellschaft interpretieren. Im Gegensatz dazu scheinen in den letzten Jahrhunderten des fünften Jahrtausends Veränderungen in der materiellen Kultur und die Einführung von Getreideanbau und -konsum, zumindest an der Fundstelle Swifterbant S3, zu korrelieren. Die zu dieser Zeit anwesenden Fremden, deren kultureller Hintergrund der Michelsberger Kultur zuzuordnen ist, könnten eine entscheidende Rolle bei der Einführung der neuen Subsistenzstrategie gespielt haben. Die Rolle der Neuankömmlinge mit ihren neuartigen Vorstellungen von Bestattung, materieller Kultur und Subsistenz sollten in diesem Prozess der Neolithisierung nicht unterschätzt werden. Die regionale Hazendonk-Gruppe in der ersten Hälfte des vierten Jahrtausends kann als Ergebnis einer kulturellen Vermischung gesehen werden, bei der Swifterbant-Kultur und Michelsberger Kultur als Quellen für ihre Bestattungsmerkmale, ihre materielle Kultur und ihre unter anderem auf Rindern basierende Subsistenzstrategie dienten.*

Introduction

Archaeology is in the middle of a major transformation, thanks to the impact of isotopic and especially aDNA analyses of prehistoric human populations across the European continent. When the first isotopic analyses with evidence of long distance human movement were published, it was still possible to

consider these as either freak observations or the result of a limited baseline dataset. To be honest, that is how I interpreted the Amesbury Archer – a burial dated c. 2,300 calBC, found near Stonehenge, but with isotopic values implying a background in the Alps (Fitzpatrick 2011). Ever since, an avalanche of more and more publications has brought us to the point where we have to conclude that the movement of people in the prehistory of Europe was quite common. Over the last few years especially aDNA studies have made a major contribution to this field (e.g. Olalde et al. 2018; Nikitin et al. 2019). It is the end of a long research tradition in which the combination of cultural continuity and contacts was the driving force to understand cultural change.

While no aDNA of Mesolithic and Early Neolithic human populations from the Swifterbant culture and subsequent Hazendonk group in northwest Europe has been published yet, in this area the narrative of cultural continuity provides a last stand against the renewed evidence of the role of incoming populations in the transition to farming. The case study area seems to stand alone in the sweeping and convincing synthesis of the neolithisation of Europe, as presented recently by S. Shennan (2019, 152). This paper will reconsider the transition to farming in this area, starting from the assumption that it was no singular exception in the new grand narrative of human mobility. What evidence is there for incoming people? And what role did they have in the transition to farming?

Theoretical consideration of the role of newcomers

There is a large number of papers that advocate that migration was a major factor in the population history of Europe. In many of these papers the contribution of archaeologists is limited, leading to a poorly defined use of the term migration (a critique worded more often, e.g. Hofmann 2015; this volume; Furholt 2019). Does it entail the movement of individuals (e.g. as part of marriage or trade networks, or transhumance), of households, or of larger social groups? In the near endless centuries and millennia of prehistoric Europe all these different modes of movement may have led to substantial changes in the genetic characteristics of a population over due time.

There are two routes to get a better understanding of the social processes that resulted in the major genetic shifts across prehistoric Europe. In theory, an increase in the number of aDNA analyses may provide a more detailed picture. It is my impression that this route is being followed already and a substantial part of available human remains will be analysed in the coming years. This route will probably find a dead end: the relatively course-grained chronological resolution of prehistoric Europe will make it very difficult to decide which social processes resulted in the genetic transformation of human populations in a given region.

The second route is far more promising: it creates an explicit connection between aDNA and archaeological studies. In case study areas such as ours, with a grand narrative of cultural continuity across the Mesolithic-Neolithic transition (e.g. Louwe Kooijmans 1993; Raemaekers 1999; Amkreutz 2013; see below), we need to develop a vocabulary that will help us understand the modes of movement (see Hofmann et al. this volume for a similar exercise). To this end, I turn to linguistics for inspiration (see Table 1).

Languages change. They do that in isolation (without outside influence), but also when new people with different languages start to interact with local language speakers. The degree of impact of the newcomers' language can differ strongly. The first option is that the newcomers and local language speakers both maintain their own language, and a multicultural community develops in which people

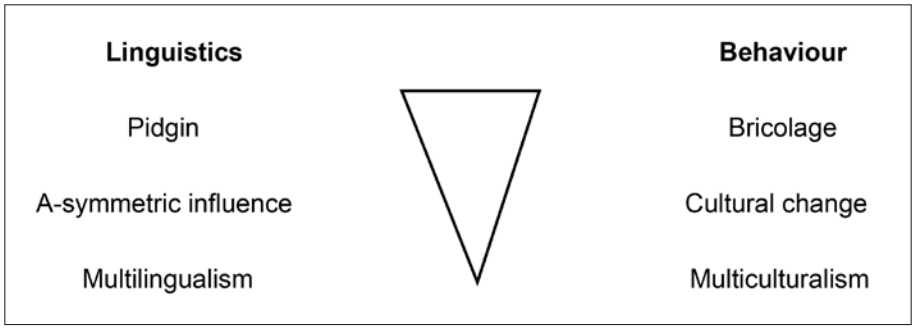

Table 1 Modes of linguistic and cultural changes compared. The triangle indicates the degree of influence between the two linguistic or cultural groups.

may command both languages and use them according to the social setting in which they operate. Multilingualism thus correlates to multiculturalism. That is a term archaeologists can work with. We would expect an archaeological record in which two distinct subsets can be found. A second linguistic set-up is one in which the two languages do influence one another, but not to similar degrees. The dominant language will develop as a *lingua franca* in an area, and language changes will result from contact with the other language. As archaeologists we might see changes in material culture and / or behavioural change within a long term history of cultural continuity. The third linguistic set-up presented here is that of the development of a pidgin language: the mixing of two (or more) languages and the creation of a new language. This can be translated to cultural bricolage, where characteristics of material culture and / or behaviour from one period are mixed and turned into a new cultural pattern.

The most promising setting in which these options of cultural interaction may be analysed are inhumations: here we can study the correlation between skeletal data (diet, mobility, DNA), burial ritual, and grave goods. Another archaeological correlate can be found in a multi-disciplinary analysis of material culture, including specialist research like petrographic, lipid or use wear analysis. By combining various types of analysis we can determine whether specific artefacts or artefact types were used for specific goals. Both types of analysis may represent input for an interpretation of the archaeological record in terms of the presence and role of newcomers in an area.

Time and place

Sites of the Swifterbant culture are found across a broad zone in northwest Europe, from the Scheldt valley in Belgium via the riverine wetlands of the Netherlands into northern Germany.[1] The type site is located in the Flevoland polders in the central part of the Netherlands. The start of the Swifterbant culture is defined by the start of pottery production in Swifterbant style around 5,000 calBC. It concerns the sites Hoge Vaart and Hardinxveld-Giessendam Polderweg (cf. Haanen / Hogestijn 2001; Raemaekers 2001a; 2011). The end of the Swifterbant culture has traditionally been set around 3,400 calBC, the supposed start of the construction of TRB megalithic tombs in the Netherlands.[2] This has been challenged, most explicitly by Ten Anscher (2012, 142–143; 2015), who stresses the continuity in ceramic characteristics between younger Swifterbant and TRB wares. To this end, he coined the term pre-Drouwen TRB to describe the ceramics from the first half of the 4th millennium calBC. Pre-Drouwen can be seen as both the final stage of the Swifterbant ceramic tradition and the start of the TRB culture in our area. On the basis of Ten Anscher's pioneering work, Raemaekers (2015) re-analysed the Swifterbant S3 ceramic assemblage (dated c. 4,300–4,000 calBC) and concluded that the onset of Pre-Drouwen TRB can be found there as well: the start of the TRB culture in the Netherlands must have been one with deep roots. The southern half of the Netherlands takes a different route. The archaeological record of the first half of the 4th millennium is here labelled 'Hazendonk group'. Its sites are mostly restricted to the Dutch coastal and riverine wetlands of the Rhine-Meuse delta.

The transition from Mesolithic to Neolithic in this area spans the entire 5th millennium calBC, and we see many lines of evidence that indicate that cultural continuity is the backbone of the development in this period. Flint technology, typology, and raw materials indicate the continuation of traditions (Deckers 1982; Niekus 2009; Devriendt 2013). The Swifterbant pottery tradition starts c. 5,000 calBC and reveals little changes throughout these 1,000 years (Raemaekers / De Roever 2010). The burial record also spans the millennium, with burials at Hardinxveld-Giessendam Polderweg (Smits / Louwe Kooijmans 2001a), Hardinxveld-Giessendam De Bruin (Smits / Louwe Kooijmans 2001b) and Swifterbant S2 (Meiklejohn / Constandse-Westermann 1978), yielding identical datasets of inhumations in flexed positions (see also below).

The one thing that does change – of course – is the subsistence strategy within the Swifterbant culture, albeit the changes are perceived to be so limited that Louwe Kooijmans (1993) coined the term 'extended broad spectrum economy' to describe the additive nature of animal husbandry and cereal cultivation to the Late Mesolithic broad spectrum economy. What is the evidence of farming activi-

1 This volume presents several papers with relevant detailed information on specific sites: Thielen (this volume) discusses Swifterbant ceramics at Hamburg-Boberg; Molthof / Baetsen (this volume) present the new Swifterbant site of Nieuwegein. Ten Anscher / Knippenberg (this volume) present the new Swifterbant site of Tiel-Medel.

2 Waterbolk 1985; Fokkens 1998, 96–97; Raemaekers 1999, 166; Lanting / Van der Plicht 1999/2000, 76–77.

Diet	U haplogroup		H and J haplogroups	
Terrestrial diet	BLA2 BLA19 BLA20	8800–8600 cal. BC		
Fresh water fish	BLA1 BLA8 BLA9 BLA11 BLA12 BLA14 BLA15 BLA21 BLA24	3800–3400 cal. BC		
Herbivores	BLA17 BLA25 BLA27	3900–3400 cal. BC	BLA5 BLA10 BLA13 BLA16 BLA17 BLA23 BLA28 BLA29	3500–3000 cal. BC

Table 2 The human remains from the Blätterhöhle. Combination of isotopic analysis ('diet'), genetic analysis ('haplogroups'), and general ^{14}C dates for each of the four groups (based on Bollongino et al. 2013, table 1).

ties in the 5th millennium? The introduction date of animal husbandry is safely set by the few bones from sheep at Hardinxveld-Giessendam De Bruin, directly dated at 4,520–4,356 calBC (Çakirlar et al. 2020, table 13.5). Because there are no wild sheep or goat in the area, it is certain that these animals were introduced to the site. More difficult are the bones from pig and cattle from the same assemblage: their interpretation as domestic is based purely on their relatively small size. Mitochondrial aDNA analysis has so far been restricted to four pig bones from Swifterbant S4 (c. 4,300–4,000 calBC; Kranenburg / Prummel 2020). One bone analysed was from a 'domestic pig', one from a 'wild boar' and two from 'domestic pig / wild boar'. All four had maternal ancestry in the European wild boar population (ANC-A and ANC-C). The state of animal husbandry in the 5th millennium is difficult to determine, as noted by Rowley-Conwy (2013; for an extensive discussion of the dataset: Çakirlar et al. 2020). The 2020–2022 project 'Early Domesticated Animals in the Netherlands (EDAN)' will address this dataset; it comprises high-resolution dating and statistical modelling as well as isotopic and aDNA analysis. The start of cereal cultivation is more clear. All sites dated before 4,300 calBC lack any evidence of cereal cultivation (Brinkkemper et al. 1999), all sites on the 4,300–4,000 calBC plateau in the calibration curve yielded the remains of emmer wheat and naked barley.[3] Moreover buried cultivated fields were recovered at three sites in the Swifterbant region (Huisman et al. 2009; Huisman / Raemaekers 2014; Raemaekers / De Roever 2020).

After 4,000 calBC animal husbandry is well-documented. Recent zooarchaeological analysis of Schipluiden material (Hazendonk group, c. 3,900–3,500 calBC) makes clear that at that stage cattle husbandry was of great importance (Kamjan et al. 2020), providing an end date for the transition to farming (contra Dusseldorp / Amkreutz 2020). Cattle bones dominate the bone spectrum, and the kill-off pattern indicates that these animals were kept both for meat and dairy consumption. The importance of dairy is also clear from the animals' extended birthing season, which would have facilitated a longer period of milk production and hence human consumption.

The Blätterhöhle cave

We start this analysis by a most intriguing site, albeit located outside the area of the Swifterbant culture.

3 See Out 2009, table 9.2, for a comprehensive overview. Swifterbant S4 (Schepers / Bottema-Mac Gillavry 2020), Nieuwegein (unpublished) and Tiel-Medel (unpublished) can now be added to her overview.

The Blätterhöhle cave is located about 10 km south of Dortmund (Germany), in the border zone between the central European mountainous area and the north European plain. It is close to the Ruhr area, a contributory river to the Meuse – its geographic location between different landscape zones is reminiscent of Hüde I.

The Blätterhöhle cave holds a large number of human remains dated to the period 9,210–3,020 calBC, from the Early Mesolithic far into the Neolithic period. Most relevant is the combination of ^{14}C dating, analysis of carbon, nitrogen and sulphur isotopes, and mitochondrial DNA analysis (Table 2; cf. Bollongino et al. 2013). The analyses made clear that these variables correlate to a strong degree. The first group (Bollongino et al. 2013: isotopic group 1) holds three individuals of Mesolithic age (c. 8,800–8,600 calBC) with mitochondrial DNA typical for European hunter-gatherers (U-haplogroup) and a terrestrial diet. The second group (Bollongino et al. 2013: isotopic group 3) comprises nine individuals dated c. 3,800–3,400 calBC, again within the U-haplogroup. Their isotopic signals suggest a high intake of freshwater fish. For individual 8 of this group the genetic build-up was analysed in more detail, indicating that 72.6 % of its genetic background stem from European hunter-gatherers (Lipson et al. 2017, extended data table 1). A third group (Bollongino et al. 2013: isotopic group 2) has a similar date (c. 3,900–3,400 calBC) and genetics, but these three individuals have isotopic signals that suggest that their diet depended on herbivores, most likely domesticated animals. The contemporaneity of groups 2 and 3 indicates that for a period of some 400 years people with similar genetic backgrounds made use of the cave for their burials, while in daily life they may have functioned rather separately, judging from the dietary signals. A fourth group (Bollongino et al. 2013: isotopic group 2) appears in the second half of the 4th millennium (c. 3,500–3,000 calBC) – these people had a different maternal genetic build-up, if one considers the haplogroups. In contrast, their paternal ancestry must have included hunter-gatherer forebears, because for three of the eight individuals in this group the genetic background from European hunter-gatherer populations has been calculated between 39.5 % and 51.9 % (Lipson et al. 2017, extended data table 1). These results indicate a strong mixing of people with different background at this time. The Blätterhöhle data reveal a complex interplay between genetics and diet. The question is how unique this dataset is: what evidence is there of genetic and isotopic variation in the period and area under study here?

The burial record

The physical anthropology of the burials from the period 5,000–3,500 calBC has been published in detail.[4] Where the Blätterhöhle burials yielded ^{14}C dates, aDNA, and isotopes, but the burial ritual is unpublished, the burials from our case study area hold a different subset of data: ^{14}C dates, isotopes, and burial ritual. The 5th millennium dataset is rather uniform in terms of body posture (all buried on their back) and grave goods (limited to a small number of beads or pendants from amber, jet, or animal teeth). The burials from the Hazendonk group (sites Schipluiden and Ypenburg) are more varied in terms of body posture. Most were buried on their side in a flexed position, but some were buried in 'traditional' fashion on their backs. Burial goods remained sparse and limited to beads and pendants from amber and jet. Schipluiden provides an unique spatial pattern as well: the settlement seems to comprise four contemporaneously occupied yards, where all burials were found at the westernmost yard. It suggests that burial ritual may have been variable on household level.

Isotopic analyses of strontium and oxygen have been carried out for ten individuals from Swifterbant and seven from Schipluiden (see Fig. 1) – it allows us to identify three individuals with deviant values, one from Swifterbant and two from Schipluiden, to be interpreted as non-local individuals. Intriguingly, two of these three also had different carbon and nitrogen values (Fig. 2), suggesting a diet deviant from the majority, and they are represented in the burial record with single molars only. The authors conclude 'it is notable that three of the identified immigrants (SWH10, SCH6, and SCH7) are represented by isolated molars only, and two of these individuals had a diet lower in fish than others at these sites. The sample size is very small, but, as these individuals are not of local origin, this does raise the possibility that differences in both diet and attitude towards burial were associated with cultural identity' (Smits et al. 2010, 24). Figure 2 also shows one individual from Polderweg with a deviant low δ^{15}N signal – again this individual is represented by a single bone and is not one of the formal burials. These correlating results (origin, diet, and burial ritual) indicate that we need to reckon with cultural diversity in this period and time.

4 See Raemaekers et al. 2009 for an overview of the 5th millennium calBC and references to the primary publications. See Molthof / Baetsen (this volume) for the burials from Nieuwegein. An overview of the burial record of the 4th millennium cal. BC is provided by Raemaekers 2018.

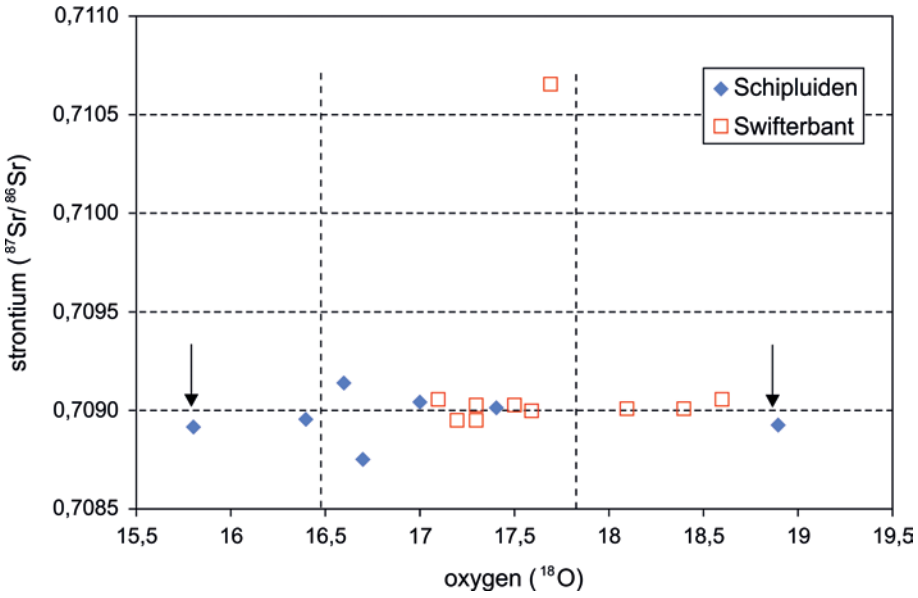

Fig. 1 Results of the analyses of strontium (Sr) and oxygen (O) on individuals from Swifterbant (c. 4,300–4,000 calBC) and Schipluiden (c. 3,630–3,380 calBC). Arrows indicate individuals with deviant values, interpreted by the authors as immigrants (after Smits / van der Plicht 2009, fig. 10).

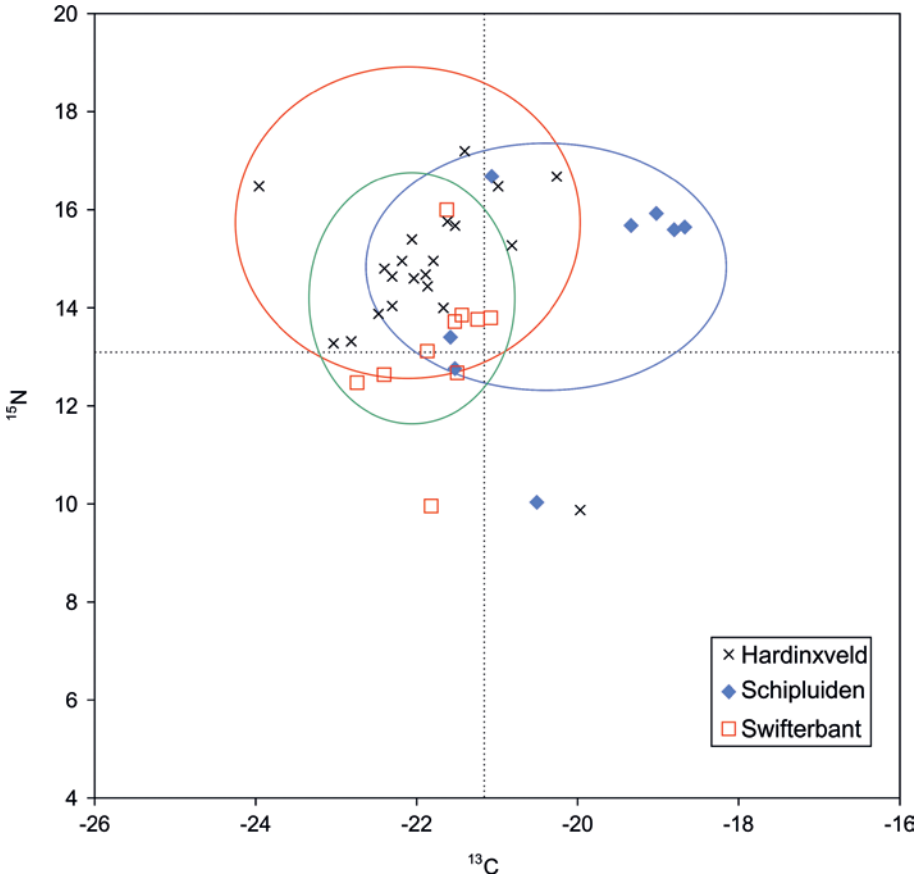

Fig. 2 Results of the analyses of carbon (C) and nitrogen (N) on individuals from Hardinxveld-Giessendam (c. 5,500–4,500 calBC), Swifterbant (c. 4,300–4,000 calBC) and Schipluiden (c. 3,630–3,380 calBC; after Smits / van der Plicht 2009, fig. 11).

Material culture

One of the characteristics of 'normal science' (Kuhn 1962) – when a discipline works within an unquestioned paradigm – is that we are unaware that the terminology we use is embedded in our theoretical framework and is considered to be descriptive instead of interpretative. In the preparation of this paper I came to realise that the term 'contact find' – used to describe parts of an assemblage considered to be of non-local origin – is such a term. The theoretical loading of this term is that it does not only describe a part of an assemblage, but it also determines the process that led to its occurrence in this assemblage. The 'contact find' is the result of interaction, exchange, or mobility of the 'true' inhabitants of the site under study.

When one is aware of this interpretative aspect of the term 'contact find', there are other interpretations to be considered for the presence of two distinctive subsets of material culture at one site. The first one is that of a palimpsest. In most circumstances the resolution of our dataset does not allow us to determine whether a site has been repeatedly occupied during a century by groups with different material culture. This observation makes clear that the use of the term 'contact find' is indeed part of our paradigm: it fits the general theory so well that equally valid alternatives are hardly considered.

A second alternative interpretation is one in which the temporal coherence of an assemblage is maintained, but material culture of supposed non-local origin is interpreted as evidence of the contemporaneous presence of people with a different cultural background. Here I focus on presenting a series of examples that might be interpreted as such. In the conclusion I will connect these observations to the different modes of movement presented above.

The first example is the presence of Blicquy-ceramics at Hardinxveld-Giessendam De Bruin (Raemaekers 2001b) and Brandwijk (Raemaekers 1999, fig. 3.7 top), dated to c. 4,600 calBC (Fig. 3).

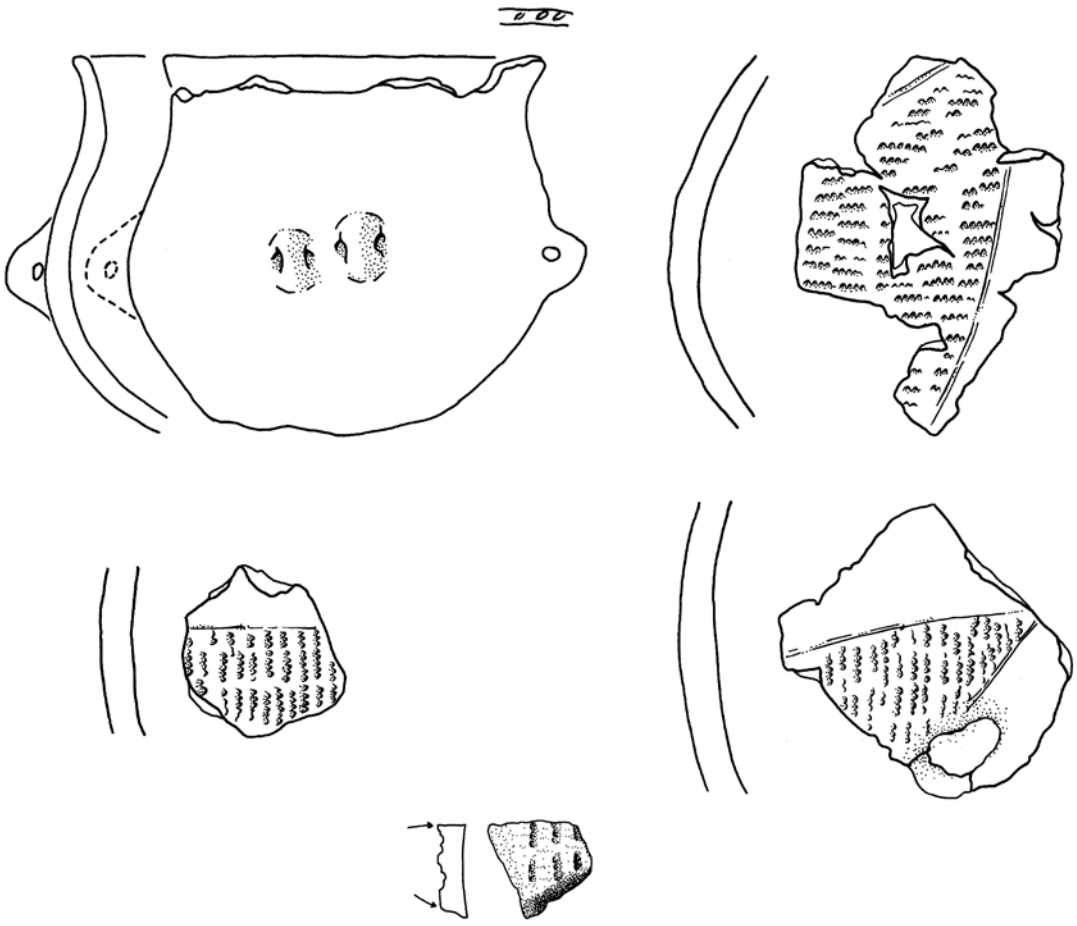

Fig. 3 Blicquy ceramics from Hardinxveld-Giessendam De Bruin (top and middle row: after Raemaekers 2001, figs. 5.4 and 5.5) and Brandwijk, scale 1:2 (bottom row: after Raemaekers 1999, fig. 3.7).

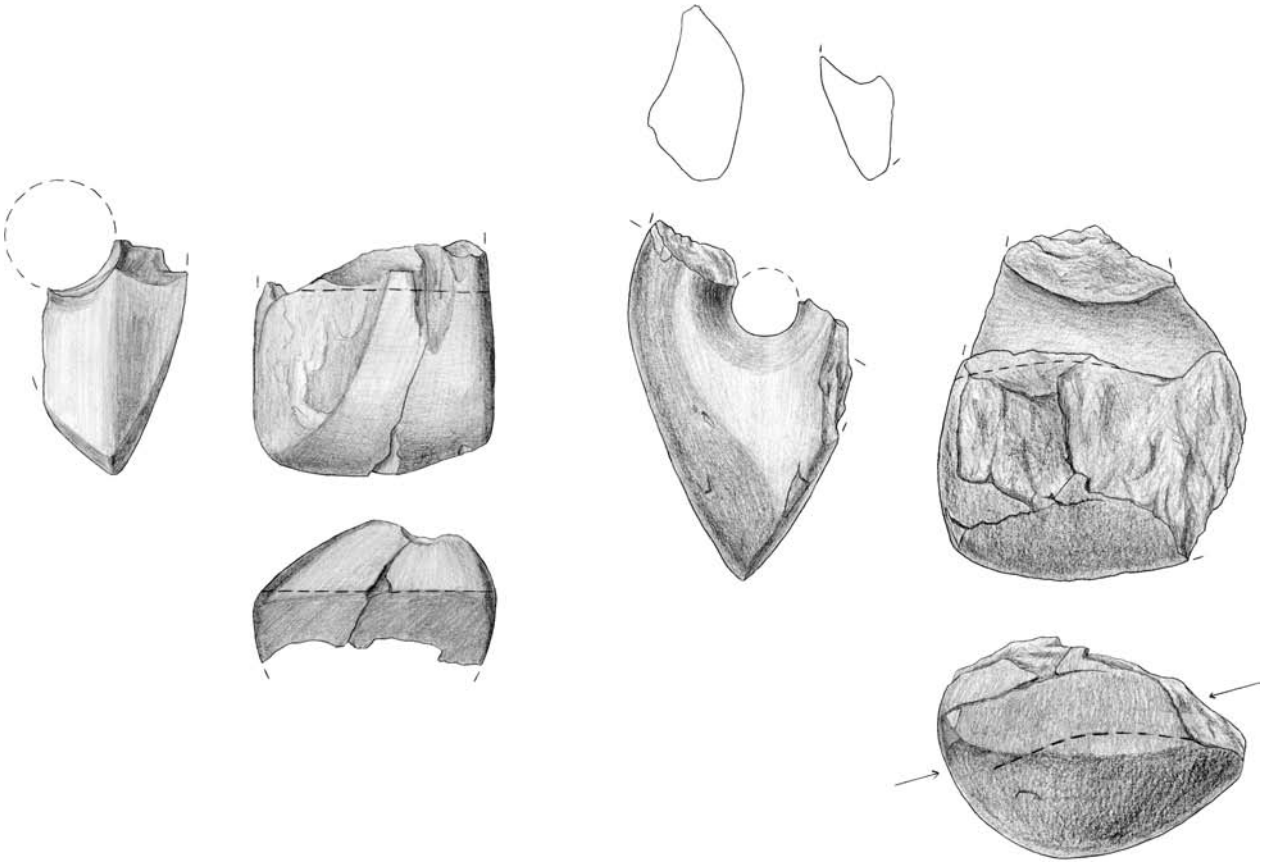

Fig. 4 Fragments of a perforated wedge (left) and a local reproduction (right) from Swifterbant S3 (after Devriendt 2013, fig. 4.8). Scale 1:2.

These ceramics stand out from the Swifterbant ceramics on the basis of their fine grit and bone temper, relative high quality, and decoration carried out with a forked spatula in fields. All these characteristics are confined to a specific subset of the assemblage – there are no sherds which combine Blicquy and Swifterbant characteristics. Blicquy ceramics are generally found more to the south (Belgium, northern France); the two Dutch examples are the northernmost sites in their distribution (Hauzeur / van Berg 2005).

A second example is the presence of two fragments of one perforated wedge ('Breitkeil') at Swifterbant S3, dated to 4,300–4,000 calBC (Fig. 4; Devriendt 2013, 68 and fig. 4.8 top left). Here the distinction between two different sets of material culture is less clear-cut: there are also two perforated axes made of locally available stone material; their perforation has a hour-glass shape instead of the cylindrical one found on the perforated wedge. They are proposed to be local reproductions (Devriendt 2013, 72), which may be true. Here we conclude that if these are reproductions, it indicates that the use (and meaning) of perforated wedges was not restricted to the people that had access to this one artefact. Moreover, a petrographic analysis of ceramics from the same site yielded one sherd with typical Swifterbant characteristics tempered with amphibolite (unpublished; analysis by O. Stilborg). Perforated wedges are commonly found in central Europe, but their distribution includes the Low Countries as well (Raemaekers et al. 2011; Verhart 2013).

A third example is the presence of flint tools from non-local flint sources at Brandwijk (4,300–3,900 calBC). It concerns a distinctive subset of the assemblage in terms of flint source, tool type and use wear (Fig. 5). These tools are explicitly interpreted within the normal science paradigm: 'it is reasonable to assume that the Michelsberg implements were brought to the coastal wetlands, not so much to be used as actual tools, but as a trophy or token of a special relationship with a person or social group far away' (van Gijn 2010, 123). It would be equally valid to interpret these finds as evidence of the presence of people with their own set of flint tools, carrying out their own specific activities, while other people used a different set of flint tools and carried out distinctively different activities.

The fourth example has already been highlighted in great detail elsewhere (Raemaekers 2015). It concerns the gradual change of ceramic characteristics at Swifterbant S3 (c. 4,300–4,000 calBC), in

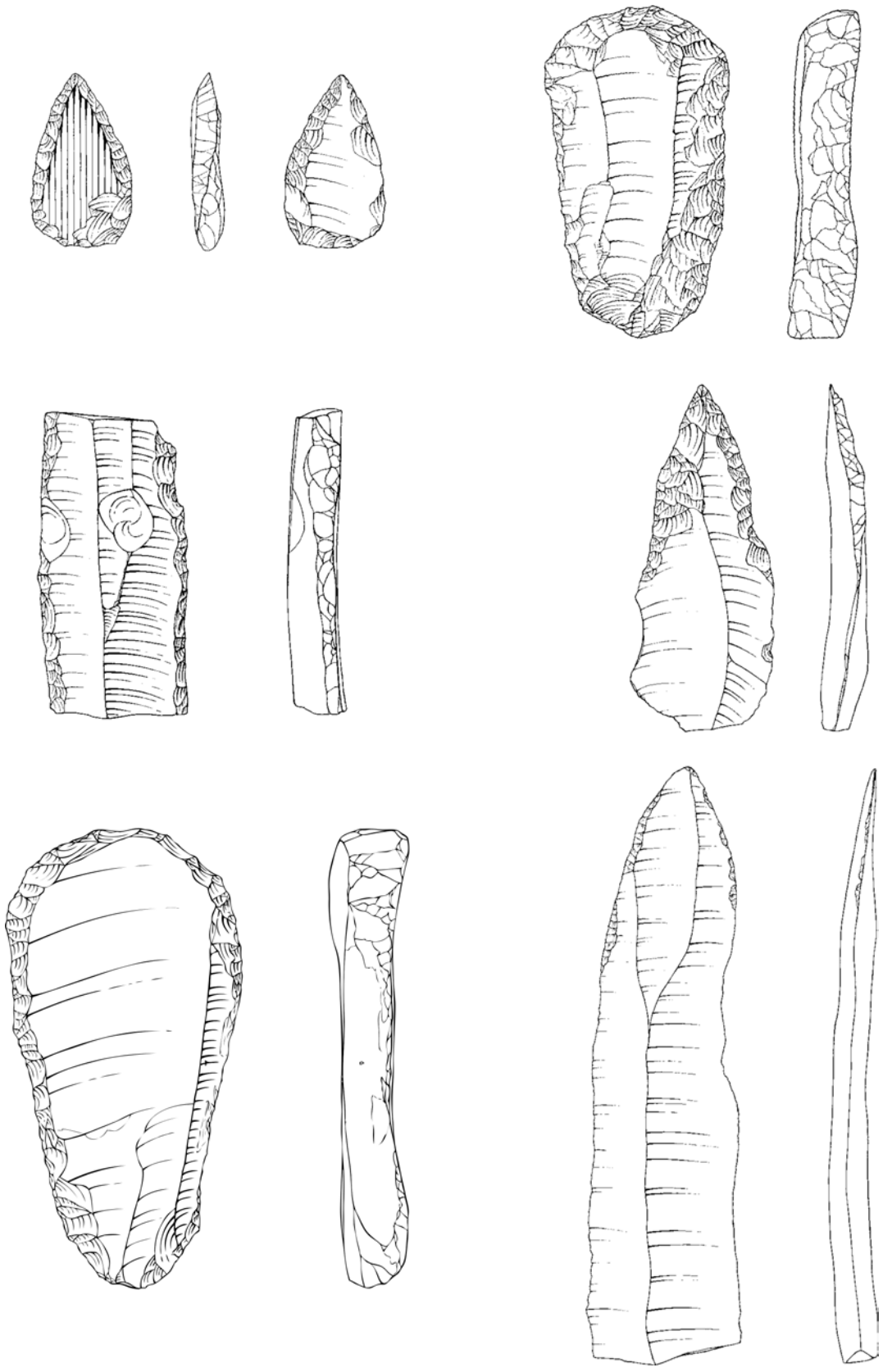

Fig. 5 Flint tools from Brandwijk L50 (c. 4220–3940 calBC). These tools were produced of non-local flints. Their morphology and technology sets them apart from the remainder of the assemblages, as does their specific use (after VAN GIJN 2010, fig. 6.4). Scale 1:1.

conjunction with the incorporation of cereal cultivation and consumption by its occupants. The outcome of this process of ceramic change is that the youngest set of S3 comprises two distinct subsets. One is the traditional Swifterbant coarse ware; the other is a newly developed thin-walled high-quality grit-tempered ware, in morphological and technological terms similar to Early Neolithic TRB ware from northern Germany. It is this second subset that exclusively holds cereals.

A final example comes from Schipluiden (c. 3,630–3,380 calBC). The large flint assemblage there is dominated by flint material collected in the region, but also holds various categories of non-local flint types. 'There is also a small quantity (5.2 %) of non-local, "exotic" flint types, deriving directly from the south Belgian Cretaceous zone. The artefacts concerned are predominantly finished products of a size larger than the rolled pebbles […], and include no cores, core-preparation or rejuvenation pieces […]. Some of this material may have been imported in the form of polished axes' (van Gijn et al. 2006, 133–135). As such, this dataset and its interpretation are very similar to that from Brandwijk. At Brandwijk, pointed blades were exclusively of non-local flint and showed exclusive use wear. At Schipluiden, pointed blades were found in larger numbers (n = 31), of which 22 could be related to the flint sources of which they were produced (van Gijn et al. 2006, table 7.3). Of these, twelve were produced of locally collected flint and ten of non-local flint. This suggests that the absolute separation between two sub-assemblages of flint artefacts at Brandwijk had decreased.

Conclusions

The narrative of cultural continuity across the Mesolithic-Neolithic transition in the Dutch wetlands has been questioned here. It has been made clear that on many sites there is evidence for non-local residents (human bones) and / or non-local material culture. How can we relate this to the modes of movement, as presented in Table 1?

Throughout the 5th millennium calBC, the evidence presented here seems to have a binary character. The assemblages are dominated by burial remains and material culture we interpret as being typical for the Swifterbant culture. At the same time, there are individuals at Polderweg and Swifterbant that have deviant isotopic signals, and these individuals were not buried in the customary way. The presence of Blicquy ceramics at De Bruin and Brandwijk, with its distinct technological and stylistic characteristics, adds to the binary character of the sites under study. And so does the non-local flint at Brandwijk, with its special use-wear restricted to these specific tools. All these patterns are interpreted here as first evidence of multicultural occupation of these sites. In the final centuries of this millennium, the introduction of cereal cultivation and consumption seems to be related to a major change in ceramics, with the earliest TRB ceramics as outcome of this process, before 4,000 calBC. This process may be interpreted as evidence of cultural change wherein newcomers – evidenced by their human remains – influenced traditional material culture practices.

The outcome of this cultural change is evidenced in the first half of the 4th millennium calBC: Whereas the developments in the northern part of the case study area are part of the TRB cultural tradition (Ten Anscher 2012; 2015; Raemaekers 2015), the southern part developed into what archaeologists have labelled Hazendonk group. The Hazendonk group can be interpreted as the outcome of cultural bricolage – with the Swifterbant culture and the Michelsberg culture as sources of the Hazendonk burial characteristics and material culture. The dominant tradition of burials on their side in a flexed position is new to the area, but is better known in the adjacent areas of central Europe (e.g. Alterauge 2013). At the same sites, the traditional practice of burials on their backs continued, too. The same re-ordering can be seen in the material culture. The practice of using local and non-local flint sources was continued, but now we see that the exclusive relation between flint sources and typology has been abandoned. The intermediate position of Hazendonk ceramics between Swifterbant and Michelsberg has been proposed already a long time ago (Raemaekers 1999, 161).

This paper focused on the archaeological evidence of the contemporaneous presence of people with different cultural repertoires in the Dutch wetlands, across the Mesolithic-Neolithic transition. This evidence suggests that throughout the 5th millennium calBC non-local people contributed to the archaeological record, with their bones and material culture. Their influence on the indigenous groups may have been restricted, and one may interpret this as a multicultural society. In the final centuries of this millennium, changes in material culture and the introduction of cereal cultivation and consumption seem to correlate, at least at Swifterbant S3. In contrast to the grand narrative of cultural continuity in this area, one might propose that the non-local people present at this time played a crucial role in

the introduction of this new subsistence strategy – if we could make sure that their non-local isotopic signals relate to areas in which farming was already established. The flint sources and tool types at Brandwijk L50 do suggest that this is the case: they point to the area of the Michelsberg culture. As such, this paper underlines the importance of the Michelsberg culture to understand the introduction of cereal cultivation in the western part of the north European plain (e. g. Kreuz et al. 2014). This spatial expansion of the Neolithic coincides with the plateau in the calibration curve to which sites like Swifterbant S3 are dated. The role of these newcomers, with new notions about burial ritual, material culture, and subsistence, cannot be underestimated. After 4,000 calBC, in the Hazendonk group, a full Neolithic had developed, with cultural (and genetic?) roots in both the Swifterbant and Michelsberg cultures.

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A view from Doggerland – interpreting the Mesolithic-Neolithic transition in the wetlands of the Rhine-Meuse delta (5,500 – 2,500 calBC)

Luc Amkreutz

Abstract The transition to agriculture is one of the most important developments in recent human history. There is evidence that this process was importantly driven by migration in large parts of Europe, but appears to have then come to a long standstill on the Atlantic margins of the Low Countries. In this elaborate wetland environment, there is evidence for a very gradual transition. Importantly some scholars, however, argue that there also appear to be indications for a quick consolidation of the transition by the end of the 5th millennium calBC. This paper argues that it is beneficial to not only study this period from an economic perspective using proxies that are both rooted in our ideas of what neolithisation entails and that suffer from severe taphomic biases. Instead, taking the developments in Mesolithic Doggerland as an example it is argued that a better understanding may be derived from a more 'indigenous' approach. Contextualising the transition to agriculture within the framework of regional communities inhabiting a living landscape leads to an increased understanding of the different pathways characterising neolithisation in this region. This eventually indicates that overall we are dealing with a very long-term process that does not end with the first sedentary agricultural sites in the wetlands.

Keywords Neolithisation, wetland, Swifterbant, Mesolithic, Doggerland, agriculture

Zusammenfassung *Der Übergang zu Ackerbau und Viehzucht ist die bedeutendste Entwicklung der jüngeren Geschichte der Menschheit. Dieser Prozess wurde in weiten Teilen Europas vor allem durch Migration ausgelöst, doch am Rand der nordwesteuropäischen Tiefebene scheint er zu einem längeren Stillstand gekommen zu sein. In dieser ausgedehnten Feuchtbodenlandschaft erfolgte der Übergang zur neuen Wirtschaftsweise in einem graduellen Prozess. Einige Forscher sehen allerdings Anzeichen für eine rasche Konsolidierung der Neolithisierung zum Ende des 5. Jahrtausends v. Chr. In diesem Beitrag wird vorgeschlagen, die Neolithisierung nicht nur aus einer ökonomischen Perpektive zu betrachten, der aus heutiger Sicht wichtige Merkmale der Neolithisierung zugrunde liegen, die zudem erheblich von taphonomischen Faktoren beeinflusst werden. Vielmehr wird hier am Beispiel der Entwicklungen in Doggerland vorgeschlagen, eine 'indigene', mesolithische Perspektive einzunehmen. Die Kontextualisierung des Übergangs im Rahmen einer regionalen Gesellschaft innerhalb ihrer spezifischen Landschaft ermöglicht ein besseres Verständnis der Neolithisierung dieser Region. Es wird deutlich, dass die Neolithisierung dieses Gebietes wahrscheinlich ein langfristiger Prozess war, der nicht mit der Etablierung der ersten permanent genutzten bäuerlichen Siedlungen in diesem Feutbodengebiet beendet war.*

Introduction

The transition to agriculture in the Lower Rhine area has been hallmarked as a very gradual process that may have taken over a millennium (e. g. Louwe Kooijmans 1987) or more (Amkreutz 2013a) to complete. Basically, there is a coarse scale subdivision into two trajectories (cf. also Louwe Kooijmans 2007). A 'terrestrial' development starting with the advent of the Linearbandkeramik (LBK) in the south on the loess and coversand soils and developing over the Rössen and Michelsberg cultures into the Late Neolithic Stein group and Corded Ware. This is flanked by a development taking place in the extensive wetland areas between the rivers Scheldt and Elbe. Culturally this is characterised by a development that is firmly rooted in the local Late Mesolithic which develops into the Swifterbant culture, Hazendonk group and Vlaardingen culture and culminates in the late Neolithic Corded Ware. Over time different perspectives have dealt with this transition and tried to explain its stages and development resulting in shorter or

Fig. 1 Abstract geological map of the Lower Rhine Area. Indicated are LBK settlement areas (open rectangles) and some of the sites that feature in the text, notably **10** Hardinxveld, **11** Hazendonk, **13** Hekelingen, **14** Vlaardingen, **15** Schipluiden, **16** Ypenburg, **21** Swifterbant (adapted from Raemaekers 1999; Dusseldorp / Amkreutz 2015, fig. 1).

longer chronologies (cf. Raemaekers 2003, 744–745; Amkreutz 2013a). At the core of the debate is the question when agriculture came to dominate the subsistence economy, but also to what extent this way of life became part of the worldview of these communities (Dusseldorp / Amkreutz 2020). Clearly this is a dicussion where both quantitative and qualitative arguments are involved that to some extent appear irreconcilable. This contribution hopes to demonstrate that a different perspective and a wider scope altogether may be more fruitful.

Some aspects of the theoretical debate on agriculture and the Neolithic

The scientific debate regarding the process of neolithisation has for a long time been coloured by a search for a defining turning point. At what moments are enough elements of the 'Neolithic package' (e. g. Thomas 1999) present to define communities as Neolithic? Already in 1984 Zvelebil and Rowley-Conwy (Zvelebil / Rowley-Conwy 1984; see also Zvelebil / Lillie 2000) in their 'availability model' placed the emphasis distinctly

within the economic realm which historically has received most attention (Amkreutz 2013a, 54). Whenever domesticates and cultigens would take up more than 50 %, the transition to agriculture has arrived in the consolidation phase, following availability and substitution, effectively ending this process. Although clearly meant as a model it has two important fallacies. The first one is the primacy of (domesticated) subsistence, which is hampered by taphonomically induced variability (e. g. Raemaekers 1999, 13), but also offers a mono-thetic view on the past. It argues that culturally defined groups are economically, socially and ideologically coherent, that their level of transition can be quantified and extrapolated. The second fallacy in relation to this is the direction of the model and the lack of historicity and a contextual approach. Czerniak (1998, 30–31) already referred to the pitfalls of universalism, rationality and progress. We are dealing with a true mosaic of transitions (Tringham 2000, 53; Graeber / Wengrow 2021), and our insight only grows when we try to understand that from meaningful and useful perspectives. In any case this would advocate using alternative theoretical perepectives that function in a complementary manner to the economic approach.

The transition to agriculture in the Lowlands: a complex affair

Here we focus largely on the process of neolithisation of the indigenous communities in the Lower Rhine Area (LRA) wetlands and their margins (Fig. 1). While

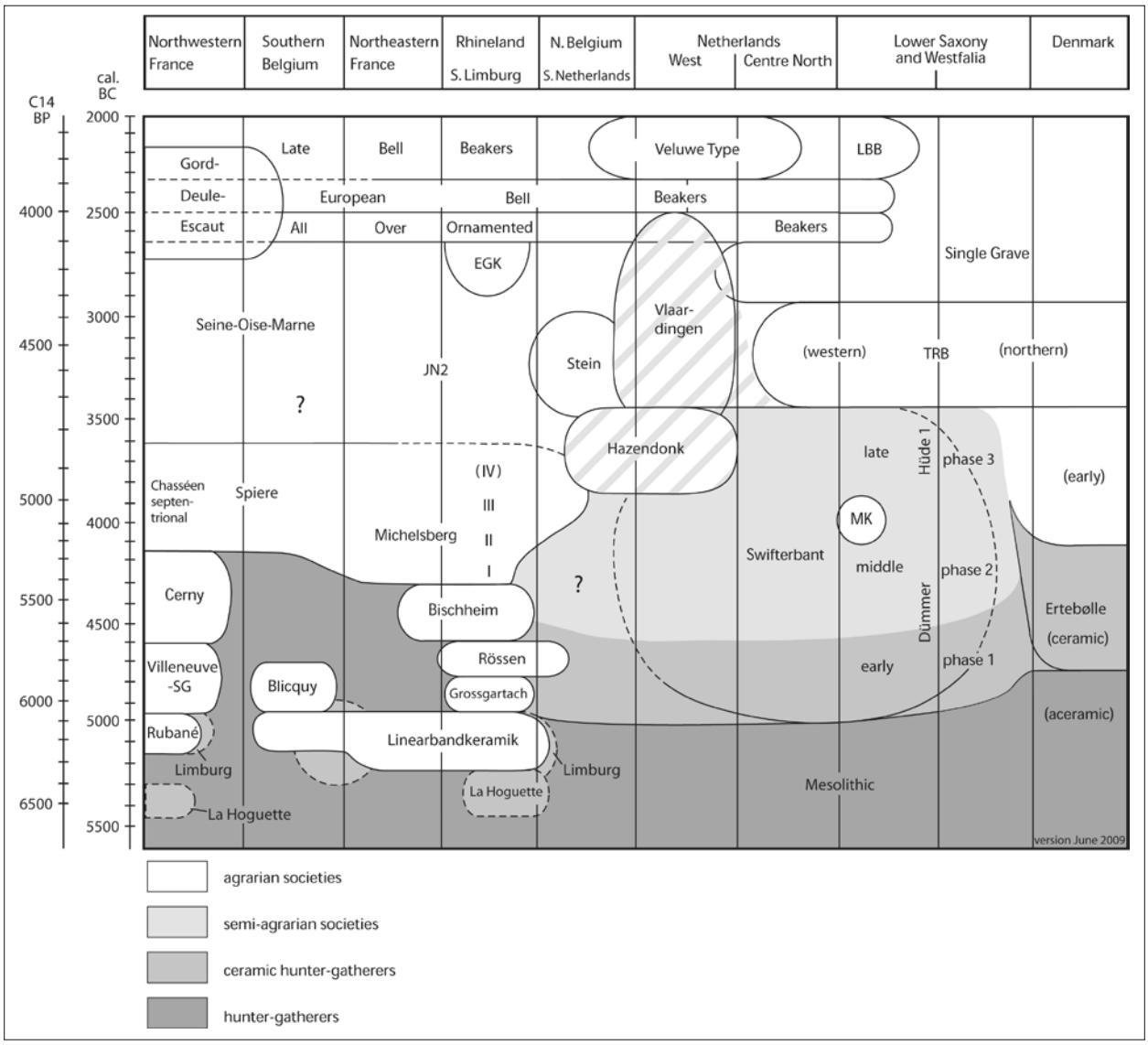

Fig. 2 Spatiotemporal perspective of the Mesolithic and subsequent Neolithic cultures in the Lower Rhine Area (based on and adapted from Louwe Kooijmans 2007; Amkreutz 2013a).

colonisation played an important part in the early stages of neolithisation, particularly with respect to the LBK, it may be assumed that the ensuing process also involved the local Mesolithic communities (e. g. Verhart 2000). Unfortunately the sites on the loess and acidic sandy soils hamper analysis of their actual contribition.

For the wetlands it may be stated that the productivity of the environment perhaps limited the inclination to adopt farming. Also, in tandem with the broad spectrum of resources a large part of this area is at or near the groundwater table and formed a dynamic wetland that in places was also flooded. It is questionable to what extent early farming strategies and crops characteristic to the valley-water-loess niche, would have worked and thrived here, whereas the higher and dryer places such as the dunes and 'donken' (elevated pleistocene dunes in the marshlands) may have provided insufficient space for any large-scale agriculture (Bakels 1986; Out 2008; 2009). Furthermore the location of the LRA wetlands and their margins at least in the early 5th millennium was situated far from the 'agricultural frontier'. In any case the developments that took place are based on a few datapoints that demonstrate an overall gradual and diverse take-up (see also Fig. 2 for a spatio-chronological background). In general the following scenario may be sketched:

– Evidence of contacts is present from the arrival of LBK farmers on the southern loess soils, most likely even predating the first LBK settlements in the Netherlands. At Hardinxveld-Polderweg a LBK-arrowhead and southern flint was found dating to phase 1 (5,500–5,300 calBC; cf. Louwe Kooijmans 2007). Rituals such as deposition practices may have been further inspired by these contacts, and in any case there is clear evidence of the acquisition of what could be perceived as prestige items or ritual objects, such as the adzes and 'Breitkeile'.[1]
– A second stage may be the indigenous production of pottery from around 5,000 calBC. This Swifterbant pottery predates Ertebølle ware, and the inspiration or incentive for its development may have been the southern contacts with LBK farmers. The brittle and fragile, low-fired vessels were used for cooking (among others, meat, fish and starch-rich plants: cf. Raemaekers et al. 2013) and probably storage, and their execution is similar to that of local basketry indicating a distinctive indigenous style (Louwe Kooijmans 2007, 297). It should be noted that the style and execution fit well in the wider boreal zone of pottery producing hunter-gatherer groups, so that this connection should be included in its appearance as well.
– Domesticated animals first appear at Swifterbant sites between 4,700 and 4,500 calBC at the sites of Brandwijk and Hardinxveld-De Bruin (Raemaekers 1999; Louwe Kooijmans 2007; cf. also Dusseldorp / Amkreutz 2016). As argued by Raemaekers (2019, 94, and references) this early date is to be questioned as it interferes with the more widely known dates around 4,000 calBC for the British Isles and Scandinavia. The numbers of bones from domestic cattle, sheep/goat and pig are small, so it is difficult to estimate whether this early livestock represents herded or individual animals, or perhaps meat either as import from farming communities or as part of (taphonomically invisible) seasonal herding activities practiced by these communities in the coversand area (Dusseldorp / Amkreutz 2015). Over time the contribution of domestic animals will have become more substantial, in general it ranges in between 3 and 39% (Dusseldorp / Amkreutz 2015). Game continues to be well represented also and it appears that livestock was added to an already existing way of life, rather than replacing that. Herding may have increased the reliability of food supply.
– Between 4,300 and 4,100 calBC the area witnesses the introduction of cereals (Out 2009), including grains, small-scale clearings visible in pollen diagrams, quern stones and horticultural fields at levee sites (Huisman / Raemaekers 2014; Raemaekers 2019). At the same time communities appear to have remained residentially mobile (Amkreutz 2013a). Previously it was thought that the area was too wet for farming and the locations too small (Bakels 1986), but this appears not to have been the case, and ethnographic data demonstrate that residential mobility can be combined with agriculture (e. g. Gregg 1988; Politis 1996; Barlow 2006). Again there appears to be no wholesale conversion. Gathered plant foods and wild game, as well as sites functioning in a system of residential mobility, remain important.
– Some researchers argue for a final stage to be represented by those sites where there is convincing evidence for intensive husbandry and crop cultivation. In particular the site of Schipluiden, a post-Swifterbant period Hazendonk group site, has been interpreted as such (Louwe

1 Verhart 2000; Louwe Kooijmans 2003; 2007; Peeters 2007; Amkreutz 2013a.

Kooijmans 2007). Such a site is considered to be an endpoint in the process of neolithisation.

Culturally (Figs. 2–3) the transition to an agricultural existence can be envisaged as follows according to the availability scheme, with an availability phase that covers the Late Mesolithic and early part of the Swifterbant culture, a long substitution phase within the Swifterbant culture and a distinct consolidation around the time of the Hazendonk group or subsequent Vlaardingen culture.

An earlier consolidation?

Although it is clear that dividing the process of neolithisation into different phases may help our understanding, it also creates a simplified version of what happened. On the one hand there are distinct chronological problems due to radiocarbon calibration plateaus and taphonomic biases. Raemaekers (2003; 2019) indeed argued that the transgression of the coastal area in the 5th millennium may have obscured a whole group of Swifterbant sites that might have been much more agricultural in nature than the sites further inland would indicate. A consolidation phase with sites where domesticates and cultigens would make up more than 50 % would then have arrived even sooner. The main point of this argument, however, is the fact that for the coastal area the domestic faunal attribution and the evidence for sedentism and cultivation during the Hazendonk period indicate that the consolidation phase may have to be placed in or even before that period. This would imply that previous research has missed finding a preceding stage, which, in turn, could be well imagined to have been in the coastal area. The fact that faunal assemblages differ more with respect to landscape (coastal, freshwater wetland, salt marsh) than over time is seen as substantiating this perspective (Raemaekers 2003, 744–746).

Recently Raemaekers (2019, 99–100) also added another, more social dimension to this discussion with the anthropological notion of taboo. Arguing that the transition to farming is in essence a subsistence change, it is reasoned that there are indications for avoidance and incorporation. For instance bone tools were made both from wild and domesticated animal bones at the S3 Swifterbant site, while depositions of cattle horns from 4,000 calBC onwards further indicate a change in perception towards livestock contrasting with the period before. Also around this time a new type of pottery with different temper, wall thickness and and quality was developed that appears to be connected to the growing and consumption of cereals. This correlating set of changes would then make the centuries around 4,000 calBC a crucial time during which domesticates and cultigens had taken centre stage. It is argued that this more social perspective centred on notions of taboo provides a different and perhaps more suitable perspective on neolithisation compared to the mechanical availability model (Raemaekers 2019, 100). Also it would align the developments in the 'Swifterbant-world' more with the transition in Great Britain and southern Scandinavia (Raemaekers 2019, 100).

Criticism of the availability model

It is interesting that it is difficult to pinpoint the 'arrival of the Neolithic' for the LRA-wetlands. The question is whether the specific situation here, both regarding landscape and indigenous communities, is suited for the application of something as abstract as an availability model (Fig. 3). Clearly, the model was intended as such, as a means of mapping a period of transition, but there are some serious flaws that question whether its variables are suitable for this task. I have discussed these earlier (cf. Amkreutz 2013a, 355–357; see also Dusseldorp / Amkreutz 2020) and briefly summarise them here again.

- The original model argues there can only be a short substitution phase due to man power and scheduling issues. The situation in the LRA indicates that this phase may have been distinctly longer.
- The model is distinctly economic and quantitative, focusing only on faunal composition. Although it is clear that that this has been done because it is one of the few comparable variables, it does not do justice to the potential set of changes the neolithisation encompasses. Similar to how hunter-gatherers have been framed in ecological terms this demeans the first farmers to operatives in an essentially economic and homogenous framework. Change or lack of change in other areas is not included.
- The model lacks the resolution to deal with spatio-temporal variability, whereas the process of neolithisation has correctly been described as a mosaic (e.g. Tringham 2000, 21). It is therefore only suited to study the process across large regions and timeframes, which begs the question whether that is the level at which it should

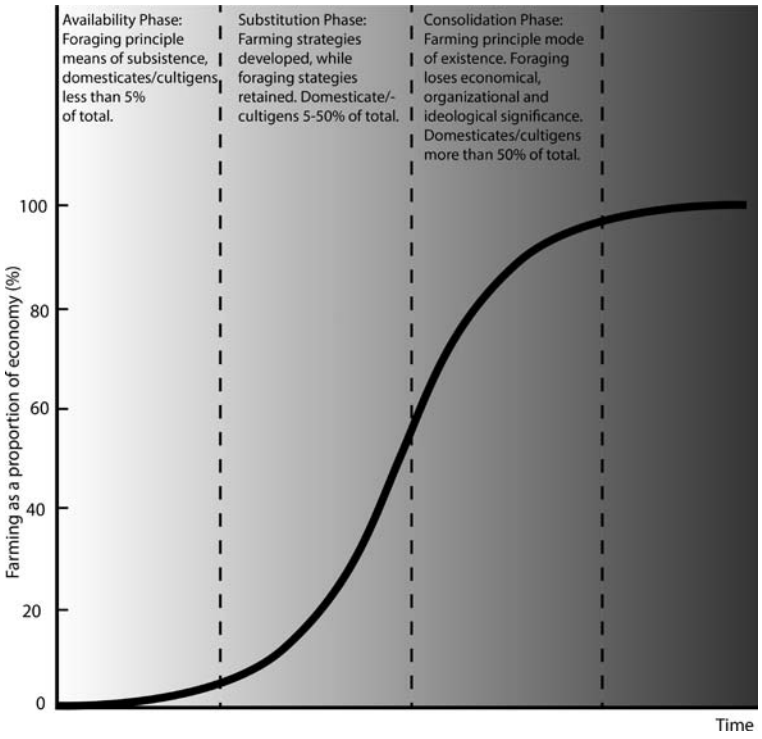

Fig. 3 The availability model (adapted from Zvelebil 1986; 1998; after Amkreutz 2013a, fig. 3.7).

be studied (eventually we all became farmers). There is therefore a need to zoom in on regional developments that are culturally meaningful and coherent yet geographically broad enough to understand the multitude of factors in play and the effects of interaction, contact and exchange. This also means acknowledging 'historicity', the notion that things developed differently at different places.

– In relation to this and opposing Zvelebil (1998, 11) this makes it questionable to what extent the contribution of domesticates may be distinguished for a cultural unit, based on single sites. Raemaekers (1999, 13) argued that presence / absence rather than proportional data may be used, as sites fit in a settlement system and the subsistence base could basically be gathered from the most agricultural sites. For instance it is argued that real agrarian settlements are distinctly present within the Vlaardingen culture in the coastal area (including house plans, many bones from domestic animals and evidence for cereal cultivation in pollen diagrams). It is argued that the main sites ('base camps') were therefore located in the (intra-)coastal area, while it is suggested that the sites with a more 'wild' signature, situated in the freshwater marshes, would have functioned in a subordinate position in this settlement system (Raemaekers 2003, 743–744). It is also suggested that this system may already have been in place during the period of the Hazendonk group (Raemaekers 2003, 743–744; Louwe Kooijmans 2007). It is questionable to what extent this underlies the differences in faunal composition between sites observed and wether it is not a relict from a final point of critique:
– That the model is read from left to right and therefore has a distinct teleological character. Our western studies of this period have been distinctly coloured by our aim to define a moment at which hunter-gatherers became farmers, and ultimately this and the vocabulary we use for this (e. g. frontier, transition, process, availability, substitution; cf. also Whittle / Cummings 2007, 2) are rooted in the antiquarian perspective of the superiority of agriculture (Graeber / Wengrow 2021).

It is thus questionable whether the diverse landscape of sites and faunal compositions in the LRA wetland lends itself easily for an economic perspective based on progress but studied primarily through a quantitative analysis of faunal remains at single sites that stand for cultural phases. The social perspective offered by Raemaekers (2019) through a diachronic model of taboo in this respect offers a welcome alternative. In any case, it tries to understand the developments taking place not by focusing on a taphonomically flawed category of faunal remains, but from the perspective of the inhabitants themselves and their actions in relation to changes taking place. These patterns, although for now based on a limited number of cases, document distinct and meaningful actions. At the same time the

trouble is that they may be interpreted differently as well: (producing) bone tools may have been something to which little meaning was attached. Offering domesticated cattle horns might be related to issues of availability, and a change in pottery production to suit new food types may be equally pragmatic. While I would advocate further case-studies in this direction, I would also argue that more or additional insight into the developments taking place in the whole wetland region and the characteristics of the process of neolithisation may come from a better understanding of that region and the mutual interaction between it and its inhabitants. Crucial here is to acquire a more fundamental notion of how communities over time interacted with their environment. Some inspiration for this may be drawn from a case study of Mesolithic Doggerland.

Surviving Doggerland

The area in front of the Dutch coast and extending to Denmark, northwestern Germany and Great Britain is known as Doggerland (Coles 1998; Amkreutz / Van der Vaart-Verschoof 2021). At the end of the last Ice Age this area witnessed sea levels that were about 70 m lower. This vast region in the southern North Sea area was a rich and diverse landscape, ideal for Mesolithic hunter-gatherers (Gaffney et al. 2009). Over time this landscape drowned, which was usually gradual, on average about 2 m per century, but at times may have been dramatic and eventful, such as during the draining of Lake Agassiz and the Storrega slide (Hijma / Cohen 2010; 2011; Peeters / Momber 2014). In any case it was something that was witnessed over the generations.

Gradually our knowledge of this area is increasing through both on- and off-shore investigations (Peeters et al. 2019), including near-shore excavations of Mesolithic sites as at Bouldnor cliff or at the Rotterdam Yangtze harbour (Moree / Sier 2015). The major source of information though are the numerous finds that surface mainly due to beach nourishment and, at least for the Dutch situation, the large infrastructural projects of the Maasvlakte 2 extension of Rotterdam harbour and the Zandmotor suppletion area near The Hague (Peeters et al. 2019; Peeters / Amkreutz 2020). The number of Palaeolithic and Mesolithic finds from this area reaches many hundreds

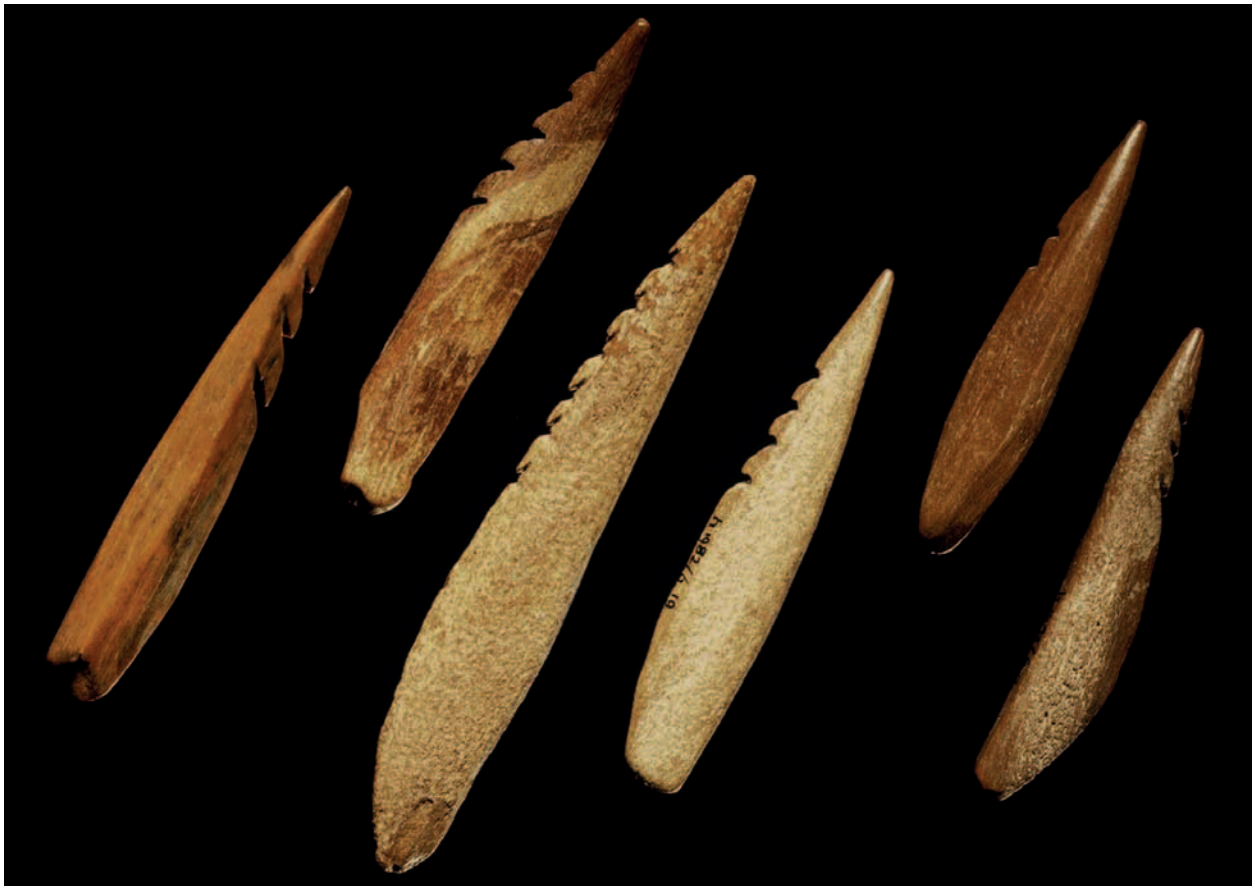

Fig. 4 Bone and antler arrowheads from the North Sea area in front of the Dutch coast and Maasvlakte 1 (photo: Rijksmuseum van Oudheden).

Fig. 5 A number of skeletal remains dating to the Mesolithic that yielded isotopic information on diet (photo: Rijksmuseum van Oudheden).

these days and includes lithics, faunal remains with cut marks, as well as bone and antler tools (e. g. Amkreutz / Spithoven 2019; see Fig. 4). Among these are also numerous human remains that potentially date to the Mesolithic (Fig. 5). These types of secondary surface finds have often been accused of having little scientific value due to the absence of contextual information. While this is partly true, their often excellent preservation and quantitative numbers make them valuable research material. In a recent study (Van der Plicht et al. 2016), the human remains from beaches were combined with those that mainly derived from fishing nets and all were studied for their isotopes, both ^{14}C and the stable isotope ratios of carbon $\sigma^{13}C$ and nitrogen $\sigma^{15}N$. This C/N value is informative as a proxy for the (palaeo) diet of individuals in roughly the last decade of their life. It points out both the trophic level and the aquatic component of freshwater, or marine resources in the diet. The information is therefore indicative of the environment, the diet and behavioural changes therein.

The study comprised 55 specimens, of which 32 had a Mesolithic date. The overall composition of the C/N ratio indicated that most individuals fell into the terrestrial / freshwater regime, with only a few coastal dwellers and a few with an 'inland' terrestrial signal (Van der Plicht et al. 2016, 115). This aquatic signature is readily comparable to that of the Late Mesolithic wetland site of Hardinxveld (Smits / Van der Plicht 2009) and contrasts with Mesolithic inland sites such as those in a study of the Meuse valley (Bocherens et al. 2007). While we cannot estimate the effects of differential preservation it is clear that there is much emphasis on a freshwater aquatic diet, which ethnographically is one of the richest environments for hunter-gatherers (Nicholas 2007). Moreover, the study also mapped the diet signals over time. While the reservoir effect prevents calculating the dates to absolute ones, the relative pattern demonstrates that the diet of the Doggerland inhabitants became more aquatic over time. Therefore the older dates are more in line with an inland signal as the coast was not yet close, while the younger dates are clearly wetland oriented. These people made use of the extensive freshwater wetlands and their resources that arose in front of the encroaching coastline. This development indicates that the Doggerland inhabitants were very capable of dealing with changing circumstances by shifting their diet to aquatic resources. The dynamics of the landscape and its changes appear to have been embraced by the occupants (Nicholas 2007, 116). For Neolithic purposes this also nuanced the well-known debate of there being a distinct shift from marine to terrestrial sources with the onset of the Neolithic (e. g. Schulting 2011). It rather appears that there is a strong tendency to make use of freshwater wetland environment and that there is a flexible disposition among these hunter-gatherers to make the most of changing circumstances and resources.

Living in a dynamic landscape

It is difficult to establish to which extent the wetland hunter-gatherers of the 7th and 6th millennium BC are the actual ancestors of the Mesolithic communities living in the LRA wetlands before and during the process of neolithisation. While some have suggested an inland relocation of hunter-gatherer groups (e. g. Newell 1973), it is up to future aDNA research to actually establish these connections (Amkreutz et al. 2017). Nonetheless it is plausible that the wetland landscape and its dynamics are comparable to a certain extent. The wetland zone where the sequence of cultural groups from the Late Mesolithic to the Vlaardingen culture may be situated lies roughly between the rivers Scheldt and Elbe (Raemaekers 2019, 93; see Fig. 1). The Meuse and several Rhine channels run east to west, and the area was under continuous influence from the rising sea level. The coastal envi-

ronment in the west did not stabilise until the start of the 4th millennium calBC. East of this zone there was an area with tidal flats, salt marshes and low dunes. This area knew both brackish and freshwater environments that shifted over time. Further east in the riverine area and the Scheldt basin further south the freshwater wetlands consisted of peat swamps, lakes and streams where Pleistocene river dunes – 'donken' – formed dry inhabitable patches. In the Ijsselmeer basin and around Swifterbant there also largely was a freshwater environment with habitation on levees and river dunes (Dusseldorp / Amkreutz 2020, and references). While this wetland landscape geographically may be characterised as diverse it moreover changed over time. The transgression of the sea until c. 4,000 calBC resulted in peat growth and an eastward shift of the system of beach barriers, lagunas and peat marsh, while later on, after the drop in sea level rise, there was an outwards extension of the beach barriers (Vos / Kiden 2005; Dusseldorp / Amkreutz 2020). The many shifts over time also will have had their effects on the vegetation and wildlife, while marine incursions and peat growth at times made certain areas uninhabitable. In conclusion it may be stated that this landscape was never stable and always in flux. In turn, its occupants, while benefiting from the riches of a wetland environment could only do so by operating in a flexible and pragmatic manner – although the latter is more of a modern research frame.

If we review the characteristics of the communities in the LRA wetlands between c. 5,000 and 3,000 calBC, focussing on the human-environment relationship, then many aspects of their habitation and livelihood (cf. Whittle 2003) can be connected to such a flexible disposition and interaction with the environment. While this has been elaborately discussed elsewhere (Amkreutz 2013a, ch. 8 and 9) I will underline some of the major points.

Subsistence

Food procurement offers an essential insight into community-environment relationships. The rich wetland landscape offered many resources to its inhabitants. As such there was little incentive to quickly adopt agriculture also in view of the fact that many locations were likely unsuitable for large scale crop farming or husbandry. Instead the new Neolithic elements were incorporated in what has been termed an 'extended broad spectrum economy', broadening the range of available resources (cf. Louwe Kooijmans 1998; 2007). At the same time while domesticates and cultigens increasingly contributed to subsistence, the practices and native knowledge of hunting, gathering and fishing also remained important (Amkreutz 2013a, 427; see Fig. 6). If we take the faunal remains as an indicator of neolithisation then these primarily reflect the natural exploitation pos-

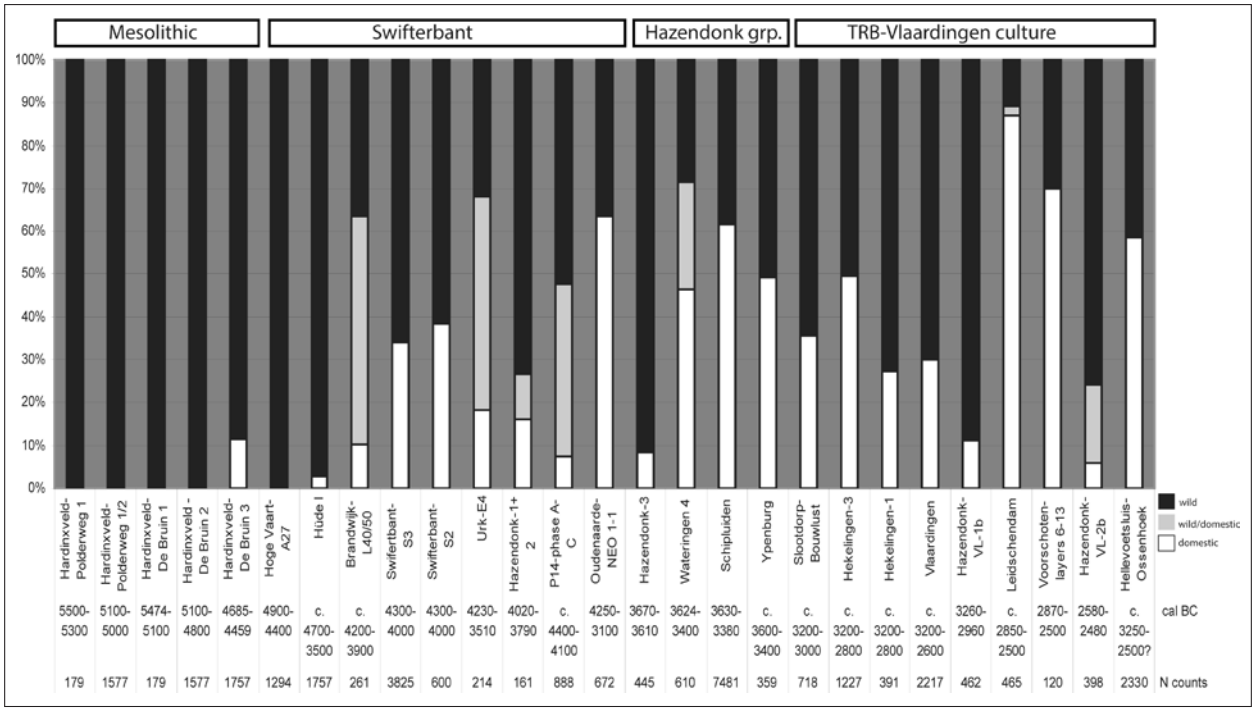

Fig. 6 Faunal spectra documented at a number of wetland and wetland margin sites between 5,500 and 2,500 calBC. Clearly visible is the continued importance of wild faunal resources until well into the Late Neolithic (adapted from Dusseldorp/Amkreutz 2015, fig. 3).

sibilities of the environment, both regarding hunting and farming (e. g. Amkreutz 2013, 427; cf. also Raemaekers 1999; 2003). As such the predominance of domesticated fauna is mainly a feature of coastal and potentially wetland margin sites from the Hazendonk group onwards, however, as late as the Vlaardingen culture there are distinctly different domestic sites, such as Hekelingen 3. These sites have a more varied faunal composition, and their records show that wild resources (at Hekelingen 3 over 50 %) remained an important aspect of subsistence (Amkreutz 2013a, 427). The contribution of crop cultivation is more difficult to establish (Out 2009, 445), but also appears to have been of greater importance in the coastal areas, while there is positive information for small-scale cultivation, for instance around the Swifterbant sites (Huisman / Raemaekers 2014). This indicates that well into the late Neolithic there is a range of different wetland 'livelihoods' existing side by side. Moreover, the supposed agricultural character of sites such as Schipluiden is also to be seen more nuanced. Hallowed as the the first site that yielded convincing evidence for a complete 'Neolithic', including crop agriculture, animal husbandry and year-round occupation (Louwe Kooijmans 2006), the stable isotope analysis of the skeletons of its inhabitants indicated that marine foods actually accounted for a large proportion of the diet (Smits / Van der Plicht 2009). Recently it has been suggested that this signal may also derive from the consumption of (for instance) meat from cattle grazing on the salt marsh as indicated by their isotopic values. It is likely that both strategies were going on as the authors conclude (Kamjan et al. 2020, 15), and the puzzle remains difficult to entangle. Also evidence postdating Schipluiden indicates that one site should not be interpreted as the norm.

In conclusion it appears that adopting producing modes of food procurement did not always have the repercussions we assume they do, based on our often used Neolithic perspective (Whittle / Cummings 2007). The flexibility and independent choices of the communities involved are also emphasised by the Delfland case-study (Louwe Kooijmans 2009), where largely contemporaneous Hazendonk-group sites such as Schipluiden, Ypenburg and Rijswijk, which are situated in close proximity and within comparable geographical and ecological contexts, display distinctly different choices in subsistence procurement, settlement layout and occupation dynamics over time. All of this speaks of a range of pursued strategies, the use of which is sometimes

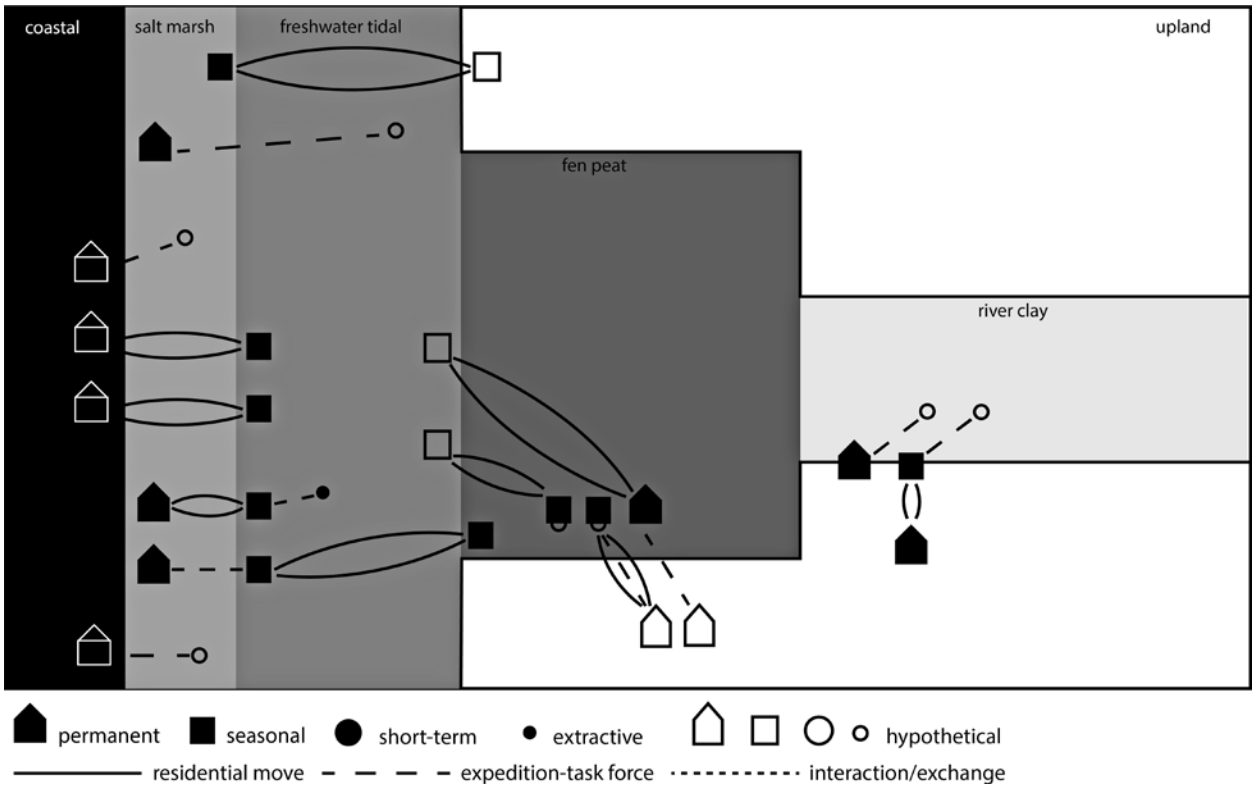

Fig. 7 Cartogram of the hypothetical range of site relationships for the Late Neolithic Vlaardingen culture based on the economic, structural and seasonal information of excavated Vlaardingen sites (cf. Amkreutz 2013a, ch. 8). Site relations are hypothetical, but the evidence allows for multiple systems instead of one focused on permanent settlement and subordinate site relations (after Amkreutz 2013a, fig. 8.9).

rather experimental or haphazard even (Amkreutz 2013a, 431), much in line with the flexible disposition that occupants of a dynamic wetland environment benefit from.

Seasonality, mobility and investment

The flexibility indicated by the subsistence mode is mirrored in site-use, mobility and the settlement system in general for this period and region. It is argued (Amkreutz 2013a, 428) that while activities were seasonally specific, the freshwater wetlands were also always residentially inhabited (Fig. 7). This domestic occupation continues into the Vlaardingen culture as demonstrated by sites such as Hekelingen, Vlaardingen, Hellevoetsluis and Hazerswoude. Here there is a substantially wild component in the economy, combined with sites that may not have been occupied permanently, but at least seasonally as residential sites (Amkreutz 2013a, 428). Both these locations, but also sites such as Schipluiden in the coastal area, are moreover characterised by an architecture of often rebuilt houses or huts, often constructed of alder posts with a small diameter and short use life (Amkreutz 2013a).

It may be argued that from the Hazendonk period onwards there is increasing evidence that a significant contribution of agriculture also changed aspects of the settlement systems. Overall there appears to be a trend from seasonal residential moves, combined with logistical mobility in the Late Mesolithic and Early Swiferbant period, towards permanent settlement combined with logistical mobility from the Hazendonk period onwards. Although in this perspective permanent agricultural settlements such as Schipluiden may take on a 'fixed' position they do not determine the system. There remains a range of viable options in which seasonal occupation of semi-agrarian to non-agrarian residential settlements can be determined until well into the Vlaardingen culture. For instance the freshwater wetland site of Hazendonk during the Vlaardingen phase 1b forms a good example (Louwe Kooijmans / Verbruggen 2011): there the presence of a palisade and evidence of (semi-)permanent occupation is combined with much terrestrial hunting (cf. Amkreutz 2013a, 400). Mobility and seasonality remained important, permanent occupation was part of a range of options and probably co-existed alongside and interacted with other systems. There appears to be a distinct sense of group agency that allows for the operation of different types of settlement systems and even different choices within the same ecological zone (cf. Louwe Kooijmans 2009). Even until the Vlaardingen culture occupation there is evidence for year-round permanency and an agricultural subsistence base, predominantly in the coastal areas, while the freshwater tidal and peat marsh areas continue to offer opportunities for logistical mobility and non-permanent residential sites (Amkreutz 2013a, 431). How all these sites function in relation to one another will be a task for future research, but to group them in a subordinate system when the first permanent settlements develop is too easy a scenario that does not sit well with the diversity of data available.

Human-environment interaction and integrative strategies

Our perspectives on the long process of neolithisation may benefit from new ideas on human-environment interaction. This demands that we overcome seeing the landscape as an economic backdrop and instead perceive it as an important agent in the structuring of its inhabitants. There is a profuse amount of ethnographic and archaeological literature on the way in which landscape shapes its occupants over time[2] – and it is likely that, much in line with the Doggerland example above, the dynamics of the LRA wetland environment will have shaped the inhabitation and therewith the character of the communities occupying it. Reasoning from Ingold's dwelling perspective (Ingold 2000), there is a distinct interwoveness between people, places, and environment. Landscape and environment have certain structural conditions, but also have a distinct structuring agency (Barrett 2000). For the LRA wetlands the internal dynamics of this environment would have been an important factor and people will have dealt with these. Processes of flooding, peat growth, waterlogging and changing compositions of resources, routes, networks and inhabitable places would have been part of these dynamics. As most of these were gradual, they were the stuff of generations, much like the drowning of Doggerland, but at times changes were also swift, unexpected and dramatic. Instead of perceiving these as misfortunes or even catastrophes (Leary 2009), it is more likely that the long-term relationship of these communities with their wetland environment made them something natural and expected. The fluidity of the environment over time again promoted

2 E. g. De Coppet 1985; Ingold 2000; Harrison 2004; Van de Noort/O'Sullivan 2006; Leary 2009.

flexibility of the communities inhabiting it. A good example of this is the fact that some sites such as Hazendonk were used over long periods of many centuries. Rather than abandoning these places they assumed new roles and became persistent places within continuing settlement systems (Amkreutz 2013b; 2013c).

Taking this into account it is perhaps good to review the introduction of new resources within the process of neolithisation. It appears that people were not dominated by environmental change (Van de Noort / O'Sullivan 2006, 25), but rather adjusted aspects of their way-of-life without fundamental change (Amkreutz 2013a, 429). This attunement to a changing environment in space and time sits well with the development of an extended broad spectrum base as proposed by Louwe Kooijmans (1998). The incorporation of new resources, agricultural products and eventually practices alongside existing ones may have offered many benefits for dealing with or buffering against shortages. At the same time it appears that these new resources at no point were really seen as something extraordinary, and while over time an increasing investment in crop cultivation and husbandry will have changed the existing rhythms, these new practices very much also became part of a very flexible habitus. It is therefore wise to move from the economic perspective of the extended broad spectrum economy to a perspective that actually investigates its operationalisation over time. This means moving from economy to strategies including mobility, symbiosis, interdependence, group interaction and exchange within resource networks. Understanding wetland communities by studying these integrative strategies (Amkreutz 2013a, 430) – which cannot be detached from the wetland environment – is more beneficial for understanding their position in the process of neolithisation than merely focusing on subsistence and economics (often through the lens of faunal remains' composition).

A long transition and a model of attunement

It is clear that the choice between a short or long transition towards agriculture for the LRA wetland communities is strongly dependent upon the accents one places with food procurement, the settlement system and the presence or absence of indicators. It is telling that different research groups focusing on the same area and process argue partly in favour of a long transition (Crombé et al. 2020, 11; Dusseldorp / Amkreutz 2020) and a long substitution phase, while others placing different accents argue for a more rapid introduction and turnover at the end

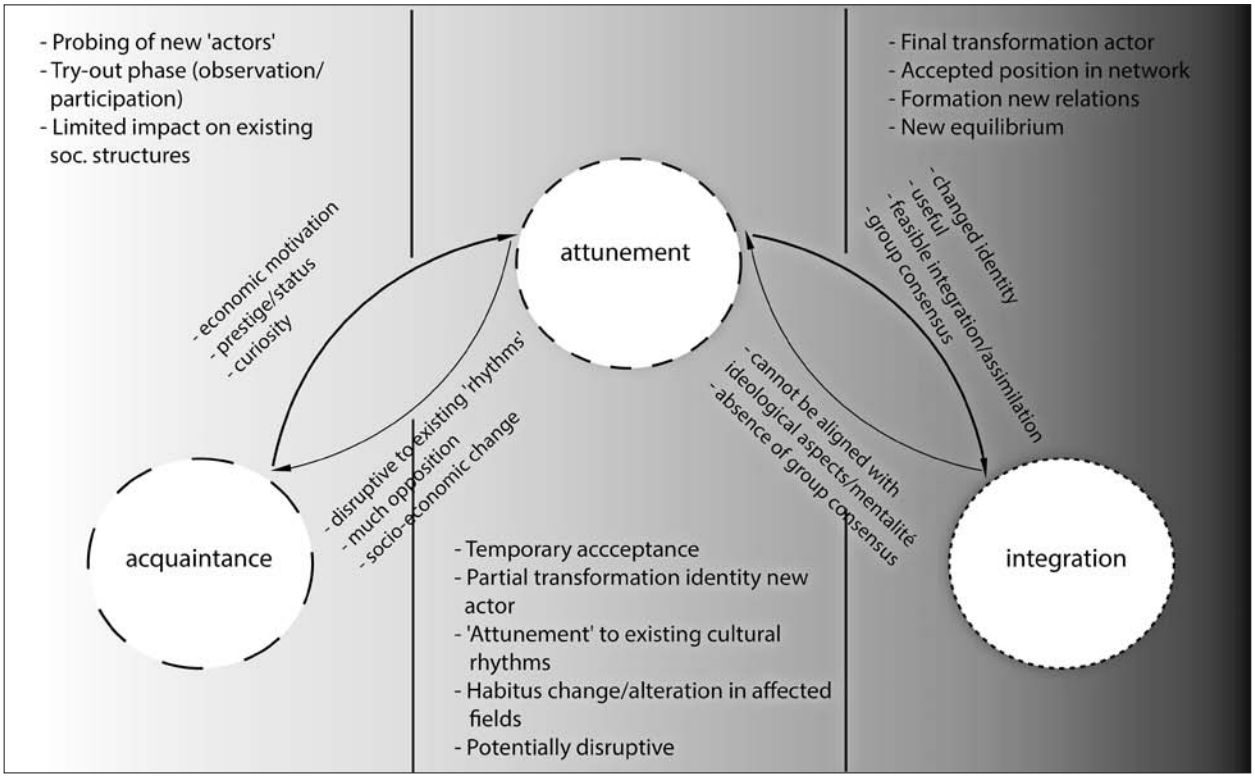

Fig. 8 A 'new' availablity model, focusing on 'attunement' and abandoning Neolithic directionality (after Amkreutz 2013a, fig. 10.2).

of the fifth millennium calBC (Çakirlar et al. 2020; Kamjan et al. 2020). In a way this perhaps already demonstrates that the area of the Low Countries was home to different processes and that it is not possible to capture just one sequence of events. Therefore, looking at the communities and their practices as a whole, there is a strong element of continuity that stretches across millennia and that points out that new knowledge, products and practices did not lead to any sudden or swift changes. The exciting aspect of this rather is the way different resources and strategies were used in and between regions, than the composition of the food economy at certain sites (Amkreutz 2013a, 535). By reasoning from the human / non-human relationships in a certain environment, an idea of a community mindset or *mentalité* may be identified (e. g. Descola / Pálsson 1996; Whittle 2003) for these wetland inhabitants. They should be studied as 'total phenomena': specific types of socio-cultural systems that historically have interacted in finite and comprehensible ways with parts of the biosphere (Balée 1998, 24).

Reasoning from this perspective it is arguable that this system which roots in the Mesolithic prevails until well into the Late Neolithic in the LRA wetlands. From this point of view a (very) long transition would be the most plausible characterisation.

This also allows us to reconsider the much used and criticised availability system. At the base of this should be the human-environment relationships and the general idea that among hunter-gatherers there is a sense of 'a giving environment' (cf. Bird-David 1992a; b), where there exist equal relationships between people and their environment and where there is no particular distinction between nature and culture. As such new elements that occur with the advent of the Neolithic may be seen as new actors in this giving environment. Actor Network Theory (ANT; e. g. Callon 1986; Latour 2004) offers a means to study this as new actors in a network, which in this case could be anything from polished axes to cows, and from migrating farmers to knowledge of cultivation practices. They are accepted in a number of stages that allow a new actor to settle in existing structures without seriously disrupting them. Drawing inspiration from this theory the model of availability, substitution and consolidation (cf. Zvelebil 1986) may be replaced by one of 'acquaintance', 'attunement' and 'integration' (Amkreutz 2013a, 449–450; see Fig. 8). The phase of acquaintance would involve the existing actors to become aware of a new element in the network, and certain elements may be in favour or against it. The phase of attunement would see the temporary acceptance of a new actor in the network whereby implementation depends on the degree to which the new elements are disruptive. Group consensus and the way in which the 'identity 'of the new actor may be transformed are crucial here. And a final phase would be integration in which the new actor is accepted. This phase would be characterised by the acculturated local implementation of the new actor and the degree of continuity in the existing socio-cultural moral network (Amkreutz 2013a, 449–450).

As argued earlier (Amkreutz 2013a, 451) this 'new' model is mainly a semantic rephrasing of the availability model, but it places a different emphasis by not foregrounding economic aspects, but a much wider body of novelties and elements, and by accentuating not quantitative contribution, but the way new elements are integrated in communities while at the same time preserving their existing structures and *mentalité*.

As such the model does not support the idea that the first use of domesticates and cultigens involved a new conception of the relationship between human beings, their environment and time (Bradley 2004, 112), and it questions the degree to which domesticates and cultigens should take centre stage in studies on neolithisation (Amkreutz 2013a, 451). It may be much more realistic, reasoning from a hunter-gatherer perspective, that they were less alien and disruptive than we expect.

Conclusion

The foregoing remarks have been an exercise in viewpoints. Taking inspiration from Doggerland and the dynamic implications for its inhabitants, the aim was to offer a new perspective on the process of neolithisation in the wetland area of the LRA. While the discussion on the economic composition of sites over time and their position in the transition to agriculture is of distinct importance, it is argued here that it may be more useful, or at least insightful, to adopt a different perspective as well. This perspective should be grounded in the notion that there exists a long-term and meaningful relationship between communities and their landscape and environment. In the case of the LRA wetlands this relationship is characterised by environmental dynamics and by a resulting community mindset or *mentalité* that benefits from a flexible attitude towards change and from integrating a variety of strategies. As such it argues there is more to be learned from studying these communities against

the background of the process of neolithisation, then the other way around. Furthermore this enables us to look at neolithisation from the perspective of the communities and processes involved whereby new elements are attuned to existing rhythms and practices, and where there is room for flexibility, change and dynamic interaction. It is less the question of when, where and why we became Neolithic and more of how communities negotiated the process we define as neolithisation while (also) remaining themselves.

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Supra-regional contacts and the earliest metallurgy in southern Scandinavia during the Mesolithic-Neolithic transition

Anne Birgitte Gebauer and Lasse Sørensen

Abstract During the Mesolithic-Neolithic transition in Europe and the Near East, four exotic materials (obsidian, amphibolite, jadeite, and copper) were acquired from distant regions through complex networks of interaction, in addition to the domesticates. In this paper we focus on the network emerging by investigations of the distribution of amphibolite, jadeite, and copper, as objects made from these raw materials are interpreted as important items connected to the introduction of the Neolithic/agrarian lifestyle and ideology in southern Scandinavia.

Keywords Network, raw materials, South Scandinavia, neolithisation, ideology

Zusammenfassung *Während des Übergangs vom Mesolithikum zum Neolithikum in Europa und im Nahen Osten wurden neben Haustieren auch vier exotische Rohmaterialien (Obsidian, Amphibolit, Jadeit und Kupfer) aus weit entfernten Regionen über komplexe Kontaktnetzwerke bezogen. Der Aufsatz setzt sich auf Basis der Untersuchung von Amphibolit, Jadeit und Kupfer mit der Verbreitung solcher Funde und den aufkommenden Netzwerken auseinander. Nach der Interpretation der Autoren waren Objekte aus diesen exotischen Rohstoffen für die Menschen wichtig und spielten daher eine Rolle für die Einführung der neuen neolithischen Wirtschaftsweise sowie die Ideologie dieser Zeit in Südskandinavien.*

Introduction

Already during the Upper Palaeolithic period, networks of varying demographic size and geographic scale were operating, and by sharing and exchanging exotic materials and objects, people extended and intensified their networks, which led to an elaboration of material culture (Gamble 1998, 432, 442). People realised that their extensive networks consisted of many people who they might never meet and/or get to know.

The intensification of exchange networks marks a significant change at the beginning of the Neolithic. According to Watkins (2008, 165; in prep.), the first large-scale human communities emerging at the Epipalaeolithic-Neolithic transformation in the Near East engaged in intensive networking with extensive 'super-communities'. The super-communities during the Neolithic were much larger than the extended networks of the Upper Palaeolithic and included larger, permanently settled, local communities (Watkins 2017). The benefits of participation in these expanded networks included a diversification of culture and the capacity for innovations with rapid evaluation and adoption of adaptations. The risks associated with the newly limited mobility connected to the farming lifestyle were countered by the intensification of the exchange networks that enabled the sharing of resources, information, and genes, but also the emergence of monopolisation and secrecy (Ibáñez et al. 2016). Exchange may also have played a role as a means of establishing mutual social relations and commitments of future collaboration in order to reduce risks related to resource shortages (Wiessner 1982). In addition, a shared cultural background created by exchange relationships may have suppressed tendencies towards suspicion and hostility towards others in case of inter-communal conflict (Ibáñez et al. 2016, 21).

Actor Network Theory

A network is traditionally associated with a group or system of interconnected humans, but recent investigations have argued with the proposal of the Actor Network Theory that all entities of both human or non-humankind can act within one or several network

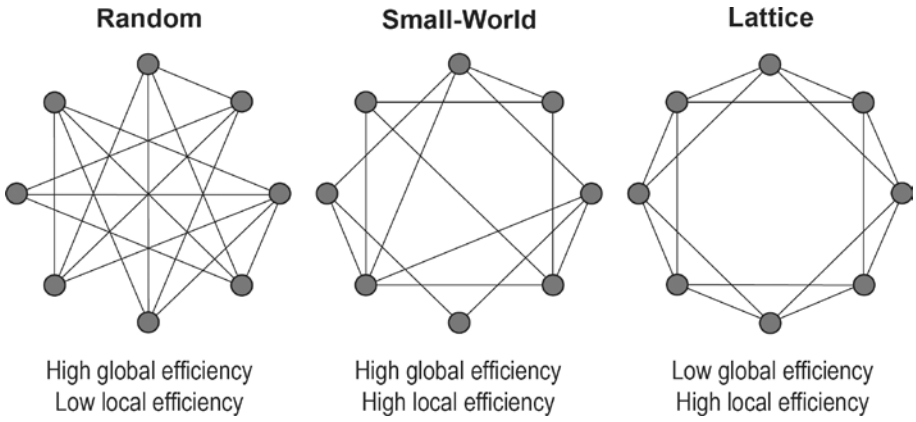

Fig. 1 A small world network (shown in the middle) processes connections between both remote localities and neighbouring communities, thus contributing to high global as well as local network efficiencies. Properties of small world networks are intermediate between those of the lattice and the random network as they are highly clustered like the former yet have small path lenghts like the latter. (after Zhao et al. 2015, fig. 2. Open access available by license CC BY 4.0).

connections, depending on the different relations and contexts (Latour 1996). As a result, knowledge and ideas can be transmitted by both humans and, more importantly, non-human agents. The Actor Network Theory operates with two different types of concepts regarding the exchange of information. *Intermediaries* are entities which transport information to another entity without any transformation. *Mediators* on the other hand are entities which multiply differences or imitations such as material objects that may be investigated in the archaeological material. Behind the exchange of mediators lies a whole range of traditions, routinized practices, or obligations connected with social interactions between human beings. Mediators may be exchanged directly between people as gifts. If, however, a mediator changes hands several times ending up in more marginal areas of a network, the original meaning and ideas associated with this object may change to something different or a hybrid of information depending on the context (Wobst 1977). The hybrids of objects, ideas, and knowledge can in turn create new networks and result in the disappearance of other networks. Using the Actor Network Theory in archaeological research makes sense, as cultures, styles, depositional practices, and technologies can be associated with networks of contact expressed through objects, burials, and structures.

Documentation of networks in archaeological context?

Beyond the scale of networks as a phenomenon, the character of their operation has been widely discussed within cultural historical contexts. The model of 'down-the-line exchange' is based on reciprocity between regularly interconnected sites each playing the same role in the network. This wealth produces a pattern of even fall-off in the amount of exchanged goods depending on the distance from the production centre. 'Directional trade' on the other hand refers to a redistribution at central places and an allocation of commodities by authorities in control of those central places (Renfrew 1975). The fall-off pattern of the exchanged goods would then be irregular, with commodities concentrating at sites with preferential access to materials being exchanged. A systemic relationship between the two models of exchange and social forms has been proposed, with Neolithic egalitarian societies being associated with the down-the-line exchange and more advanced ranked societies with directional exchange (Renfrew et al. 1966; 1968; Renfrew / Dixon 1976). However, the simple transfer of goods between neighbouring sites implied in the down-the-line model has been questioned based on both archaeological and ethnographic data (Hodder 1974; Wiessner 1982; Ibáñez et al. 2015, 10).

On the contrary, Ibáñez et al. (2016, 23) suggest that complex networks can emerge without any specific agents controlling the interaction – mentioning Wikipedia as a modern example. Such 'small-world networks' are characterised by a combination of regular and short interaction links joining neighbouring agents, in addition to some sporadic links between distant agents. The model has been used in a recent analysis of obsidian exchange (Watts / Strogatz 1998; Ortega et al. 2014; 2016; Ibáñez 2016, 19; see Fig. 1). In practical terms, sporadic but substantial and distant exchange may have taken place through visiting trade expeditions as well as exchange associated with feasting at various occasions or seasonal movement related to subsistence. Also, several tribes might have met and bartered at designated sites or middlemen may have mediated in exchange affairs (Ibáñez et al. 2016, 20).

Exchange objects and their role?

Considerable efforts were invested by prehistoric communities in exchanging certain objects within large

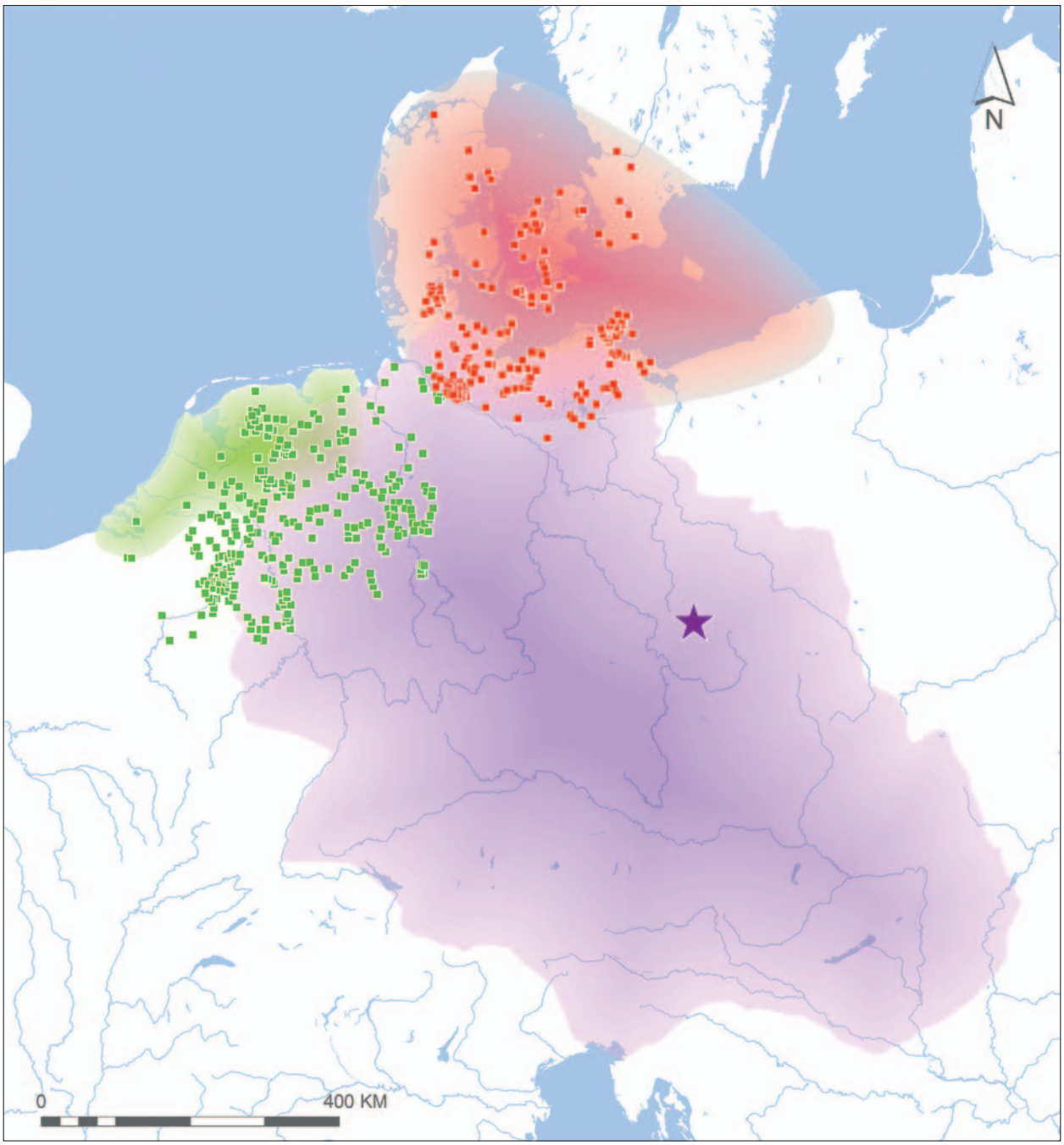

Fig. 2 Distribution of shoe-last axes in agrarian and hunter-gatherer societies in Europe. Ertebølle (red) and Swifterbant (green) cultures, with the primary source of amphibolite in northern Bohemia marked by a star (after Klassen 2004; Raemaekers et al. 2011; Bernardini et al. 2012; Verhart 2012).

scale networks lasting for centuries.[1] The raw materials are all exotic ones, procured at specific or limited places, and easily recognizable through their colour. The objects thus acted as visible symbols and mediators within specific exchange patterns and networks. Raw materials such as obsidian, jadeitite, nephrite, eclogite amphibolite, and copper were chosen because of the properties of the various materials. Obsidian with its recognisable black glass colour is also the sharpest lithic material available for making cutting tools. Jadeitite and amphibolite are some of the toughest metamorphic rocks prehistoric people could exploit for making axes or adzes, both materials requiring a long time to grind and polish. Besides its reddish golden colour, the metal copper can not only be resharpened but also re-melted and transformed into

1 Radivojević et al. 2010; Bernardini et al. 2012; Pétrequin et al. 2012; Milić 2014; 2016.

new objects. These functional advantages, together with such objects' rarity and visual quality, raise the question whether they might be characterised as a primitive form of currency, perhaps with a symbolic role within Neolithic societies? Such qualities may explain the surprising resilience of these exchange networks (Pétrequin et al. 2008, 264; Ibanez 2016, 23). Furthermore, the appearance of complex networks of interaction may have played a role in the origin of the Neolithic by enabling a rapid and efficient spread of innovations across the Near East.[2]

Southern Scandinavia on the periphery of four trans-European networks

During the Mesolithic-Neolithic transition in Europe and the Near East, four exotic materials (obsidian, amphibolite, jadeite, and copper) were acquired from distant regions through complex networks of interaction, in addition to domesticates. The scale of Neolithic networking was first explored by Renfrew and his collaborators through quantitative analysis of the obsidian distribution in the Near East (Renfrew et al. 1968, 328; Watkins 2008, 155). Obsidian was acquired in central and eastern Anatolia as well as on a few Mediterranean islands and circulated over distances of several hundred kilometers in the Near East and the Mediterranean area during several millennia between c. 10,000–3,600 calBC (Ibáñez et al. 2016; Milić 2016). In addition, obsidian from the Carpathian area was used in southeast Europe and also in Poland, but never spread further north to southern Scandinavia (Williams-Thorpe et al. 1984).

The amphibolite used for the shoe-last axes ('Schuhleistenkeile') derived from outcrops located in the Czech Republic or Slovakia. Shoe-last axes were distributed in central Europe via the major rivers, such as the Elbe, Saale, and Oder from c. 5,000 to 4,000 calBC by a large Neolithic network that also included hunter-gatherer groups from the Ertebølle and Swifterbant cultures in the north[3] (Fig. 2). Besides being used for heavy wood-working (such as the construction of large trapezoidal longhouses), the shoe-last axes also had an important symbolic meaning to some of the earliest central European agrarian cultures, and have been found in burials, hoards, and at settlements (Lu-

ley 1990; Klassen 2004). From 4,600 calBC shoe-last axes came to southern Scandinavia from the Neolithic Rössen culture, where the majority of these objects date from 4,300 to 4,000 calBC (Klassen 2004). The lack of local imitations of shoe-last axes within late Ertebølle or Swifterbant contexts suggests that any ideas behind the axes as a mediator of agrarian ideas and ideology may have been lost in hunter-gatherer communities.

Alpine jade axes were produced from raw materials found in the western Italian Alps between 5,200–4,700 calBC and circulated for several hundreds of years over vast areas in western Europe, with a limited number of axes reaching southeastern Europe (Klassen 2004, 83; Pétrequin et al. 2008, 264; Sørensen 2014, 142; see Fig. 3). Even earlier green stone axes were exchanged between the jadeitite sources found on the Greek island of Syros and some of the earliest farming communities in Anatolia dating back to 6,500 calBC (Sørensen et al. 2017). The occurrence of Alpine jade axes of the late Puy type seems to correlate in part with the opening of the flint mines in the Paris basin, Normandy, and Belgium around 4,300–4,200 calBC. The transfer of Alpine axe heads to Britain may correspond to the initial neolithisation of the British Isles around 4,000 calBC (Pétrequin et al. 2008, 276).

About ten large Alpine jade axes reached Denmark; most of them seem to have been distributed from secondary centres in the Paris basin or Morbihan, where they had been re-polished and re-shaped (Petrequin 2013, 91). The dating of these Alpine jade axes is uncertain, because most of them are stray finds, and because of their extended circulation time (Klassen 2004, 83; Sørensen 2012, 82). Nevertheless, local imitations of the alpine jade axes made of flint, local rock types, and copper suggest a dating to the early Neolithic period of the northern Funnel Beaker culture (Klassen 2004, 84, 89; 2010, 40, 42; 2012, 86; Sørensen 2014, 154 fig. V.90–91). As in Britain, these Alpine jade axes have been interpreted as a kind of mediator of agrarian ideology, perhaps even associated with pioneering farmers (Sørensen 2012, 84).

The fourth major network involved the use of copper and the spread of this metal in the Near East and Europe. From the 9th millennium calBC onwards native copper, malachite, and azurite were extracted in small quantities in the Near East (Yalcin 2000; Rosenstock et al. 2016, 68). The copper was processed by cold hammering and annealing into beads, pendants, and sheet ornaments (Hansen 2013, 137). While the aesthetic allure of these copper ornaments may first have been associated with the 'Neolithic

2 Bar-Yosef / Belfer-Cohen 1989; Watkins 2008; Price / Bar-Yosef 2010; Ibáñez et al. 2016, 24.

3 Fischer 1982; Klassen 2004; Raemaekers et al. 2011; Bernardini et al. 2012; Verhart 2012; Přichystal 2013, 192.

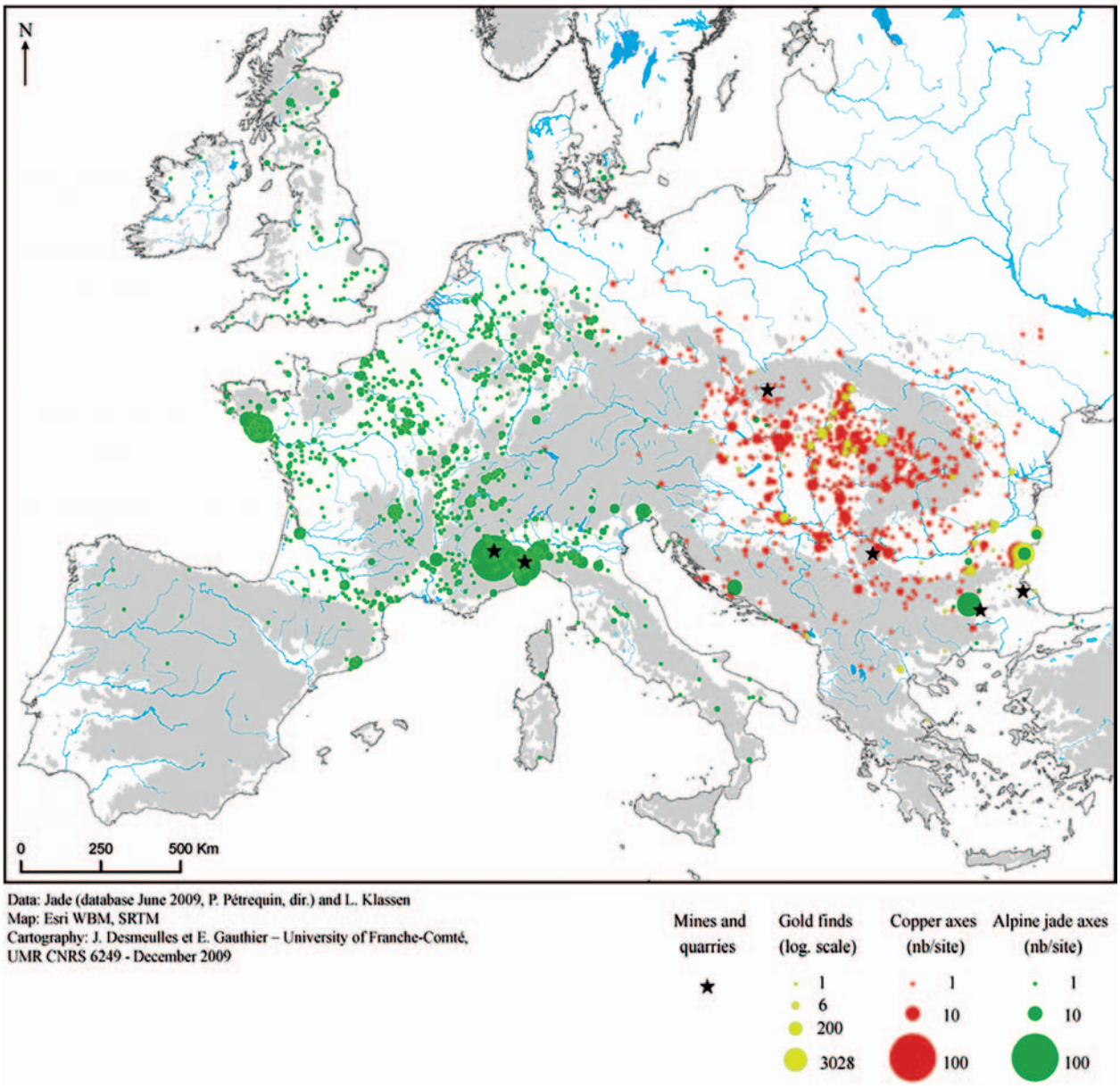

Fig. 3 Distribution of the Alpine jade axes of type Bégude (green) and heavy copper implements (red) from the late 5th millennium. Southern Scandinavia and a part of southeast Europe are the only areas where the two trans-European networks meet (after Klassen et al. 2012, 1281 fig. 1).

package' originating in the Near East, both Europe and the Near East developed the pyro-technological knowledge necessary for the smelting and casting of copper around the turn of the 5th and 6th millennium.[4]

From the late 6th to the middle 5th millennium the earliest evidence of metallurgy is associated with the Vinca culture in the central Balkans, while later centres of metallurgical activity changed from the Bulgarian west Pontic area (4,600–4,200 calBC) to the Caparthian basin (4,200–4,000 calBC) and the Slovakian-Moravian region (4,000–3,400 calBC). Thus, between 6,000–3,400 calBC the distribution of early copper shows a dynamic interaction between southeastern and central Europe, while western Europe is barely involved and the connection to northern Europe is unclear (Fig. 3).

The earliest evidence of metallurgy in central Europe in the form of crucibles and slag has been found at a few settlements in Austria dating from the late 5th and early 4th millennium (Brixlegg, Bisamberg-Hochfeld, and Keutschacher See) and at Makotrasy in Bohemia (Turck 2010, 19–33; Bartelheim 2013). Copper production took place in the northern Alpine

4 Boric 2009, 237; Roberts et al. 2009, 1014; Radivojevic et al. 2010, 2778; Bartelheim 2013; Garfinkel et al. 2014; Hansen 2017, 144.

region in the Pfyn-Cortaillod and Mondsee groups between 3,830–3,500 calBC (Matuschik 2016, 57; Rosenstock et al. 2016, 88).

North of the Alps, a number of stray finds of copper flat axes and burials furnished with copper trinkets have been found in central Germany, dating from 4,000–3,600 calBC, but evidence of metallurgy has not been found yet (Müller 2011, 296; Strahm et al. 2013, 72; Rosenstock et al. 2016, note 263). In contrast, local metallurgy was apparently practiced in southern Scandinavia, where a considerable number of copper objects date from 4,000–3,300 calBC (Klassen 2000; 283; Gebauer et al. 2021; see also below). Metallurgy also spread towards the Ukraine (Tripolje) around 4,000 calBC and south towards northern Italy during the third quarter of the 5th millennium calBC, with a possible independent development at Cerro Virtud, Almeria, in Spain, during the first half of the 5th millennium.[5]

The earliest European copper was mined in the Balkans. Extraction at Rudna Glava, Serbia, related to the Vinča culture, began c. 5,400–5,200 calBC and peaked between 5,000–4,700 calBC. The site of Ai Bunar, Bulgaria, related to the Kodzadermen-Gumelnita-Karanovo VI complex, dates from the middle of the 5th millennium (Roberts et al. 2009; Rosenstock et al. 2016, 77). The first evidence of metallurgy was found at the Vinca site of Belovode in Serbia (5,000–4,650 calBC; cf. Radivojevic et al. 2010, 2776).

Early Metallurgy in southern Scandinavia

While southern Scandinavia represents the most distant extension of the copper exchange networks, the quantity of copper in terms of weight nevertheless exceeds that found in the north Alpine region and the areas in between Scandinavia and the Alps (Klassen 2014a, 228; see Fig. 4). All the copper was imported from the continent, as local sources of metal were not available at this time (Klassen 2000, 212, 217; Gebauer et al. 2021).

Already during the late Mesolithic, rare imports of copper axes dating from 4,400 calBC are associated with the Ertebølle culture, at the same time as the already mentioned imports of amphibolite 'Schuhleistenkeile' (Klassen 2000, 111; Turck 2010, 33). Connections to the south are also apparent in Ertebølle artefacts made of bone and antler, such as bone combs, bone rings and T-shaped antler axes, as well as examples of Rössen-like pottery decorations (Andersen 1973, 33; 1975, 62; Klassen 2004, 109). Likewise, a common notion in the manufacture and use of small jewellery in the form of white beads, so-called double buttons, is seen across Europe, ranging from late Mesolithic Ertebølle communities in the north, to Neolithic and Copper Age groups further south during the 5th and early 4th millenium (Andersen 2008, 5; Heumüller 2012, 369, Sakalauskaite et al. 2019).

During the early Neolithic period of the northern Funnel Beaker culture (4,000–3,300 calBC), more than 135 copper objects, including 30 pieces of jewellery made of sheet metal, 103 flat axes, a halberd, a polygonal battle axe, and two adzes, are known from southern Scandinavia (Klassen 2000, fig. 111; Price / Gebauer 2017; Sørensen 2014, 159; see Fig. 4). The jewellery tends to be found in funerary contexts, while other objects have been found singly as stray finds or in hoards (Tilley 1996). According to Klassen (2000, 235), the influx of copper into Scandinavia took place in three phases. During the first phase, between the second half of the 5th millennium and the beginning of the 4th millennium, imports of a few heavy copper axes reached the late Mesolithic communities from southeast Europe. Around 4,000 calBC flat axes of type Kaka copper were exported from the Bohemian/southeast German area, and the first thin and wide flat axes reached Scandinavia, possibly from the east Alpine area.

During the second phase, between 3,800–3,500 calBC, a limited import of trapezoidal flat axes from the Mondsee, Altheim, or Pfyn groups reached Scandinavia, and locally produced trinkets made of copper sheets were used as grave goods. The third phase (3,500–3,300 calBC) included by far the majority of the copper, in the form of flat axes, trinkets, and one dagger/halberd. The copper was mainly of east-Alpine origin, but there are also a few examples from other sources, possibly in west Slovakia, the central Alps, and southeast Europe (Klassen 2000, 235–238). In addition, several items were made of Riesebusch copper, most likely a variety of the so-called 'Mondsee copper', but these are only distributed in the western Baltic area (Klassen 2000, 176; Klassen / Stürup 2001). According to Klassen (2000, 225) this regional type of copper, together with 58 flat axes with local typological features unknown in the Alpine region, is evidence of an independent Scandinavian metallurgy around the middle of the 4th millennium.

The recent find of a crucible at Lønt on the east coast of southern Jutland, Denmark, provides the final

5 Dolfini 2013, 43; Hansen 2013, 148; Bartelheim / Pearce 2015, 694; Rosenstock et al. 2016, 148.

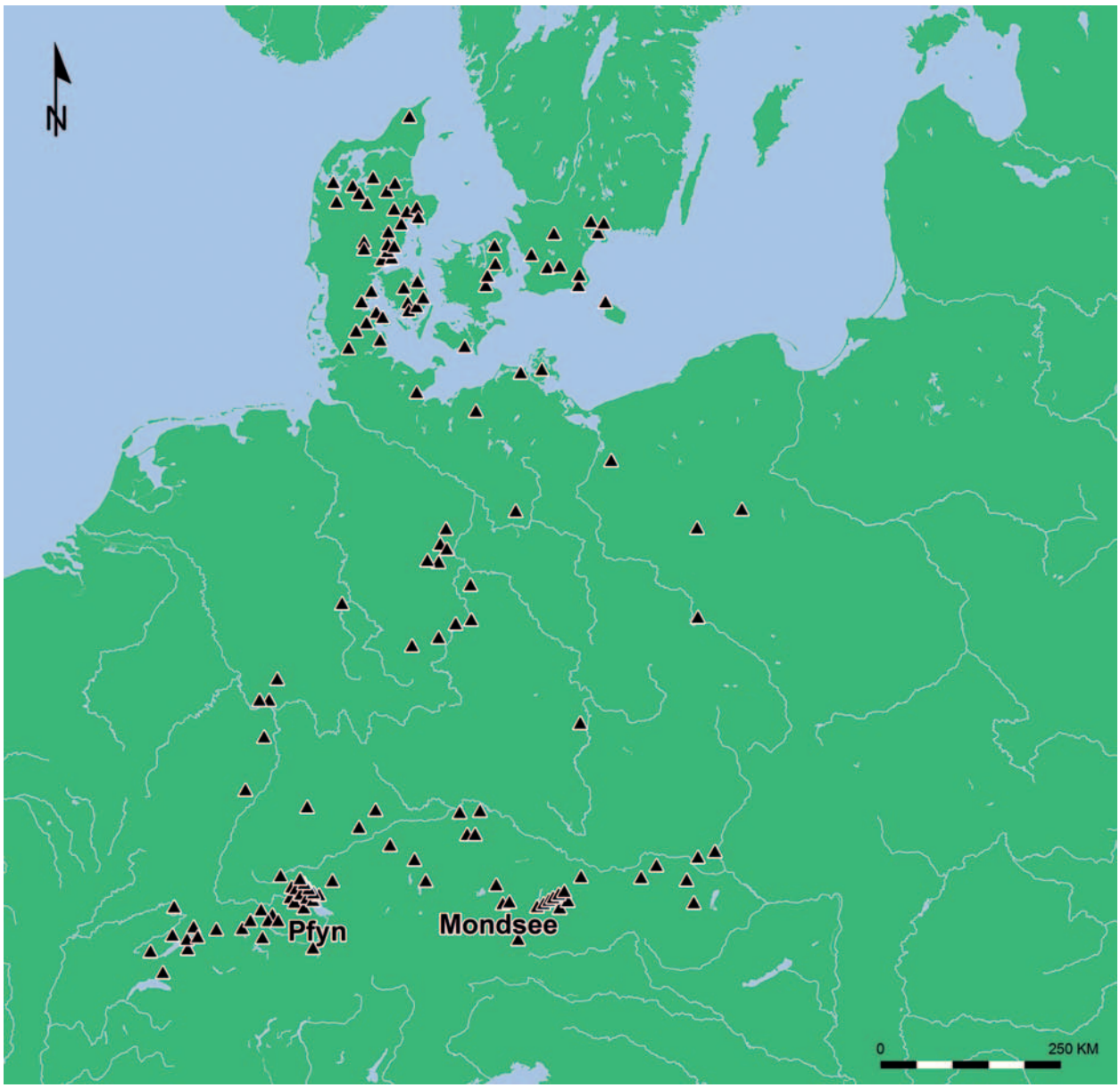

Fig. 4 Distribution of artefacts made with Mondsee copper in central and northern Europe (after Gebauer et al. 2021, fig. 1).

proof for Klassen's hypothesis regarding local Scandinavian metal work (Gebauer et al. 2021; see Fig. 5). The crucible was found in a cultural layer together with pottery dating from EN I (3,800–3,500 calBC), while pottery from EN II (3,500–3,300 calBC) was distributed further east within the same layer. The cultural layer was sealed by a series of four megalithic chambers embedded in a long dolmen, with the oldest chamber dating from the beginning of period MN I of the northern Funnel Beaker Culture, i. e. c. 3,300 calBC. The crucible has been dated to 3,800–3,500 calBC (Gebauer et al. 2021).

The fragmented crucible from Lønt was once probably oblong, oval in shape with a rounded rim edge and a heavy base, but without a handle or spout. Similar bathtub-shaped crucibles were used in both the Pfyn and the Mondsee groups alongside the more common spoon-shaped crucibles and date from the same time period: c. 3,800–3,600 calBC (Altorfer / Conscience 2005, 72; Altorfer 2010, 128; Matuschik 2016, 59). Copper residues and studies of heat impact show that bathtub-shaped crucibles were indeed used as crucibles, but perhaps as a special kind of casting crucibles (Fasnacht 2006, 147).

The copper in the crucible from Lønt is a type of arsenical copper commonly used in central Europe in the first half of the 4th millennium. Arsenic copper has been labelled 'Mondsee copper', but the concept is misleading as several regional varieties of arsenical copper exist, with the so-called 'Mondsee copper' being only one variety (Lefranc et al. 2012, 718). In general, different varieties of arsenical copper were

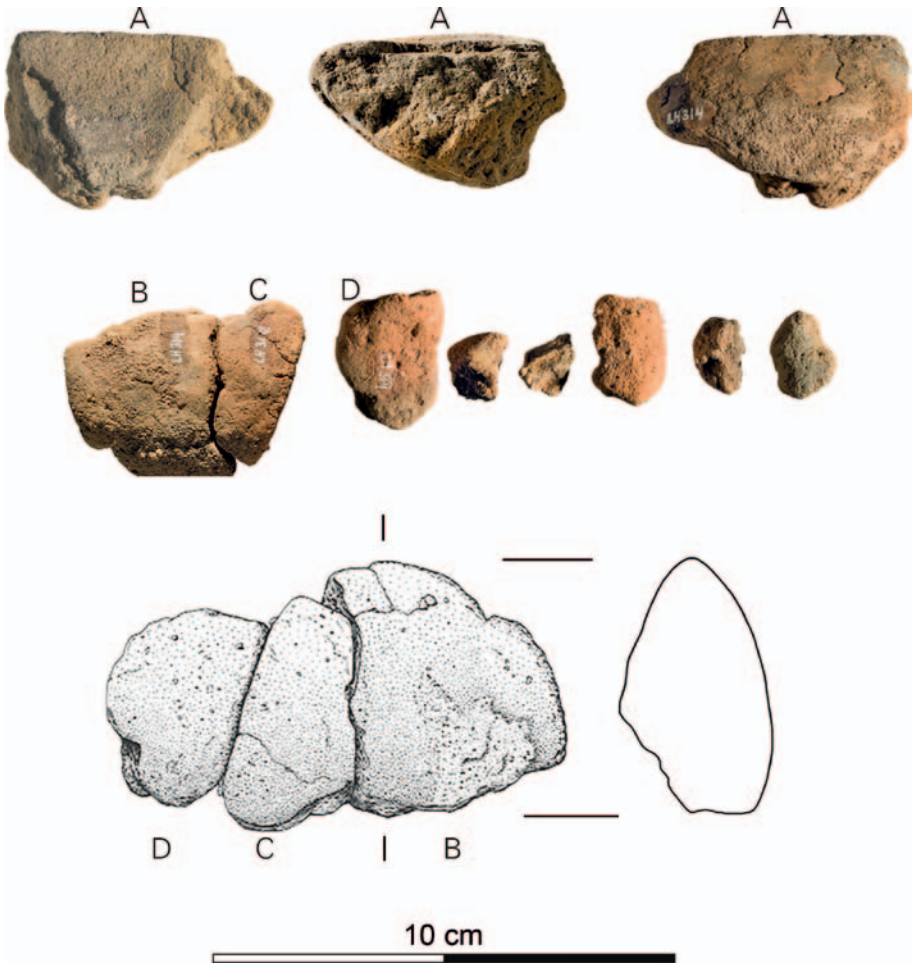

Fig. 5 The nine crucible fragments from Lønt. The largest and best-preserved fragment (A), is depicted with views of the interior with a whitish burnt area with copper residue at the bottom, a cross-section, and the exterior showing its coating with a fine-grained slurry. The piece is lightly curved along the outer perimeter (9.1 cm long, 6.4 cm high, 0.7 cm thick at the rim and 3.6 cm thick toward the bottom of the object). The second-largest fragment (B) has a stronger curvature (5.7 cm, long, 5.7 cm high, 0.8 cm thick at the rim, maximum thickness 3.5 cm). The outer surface is only preserved on fragments A and B. Three matching fragments – B, C, and D – form a 10-cm-long curved piece (photos J. Lee, drawing F. Oldenburg, layout M. L. Bendtsen, National Museum of Denmark).

used in the eastern and western Alpine region, probably reflecting different sources of supply (Lefranc et al. 2018, 33). The bipolar distribution of sites with evidence of metallurgy in the Alpine area, combined with differences in the shape and weight of the flat axes, suggest the existence of two independent areas of copper production in the Pfyn-Cortaillod and Mondsee groups (Matuschik 2016; Lefranc et al. 2018, 30). The origin of the copper in the Lønt crucible is unknown, but a connection to the eastern Alpine group might be more likely, considering the greater degree of heterogeneity of the copper in the Pfyn group (Klassen 2000, 227). Presently, the source of the east Alpine copper is thought to be located further towards the east and not in the immediate Mondsee area (Klassen 2014, 228).

Discussion

Melting pot of four trans-European networks

Although positioned geographically at the northern margins of the trans-European networks operating in the 5th and 4th millennium, people in southern Scandinavia engaged in both the southeast European copper network and the central and western European exchanges of amphibolite shoe-last axes and Alpine jade axes, while the trade in obsidian was limited to the Near East and southern Europe (Figs. 2–3). The willingness to accept objects and influences from distant regions reflects a dynamic and open-minded society with resources to integrate innovations and reciprocate exchange partners. Agricultural intensification following the introduction of the ard c. 3,640 calBC increased the overall productivity and contributed to new notions of territoriality, landownership and user-rights, and probably inheritance and marital systems as well (Beck 2013, 102; Johannsen 2017, 125 and 130). New ideas about communication with higher powers likely evolved in connection with ritual depositions in bogs and in the form of hoards as well as prestigious burial rites in monumental tombs. A segment of the population developed an increasing interest in prestige goods and the exchange of these items (Klassen 2004, 330). In addition, the availability of amber and high-quality flint as exchange objects probably facilitated the acquisition of exotic goods

Fig. 6 The Bygholm hoard, placed in a funnel beaker containing three large copper spirals, four copper flat axes (of which only the smallest one was an Alpine import) and a copper halberd (cf. Brøndsted 1957, 188; Klassen 2000, 20 Abb. 2; Tilley 1996, 103) (photo: National Museum of Denmark).

(Klassen 2000, 277; Klassen / Nielsen 2010, 34). Considering the sparse and uneven distribution of amphibolite shoe-last axes, Alpine jade axes and copper in northern Europe, conditions in southern Scandinavia and the adjacent areas of northern Germany must have been especially favourable for engaging in far-reaching networks. The dense concentration of megalithic tombs is likewise a testimony to the wealth of resources in this area, and to the ability to absorb innovations communicated through the trans-European networks (Fritsch et al. 2010, 2; Ebbesen 2011 preface; Klassen 2014b, 207).

Organisation of networks

It is a challenge for archaeologists to chart different kinds and degrees of mobility – not just of people, but also of things. Distribution maps may reflect intentional deposition patterns in the past and thus provide an inaccurate picture of the availability of certain objects (Klimscha 2017, 154). In the case of copper, the majority of the metal may have been recirculated in later periods (Hansen 2013, 139). Nonetheless, the distribution of a few objects gives an idea of the complexity of the networks at play in providing links to distant settlements.

The distribution of shoe-last axes in northern Europe becomes less dense in the Netherlands and southern Scandinavia and may therefore be interpreted as a classic 'down-the-line' exchange, implying a more indirect type of contact between farming communities and hunter-gatherer groups towards the north. In contrast, the inclusion of copper items appears to have been regulated by cultural and social norms rather than accessibility north of the production centres in central Europe (Bogucki 1988, 190). A regular fall-off pattern is not observed in the distribution of either copper or Alpine jade axes (Klassen 2004, 269 fig. 145). Long distance routes may have provided connections between Scandinavia and central Europe, where intermediate sites are scarce or non-existent, as in the case of the distribution of Cucuteni type daggers, tetraploid naked wheat, or polygonal battle axes made of copper (Klassen 1999, 30; 2014, fig. 141, 132; Turck 2010, 58; Sørensen 2014, 200 fig. 147).

Areas in central Europe may also have served as 'middlemen' in the interaction between Scandinavia and more distant regions. The east Alpine Mondsee area may have facilitated further contacts to southeast Europe as suggested by the distribution of Cucuteni type daggers, polygonal battle axes and thin-butted axes made of copper as well as flint (Zapotocky 1992; Klimscha 2007, 24; 2011; Sørensen 2014, 175). The Elbe-Saale area may have served as a mediator between the eastern Alpine region and southern Scandinavia in case of flat axes of type Kaka, flat axes with hexagonal cross-section, and spiral rings (Klassen 2000, 242; Turck 2010, 58). As mentioned above, certain Alpine jade axes were reshaped in the Paris basin or the Morbihan area before reaching Scandinavia (Pétrequin 2013, 91). The type Zug axes produced in Switzerland were imitations of the Morbihan Alpine

jade axes of Tumiac type and inspired production of perforated pointed-butted stones axes in Scandinavia (Klassen 2014b; Sørensen 2016, 224).

The concept of networks is just a spatial metaphor for the flow of objects that can be traded or exchanged even without people or cultural knowledge moving with them. Only when practice is involved is it possible to deduce the mobility of cultural knowledge and perhaps also people (Van Oyen 2017, 56–57). The introduction of metallurgy to Scandinavia is an example of knowledge transfer that would require the mobility of people. In contrast to the Vinča culture with its advanced pottery production, experience with high-temperature firing was not available locally in the north (Hansen 2017, 138–140; cf. also Koch 1998, 128). Either Scandinavians worked as 'apprentices' at the production centres in the north Alpine region, or travelling craftsmen from the south at times performed their work in Scandinavia (Wrobel Nørgård 2014, 49). According to Klassen (2000, 276) direct trading expeditions, perhaps shrouded within a religious purpose, may be responsible for the movement of copper to Scandinavia. Sporadic periods of apprenticeship in the Alps have been suggested as a means of acquiring Riesebusch copper (Klassen / Stürup 2001). A mould, practically identical to the smallest flat axe in the Bygholm hoard (Fig. 6), seems to demonstrate a direct link between metal work at Mondsee in the Alps and copper consumption in Scandinavia, although personal mobility may not have been involved in this transfer (Klassen 2000, 160 fig. 70).

Role of imports in early Neolithic Scandinavian society

Objects may move in and out of shifting value systems, and in particular back and forth between the statuses of gift or status symbol and commodity (Van Oyen 2017, 56). In contrast to these observations, the general assumption is sometimes that imported objects belong in the ritual sphere of society, and that their meaning and significance will have remained stable throughout their journey across the trans-European networks (Pétrequin 2012, 89). Seen as true objects of power, axes of Alpine jade were – according to this way of thinking – connected with specific ritual beliefs, which circulated along with the axes throughout Europe (Klassen 2012, 88). Likewise, the practice of metallurgy has been associated with leaders of society and the ritual sphere, as also seen in ethnographic studies (Eliade 1978, 93; Klassen 2010, 40).

However, if an artefact is exchanged indirectly several times and reaches marginal regions of a network, then the original meaning behind the object may be lost and change to something different – as it may have been the case with the shoe-last axes (Latour 1996). Ertebølle hunter-gatherers imported these amphibolite axes for specific purposes, such as the preparation of dug-out canoes and large hut constructions, which explains the significant use-wear and damage to the neck of many shoe-last axes found in the north.[6] A purely functional role in society may also be supported by the lack of imitations in local raw materials. On the other hand, some of the unused shoe-last axes might have been associated with prestige. The Ertebølle hunter-gatherers probably had their own preferences regarding when and why certain objects were associated with prestige and status, which may have differed from the perceptions within agrarian societies in central Europe (Vang Petersen 1984; Klassen 2004; Sørensen 2012).

In contrast, countless flint copies or other imitations of imported Alpine jade and copper axes reveal the desirability and high status of these objects, even if some connotations of their original meaning may have been 'lost in translation'. The imitations include exact copies of alpine jade axes as well as a number of stone axes adapted to the shape of a certain type of Alpine jade axe, most notably the pointed-butted flint axes (Klassen 1999, 41; 2004, 89 and 211; Sørensen 2014, 22). On the other hand, the prototypes of the thin-butted, four-sided flint axes were copper axes in the Gumelnita culture at the lower Danube in northeast Bulgaria. The four-sided flint axes spread further north via the Cucuteni-Tripolje culture and the southeastern Funnel Beaker groups in Poland to the Baltic area (Klimscha 2007, 24 fig. 10; Sørensen 2014, 175). Alternatively, the thin-butted, four-sided flint axes have been interpreted as a local Scandinavian imitation of imported copper flat axes of type Kaka (Klassen 2004, 215). Certain green stone axes combine features of both copper and Alpine jade axes (Klassen 2004, 258; 2014b; Sørensen 2014, 175). The numerous amber beads might represent local Scandinavian adaptations of copper trinkets.[7]

6 Christensen 1990; Grøn 2003; Klassen 2004; Raemaekers et al. 2011.

7 Larsson 2001, 68; for a general discussion of the effect of imported objects on local material culture, see Klassen 2004, 258; Sørensen 2014, 126; Price / Gebauer 2017, 145.

The imported artefacts and a number of their imitations became prestige objects indicating an increasing degree of social inequality during the early Neolithic period (Price / Gebauer 2017, 145; Nielsen / Sørensen 2018, 23). Participation in new forms of social and economic organisation, fostered by the intensification of agriculture, gave rise to hierarchical leadership in societies that used prestigious objects to signal their social status.

While a number of imported items retained their role as prestige objects, the imported copper axes may over time have changed status to a commodity, similar to the mass-produced 'Ösenringe' in the Bronze Age, which are basically considered as ingots (Wrobel Nørgaard et al. 2019, 17). According to Klassen (2000, 225), more than half of the flat axes found in Scandinavia (58 trapezoidal and tongue-shaped flat axes), five large spiral rings and a number of trinkets were produced within the area of the northern Funnel Beaker group using east Alpine copper. The most likely source of metal for this production would be re-melted flat axes imported from the Alps. Nevertheless, the innovation of metallurgy was never fully adopted by the northern society and disappeared again around 3,300 calBC. Everyday items like awls and fishhooks were never produced in copper, only larger replicas of the imported flat axes and jewellery were made. As mentioned by Ottaway (2001, 88–89) a decisive innovation is social rather than technical. Innovation is also a social integration process which failed in terms of metallurgy during the early Neolithic in Scandinavia.

Role of networks at the transition to the Neolithic

The complex supra-regional networks of interaction associated with exchange of objects made of obsidian, amphibolite, alpine jade, and copper may have played a role in the origin and spread of the Neolithic across the Near East and Europe by enabling a rapid and efficient spread of innovations.[8] As mentioned by Renfrew et al. (1966, 55) the obsidian trade provided 'evidence of widespread and early traffic in ideas and commodities, of which obsidian was by no means the most important'. The transmission of know-how was fuelled by the mobility of materials, styles, things, and persons because of an increased interaction among people near and far. Links across eastern and western Europe were established by the exchange of copper, amphibolite, and Alpine jade, with the use of these materials and objects being part of an ideological 'package' associated with the introduction of a Neolithic lifestyle and ideology (Klassen 2000, 251 fig. 116; Pétrequin et al. 2008, 276; Sørensen 2012, 84). In addition to the supra-regional networks, a high degree of interaction at the regional level was spurred by large scale production of flint axes in association with flint mines, and at the local level by a degree of craft specialisation among local communities (Price et al. 1996). Both regular local and more sporadic distant communications were required in the social integration process of the innovations that enabled the Neolithic way of life.

8 Watkins 2008; Bar-Yosef / Belfer-Cohen 1989; Klassen 2004; Ibáñez et al. 2016, 24; Sørensen 2016.

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A biological view on neolithisation

Walter Dörfler

Abstract A model calculation of the possible game density in the forest of the late Atlantic period shows the potential share of game in the diet of hunters, gatherers and fishermen from the Ertebølle era. It could be shown that a relatively small population of 0.11 people per km² already reached the limits of growth, even with a balanced use of terrestrial and aquatic resources. A significantly larger population could only have been realised with the acquirement of new food resources. The keeping of domestic animals in the Neolithic since approx. 4,100 calBC, with the possibility to feed branches and leaves, made it possible to create food stores for the winter and to use the domestic animals as a living stock to improve one's own food supply. This ensured a significant improvement in security of supply. A further step in this development was the expansion of agriculture in the form of larger fields from approx. 3,700 calBC. Grain as an easily storable food was another way of overcoming the winter food shortage and stabilising population growth. The same area that had previously been forested with only a small usable biomass thus became a usable cultural landscape that could feed significantly more people. As the Mesolithic population size and growth might have been limited by natural resource availability, the new subsistence strategy widened the horizon of possibilities and enabled a population growth that followed the Darwinian rule of reproductive success. This process was not reversible without a great loss of people.

Keywords Northern Germany, horizon of possibilities, woodland density, game density, population density, Mesolithic, Neolithic

Zusammenfassung *Eine Modellberechnung der möglichen Wilddichte im Wald des ausgehenden Atlantikums zeigt den potenziellen Anteil des Wildes an der Ernährung von Jägern, Sammlern und Fischern für die Ertebølle-Zeit. Es ist festzustellen, dass eine relativ kleine Bevölkerung von 0,11 Personen pro km² bei einer ausgewogenen Nutzung der terrestrischen und aquatischen Ressourcen bereits an die Grenzen des Wachstums stieß. Ein Bevölkerungswachstum konnte nur durch das Erschließen neuer Nahrungsressourcen realisiert werden. Mit der Haltung von Haustieren im Neolithikum seit ca. 4100 calBC (unter Nutzung der Möglichkeit, diese mit Zweigen und Blättern zu füttern), konnten Vorräte für den Winter eingelagert und Haustiere als lebender Bestand zur Absicherung der eigenen Lebensmittelversorgung genutzt werden. Dies sorgte für eine deutliche Verbesserung der Versorgungssicherheit. Ein weiterer Schritt in dieser Entwicklung war die Ausweitung der Landwirtschaft in Form größerer Felder ab ca. 3700 calBC. Getreide als leicht lagerfähiges Lebensmittel war ein weiteres Mittel, um die Nahrungsmittelknappheit im Winter zu überwinden und ein Bevölkerungswachstum zu stabilisieren. Das gleiche Gebiet, das zuvor bewaldet war und nur eine geringe für den Menschen nutzbare Biomasse aufwies, wurde so zu einer ergiebigen Kulturlandschaft, die deutlich mehr Menschen ernähren konnte. Da die Bevölkerungszahl und das Wachstum im Mesolithikum offenbar durch die Verfügbarkeit natürlicher Ressourcen begrenzt waren, erweiterte die neue Subsistenzstrategie den „Horizont der Möglichkeiten" und führte zu einem Bevölkerungswachstum, das der darwinischen Regel des Fortpflanzungserfolgs folgte. Dieser Prozess war ohne großen Bevölkerungsverlust nicht umkehrbar.*

Introduction

If we want to describe the neolithisation from a biological point of view, we cannot avoid Charles Darwin. In Darwin's sense (Darwin 1859), life is an evolutionary process based on variance and selection. This selection leads to adaptation or optimal adjustment to changing conditions of the environmental setting. In the following, the neolithisation process in northern Germany at the transition from the Ertebølle to the Funnel Beaker culture will be observed from the point of view of this concept. The focus will be on the subsistence strategies and energy balances. Chronologically this regards the Final Mesolithic and Early Neolithic (Müller et al. 2012), i. e. the period between 4,500 and 3,500 calBC, geographically the north German plain.

According to the Darwinian concept, human beings, like any biological species, aim to maximize

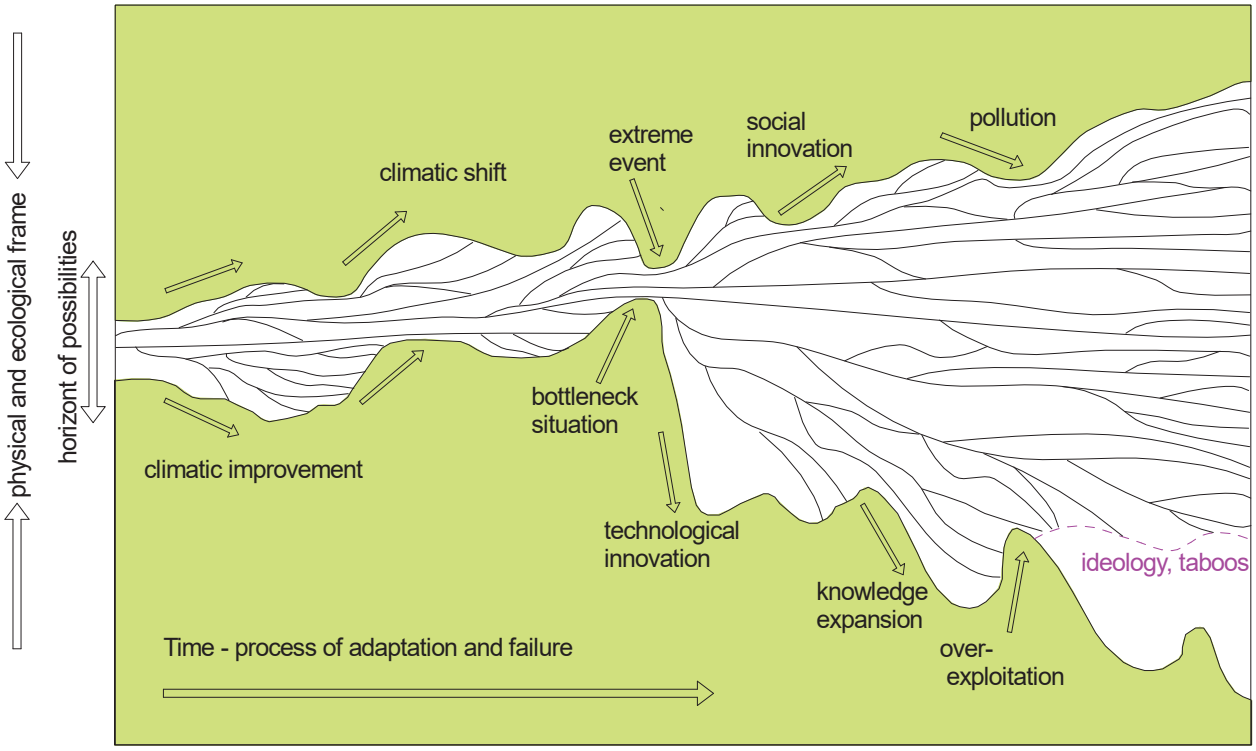

Fig. 1 Model for the temporal development of the horizon of possibilities, which determines the range of possible subsistence strategies (variance).

their reproductive fitness. The term 'survival of the fittest' is not understood here as a fight for survival as interpreted by Social Darwinism. In modern sociobiology it is understood as the selection advantage for the best adapted (Voland 2009). Fitness is not physical fitness in this sense, but describes the reproductive success of one's own and closely related genes. This implies that population growth is a natural process that is also a driving force behind economic, social and cultural decisions. God's call 'Be fruitful and multiply' was not only meant for sea animals and birds, but also for humans (Gen 1:28). All biological systems follow this premise, mostly until population growth is ended by resource scarcity or 'repression by the end product'. The diagram in Figure 1 shows such a model, which displays the wide range of possible subsistence strategies (variance), but which have been 'checked' and 'put in the limits' in the course of history by external or internal factors (selection). Survival is based on the fulfillment of elementary basic needs, which can be outlined by the terms nutrition, clothing, housing and social interaction. The fulfillment of these basic needs sets the biological-physical frame of human existence, they form the so-called *biological imperative*. Within this framework, which Harari (2013) calls 'Horizon of Opportunities', there is a multitude of economic, social and mystical-religious manifestations, which together form the culture of a population or group. As long as these forms do not go beyond the biological-physical framework, they can develop further, i. e. develop variance in the Darwinian sense. Internal and external processes can shift this frame. For example, climate change can force a change in economy or migration. The framework can be expanded by climate improvements (usually warmer and drier conditions in northern Germany) or narrowed by climate deterioration (usually cooler and wetter). Extreme events, such as large volcanic eruptions, earthquakes, storms or heavy rain and high tides can lead to bottleneck situations. These have a direct impact on the population in the form of crop failures, famines or epidemics, but they also have a selective effect on economic, social or cultural strategies that are adaptive or maladaptive for this situation. Accordingly, populations or groups as carriers of such strategies are more or less resilient or vulnerable to changes in the external framework. Innovative strategies may have been particularly successful but also risky. On the other side of the pendulum, conservative behaviour may have prevented adaptation and thus increased vulnerability. Through contacts between groups, combinations and hybridisations of different subsistence strategies will always have occurred.

The exciting question of which factors have limited the growth of the species Homo sapiens in the

various phases of human history remains unanswered. On the one hand, there are health aspects, such as child mortality or childbed fever, the occurrence of epidemics or the high risk of infection from simple injuries that limit the growth of population. On the other hand, it is limited by the carrying capacity of a landscape and by technological aspects, such as those relating to food production, storage, food preparation, or tools and devices that make it more efficient to meet basic needs (factor 'time', see Kerig 2010). But social aspects such as specific marriage rules or the uneven distribution of resources can also have a regulating effect on population growth. In addition, the reliability of the climate comes into play as an external factor: Extreme weather or climate change pose threats, but can also offer opportunities. Soil depletion or the consequences of other natural hazards can also have a negative impact. Most of the time, these different factors cannot be completely separated, e.g. the impact of epidemics or famines very much depends on the general state of health and the distribution of resources within a population. Extreme weather events can also trigger famines and in turn lead to epidemics. The following model calculations will focus on the role of food supply in the transition from the Mesolithic to the Neolithic.

Game density as an aspect of Mesolithic subsistence

Mesolithic life was very well adapted to the environment. However, the resources available to hunting, gathering and fishing communities were not unlimited. The greatest variety of these resources existed at the transition areas between different ecotopes. At the coast, at river banks and lakesides, access to both aquatic and terrestrial sources was provided. Accordingly, Mesolithic sites are found mostly in river valleys and at lake and sea shores (Hinz 2018). In addition to mineral raw materials (e.g. flint, amber or pyrite), resources are primarily understood as biogenic raw materials in the form of wood, leaves or fruits as well as meat, fat, feathers, fur, etc. Quantitatively, most of the biomass in the inland is bound in the wood, the roots and the leaves of the trees. These are difficult to use for many terrestrial animals and are also difficult to reach. Since the sunlight is filtered by the tree cover, the herb and shrub layer does not form high amounts of biomass. However, this varies considerably depending on the plant society (see below). Inland, clearings and river and lake shores were attractive locations for game and thus also for hunters (Gross et al. 2019). In such environments there is a better overview and more understorey as well. For hunters there are correspondingly better chances of encountering game.

The limited amount of plant biomass available in a closed forest implies a low carrying capacity for wild animals and a low game population density accordingly, as Iversen stated already in 1949 (Iversen 1949). This applies particularly to large herbivores, such as red deer, roe deer, aurochs, bison or elk, and the omnivorous wild boar. Realistic estimates for natural or near-natural values for the population density of those animals still living in our modern forests are almost impossible to get. Today's game density values are artificially regulated and are based on a balance of interests between forestry, agriculture and hunting. Game is fed in winter, salt licks are offered to ensure mineral supply, and it can provide itself with additional food on fields, meadows and pastures during the growing season. The forestry and hunting literature differentiate between economically viable and biotically viable game density (Ueckermann 1960; 1986). The biotically viable game density is not exceeded as long as the body and antler quality of the game does not deteriorate and as long as no epidemic diseases occur – regardless of the condition of the forest. In terms of economic viability, it must be possible to 'economically ward off game damage that occurs with the tools currently available' (Ueckermann 1960, translation by W. D.). The recommended values can also be seen as a compromise between hunting and forestry. The available aids include, for example, fencing as a protection for the rejuvenation of the tree population. The values for the economically viable game density vary, depending on the quality of the soil and the amount of undergrowth in the forest.

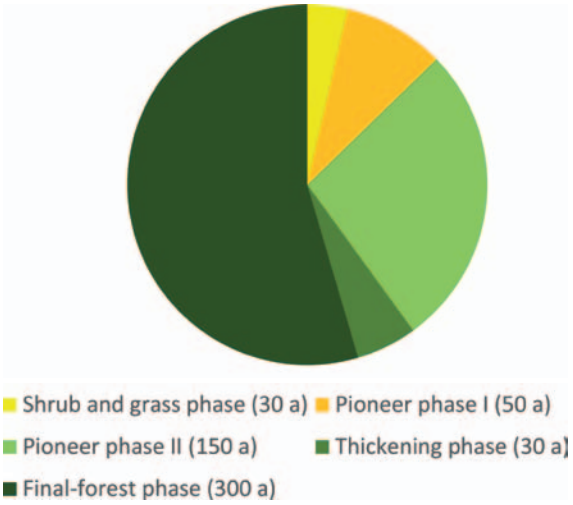

Fig. 2 Regeneration cycle (Mosaic-cycle) of a central European woodland (after Remmert 1991).

When we try to reconstruct wild population densities for prehistoric times, we first have to estimate the supply of grazing. Two components must be taken into account here: firstly, the proportion of clearings in the forest, secondly, the degree of shading that is responsible for the formation of the herb and shrub layer.

How much light was available to form a herb layer in the forest?

Closed forests form the natural vegetation in central Europe – with a few exceptions. These exceptions include areas along the coasts and inland salt springs, fens and raised bogs, and debris heaps in the highlands (Ellenberg 1986). All other locations in central Europe are occupied by forests which, depending on the moisture and soil quality, belong to different plant communities (see below). The proportion of open clearings in these forests depends on the maximum age of the trees and whether trees have been killed by plant pests, by lightning or by storm. Each individual tree has a natural life cycle. In sum this creates a mosaic of stocks of different age groups. This begins with the pioneer phases I and II, which are followed by a thickening phase. This passes into a final forest phase with a subsequent ag-

Species name	Shade producing	Shafe tollerating	Maximum Height	Maximum lifespan [a]	Summer drought sensitivity	Late frost sensitivity	Winter frost-sensitivity	Wintergreen
Abies alba	5	5	>60	150-400	3	5	3	0
Fagus sylvatica	5	5	>40	150-400	4	5	4	0
Carpinus betulus	5	4	<30	<150	3	3	4	0
Taxus baccata	5	4	<20	>400	2	2	5	5
Picea abies	4	3	>60	150-400	5	3	2	5
Tilia Platyphyllos	4	4	>40	>400	3	3	4	0
Acer pseudoplatanus	4	4	<40	150-400	3	3	3	0
Sorbus domestica	4	4	<40	150-400	3	4	4	0
Pinus cembra	4	3	<30	>400	1	1	1	5
Tilia cordata	4	3	<30	>400	2	3	3	0
Acer platanoides	4	4	<30	>400	3	3	4	0
Ulmus glabra	4	4	<30	150-400	3	2	4	0
Ulmus laevis	4	4	<30	150-400	4	2	4	0
Quercus petraea	3	2	>40	>400	3	3	4	0
Ulmus minor	3	3	<40	>400	2	2	4	0
Fraxinus excelsior	3	4	<40	150-400	4	5	4	0
Prunus avium	3	4	<30	150-400	3	4	4	0
Sorbus torminalis	3	4	<30	150-400	2	4	4	0
Alnus glutinosa	3	3	<30	<150	5	3	3	0
Sorbus aria	3	2	<20	150-400	2	3	3	0
Acer campestre	3	3	<20	<150	2	3	4	0
Prunus padus	3	3	<20	<150	4	4	3	0
Pyrus communis	3	3	<20	<150	3	4	4	0
Alnus incana	3	2	<20	<150	5	2	2	0
Quercus robur	2	1	>40	>400	1	3	3	0
Populus nigra	2	3	<40	150-400	5	2	3	0
Populus alba	2	3	<40	150-400	4	3	4	0
Populus tremula	2	2	<40	<150	3	1	2	0
Quercus pubescens	2	1	<30	150-400	5	1	2	0
Salix alba	2	3	<30	<150	5	2	4	0
Malus sylvestris	2	1	<20	150-400	3	4	4	0
Sorbus aucuparia	2	2	<20	<150	2	1	2	0
Pinus sylvestris	1	1	>40	150-400	1	1	2	5
Larix decidua	1	0	>40	>400	4	3	1	0
Betula pendula	1	1	<40	<150	4	1	2	0
Betula pubescens	1	1	<40	<150	5	1	2	0
Pinus mugo	1	0	<30	150-400	1	1	2	5

very great	great	medium	low	Very low	extremely low
5	4	3	2	1	0

Table 1 Properties of central European tree species important for competitiveness, sorted by shadow production (modified according to Ellenberg 1986, table 9).

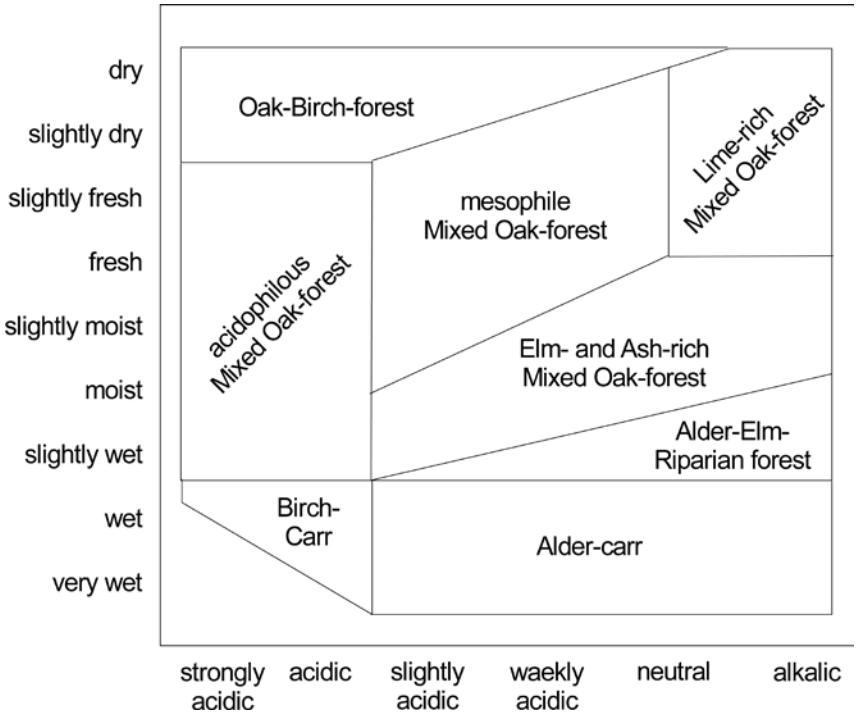

Fig. 3 Ecogram of the potential prehistoric vegetation of the late Atlantic period (after Feeser in Knitter et al. 2019, changed).

ing and death phase. The circle closes with a clearing phase with perennials and grassy vegetation, which then again passes into the pioneer phase I. Figure 2 shows the percentage of the individual phases according to their duration as listed in Remmert (1989; 1991). According to this concept, there is about 4 % open grass-rich vegetation in a natural woodland. If we add the light pioneer phase and a relatively light dying-off phase, we get 10 to 15 % light spots compared to 85 to 90 % dense forest cover due to closed stands of trees of different ages.

A comparison with pollen diagrams confirms these values: In the late Atlantic, about 95 % tree pollen contrasts with 5 % grasses and herbs. Due to the differences in pollen production and pollen distribution, these values have to be transferred to area estimates. When we use a calibration with the REVEALS program according to Sugita (2007), the proportion of clearings and light stocks is approx. 15 % (Dörfler 2017).

The degree of shading in the final woodland phase varies with the composition of the forest, as the trees allow different amounts of light to pass through to the forest floor. For this, Ellenberg has determined values that range from 0 to 5 for the degree to which they produce shadow (Ellenberg 1986, 82). Table 1 shows these values for the central European forest trees. An average value for the degree of shading can be derived from the share of the individual trees in the forest composition.

As there are no recent comparisons for the composition of the deciduous forests of the late Atlantic (5,000 to 3,800 calBC), we postulate potential prehistoric plant communities in analogy to modern plant communities. Ellenberg (1986, 106) created an ecogram of modern plant communities for the vari-

Average values of a Late-Atlantic Mixed Oak-forest (Lake Belau 5000 to 4000 BC)							
	Quercus	Tilia	Ulmus	Fraxinus	Pinus	Betula	Alnus
Average value in the pollen diagram [percent landplants]	22	6	9	4	5	12	25
Average value in the pollen diagram [percent arboreal pollen]	27	7	11	5	6	14	30
PPE (S-Sweden)	7.6	1.3	0.8	0.7	5.7	8.9	4.2
Percent values/PPE	2.9	4.6	11.3	5.7	0.9	1.3	6
Calculated area share	8.9	14.1	34.4	17.5	2.7	4.1	18.2
Shadow value according to Ellenberg 1986. Tab. 9	3	4	4	3	1	1	3
Shadow value * area share	0.27	0.56	1.38	0.52	0.03	0.04	0.55
Mean shade number for the woodland in the Lake Belau area	3.34						

Table 2 Conversion of the pollen percentages (average values for the time between 5,000 and 4,000 calBC) into the degree of coverage and determination of a value for the mean shade number.

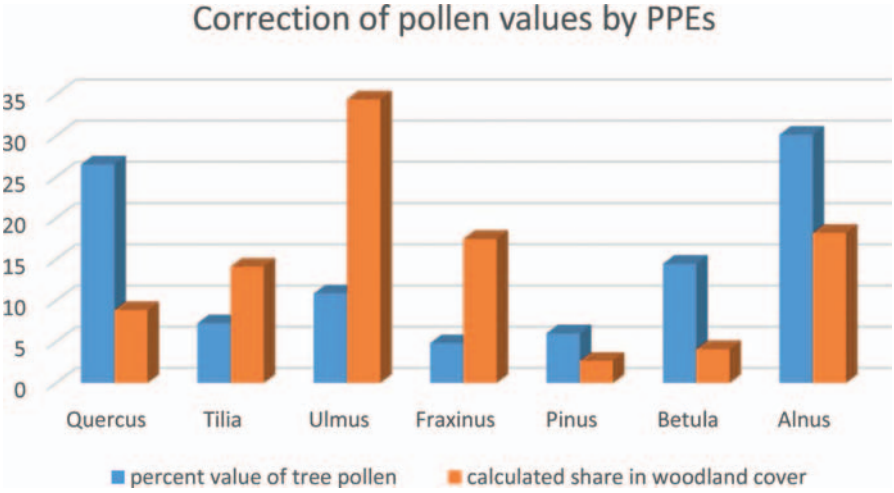

Fig. 4 Conversion of pollen percentage values into the degree of coverage in the catchment area of Lake Belau during the late Atlantic period.

ous soil conditions from acidic to alkaline, and from dry to very wet. In Figure 3, an allocation was made analogously to this, which corresponds to the location requirements and competitive properties of the tree species of the late Atlantic.

A regional pollen diagram, such as the one from Lake Belau (Wiethold 1998; Dörfler et al. 2012), shows the mix of all these different plant communities. The proportion of their area in the landscape in the catchment of a pollen diagram depends on the spatial distribution and quantity of the respective soil conditions. With the help of pollen productivity estimates (PPEs) we can convert the frequency of the individual pollen taxa to the degree of coverage from a pollen diagram for the time in the late Atlantic. The corresponding values of such a calculation are summarised in Table 2. Values from southern Sweden were used as PPEs (Broström et al. 2008). Figure 4 shows the first step of this calculation, from the percentage values to the projected area share. According to this calculation, 14 % of the catchment area of Lake Belau consisted of limewood, 9 % of oak, 34 % of elm, and 18 % of ash. The pine reaches 3 %, but its share in the pollen diagram is probably due to long-distance pollen flight; the hazel is excluded from this view as a plant of the shrub layer.

As shown in Table 2, a degree of shading can be determined from these values. The landscape occupied by different forest communities in the catchment area of Lake Belau would therefore have had an average shading value of 3.34. In comparison, a pure beech forest has a value of 5 on a scale from 0 to 5. Thus it becomes clear that the forest in the Atlantic in its herb layer was able to offer more food for the game during the vegetation period than, for example, modern beech (5) or spruce (4) forests.

This information has consequences for the food supply for wild fauna in the Atlantic deciduous forest, but it applies to the growing season only, i. e. from spring to autumn. The actual bottleneck of food supply is the winter, for wildlife as well as for humans.

In addition to the food supply, what factors determine the population density of game?

In a landscape without humans, the wild animal population of prey will be in balance with the population of predators, i. e. wolf, lynx, wildcat, and bear. If the population of the game increased, for example due to a mild winter, the predator population would also increase and accordingly lead to a reduction in the former. Humans also have to fit into this balance if they want to make a sustainable use of wildlife. Overuse would require larger hunting areas and thus a much higher hunting effort. In this situation, humans compete with other predators, so they have to 'share' the prey with them.

How high was the population density of red deer, roe deer, wild boar, aurochs, and elk?

From a modern hunter's point of view, the artificially high population densities of wild game are quite acceptable. Foresters would vehemently contradict. Rejuvenation by nature through tree seedlings is nowadays mostly only possible in protected plantations, and in snow-rich winters the tree population suffers from deer peeling bark as an emergency food. Other mechanical damage, such as sweeping the antlers, is negligible. The species of hoofed game are listed in Germany under the title 'Forstschädlinge Europas' (Forest pests in Europe; translation W. D.), although it is emphasised that deer, roe deer and wild boar belong to the forest in an appropriate density and only become pests if the population density is too high (Ueckermann 1986). A biotically portable population density of game that

	Red deer	Roe deer	Wild boar	Aurochs	Elk
Food ecology	Intermediate type	Selector	Omnivore	Rough forager	Selector
Economic viable density/ km²	1.5	5	2	(0.1)	0.7
Animals per 500 km²	750	2500	1000	50	350

Table 3 Food ecology and economically viable population density of hoofed game species in northern central Europe.

today's hunters might strive for would thus in the long run lead to a degradation and clearing of the forests. As could be shown, we see in the pollen diagrams for the Atlantic a largely closed forest with a proportion of clearings that corresponds to natural tree regeneration. Accordingly, the forest-destroying effect of herbivores can have been only slight, which suggests a maximum game density in the order of magnitude of the modern assumed economic viability. As this modern calculation for the potential game density is calculated for a modern landscape with many possibilities for wild animals to feed from fields and meadows we take this aspect as compensation for the better light conditions in the forests of the Atlantic (see above).

The information on the food ecology of hoofed game in Table 3 shows how far the species compete with each other. As an omnivore, the wild boar hardly competes with the pure herbivores. Selectors, such as deer and elk, selectively pick nutrient-rich grazing. Due to the different body heights and the fact that elk also feed on aquatic plants near the shore, there is hardly any competition between these species, which are also known as concentrate selectors (Wokac 1997). The other extreme is the aurochs as a rough forage eater ('Rauhfutterverwerter'). Its gastrointestinal tract is adapted to nutrient-poor, fiber- and cellulose-rich food. Red deer is considered to be an intermediate type, which can adapt to different food offerings relatively flexibly. Thus we assume that all these game animals can live together with little competitive stress.

The data on the population density of the game in Table 3 come from Ueckermann (1986) for red deer, roe deer and wild boar, and from Lavsund et al. (2003) for elk. There is no information for aurochs because this species has died out. Therefore, values for bison were taken from Ueckermann (1986), because the bison is supposed to cover a food spectrum similar to that of the aurochs (Table 3, values in brackets).

How many animals can be hunted without endangering a stable population?

The answer to this question depends on the reproduction rate of the respective species. For example, red deer females ('Alttiere' and 'Schmaltiere') usually breed one fawn per year. With roe deer there are one to two, rarely three fawns, and with wild boar there are four to six piglets. These numbers affect the age structure of a population and the rate of regeneration after severe losses. Wild boars are therefore on the scale between K strategists (low reproduction rate, pronounced parental care, long life span) and R strategists (high reproduction rate, low parental care, short life span) less strong K strategists than red deer.

Since we only have information on the age structure of the hunting prey of Mesolithic hunters in exceptional cases, for the sake of simplicity, it will be assumed here that a game population may not be decimated by more than 30 % of its previous year's number. Even in today's hunting grounds, shooting rates of at most 30 % of the stock are sought to preserve the wild population (Ueckermann 1986). The potential maximum hunting yield would therefore

	Red deer	Roe deer	Wild boar	Aurochs	Elk
Economic portable density	1.5	5	2	0.1	0.7
Maximum rate of prey	0.30	0.30	0.30	0.30	0.30
Rate of prey for other predatores	0.66	0.66	0.66	0.66	0.66
Rate of prey for humans	0.33	0.33	0.33	0.33	0.33
Potential prey for humans per km²	0.15	0.50	0.20	0.01	0.07
Potential prey per 500 km²	74.3	247.5	99.0	5.0	34.7

Table 4 Potential hunting prey based on the economically viable game density.

be just under a third of the game population of the previous year.

Presuming that humans compete with other predators, i. e. wolf, lynx, wildcat, and bear, we can further assume that about a third of the potential prey falls on humans. Table 4 shows the potential hunting prey of a hypothetical area of 500 km^2 based on these specifications.

Mellars (1975) made a comparable calculation for the yield from wild animal populations; however, he assumes that the potential wild animal populations are significantly higher. The historical data he gives relate, at least for central Europe, to a biotic rather than an economically viable wild density and to times when non-human predators had already been eradicated.

Game population density as basis for a potential population density of hunters

In order to calculate the nutrition of hunters in the next step, it is necessary on the one hand to record the energy content of the respective animal species and on the other hand to determine the energy requirement. How much kcal does a red deer, roe deer, wild boar, auroch / wisent, or elk provide, to name only the large hoofed game species? Table 5 summarises values from Ueckermann (1986), Souci et al. (2008) and Kujawski (2016) for red deer, roe deer and wild boar. Values of aurochs and wisents are given in analogy to domestic cattle and therefore put in brackets, values for elk are taken from Holm (1991). These are not the maximum weights, but average values, which is why they are also shown in brackets. The meat weight was averaged between adult and juvenile animals.

Human energy requirements depend on age, gender and physical exertion; they vary therefore considerably within a population. As an average for all these variables, I determined a value of 2,400 kcal / day per person (Dörfler 2012). Certain phases can also be endured with less, others – like pregnancy and strenuous physical activity – only with higher values.

The nutritional value of game meat depends heavily on the fat content of the animals and on the meat batch used. The fat content of game is significantly lower than that of domestic animals, and also fluctuates seasonally. The weight of an eviscerated roe deer body is 8 to 13 kg for a young animal, 12 to 16 kg for a 1-year-old one, and 14 to 21 kg for an older animal. The values thus range from 8 kg to 21 kg including the bones. If one takes into account a significant proportion of younger pieces in the total prey, the average is 12.5 kg (Kujawski 2016). The same applies to red deer. A red deer, for example, is to be considered as an adult at 4 to 5 years and then reaches 95 % of its maximum weight. For red deer the information from Ueckermann (1986) was used, which on the one hand gives average values for the weight of the prey of gender-specific age groups and on the other hand recommended shooting rates for a normal age structure of a herd. The initial values are between 33.5 kg for (female) calves and 109.4 kg for adult deer. The value determined from the recommended launch rate is 51 kg. These calculations were also used for the other wild animals, which explains the relatively large difference between the maximum life weight and the slaughter weight. However, the zoo-archaeological investigations of material from the early Mesolithic site Friesack 4 (Schmölcke 2019) show that these recommended shooting rates were not always met in the Mesolithic.

In wild boar, the weight of the male pieces varies between 50 and 175 kg, that of the female ones between 55 and 150 kg. Average values for boars (2 years old and older) are 55.5 kg, for 1-year-old animals 34.6 kg, and for piglets (up to 1 year) 20.2 kg.

	Red deer	Roe deer	Wild boar	Aurochs	Elk
Food ecology	Intermediate type	Selector	Omnivore	Rough forager	Selector
Maximum life weight [kg]	100–150	11–34	150–200	700–1000	225–385
Weight broken up without innards [kg]	51	12.5	34.2.	(?)	(?)
Meat share without bones	47 %	49 %	37 %	(50 %)	(50 %)
Average meat weight per animal [kg]	24	6.1	12.7	(300)	(160)
Fat content In g per 100 g	3.34	3.55	9.3	(5)	(1.9)
Energy content In kcal/100 g	114	122	162	(150)	(146)
Average energy content per animal [kcal]	27,326	7,440	20,500	(450,000)	(233,600)

Table 5 Live and slaughter weight of the most common wild animals.

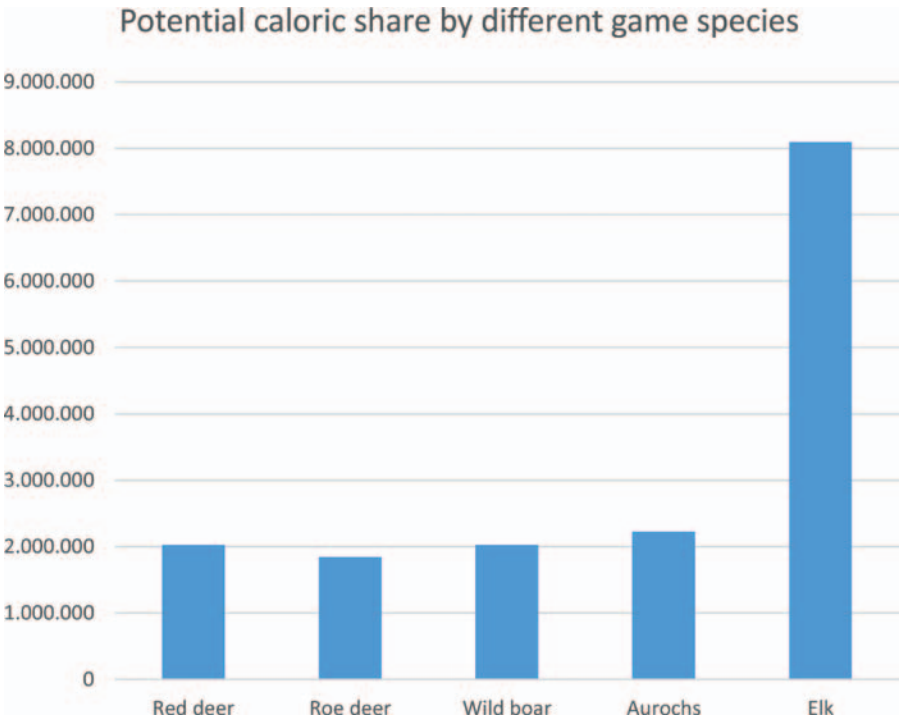

Fig. 5 The potential caloric intake from wild game according to the variables of the model calculation (30 % of the economically viable game density, 1/3 of the prey by human hunters and 2/3 by other predators).

The corresponding values for female animals are 46.5 kg, 32 kg and 18.5 kg. For a 'normal' prey structure, the average value is 34.2 kg for broken-up animals (Ueckermann 1986).

The game density fluctuates very much in wild boar, and it depends heavily on food supply and conservation measures. In the recent past, the stocks have increased enormously due to the intensification of maize cultivation. Data from the 1970s assume values from 1.5 to 2.5 animals / km^2 (Ueckermann 1986, 192). A value of 2 animals / km^2 is therefore chosen for the calculation, in assumption that modern humans – in the form of hunters and motorists –, will take a number of prey similar to that wolves, lynxes, wildcats, and bears took in historical and prehistoric times.

When determining the calorific value of meat, the information also varies considerably – depending on body part and season and thus the food supply (possibility of grazing and browsing, see above). The fat content is greatest at the beginning of winter. The values from Kujawski (2016) were adopted for the wild animals. Souci et al. (2008) give values of 109 kcal / 100 g for muscle, 130 kcal for shoulder and 200 kcal for breast meat. In analogy to this, the mean value for the model calculation was therefore set at 150 kcal for the meat of an aurochs. Modern cattle breeds for meat production are based on a proportion of 50 to 65 % of meat in slaughter weight (Bayerische Landesanstalt für Landwirtschaft 2020). In comparison to other wild animals, a value of 50 % was chosen for aurochs, as it is not a domestic cattle breed. Elk data refer to Swedish animals listed in Holm (1991). Individuals of this species can reach a significantly higher maximum live weight with up to 800 kg. The data are mean values for female animals, male animals, and calves. This listing shows the nutritional potential for the different hunting prey of Mesolithic people.

If a human population wants to survive long-term hunting and gathering in a region, a balance between hunters and prey must be maintained, as mentioned above. The game population cannot be reduced in size, and there must be sufficiently large areas as hunting grounds to allow the game stocks to recover. Winter is a time of food shortage for both game and humans. That is why a focus on seasonal food can be assumed: bird hunting, fishing, hunting for game, collecting eggs, mussels and snails, as well as gathering berries and nuts and other food plants are seasonally confined and will have been performed during the year at different intensities. From ethnological comparisons, Binford (2001) determined an average balance of terrestrial animals, terrestrial plants and aquatic resources of one third each. Accordingly, it is assumed for this calculation that Mesolithic people met one third of caloric requirements through hunting for red deer, roe deer, wild boar, elk, and aurochs.

Accordingly, this would mean a demand for game meat of on average 800 kcal per person and day (one third of 2,400 kcal) or of 292,000 kcal / person and year. This means that a maximum of approx. 56 people in an area of 500 km^2 could feed on a third of the

	Red deer	Roe deer	Wild boar	Aurochs	Elk
Potential prey per 500 km²	74.3	247.5	99.0	5.0	34.7
Average energy content per animal [kcal]	27,326	7,440	20,500	450,000	233,600
Potential energy per 500 km² [kcal]	2,028,956	1,841,400	2,029,500	2,227,500	8,094,240
Potential share in nutrition [%]	12.5	11.4	12.5	13.7	49.9
Sum of potential energy: 16,221,596 kcal					

Table 6 Available calories as combination of Tables 4 and 5.

hunting yield. With no other food available, this number would drop to 18 individuals. This corresponds to values of 0.11 people / km² or 0.04 people / km². These values are of the same scale as those given by Zimmermann (1996) or Müller (2013) for Mesolithic societies. The distribution of the number of calories among the potential game according to this calculation is shown in Figure 5 and Table 6.

These values for potential human population densities by no means show absolute numbers, but they describe the order of magnitude that can be determined on the basis of the specifications and assumptions made. As a consequence, the population density is limited by the carrying capacity in form of the available food resources. Supply shortages due to extreme weather events, climate changes or animal diseases would have a direct impact on human populations. Switching to other nutrition strategies or to other territories was probably only possible to a very limited extent in Mesolithic hunting, gathering and fishing societies. The use of resources in neighbouring areas will have led to competitive situations and conflicts with the neighbours. A further growth of the population, in accordance with the Darwinian concept of an increased reproductive success, could only have been made possible by acquiring new resources. For the growth of human populations and a higher population density as recorded e.g. by Hinz et al. (2012), an improvement of the area yield of the used landscape and the increase of the security of supply would have been a prerequisite.

New resources due to a Neolithic subsistence strategy

Both conditions can be met by the Neolithic economy. Since domestic animals, unlike wild animals, no longer have an escape reflex they can be protected and cared for in a controlled manner. Additionally, feeding also ties the cattle to humans. In the forest, people can improve the range of fodder for their domestic animals on the one hand through targeted clearing and, on the other hand, through the cutting of branches and twigs. By climbing into the crowns of trees and cutting there, people can open up resources to cattle that are not available to the game, and they do not have to share the yield of their stock with other predators (with exceptions). Ongoing grazing of areas close to settlements may also have prevented the natural regeneration of the forest, so that a semi-open pasture landscape with grazed and browsed forests will gradually have developed in these areas. In particular, however, the storage of winter fodder in the form of leaf hay will have helped to overcome the food shortage in winter (Dörfler 2017). The cattle, in turn, formed a living stock that could significantly increase the security of supply for people. Because of the cutting, the clearing and the storage of animal feed, significantly larger food resources can be tapped from the same area. This process of neolithisation is connected to the Funnel Beaker societies. In northern Germany it began around 4,100 calBC (Müller et al. 2012). Pollen diagrams show a first opening of the forest, which can be seen above all by an increase in the values of the hazel as a shrub in need of light (Feeser et al. 2012). Also, the pollen production of trees is initially increased by the small openings and a general thinning (Feeser / Dörfler 2014). It is only gradually that herbs and grasses become more common in this early stage when cereal cultivation was practiced in an intensive way but on a small scale in garden-like areas. In a second phase around 3,700 calBC land use is extensified with grain cultivation in open areas (Feeser et al. 2012; Kirleis this volume). At the latest about 3,600 calBC also the plow was introduced (Klimascha / Neumann this volume). Another source of food is opened up with the cereals, which, due to their good storability, again increase the security of supply, especially in the winter months. In combination with ceramics as a means of acquiring nutrients through cooking, cereals represent a significant improvement in the food supply. Ceramics, however, were already used

during the Final Mesolithic (cf. Müller this volume) and are certainly an innovation that had strongly improved the living and nutritional conditions of the Mesolithic population. For the consumption of cereals the Late Mesolithic invention of ceramics can be understood as a predisposition or preadaptation.

The innovations mentioned made a significantly larger population possible through higher area yields, overcoming the winter food shortage, and increasing supply security. Hinz and Müller (2015) estimate a population density of 2.5 to 7.5 people / km^2 for Schleswig-Holstein for the time between 3,700 and 3,200 calBC. But the new larger population also created new dependencies. Cattle epidemics and crop failures created new risks that could only be buffered to a limited extent by stockpiling. As a consequence, boom and bust phases represent the human population development in the following centuries (Feeser et al. 2019). This path in general, however, was difficult, if not impossible, to reverse, since a return to hunting and gathering would have presupposed significantly smaller population numbers.

How could such a population growth have worked out? According to Volk and Atkinson (2013) population growth can have various causes. One aspect is a reduced infant and child mortality rate. However, this rate does not appear to have changed significantly during the transition from hunting, gathering and fishing to agriculture. According to them, in hunters and gatherers as well as in historical agricultural societies on average 26.9 % of babies die in the first year of life, and 46.2 % of children before they reach puberty. However, an improved nutritional situation can shorten the period between two births and thus allow a higher number of births. A sedentary way of life can favour the care for the offspring and thus ensure higher chances of survival. Whether a woman gives birth to four children, two of whom reach sexual maturity and will have children themselves, or whether she gives birth to eight children, four of whom in turn produce offspring of their own is very important. In one case the population remains stable, in the other case it grows exponentially: if each woman gave birth every second year between her 16th and 32th year of life, which corresponds to an average generation period of 24 years, the population would have increased eightfold after 96 years.

Discussion

The above-mentioned value of 500 km^2 for a home range is derived from estimates by Piggott (1972, 67). Based on the investigations at the British site Star Carr and on the basis of ethnological analogies to historical North American hunters and gatherers, he postulates an average group size of 25 people. Based on model calculations by Braidwood and Reed (1957), he concludes that there is a population density of 13 people per 100 square miles, corresponding to 0.05 people per square kilometer. This results in an activity area of 500 km^2 for a group of 25 people. This area corresponds to a circle with a radius of 12.6 km or, in the case of a coastal or shore settlement, a semicircle with a radius of 17.8 km. With a diet based primarily on red deer, he assumes a requirement of 50 animals per year for a group of 25 people. With a postulated game population of 6.6 animals per km^2, which is certainly a much too high starting value, he sees no limitation in population size in the food procurement. The calculations above show, however, that if the corresponding information is given, a comparable value for the human population density is reached, but this is already at the limit of the area's carrying capacity with a nutrition based to one third on game hunting.

Frequency of furred game in the bone spectrum of Mesolithic sites

Friesack 4, a well-researched inland Mesolithic site, will be used here for an evaluation. Extensive archaeozoological studies (Schmölcke 2016; 2019) show that roe deer predominate in the number of bones identified (between 29.3 % and 41.1 %) in the prey. This affects all three phases from the middle Preboreal to the Boreal. Red deer (23,2 % to 28,3 %) ranks second in terms of bone numbers, followed by wild boar (11 % to 17.2 %), elk (4.4 % to 6.9 %) and aurochs (0.3 % to 1.9 %). This order changes when the bone weight is taken as a basis, which would be proportional to the meat weight if all parts of the skeleton were preserved representatively. With values between 32.2 % and 43.5 %, red deer comes first in the bone weight. Due to its high body weight, the elk follows with values between 20.2 % and 28.4 %. This is followed by wild boar (14.1 % to 25.2 %), roe deer (14.1 % to 16.6 %) and aurochs (2.4 % to 8.3 %). The game population in the late Atlantic may not have been identical to that in the early Holocene, but these values will be compared below with the potential population density of game. According to the above model calculations, about 50 % of the calorie requirement could have been covered by elk. On the one hand, this suggests that the population density data for elk, which originate from modern Sweden, probably cannot be transferred to the middle Holocene

in northern central Europe. On the other hand, the data from Friesack 4 show that a considerable part of the hunting prey consisted of elk. The quarry, especially large and heavy animals, was broken up at the place of a successful hunt and therefore reached the settlement in parts. In this way, only selected parts of the carcass may have reached the settlement site. So Schmölcke (2016, 83) writes (translation by W. D.): 'Similar to the roe deer, certain parts of the body [of the red deer], especially the back, seem to have been reserved for the hunters who ate them away from the settlement site, perhaps already at the place of the successful hunt'. He also notes a selection of bones (originally representing certain body parts) brought into the settlement for the elk. Accordingly, it is difficult to compare the data from the Mesolithic site Friesack 4 with the calculation above. But both show the great importance of the large ungulates elk and red deer.

Goldhammer (2008) summarised the archaeozoological investigations of the Ertebølle site at Grube-Rosenhof (analyses carried out by U. Schmölcke as well). Subsequently, fish with 3,846 bones contrast to 290 bones from mammals. This exceptionally high number of fish residues is mainly due to the fact that the samples from this coastal place were intensively washed and sieved during the excavation. Red deer dominates among mammals with a bone count of 116 (40 %). This is followed by the wild boar with 56 (19.3 %), aurochs with 29 (10 %) and roe deer with 27 (9,3 %). Elk has not been reported from this Late Mesolithic site. Since no information has yet been given on the bone weights or minimum individual numbers, only a rough estimate of the importance of the individual wild animal species for nutrition can be made. Red deer clearly dominates in front of the aurochs, which, as a large game, will have had a higher share in the diet than the number of bones suggests. Wild boar is also strongly represented, while the light-weight roe deer, with a share of 9.3 % in the number of bones, may have had only a small share in the nutrition at the Late Mesolithic site Grube-Rosenhof.

In comparison, one can look at the well-researched Danish Erbebølle inland site of Ringkloster, which, however, has a different calculation basis for the given bone numbers (Rowley-Conwy 1998). Here, wild boar dominates clearly before red deer and aurochs. Here, too, is a comparatively low evidence of roe deer, and elk is also found to a small extent only. Due to the indicators of seasonality, this place is interpreted as a winter place that had been visited again and again over many years (Rowley-Conwy 1998). There is therefore no uniform pattern at the various Mesolithic sites, but rather a typical variance in the subsistence strategy.

Nutrition of Mesolithic hunter-gatherer-fishermen after isotope measurements on skeletal material

Fischer et al. (2007) have examined extensive skeletal material from Denmark's Mesolithic and Neolithic sites. The portions of the carbon isotope ^{13}C and the nitrogen isotope ^{15}N are enriched in the food chain by isotope fractionation. As the limnic and marine food chains are longer than the terrestrial ones, the proportion of fish and mussels in the diet can be estimated under favourable circumstances. With a supply based on the terrestrial food chain, the proportion of meat in comparison to plant components can be estimated (Fernandez et al. 2015). The Danish isotope measurements indicate a high proportion of fish in the diet, both inland and on the coast. Since both humans and dogs with high values indicating marine nutrition occur inland, the authors assume seasonal mobility. This contradicts the alternative hypothesis that there would have been separate inland and coastal populations with typical subsistence.

Terberger et al. (2018) carried out comparable isotope measurements on skeletal material from northern Germany in order to reconstruct the nutrition of Palaeolithic, Mesolithic and Neolithic communities. Due to the small number of graves or human bones found in other contexts, the sample for Mesolithic individuals is relatively small. For the late Atlantic, i. e. the Late Mesolithic, there are two samples from the site Criewen 4, which show a high proportion of fresh water components in the food (Terberger et al. 2018). Older finds from the early and middle Atlantic have similarly high $\delta^{15}N$ values, which indicate high proportions of fish and mussels in the diet. In contrast, the values of Neolithic individuals show a wide spectrum between predominantly terrestrial and varying limnic and marine food proportions. In the sample, the transition from strongly marine to predominantly terrestrial food dates back to the first centuries of the 4th millennium, i. e. the early Neolithic Ia and Ib of the Funnel Beaker communities. Very limited data is available from Late Mesolithic sites, so that little can be said about the subsistence of these mobile communities from this point of view. The authors interpret the data in the way that three strategies can generally be distinguished for Mesolithic hunt-

ers, gatherers and fishermen: specialised hunting of large mammals, specialised development of fresh water resources, and a mixed economy with a high proportion of gathering (Terberger et al. 2018, 81). It remains open whether these strategies were reserved for individual groups exclusively or whether they only gradually changed in importance for the seasonal cycle in the nutrition of a population. The latter is proposed for the well-investigated Danish Erbebølle inland area of Ringkloster, where bones of marine vertebrates and oysters were regularly detected (Rowley-Conwy 1998).

A clear separation into one or the other food strategy would contradict the observed strategy of the 'one third proportion' of hunting, collecting and the use of limnic and marine resources, as it is found in numerous ethnological examples and postulated for the Mesolithic (Binford 2001). The strategies seem to vary according to regional conditions and do not follow any trend over time. Neolithic populations differ significantly in the sharply decreasing share of hunting and fishing in favour of plant-based food sources (Terberger et al. 2018).

Summary

The model calculation of the possible game density in the forest of the late Atlantic presented here showed the potential share of game in the diet of hunters, gatherers and fishermen from the Ertebølle era. It was shown that a relatively small population of 0.11 people per km^2 would already have reached the limits of growth even with a balanced use of terrestrial and aquatic resources. A significantly larger population could thus only be realised with the acquirement of new food resources. With the keeping of domestic animals in the Neolithic since approx. 4,100 calBC there was the possibility to feed them branches and leaves, to create food stores for the winter, and to use the domestic animals as a living stock to improve one's own food supply. This ensured a significant improvement in security of supply. A further step in this development was the expansion of agriculture in the form of larger fields from 3,700 calBC and ploughing from 3,600 calBC at the latest. Grain as an easily storable food was another way of overcoming the winter food shortage and stabilising population growth. The same area that was previously forested and presented only a small usable biomass had by then become a usable cultural landscape that could feed significantly more people. As the Mesolithic population size and growth might have been limited by the availability of natural resources, the new subsistence strategy widened the horizon of possibilities and enabled a population growth that followed the Darwinian rule of reproductive success. This process was not reversible without a great loss of people.

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A long lasting transformation: northern Late Mesolithic/Early Neolithic multi-dimensional developments (c. 4,750 – 3,800 BCE)

Johannes Müller

Abstract During the last decades, a large amount of new data on the Late Mesolithic and the Early Neolithic in northern Germany has been collected. Both detailed dating procedures and taphonomic processes at different sites have been discussed. With the help of vertical stratigraphy and absolute chronological dating, it is possible to newly describe the pottery sequence of the Middle and Younger Ertebølle and the Early Funnel Beaker (TRB) ceramic societies from c. 4,750 – 3,800 BCE. It becomes clear that the development of the ceramics reflects societies for which the simple differentiation between Mesolithic and Neolithic terminology does not go far enough.

The information from the south Cimbrian Peninsula suggests a mosaic-like habitus, which integrated 'foraging', 'pastoral' and 'horticultural' practices differently. A long-lasting transformation process becomes visible, which begins during the 43rd century BCE with the introduction of first flat-bottomed funnel beaker ceramics and first domestic animals. Accelerated by a period of climatic stress, the new way of life asserted itself in the 41st century BCE with horticultural subsistence practices and a new ceramic style, among other things. However, for at least three centuries, the Ertebølle ceramic style and the aquatic subsistence remained intact at sites near water, while in other places non-megalithic long mounds were already being built as an expression of the new ideology.

Keywords Ertebølle pottery, Funnel Beaker societies, transformation processes, ceramic typology and chronology

Zusammenfassung *Während der letzten Jahrzehnte wurden neue Daten zum Spätmesolithikum und Frühneolithikum in Norddeutschland gesammelt. Sowohl detaillierte Datierungsverfahren als auch taphonomische Prozesse an verschiedenen Fundstellen wurden diskutiert. Mit Hilfe vertikalstratigraphischer Befunde und absolutchronologischer Datierungen ist es möglich, die Keramikabfolge der mittleren und jüngeren Ertebølle- und der frühen Trichterbecherkeramik-Gesellschaften (TRB) von ca. 4750 – 3800 v. Chr. neu zu beschreiben. Es wird deutlich, dass die Entwicklung der Keramik Gesellschaften widerspiegelt, für die die Unterscheidung zwischen mesolithischer und neolithischer Terminologie nicht weit genug greift.*

Die Informationen von der südkimbrischen Halbinsel deuten auf einen mosaikartigen Habitus hin, der die Praktiken „Wildbeuter", „Viehhaltung" und „Bodenbau" unterschiedlich integrierte. Es wird ein lang anhaltender Transformationsprozess sichtbar, der ab dem 43. Jahrhundert v. Chr. mit der Einführung der ersten Trichterbecherkeramik mit flachen Böden und den ersten Haustieren beginnt. Beschleunigt durch eine klimatische Stressperiode, setzte sich die neue Lebensweise im 41. Jahrhundert v. Chr. u. a. mit einfachem Bodenbau und dem neuen Keramikstil durch. Mindestens drei Jahrhunderte lang blieben jedoch der Keramikstil von Ertebølle und die aquatische Subsistenz an wassernahen Standorten intakt, während an anderen Orten bereits nicht-megalithische Langhügel als Ausdruck der neuen Ideologie errichtet wurden.

Introduction

Besides the terminological use of the terms 'Final Mesolithic' or 'Early Neolithic', which partially conceal the similarities in the archaeological and palaeoecological archives between the mentioned periods, there have been various attempts thus far to better determine the corresponding period between about 4,750–3,800 BCE. In most cases, we know of numerous individual studies, in which typo-chronological discussions about the spatial and chronological distribution of key types have been conducted, which usually can be traced back to the typological discourses before the possibility of scientific dating. This often results in spatial-temporal groupings, which mostly originate from the identification of these key types.

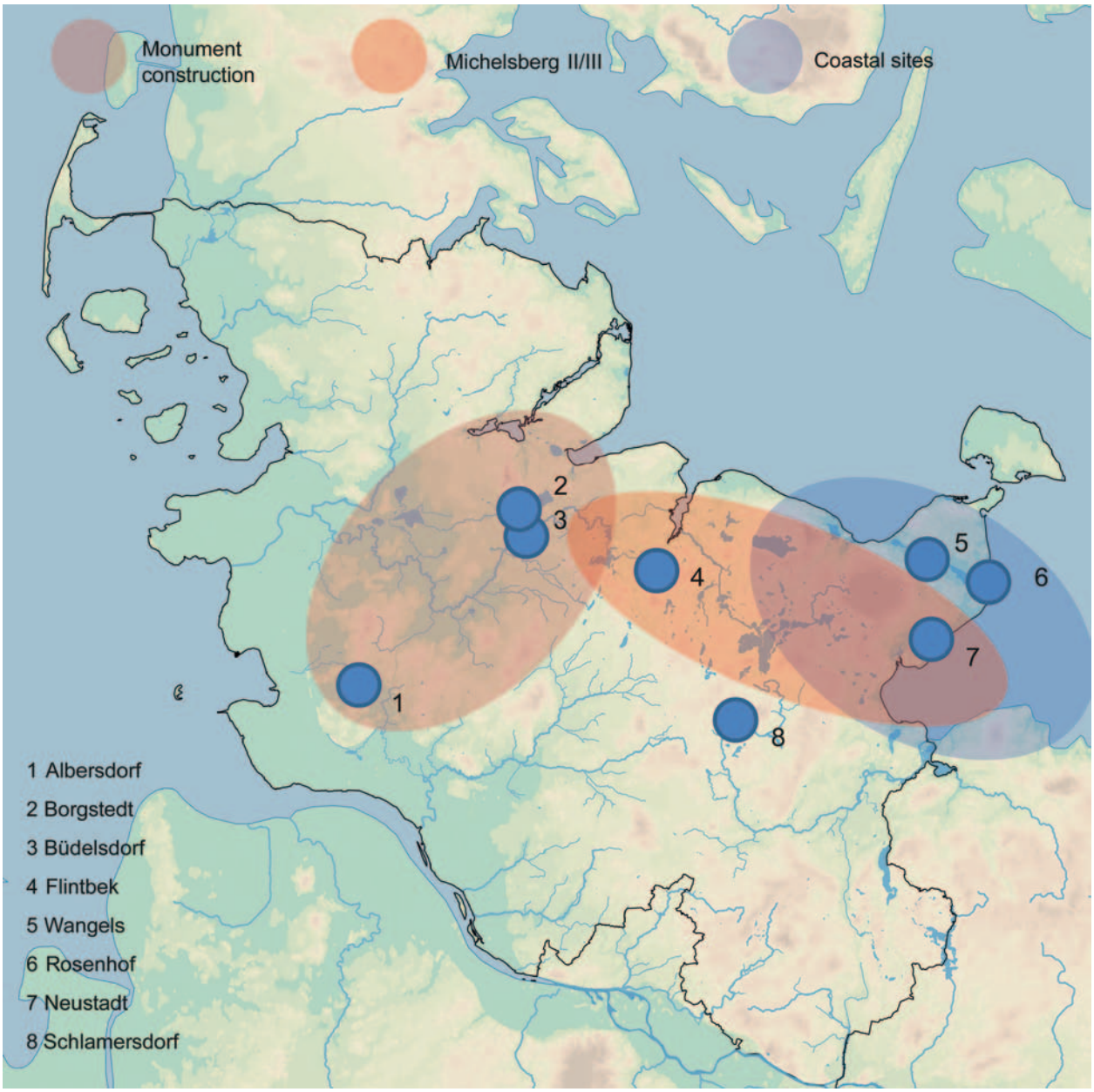

Fig. 1 The location of the discussed sites in the western Baltic area. The spatial differentiation on the south Cimbrian Peninsula from c. 4,100–3,800 BCE is displayed.

Only in the rarest cases are efforts made to compare not only individual types, but also the quantitative composition of these types and to test corresponding typological similarities with scientific dating for their chronological relevance (Hartz 2004; Sørensen 2014; Mischka et al. 2015). In analysing various important sites, we also recognise the basic tendency of the researchers not to compare closed or relatively closed inventories with each other, but instead to discuss the entire inventory of a site as *one* assemblage.

Furthermore, the attempt to classify individual vessels in absolute chronological order by means of food crust dating has led to considerable difficulties. The reservoir effects have made the discussion of the data difficult and have not inspired sometimes necessary typological discourses about Ertebølle pottery (Philippsen 2010; Fernandes et al. 2014; Meyer 2017). In this respect, an attempt will be made in the following to use dates that do not involve reservoir problems. This also includes, for example, indirect palynological dating of ceramic objects in the analysis (cf. Meurers-Balke / Kalis 2011).

Irrespective of these remarks, in the meantime, after the publication of intensive site evaluations[1]

1 Cf. Goldhammer 2008; Glykou 2016; Hage 2016; Faasch 2017; Meyer 2017.

new vertical stratigraphic observations as well as new dates are available. In light of the current state of research, we can determine the basic lines of typo-chronological development for the period of interest with the aid of six south Cimbrian sites. The results support the chronological model of S. Hartz and H. Lübke (Hartz / Lübke 2004), which was primarily based on silex assemblages from the Mecklenburg Bay, not ceramics.

Accordingly, the following questions are asked: Can chronological differences in Ertebølle pottery be typologically identified? Can we record the transition to Funnel Beaker pottery? Is it possible to identify the variety of regional developments spatially with a model based on the new approach? How can the new results of the Late Mesolithic/Early Neolithic transformation process be interpreted in terms of economic and ideological changes?

South Cimbrian Peninsula: Chronological development of pottery

The chronological development of the south Cimbrian Peninsula can be reconstructed by the integration of information from newly researched sites (Neustadt, Büdelsdorf, Borgstedt, Wangels, Oldenburg-Dannau LA77, Albersdorf-Dieksknöll, Albersdorf-Brutkamp; Fig. 1) with ^{14}C dates and stratigraphical information, which add information to other, already known and diversely discussed sites such as Satrup and Siggenben-Süd (cf. Klassen 2004, 109–222).

The transition from Late Mesolithic to Early Neolithic ceramic assemblages 4,700–3,800 BCE

The LM/EN keysites: Neustadt LA 156, Wangels LA 505, Grube-Rosenhof LA 58, Flintbek LA 48, Borgstedt 1, Büdeldorf LA1

Due to excavations and re-analyses of assemblages and contexts, six key sites are identified for the south Cimbrian Peninsula, which are of relevance to reconstruct the chronological development within the transitional phase from Ertebølle to Funnel Beaker societies, thus from the Final Mesolithic to the Early Neolithic. These are:

- Grube-Rosenhof LA 58: first excavated by Hermann Schwabedissen in the 1960 s and 1970 s (Hartz 1999a; 1999b; Schwabedissen 1972; 1979), reanalysed by Arie Kalis and Jutta Meurers-Balke 2008 (Meurers-Balke / Kalis 2011) and re-excavated from 2001–2002 by Sönke Hartz and analysed by Julia Goldhammer (Goldhammer 2008);
- Wangels LA 505: excavated by Sönke Hartz from 1996–1997 (Hartz 2002/2003), with ceramic analyses by Ines Maria Grohmann (Grohmann 2010), silex analyses by Felicitas Faasch (Faasch 2017) and a stratigraphical reanalysis by Arie Kalis and Jutta Meurers-Balke (Meurers-Balke / Kalis 2011);
- Neustadt LA 156: excavated by Sönke Hartz from 2000–2006 and analysed by Aikaterini Glykou (Glykou 2016);
- Flintbek LA 48: a pit excavated by Dieter Stoltenberg in 1984 and analysed by Doris Mischka (Mischka et al. 2015);
- Borgstedt LA 28: a burial ground excavated from 1973–1994 by the Landesdenkmalamt Schleswig-Holstein (Hage 2016);
- Büdelsdorf LA 1: a Neolithic enclosure excavated from 1969–1974 mainly by Wolfgang Bauch and from 2014–2015 by Franziska Hage (Hage 2016).

The site of Schlamersdorf, which has been intensively discussed, in particular due to its relatively early ^{14}C values for pottery, displays a mixed inventory according to the features and finds (Meyer 2017). In most cases, the numerous radiometric determinations cannot be used to date artefacts because of the mixed contexts and reservoir effects (Meyer 2017, 72–75). Nevertheless, this is an extremely important site that provides information on domestic aspects of the Ertebølle communities.

Within the presentation and discussion of the chronological differentiation within each site and the cultural and spatial links, primarily the overall distribution of artefact types within each site played a central role. Furthermore, the stratigraphical analyses now enable an in-site and a comparative interpretation. From a chronological point of view, three methodological approaches allowed a detailed differentiation of phases and sub-phases:

- For Neustadt LA 156, vertical stratigraphy and radiometric dating allowed the chronological interpretation of a correspondence analysis of ceramic types (Glykou 2016, 152–165). The association of radiometric dating with phases enabled an absolute-chronological differentiation of the site.
- For Grube-Rosenhof LA 58 and Wangels LA 505, an indirect dating method was applied (Meurers-Balke / Kalis 2011) to overcome the limited strati-

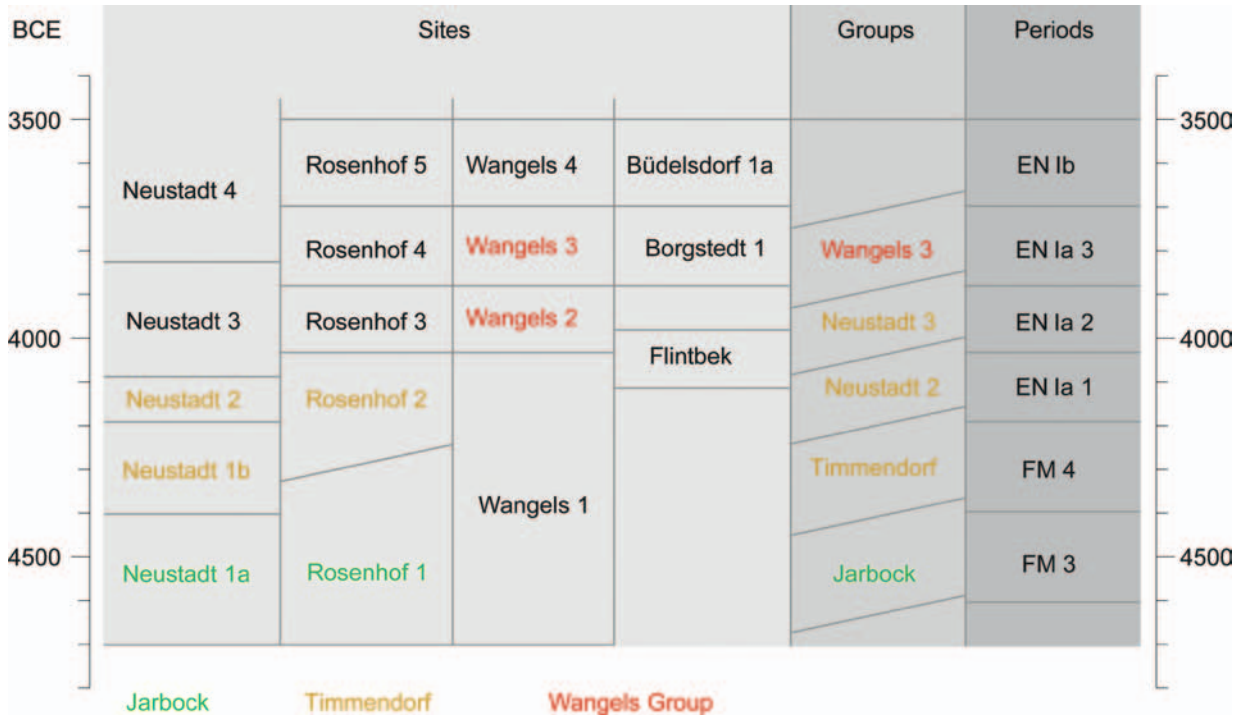

Fig. 2 The synchronisation of the phases of individual sites. The phases of individual sites are related to archaeological groups and periods.

graphical information: Pollen samples that were located with ceramics were analysed and categorised according to vegetation-processes, which are absolutely dated within main pollen sequences (Meurers-Balke / Kalis 2011, 43 table 1). As single pots could be associated with absolute time-markers, a general chronological positioning of the Ertebølle layers (Goldhammer 2008, 88–90) could be divided into different sub-phases.

- For Flintbek LA 48, radiometric dating was applied on samples without reservoir effects. The dating could be verified by typological analyses, which placed the assemblage in an absolute dated general sequence (Mischka et al. 2015, 466–474). The same applies to Büdelsdorf LA 1 and Borgstedt LA 1/28 (Hage 2016, 128–199).

In result, we can distinguish five phases in Neustadt, five phases in Grube-Rosenhof, four phases in Wangels and one phase in Flintbek (Fig. 2). The earliest phase of the non-megalithic and megalithic cemetery at Borgstedt (Hage 2016) was also considered. On the one hand, the temporal correlation of these phases by absolute dating displays similarities of the assemblages and, on the other hand, some differences. The mosaic of communities that already built non-megalithic long mounds, and those who were still mainly engaged in foraging activities becomes visible.

The chronological model

A chronological model derived from the key sites of the south Cimbrian Peninsula is also visualised by a correspondence analysis (Fig. 3). Within the chronological terminology, the difference between chronologically defined phases (cf. 'Final Mesolithic') and the material practises (cf. 'Middle Ertebølle') should be taken into account.

FM (Final Mesolithic), south Cimbrian Middle Ertebølle (4,700–4,200/4,100 BCE, sites: Rosenhof 1 / Neustadt 1): Both in Rosenhof 1 (Fig. 4) and in Neustadt 1 (Figs. 5–6), lamps and pointed-bottomed vessels indicate the earliest ceramic Mesolithic phase. At Neustadt, a division into an early phase – Neustadt 1a with pointed-bottomed beakers – and a later one – Neustadt 1b with both lamps and pointed-bottomed beakers (from 4,400 BCE onwards) – is possible. The lamps from Wangels 1 (Fig. 7) probably also belong to this phase. For the Mecklenburg Bay, the earlier part was defined by Sönke Hartz and Harald Lübke (Hartz / Lübke 2004, 126–128) as the Jarbock-Phase (c. 4,750–4,450 BCE), the later part as the Timmendorf-Phase (c. 4,450–4,100 BCE).[2] It is obviously not

2 But in our study, we exclude the later part of the Timmendorf-Phase with N-technique.

BCE	plastic strips	arcade rims	vertical strips	amphorae/flasks	N-technik	K1	lamps	Koch 0	TR-Schale	Ösenbecher	Tulpic B	pointed bottom vessels	U-technik	Sites
3950 - 3750	1	1			1									Borg1
3750 - 3650	1		1	1	1	1								Büd1a
< 3900		1			1	1								Neu4
3900 - 3700	1		1		1		1							Wan3
4000 - 3800					1	1								Stra225
3900 - 3700				1	1		1							Ros4
3700 - 3400				1	1		1							Ros5
3900		1			1		1					1		Wan2
4050 - 3700					1	1		1	1					Lüb
4100 - 3900			1	1	1	1	1	1	1	1		1		Neu3
4050 - 3900					1	1	1	1				1		Ros3
4100 - 4050					1			1			1			Flint
4100					1		1		1	1	1	1		Neu2
? - 4050					1		1					1		Ros2
4400							1					1	1	Neu1b
4700 - ?							1					1	1	Ros1
4700 - 4050							1						1	Wan1
> 4400												1	1	Neu1a

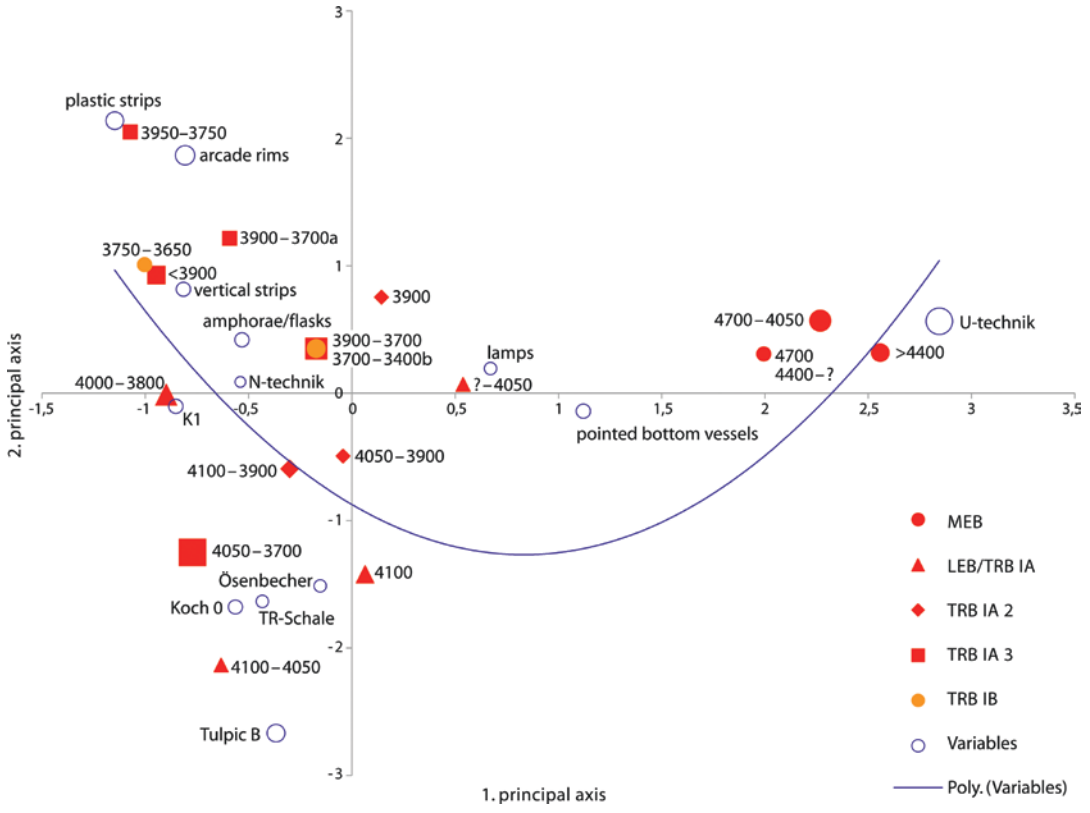

Fig. 3 Correspondence analyses of Final Mesolithic and Early Neolithic sites (CAPCA. Eigenvectors 1–2 [45 % explanation]).

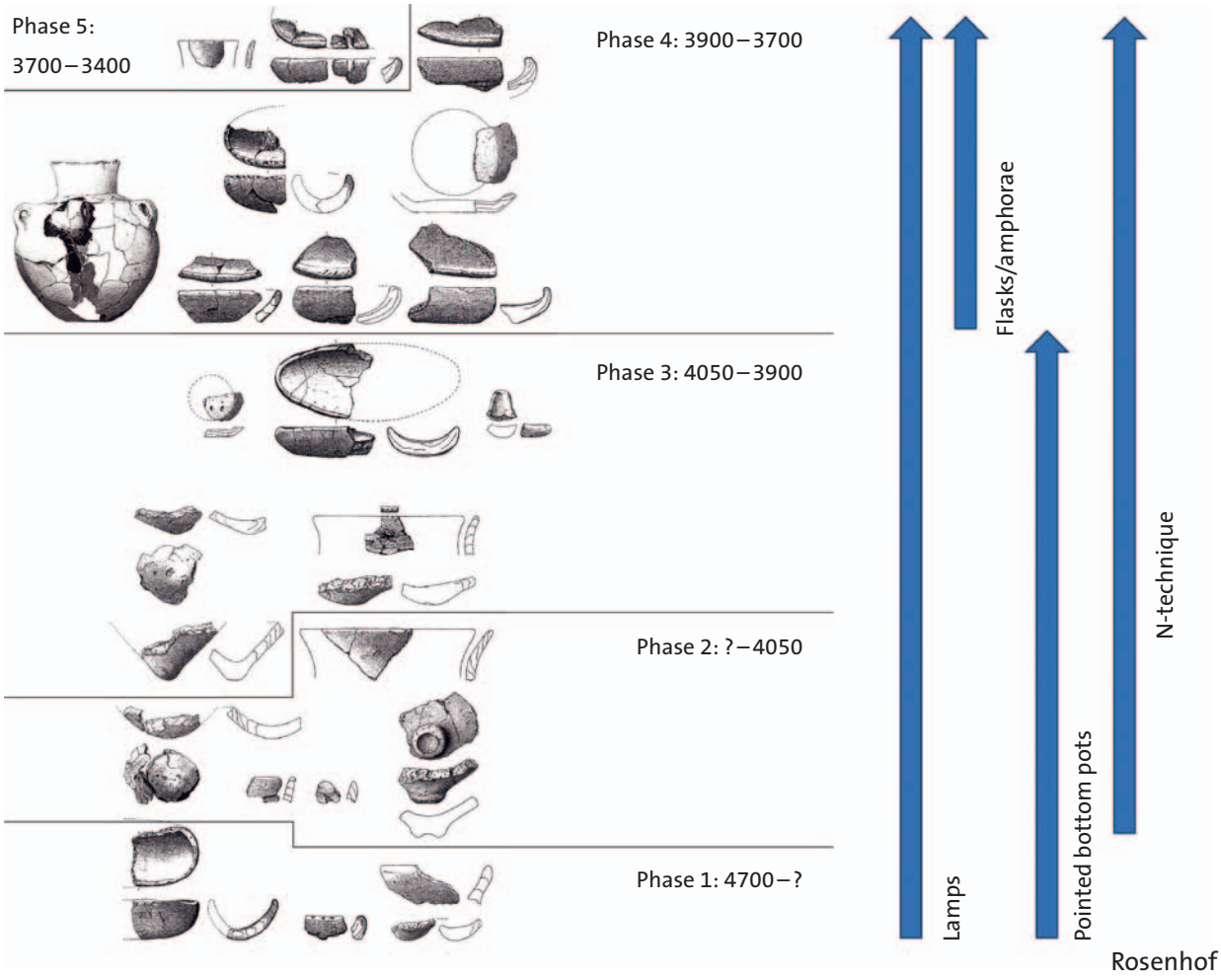

Fig. 4 The dated assemblages from Grube LA 58 (Rosenhof). The phasing and dating is based on Meurers-Balke / Kalis (2011, 35–38 figs. 6–7). The overall duration of the site is partly in line with the ^{14}C-values from the site (Hartz/Lübke 2005, 137–138 table 1; Goldhammer 2008, 41–43), even if the reservoir effect has to be considered.

possible to differentiate only on the basis of the ceramic inventories.

FM/EN (Early Neolithic) Ia, south Cimbrian Late Ertebølle/Early TRB Ia 1 (4,200–4,050 BCE, sites: Neustadt 2 / Flintbek): In Neustadt 2 (4,200–4,100 BCE) and in Rosenhof 2 (4,300/4,200–4,050 BCE), not only ceramics with pointed-bottomed vessels and lamps but also funnel rim vessels, funnel bowls and lugged beakers ('Trichterrandgefäße', 'Trichterschalen', 'Ösenbecher'), funnel beakers of Koch type 0 (Neustadt 2) and rim sherds with N-technique (probably of funnel-shaped vessels; Rosenhof 2) are identified as first Funnel Beaker ceramics (Figs. 4–5). In Flintbek, in addition to funnel beakers of Koch type 0, tulip beakers of Höhn type Kw3 were also identified (Mischka et al. 2015, 469; see Fig. 8). Such a Michelsberg beaker is also known from Neustadt 2 (Glykou 2016, 518 plate 18, N2449; see Fig. 5).

From a typological point of view, apart from Ertebølle pottery assemblages with first TRB elements at the east Holstein Baltic coast, we observe Michelsberg II/III pottery and early TRB Koch 0 vessels at the inland Flintbek site (Fig. 8).

EN Ia, south Cimbrian Early TRB Ia 2 (4,050–3,900 BCE, sites: Wangels 2 / Neustadt 3 / Rosenhof 3): At Neustadt 3 (Fig. 6) and Rosenhof 3 (Fig. 4), in addition to lamps and pointed-bottomed beakers, we also observe funnel beakers of Koch type K0 and K1 with flat bases and a probable scoop. While first TRB elements are further indicated here, at Wangels 2 only pointed-bottomed pottery is observed (Fig. 7).

EN Ia, south Cimbrian Early TRB Ia 3 (3,900–3,700 BCE, sites: Wangels 3 / Neustadt 4 / Rosenhof 4 / Borgstedt 1): Around 3,900 BCE, pointed-bottomed beakers disappear from the assemblages, while lamps are still in use. Now, Funnel

Fig. 5 The dated assemblages from Neustadt LA 156, phases 1–2. The phasing and dating is based on Glykou (2016).

Beaker pottery becomes a major player with both lugged amphorae, flasks, and cannelur-like vertical stripes within the assemblages. Decorated rims with plastic stripes are known from Wangels 3 (Fig. 7). The ceramic inventories of the Borgstedt I phase (3,950–3,740 BCE) (Fig. 9), including arcade rims, plastic ridges and finger imprints (Hage 2016, 241 fig. 284; cf. arcade rims of Klassen 6 type, LA 27 GE1 [ibid. 284 pl. 1,7] and GE10 [ibid. 285 pl. 2,4] and arcade rims of Klassen 8 type, LA 28 GE72 [ibid. 286 pl. 3,1] and LA 32 GE7 [ibid. 310 pl. 27,7]), could be associated with the ceramic finds, e. g., from Wangels 3 (Fig. 7).

EN Ib, south Cimbrian Early TRB Ib (3,700–3,500 BCE, sites: Wangels 4 / Rosenhof 5 / Büdelsdorf 1a): In all east Holstein assemblages, TRB pottery with flat-based bowls, funnel beakers with punctures below the rim or plastic rims dominate. A lamp is still only known from Rosenhof (Fig. 4). In the north, the inventory of Büdelsdorf 1 displays further elements, such as vertical rips, but also plastic and band decoration (Hage 2016, 233 fig. 275).

From a terminological point of view, Wangels 3 and 4 are the assemblages that form Sönke Hartz's 'Wangels Group' (Hartz 2004). In principle, it is mainly associated with late Wangels ceramics. In

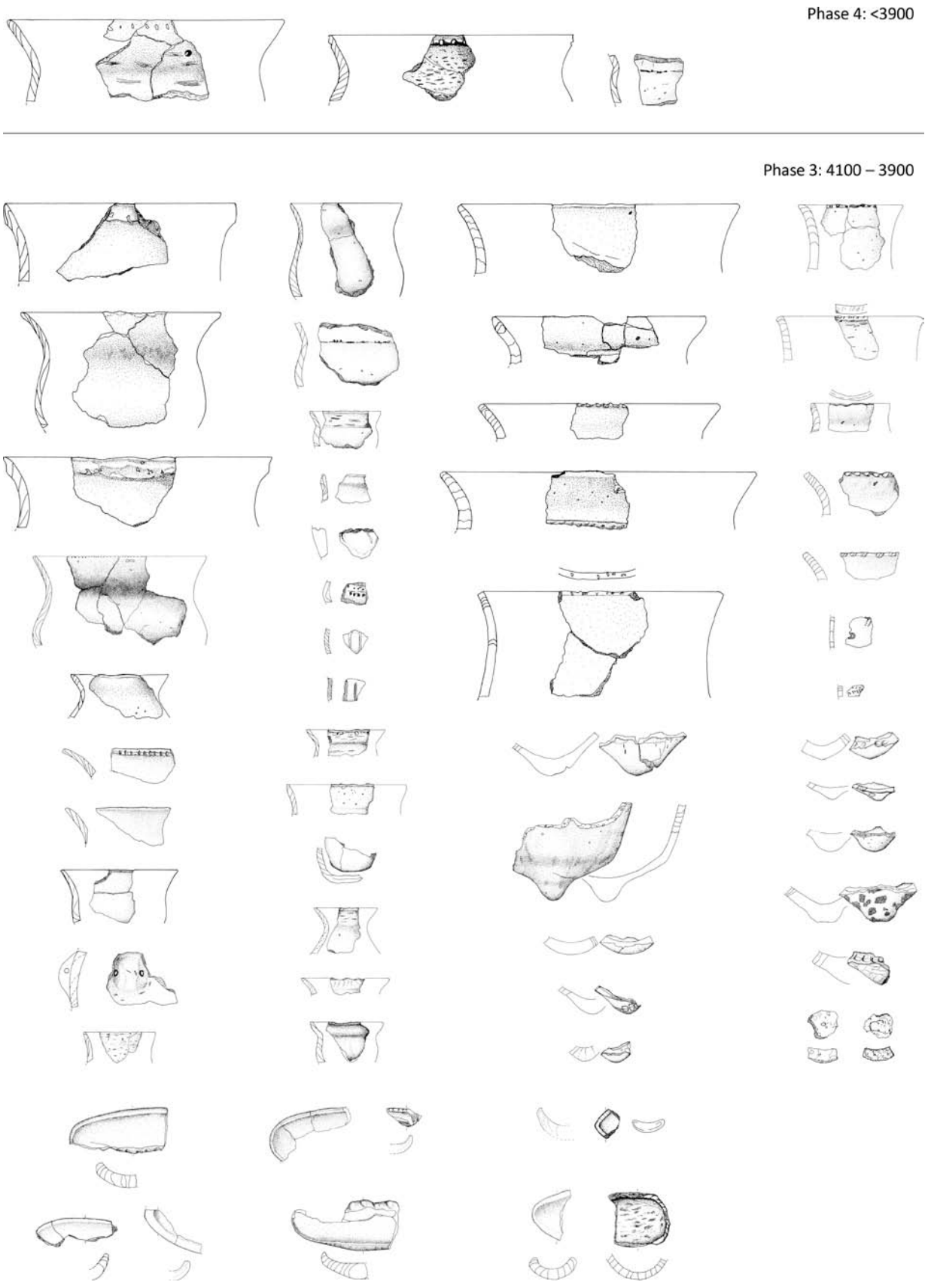

Fig. 6 The dated assemblages from Neustadt LA 156, phases 3–4. The phasing and dating is based on Glykou (2016, 155–165 and plates).

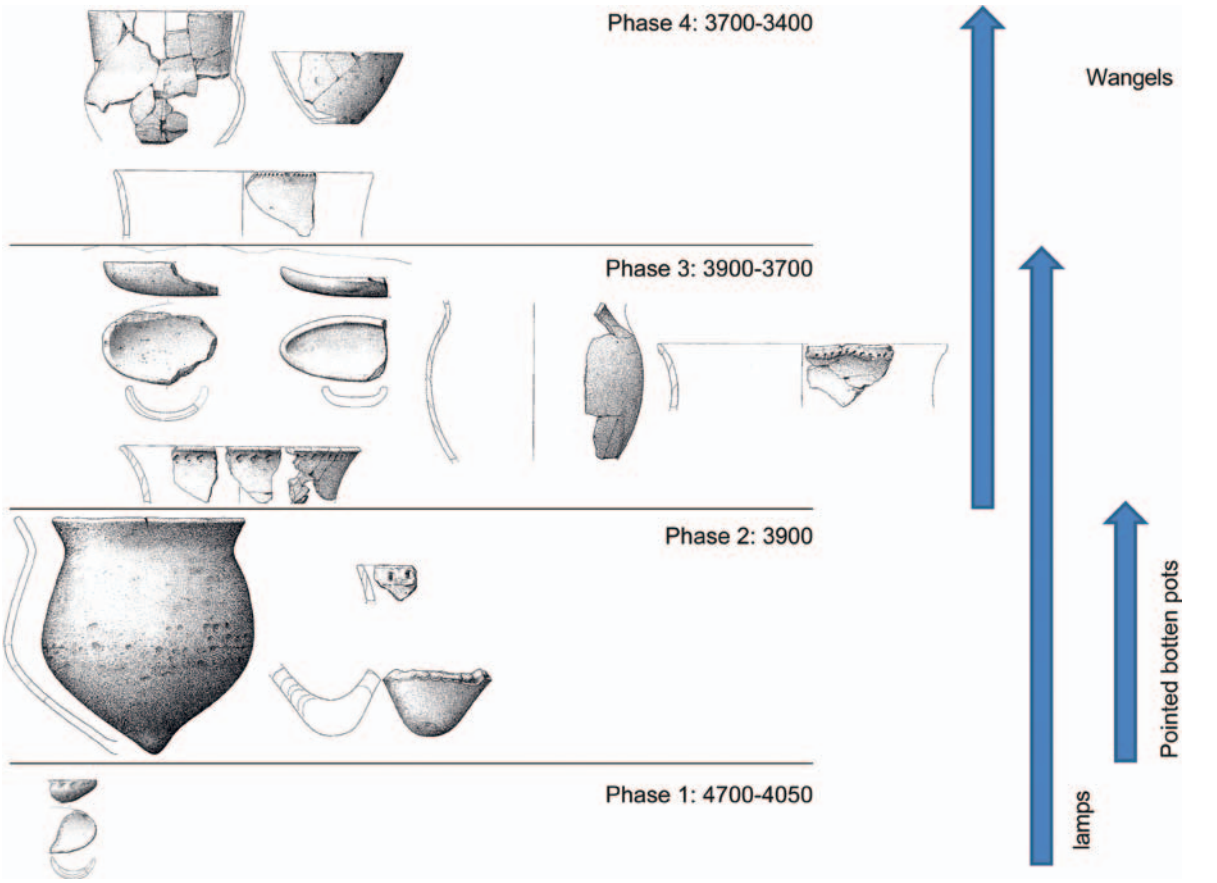

Fig. 7 The dated assemblages from Wangels LA 505. The phasing and dating is based on Meurers-Balke/Kalis (2011, 38–42 figs. 8–9). The overall duration of the site is in line with the ^{14}C-values from the site (Faasch 2017, 137 table 1).

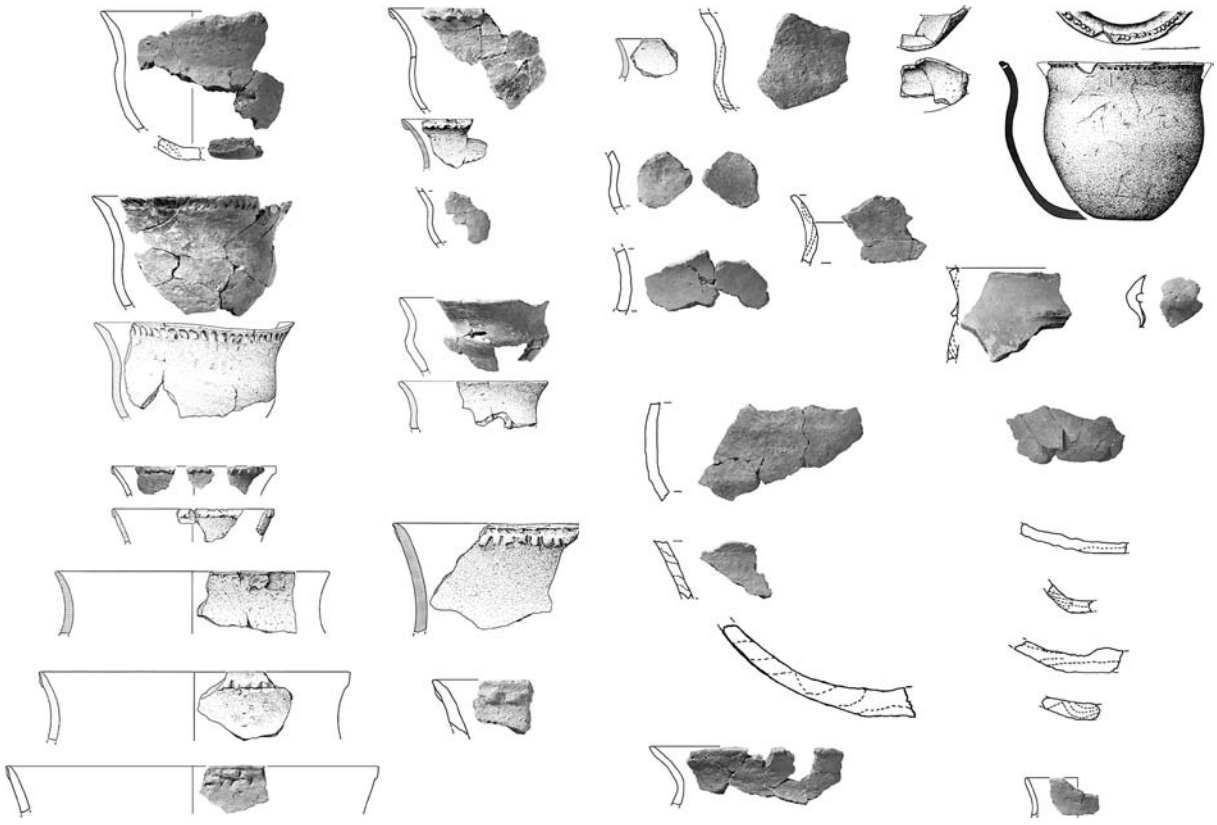

Fig. 8 The assemblage from Flintbek LA 48 (after Mischka et al. 2015, 467–468 figs. 2–3).

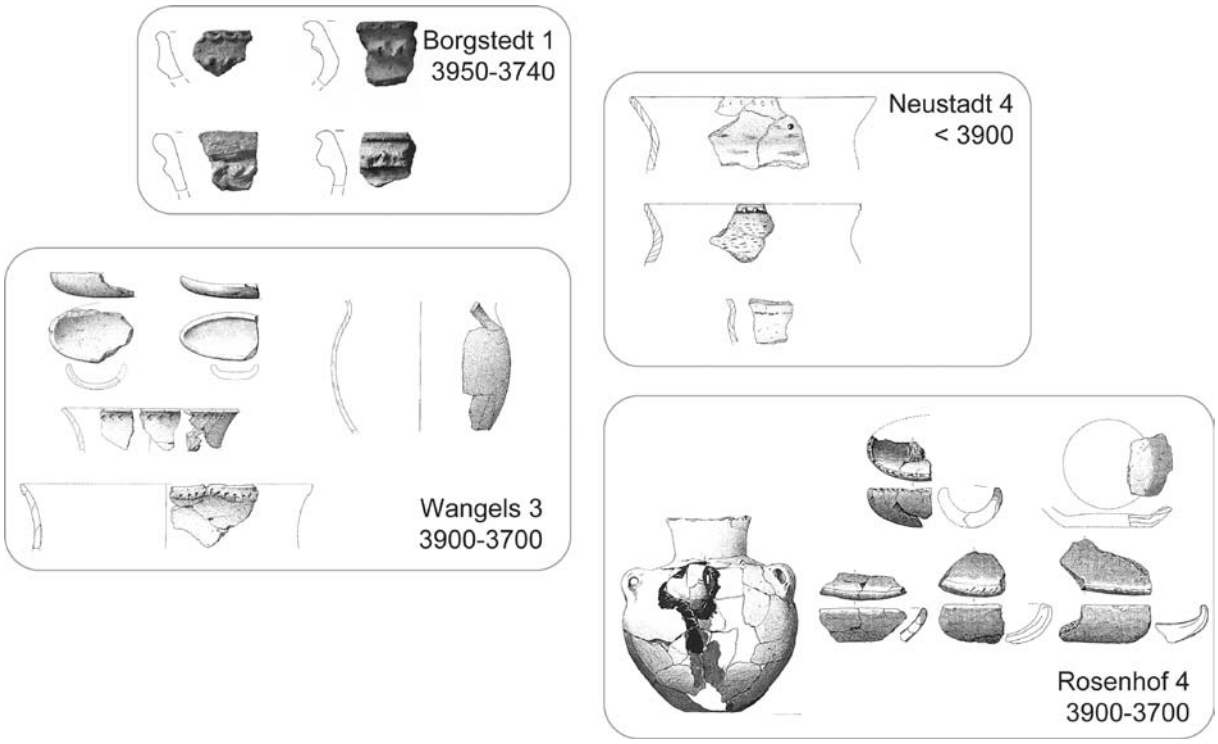

Fig. 9 The assemblage from Borgstedt I (after Hage 2016, 240–241; 284 pl. 1,7; 285 pl. 2,4; 286 pl. 3,1; 310 pl. 27,7) and contemporary assemblages (cf. fig. 4;6–7 in this contribution; TRB FN IA3).

contrast to Oxie ceramics, the presence of amphorae and elaborated flasks is obvious.[3]

Principally, for Borgstedt 1, Neustadt 3 and Wangels we observe an Early Neolithic phase, which, on the one hand, corresponds to Jutland's Oxie type, but assumes, on the other hand, a more independent typological character via arcade rims. The inventory of Flintbek LA 48 should be included here. In this respect, an early beginning is to be distinguished from a later development, which, however, ends on the entire Cimbrian Peninsula around 3,800 BCE and leads to a new phase, which is characterised by the Volling style.

In conclusion, there are three sub-phases of the ENIa (Fig. 10):

- Sub-phase ENIa1 (only in the south): with first TRB ceramics including funnel beakers of Koch type 0 and rim decorations;
- Sub-phase ENIa2: with rip-decorated funnel beakers, flasks, etc., as Oxie ceramics in the north and as Wangels ceramics with arcade edges in the south;
- Sub-phase ENIa3: with late Oxie and Wangels ceramics now also displaying overturned ledges and sack-shaped bottles with two handles.

Remarks on the style transformation from Ertebølle to TRB

Earliest appearance of TRB pottery

At the Neustadt site after a phase with pointed-bottomed beakers (1a) and pointed-bottomed beakers and lamps (1b), we observe a phase around 4,100 BCE (Neustadt 2) that still exhibits pointed-bottomed beakers and lamps, but also includes funnel rim vessels, funnel bowls and lugged beakers ('Trichterrandgefäße', 'Trichterschalen', 'Ösenbecher'). They demarcate the earliest TRB-like pottery on the Baltic coast, followed by Neustadt 3 (until probably 3,800 BCE) with funnel beakers of Koch type 0 and 1.

3 Wangels Group after Sönke Hartz (Hartz 2004; Hartz / Lübke 2004, 133). – Ceramics: wide-mouthed funnel beakers with punctures below the rim or folded arcade rims, funnel bowls, lugged beakers, lugged corononay amphorae with dented handles, thin-walled bowls, bottles, clay discs; antlers/stone implements: No differences in antler and bone industry to Timmendorf phase, also for stone implements with soft, regular blades; large implements: trapezoidal disc axes, new: core axes with specialised cutting edge preparation, small ground rock axes. Difference to Oxie: amphorae, bottles. The Oxie Group ceramics consist mainly of undecorated funnel beakers of type 0 and I, lugged beakers with funnels at the top of the belly, large storage vessels with funnel-shaped rims, spherical bowls, lugs and lugged rim bottles, clay discs and clay spoons (see e.g. Klassen 2004, 242). In rare cases, simple incisions, abraded edges or smooth marginal ridges can occur on the edge or neck.

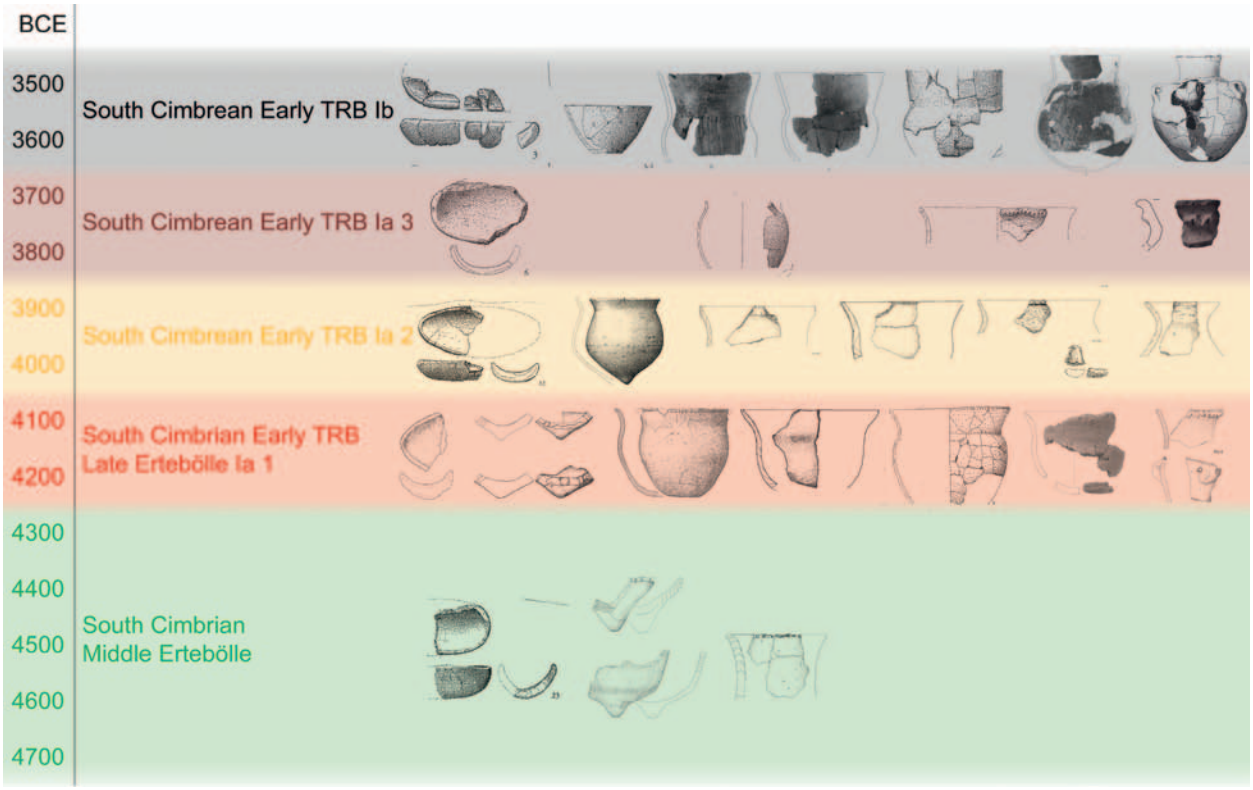

Fig. 10 The chronological model of the ceramic development.

At Stralsund 225, ENIa is represented by a site with canoes. Pottery there comprises funnel beakers and a funnel neck vessel of Koch 1 or Koch 3 type. The radiometric dating (4,000–3,700 BCE) can be traced, since a freshwater effect can be excluded via the stratigraphic position (Kaute et al. 2004, 234–237 fig. 14; Lübke 2004, 259–260).

Spatial differences of typological elements

While so-called arcade rims are not present at either Neustadt 2 or Neustadt 3, these are observed at Flintbek LA 48 and Wangels within the early ceramic assemblages. They are mostly unornamented with horizontal rows of simple impressions, mostly from fingers, and arcade rims beneath the rim. While at Flintbek clear influences, such as tulip beakers of Micheslberg II/III, are visible in the assemblage, the Wangels assemblage seems to indicate a slightly later appearance with beaker forms that are also known from many different Oxie sites in other areas of the Cimbrian Peninsula and the Danish Isles, but without tulip elements. Typical in this respect are Koch 0 and 1 type beakers (usually coarse and variable in size, but always with a short neck), lugged beakers of similar type (but with lugs placed on the upper part of the body), lugged jars and flasks, clay discs and clay spoons. While clear differences between the earlier Flintbek LA 48 assemblage and Neustadt 2, which exhibits a much poorer assemblage and the presence of pointed-bottomed beakers and lamps, are obvious, the later Wangels assemblage and the Lübeck assemblage (Hartz 2015) are comparable with Danish Oxie assemblages.

In principle, a chronological division between sites with Koch 0 and Koch 1 types is plausible, if the evidence from Bornholm is translated into the western Baltic area (Nielsen 2009, 15 table 1) and by considering the dating from other Scandinavian sites.

Conclusion: a mosaic of contemporaneous style elements

In conclusion, an early sub-phase with Michelsberg influences on the southwest Cimbrian Peninsula and with Ertebølle types in the southeast is followed by an Oxie-Wangels sub-phase that already includes Koch 1 type beakers and other features in the inland and similar assemblages still exhibiting lamps and pointed-bottomed beakers at the coast or bigger inland lakes. From a typochronological point of view, there is no reason for a north-south division of the whole Cimbrian peninsula with the exception that

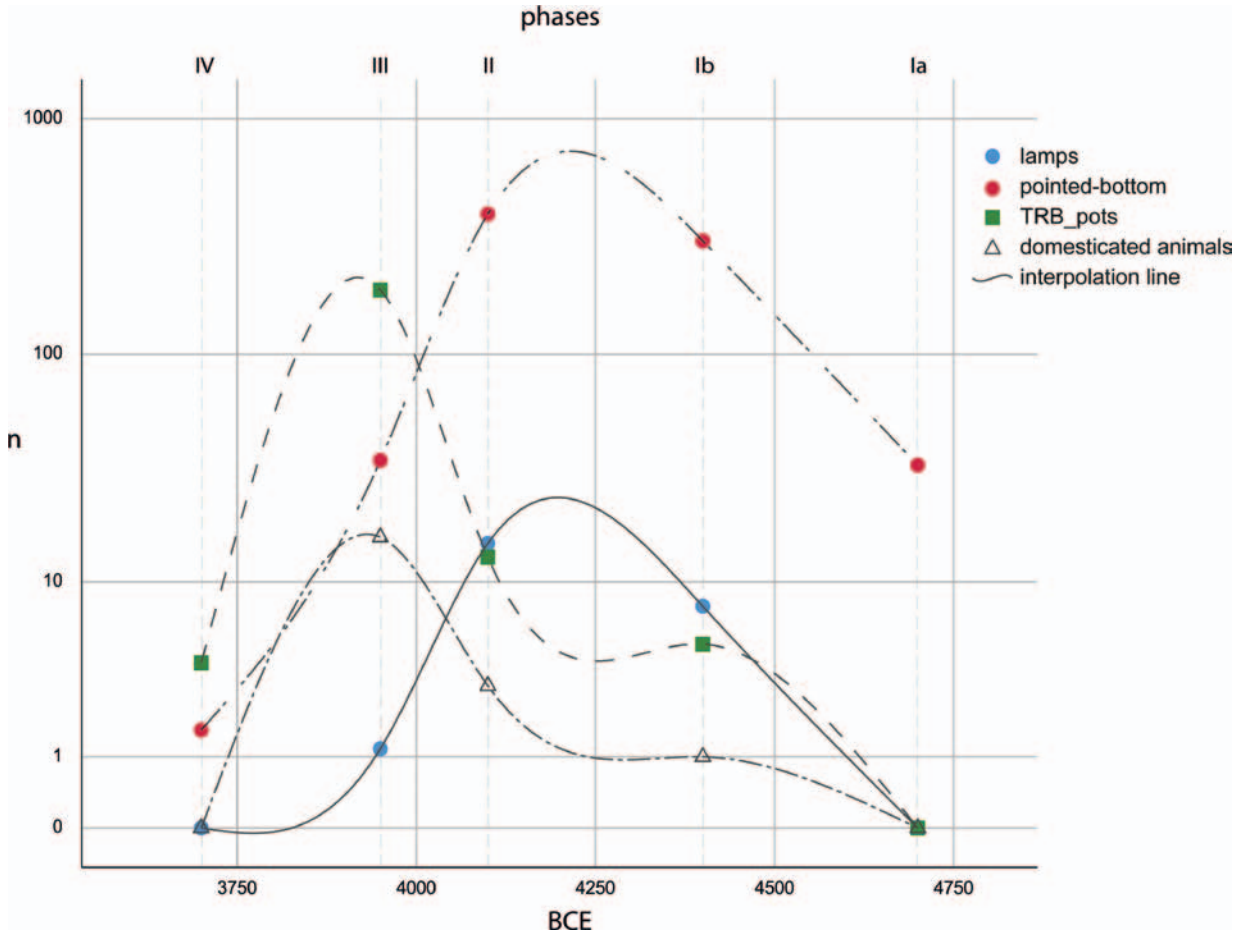

Fig. 11 Neustadt LA 156. Quantitative distribution of ceramic types and domesticated animals from 4,700–3,650 BCE based on Glykou (2016, 157 table 10).

the development started some generations earlier on the south Cimbrian Peninsula: from Flinbek LA 48 around 4,200–4,000 BCE (Mischka et al. 2015, 466–467) to Wangels around 4,100 BCE and then to early northern Oxie sites, such as Kongemosen and Bjørnsholm, with type 0 beakers around 4,070–3,800 BCE (Koch 1998, 83 ff.), whereby a slight shift in chronological terms is visible.

Most important: From a typological point of view with respect to ceramic assemblages, the latest similar ceramic forms with pure decoration were used around 3,950 BCE all over the western Baltic. The division of groups is mainly visible with respect to the use of long-known pottery types, such as lamps and pointed-bottomed beakers, at coastal or inner aquatic sites in contrast to such with flat-bottomed and tulip-like beakers.

Interpretation: From the Mesolithic to the Neolithic – the invention of ceramics

In the western Baltic, we can postulate the use of ceramics from about 4,800 BCE for the Final Mesolithic (cf. Hartz 2011).[4] The use of the mostly pointed-bottomed Ertebølle pottery, which due to its variation enables a typological differentiation into smaller regions for sites from Jutland, the Sund Islands and Scania, is known until about 3,800/3,700 BCE.

From the southern distribution area of the mentioned overall region, the Neustadt site is the location where a vertical stratigraphic differentiation of the ceramic inventories can be traced. In the Neustadt Ia phase, which is older than 4,400 BCE, the first pointed-bottomed beakers are known. In the Neustadt Ib phase, which dates from about 4,400–4,200 BCE, ceramic lamps are added to the pointed-bottomed vessels (cf. Glykou 2016, 157 table 10; Fig. 11). In the Neustadt 2 phase, which begins around 4,200 BCE, Funnel Beaker ceramics in the form of funnel rim vessels, funnel bowls and lugged beakers ('Trichterrandgefäße', 'Trichterschalen', 'Ösenbecher') are

4 For Schlamersdorf, A.-K. Meyer was able to show that it is highly probable that the pottery there was not deposited before ca. 4,700 BCE (Meyer 2017, 60–64).

found next to the two typical Ertebølle ceramic types. First funnel beakers of Koch 0 type are known from c. 4,100 BCE from Neustadt 2 or even a little earlier from Flintbek LA 48 (from approx. 4,200 BCE). In fact, until Neustadt 3 (c. 4,100–3,800 BCE), the pointed-bottomed ceramics still predominate alongside the TRB beaker types Koch 0 and I. TRB ceramics make up the majority of the assemblage at Neustadt only from approx. 3,800 BCE onwards, when beaker type Koch 0 is no longer used, but rather the beaker types Koch I and II.

This means that we record Funnel Beaker ceramics from about 4,200 BCE in the southern distribution area of the TRB North Group ('Trichterbecher-Nordgruppe') and from about 4,000/3,950 BCE in the northern distribution area of Funnel Beaker ceramics, which is characterised by funnel bowls, lugged beakers and beakers of Koch 0 type ('Trichterschalen', 'Ösenbecher', 'Becher Typ Koch 0'). This is also the time in which domesticated animals are increasingly detectable for the first time (Glykou 2016, 310–321), unless the pig bones from approx. 4,800 BCE are also to be evaluated as evidence of domestication processes (Krause-Kyora et al. 2013). With a certain chronological emphasis, we can assume the development of the EN ceramic sequence in Flintbek LA 48 and (a little younger) in Wangels for the ENIa in the south, while in the north of the Cimbrian Peninsula, we observe the sequence Oxie-Volling and on the Danish islands the Oxie-Svaleklint development (Mischka et al. 2015, 473–475 figs. 6–8). In fact, early elements in Flintbek strongly correspond to Michelsberg II so that a close relationship between the TRB elements and Michelsberg II can be assumed here (see below).

While we identify a rather early transition from Ertebølle ceramics to Funnel Beaker ceramics both in Neustadt and in Flintbek in the southern distribution area of the TRB North Group, which finally flows into the Wangels Group, from the Danish region only later data are available (cf. Soerensen 2014). In Norsminde and Björnholm on Jutland for the time phase from c. 3,950–3,850 BCE, Eva Koch identified beaker type 0 with agricultural production elements and in Åkonge in Store Amose (Zealand) with forager-like subsistence, but both can certainly already be assessed in connection with Oxie ceramics (Koch 1998, 172). In the shell middens of Ertebølle, Bjornsholm, Krabbesholm and Ringkloster, narrow, round ceramic bottoms can also be identified, which are not typical of Ertebølle ceramics, and indicate a process of change in the ceramic design. However, this happens with some certainty after 4,000 BCE so that a temporal difference to the chronological position of Neustadt 2, Flintbek and Wangels becomes clear. The evolving inventory of the Oxie Group mainly includes undecorated funnel beakers of type 0 and I, lugged beakers with lugs at the top of the belly, large storage vessels with funnel-shaped rims, spherical bowls, lugged and lugged coronary flasks, clay discs and clay spoons (see e.g. Klassen 2004, 242). In rare cases, simple incisions, arcade rims or smooth rim bar applications ('Randleisten') occur on the rims or necks.

In principle, there are no major differences between Wangels and Oxie ceramics, while in Flintbek the Michelsberg influences are typologically more obvious. A continuous duration of Oxie ceramics after 3,800 BCE in Danish Amose and on the Swedish Öresund coast is indicated by Klassen (2004, 242 fig. 134). Primarily, we should distinguish an early Oxie phase with Koch type 0 beakers from a younger Oxie phase with Koch type I pottery. In Jutland, the Volling Group replaces the early Oxie Group around 3,800 BCE. Overall, however, the duration of the Oxie Group until approx. 3,500 BCE, as also indicated by Klassen (2004, 244), appears to be considerably too long.

Basically, these considerations make it clear that with the emergence of first Funnel Beaker ceramics a continuous ceramic development already commenced at Mesolithic contexts, which later reaches far into the younger Early Neolithic. The local and small regional demarcations of the ceramic sequences, but also their chronological phase differentiation, are thus only an arbitrary technical attempt to order the sequences. Nevertheless, these regional sequences offer the possibility to describe the development overall and to interpret it with respect to the connectivities of the mosaic-like distribution of different elements (Fig. 1).

A mosaic of change: Dual ways of life

In fact, we can thus see the coexistence of different ceramic styles with other social practices on the southern Cimbrian Peninsula. On the coast and at lagoons of eastern Holstein, aquatic communities existed for several centuries simultaneously, for example, with first pastoral and horticulture practices in the hinterland near the Kiel Fjord, or parallel to the first communities that built non-megalithic long burial mounds, e.g. in Borgstedt. Such a dual way of life only disappeared entirely during the Early Neolithic II phase (c. 3,650 BCE). The shift that occurred

becomes visible not only in changes of ceramic design, but also in the adoption of pastoral practices and the integration of intensive cultivation of arable plots in the environment (cf. Kirleis 2019a; 2019b). The attempt made here to arrange the ceramic inventories typochronologically is only one means to be able to describe the corresponding social processes – which is much more important.

Environmental, economic and ritual changes

The described typo-chronological differentiation of the ceramic inventories of the Late Mesolithic and Early Neolithic concerns the changes in the use of ceramics. However, it should also serve to make a comparison with other socio-economic or ritual spheres of the societies of that time. In this respect, we would like to reiterate the following: While pointed-bottomed ceramic vessels and lamps hardly changed in terms of typology, but rather in their relative quantities, a development began around 4,200 BCE at the latest, in which new, flat-bottomed ceramic forms appeared. These later become the main component of the funnel beaker inventories.

Chronologically, this is contemporaneous to various events in the rest of north central Europe. Thus, in the loess settlement zones, which were occupied by farming communities since around 5,300 BCE, enclosures were constructed from about 4,200 BCE onwards, e.g. by the central German Schiepzig group, which represents a typological link between Michelsberg II/III and Late Lengyel. The use of funnel-shaped storage pits in connection with ditch systems indicates a new practice, probably also a new economic order, which differs strongly from the previous one (Müller et al. 2019).

Typologically, we recognise not only the developmental series of tulip beakers in this Michelsberg area, but finally, from about 4,100 BCE onwards, the use of flat-bottomed funnel beakers (Höhn 2002, 180 fig. 69; 212 fig. 164). Thus, the changes towards flat-bottomed ceramics in parts of the inventories, which can be traced back in their entirety to corresponding contacts between western Michelsberg and eastern flat-bottomed ceramic traditions, are based on processes that cover not only the Cimbrian peninsula, but also large parts of central Europe. In a model way, this can be attributed to increased interactions between the Early Michelberg and Late Lengyel groups.

The new developments that changed the social situation in the loess regions in the last three centuries of the 5th millennium BCE are similarly incisive as, for example, the end of the Linear Bandkeramik (LBK) around 4,900 BCE. While the latter took place more or less contemporaneously to the earliest pottery use in Ertebølle, the former was also synchronous to the introduction of flat-bottomed vessels in the north, i.e. the first evidence of funnel beakers.

Corresponding changes or additions to ceramic design are obviously already linked to changes in economic preferences. For example, the food spectrum is already supplemented by domestic cattle in Neustadt 1b (4,500–4,200 BCE) and sheep/goat in Neustadt 2 (4,200–4,100 BCE). If increasingly more local evidence is taken into consideration, the variability of practices stands out. While, for example, clearances and open land are already documented for the Horstenmoor in west Holstein (Dörfler 2005; Feeser/Dörfler 2016) around 4,500–4,200 BCE, high *plantago lanceolata* values in the pollen profile of Saiser, Fundplatz 1 (Lietzow-Budelin) on the island of Rügen, around 4,300/4,200 BCE are associated with the grazing of domesticated animals (Terberger/Seiler 2004, 178; Endtmann 2004).

Interestingly, the described developments take place before 4,050 BCE, i.e., a noticeable climate event was prevalent at least in the western Baltic region. Based on high-resolution sedimentological evidence from laminated lake profiles (Dreibrodt et al. 2012; Zahrer et al. 2013), very cool and wet conditions can be postulated for about 40 years, which led to a considerable deterioration of living conditions (both for foraging and farming). At the latest during this period, interaction networks with the south (i.e. with Michelsberg) are 'opened'. Horticultural elements, such as the application of local slash-and-burn practices ('Brandfeldbau') commence (Schier 2009). Both the increased micro-charcoal records in pollen profiles (4,050–3,750 BCE) with only few signs of clearances (Feeser / Dörfler 2015; Feeser et al. 2012), and the boom in pointed-butted flint adzes point to changes in subsistence economy. They are associated with an increased population growth from about 4,000 BCE onwards, which may be connected to the introduction of the new horticultural techniques (Feeser et al. 2019, 1602 fig. 6).

Within this period of intensive changes (c. 4,300–3,800 BCE), individual ritual marking in the groups obviously decreases. The number of individual burials is reduced accordingly. After final changes – both in economic and ideological respect – begin to

stabilise, the marking of single individuals increases again. From about 3,800 BCE on, this is observable in long mounds and flat graves (Müller 2013).

From this synopsis, the possible significance of our observations becomes apparent: (1) The beginning of ceramic use in Ertebølle contexts is simultaneous with intensified processes of change in central Europe (Final LBK). (2) The beginning of flat-bottomed funnel-beaker pottery can be observed at south Cimbrian Mesolithic sites even before considerable changes i. e., the dominance of the 'Funnel Beaker Phenomenon' from c. 4,050 BCE onwards. (3) Simultaneous with the newly emerging pottery, domestic animals can be found in addition to the still dominant, appropriated production method. (4) The introduction of horticultural subsistence practices took its course primarily during or after the climate crisis around 4,050–4,010 BCE, similar to the introduction of pointed-butted flint adzes. (5) Pointed-bottomed pottery and lamps are used at some coastal sites parallel to the development of funnel beakers, partly still in the time when first non-megalithic long mounds were erected. (6) Corresponding 'parallel worlds' finally disappear with the introduction of the animal-drawn plough and the intensification of agriculture from 3,650/3,500 BCE onwards.

Interestingly, we recognise many aspects of the same scenario, quite simultaneously, in other regions of north central Europe. For example, in the east, on the Polish Baltic coast in Dąbki, the introduction of funnel beaker ceramics took place from 4,200 BCE onwards with Ertebølle ceramics still in use at the latest until about 4,000 BCE (Kotula et al. 2015, 122–123). However, at this seasonally used station for the production of beaver fur (Schmölcke/Nikulina 2015), no domesticated animals were found, probably due to its special function. The continuity of the Dąbki settlement with, e. g., decorated lamps as an Ertebølle-TRB transitional form (Czekaj-Zastawny/Kabacinski 2015) suggests a similar development like that which took place at the coastal sites of east Holstein.

Furthermore, in the west, in Swifterband (SW) contexts, we recognise the emergence of flat-bottomed vessels for SW2b from 4,150 BCE at the latest (Ten Anscher 2015, 346), which is synchronous to the changes observed in Schleswig-Holstein and north-west Poland. At least in Schokland P14, these form the basis for the older group of the TRB-West Group (Pre-Drouwen), which starts at c. 3,900 BCE. Consequently, the interaction sphere of early funnel beaker transforming styles (Müller 2011, 295) should be seen as a multi-dimensional interaction sphere, in which Swifterband continuities in the west, Michelsberg expansion in the centre, and Late Lengyel influences in the east demarcate the new developments.

Conclusion

In summary, there is much to be said for a gradual process of transitions that affected different parts of the north central European societies. Thus, the south Cimbrian region is an exemplary part of an overall structural change. Even if certain triggers for development can be observed (e. g. the acceleration of change processes through climatic and external influences), the causes of change remain open: increased population growth or increased mobility are certainly only two parts of a causal structure. We can still only describe the changes, but not explain them entirely.

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A *longue durée* perspective on technical innovations in the Late Mesolithic and Early Neolithic of the North European Plain

Florian Klimscha and Daniel Neumann

Abstract This paper examines the technical innovation trajectories of polished stone axes, copper melting, arsenic copper alloys, cattle-drawn ploughs, and wheeled vehicles in the North European Plain and discusses their emergence, spread, and relation to the neolithisation. Even though Late Mesolithic societies in the northern lowlands did not adopt the Neolithic economy for more than a millennium, they maintained networks on different scales and got into contact with new technologies from the 6th millennium calBC onwards. But innovations were rather consumed, not adopted, even though knowledge about new technologies reached the North European Plain. It is argued that the reason for this mode of interaction may be seen in a lack of mandatory sociotechnical substructures in hunter-gatherer-fisher groups. Only with the shift to the Neolithic way of life these groups began to lay the foundations on which new technologies could be created locally. This transformation at the end of the Early Neolithic (EN II) is accompanied by a rapid adoption of other innovations, e. g. wheeled vehicles and experiments in local re-melting of copper items.

Keywords Technical innovation, metallurgy, wheel & wagon, ploughing, FN II / Fuchsberg stage, Funnelbeaker culture, Mesolithic, North European Plain

Zusammenfassung *Der Beitrag befasst sich mit den Innovationsgeschichten des geschliffenen Steinbeils, der Kupfermetallurgie, Arsenkupferlegierungen, des von Rindern gezogenen Pflugs und der Räderfahrzeuge in der nordeuropäischen Tiefebene und erörtert deren Emergenz, Verbreitung und Verhältnis zur Neolithisierung. Auch wenn die spätmesolithischen Gesellschaften der Tiefebene die neolithische Wirtschaftsweise für mehr als ein Jahrtausend ablehnten, unterhielten sie doch Kontaktnetzwerke unterschiedlicher Reichweite und gerieten dadurch seit dem 6. Jahrtausend v. Chr. mit wichtigen Innovationen in Kontakt. Der Beitrag führt dies auf die fehlenden soziotechnischen Substrukturen von Jäger-Sammler-Fischer-Gruppen zurück, was lediglich die Konsumption, nicht aber die Adaption dieser Innovationen erlaubte. Erst mit dem Wechsel zur neolithischen Lebensweise bauten ebenjene Gruppen, vermutlich unbewusst, die notwendigen Fundamente auf, auf denen neue Technologien auch lokal produziert werden konnten. Am Ende des Frühneolithikums (FN II) führte dieser Weg zur schnellen Annahme von Rad und Wagen sowie ersten Experimenten im Umschmelzen von Kupferobjekten.*

Introduction

Innovations are what makes prehistory tick. Without technical change and 'progress', there would not be a sequence from a Stone Age to a Bronze Age and an Iron Age. Pyrotechnology, agricultural tools, weapons, dwellings, and many other aspects of prehistoric life changed over time and were thereby further developed (improved in a technical, rather modern sense); this in turn is interwoven with social changes of different scale. The challenge in retrospective is that this improvement was not solely made to gain market advantages (as often implied by underlying theory), but considerably influenced by ideological and social aspects as well as individual agendas. Individuals chose 'the new' for often erratic and esoteric reasons. Thereby seemingly obvious possibilities to exploit new technology were often ignored. Gift-giving, barter, raiding, and personal mobility were, among others, responsible for the distribution of goods. There were no institutions that developed new technology, but technology was tinkered with by craftsmen who were often not aware of essential scientific principles. Knowledge was tacit and kept within kin groups who did not necessarily have an interest in making their know-how available to

others. Furthermore, power sources were limited to the muscles of humans and domesticated animals.

The combination of these factors resulted in the development of technology in a way that does not conform to modern expectations. It is actually barely known how innovations emerged under these circumstances. This means that models developed from fully-industrialised, capitalist societies cannot simply be applied to fill the empty spots in the archaeological records, but innovation-processes rather have to be reconstructed in large parts from the finds themselves.

The neolithisation may have been the most important socioeconomic shift in human history. Without the Neolithic technology package our modern subsistence and urban lifestyle would not have become possible, but also key technologies like metallurgy or animal traction would not exist. After its lengthy development into a working 'package' in the Fertile Crescent,[1] Neolithic ways of life spread to Western Anatolia, and from there were brought to the European subcontinent. Within the Carpathian Basin the Linear Pottery culture (Linearbandkeramik, LBK) was formed as the oldest Neolithic group of Central Europe (Bánffy 2019 [with recent reevaluation]; cf. also Bánffy 2013). In a rather short period of time the LBK spread to the northwestern fringes of the Loess sediments.[2] The indigenous population did apparently not welcome the initial arrival of LBK settlers in the European northwest,[3] and, apart from stone adzes ('Schuhleistenkeile') and very few clear imports found in Mesolithic layers or in the surroundings of Mesolithic sites, there is not much evidence of regular interaction.[4] With the following Rössen and Stroke-ornamented Pottery (Stichbandkeramik) cultures in the 5th millennium calBC the number of Neolithic objects, primarily adzes and heavy perforated shaft-hole axes, acquired by Mesolithic communities rose significantly.[5] The regular appearance of such stone tools in sites of the Swifterbant and Ertebølle cultures demonstrates their use by Mesolithic communities, even though it is unclear how they were brought there. Apart from mutual exchange, expeditions of Rössen descendants into the north, Mesolithic groups raiding Neolithic farmsteads, or 'Grenzgängers' living between both worlds seem possible. In any way, it seems plausible that the axes were accompanied by information about the new way of life. However, even though Mesolithic communities *did* know about agriculture, animal husbandry, polished stone tools, and long houses, they were apparently not motivated to adopt them. For c. 1,200–1,500 years societies of farmers and complex hunter-gatherer-fishers existed next to each other in the North European Plain.[6]

The successive introduction of Neolithic cultural elements started only during the last centuries of the 5th millennium calBC and culminated in the Funnelbeaker culture (Trichterbecherkultur, TRB) around 4,200/4,000 calBC. The shift from Late Mesolithic subsistence to the TRB was not as drastic as it seems at first glance. Especially during the early part of the TRB food was still acquired in large parts by hunting (Steffens 2005; cf. also Skaarup 1973). It was considerably later that the TRB system, consisting of a very elaborate ideology, visible in massive megalithic graves, ritual causewayed enclosures, and a huge number of hoards, and also a bundle of technological innovations, came into full effect.

Ploughing and wagons

The plough and the wheel are strongly connected with each other.[7] The northwest European finds are among the earliest in Eurasia (Burmeister 2004a [with further references and a detailed record]; 2017). The earliest finds belong to the TRB culture

1 Recently discussed again by Çilingiroğlu 2015; cf. also the papers in Klimscha et al. forthcoming.

2 With the exception of small outposts like the recently discovered settlement at Niedernstöcken: cf. Gerken et al., this volume.

3 According to palaeogenetic sampling this diffusion was the result of the movement of larger groups of settlers, and Mesolithic foragers apparently did not regularly intermarry with the LBK newcomers (Haak et al. 2015).

4 Hülsebusch / Jockenhövel this volume, refer to one such instance: the assumed destruction of the LBK well at Erkelenz-Kückhoven by Mesolithic raiders.

5 Although we can see some evidence, possibly in the adaptation of pottery in the La Hoguette group, (cf. Cziesla this volume), and during the later phase of the LBK in the adaptation of pottery in the Swifterbant culture.

6 Details of the shift to agriculture are presented in several other papers in this volume and will therefore not be further discussed here (cf. Müller this volume; Amkreutz this volume; recently also Terberger et al. 2018).

7 Andrew Sherratt's model of a Secondary Products Revolution (Sherratt 1981; 2004) was tremendously influential even though it has been criticised by a variety of authors, for instance Vosteen 1996; Bakker 2004. Cf. most recently: Burmeister 2017; Klimscha 2017a.

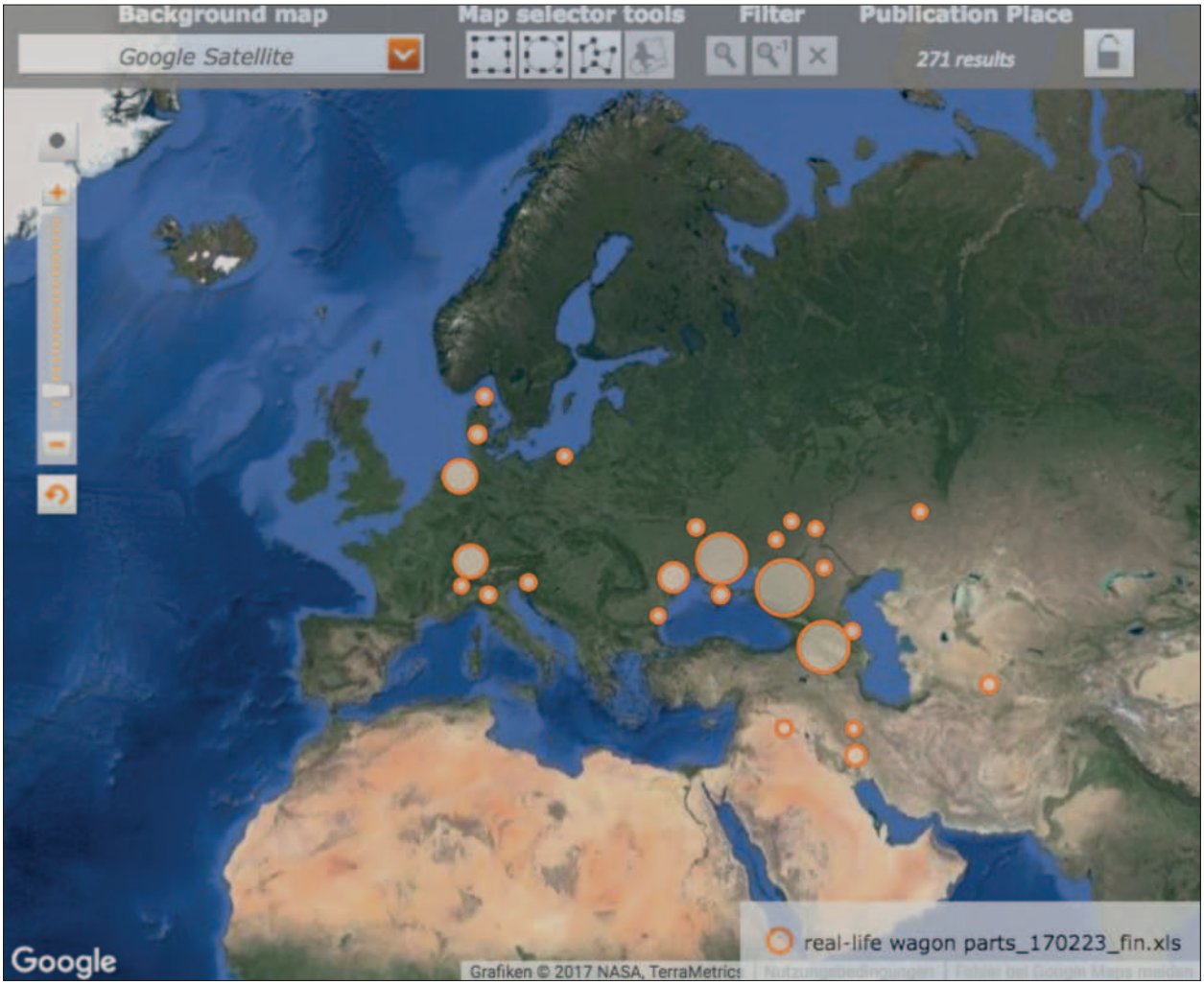

Fig. 1 Wooden wagon parts and wagon tracks in Eurasia (c. 4,000-2,750 BC) (© F. Klimscha, Digital Atlas of Innovations).

(Bakker 2004), and the early datings of some of the northern finds have stimulated a lively discussion about whether the technology was invented autochthonously (Vosteen 1999), or should be considered as the result of a quick diffusion of knowledge (Bakker et al. 1999). The northern Pontic area holds the earliest sequence of sledges and wheeled vehicles and thus might be the zone of origin for this technology (Klimscha 2012–2021; Hansen et al. 2017; Klimscha 2017a; 2018). In the North European Plain, eclectic evidence can be brought forward consisting of wheel tracks, two-dimensional depictions on pottery, megalithic slabs as well as wooden remains of wagons (Bakker 2004 [with further references]; cf. esp. Van der Waals 1964; Vosteen 1996). The finds are concentrated in the bogs of northwestern Germany, the Netherlands, and northern and central Jutland (Fig. 1). The evidence for ploughing is very similarly distributed and, in many cases, closely related to that of wagons (cf. Sherratt 1981). The earliest evidence is currently known from the 6th/5th millennia calBC in the southern Levant in the form of pathologies on cattle bones and in slaughtering patterns of cattle (Hill 2001; cf. also Hill / Klimscha forthcoming), and an *ad hoc* usage of cattle traction has also been claimed for southeastern Europe during this time (Gaastra et al. 2018). Central European evidence is significantly later and consists of few remains of ploughs and yokes, plough marks, and depictions of cattle teams (mostly in the Alps) as well as a handful of copper figurines that belong to the 4th millennium calBC and are contemporary to or slightly earlier than the evidence for wagons.

Wooden wagon remains

The Neolithic wheels found in the Netherlands have been frequently studied,[8] and none of them is older than 3,000 calBC.[9] The situation for the finds from northern Germany is very similar, which is not surprising, as the northwest German bogs are a direct continuation of the Dutch landscape. Frequently the finds were discovered during peat digging and during the systematic excavations of bog roads (cf. the catalogue by Both / Fansa 2011). The oldest finds date to around or after 3,100/3,000 calBC.[10] although significantly later dates for the respective contexts have also been proposed.[11] The Neolithic wheels from Jutland are slightly younger and belong to the early 3rd millennium calBC.[12] The apparent absence of early wagon parts in Mecklenburg and Pomerania is striking. Whether this reflects the prehistoric reality or simply a different level of research is difficult to assess. From a taphonomic perspective the preservation of wheels is certainly possible.[13]

Wheel tracks

Wheel tracks of wagons are a source-group documented relatively recently. The possibility to discover them is dependent on quick sedimentation over the tracks to protect these very delicate features from later interferences and erosion. This is normally only the case, if a burial construction was built immediately after a wagon had crossed the surface. Thus, the number of discovered wheel tracks is extremely sparse. Additionally, their identification rests on the premise that a track from a wagon wheel can be differentiated from a track caused by a sledge or travois.[14] A spectacular discovery from Flintbek, distr. Rendsburg-Eckernförde, Holstein, has pushed the beginning of wagon use to a significantly earlier date (Zich 1992; 1993; Mischka 2010; 2011). Here, two elongated-oval, parallel features were found beneath a megalithic grave of the Funnelbeaker culture (Fig. 2). The excavator B. Zich interpreted the traces as those of a wheeled vehicle and considered its use in the building of the monument (Zich 1993). He assumed that soil from a freshly dug pit was transported to the dolmen several times and that the wheel tracks thus were the result of multiple transports on the same route. The barrow was constructed in seven phases and included twelve graves altogether. The tracks were found beneath the filling of the extended dolmen IV (phase 7). Dolmen IV can be dated to the Fuchsberg / EN II-phase due to the find of a looped bottle ('Ösenflasche'). D. Mischka was able to pinpoint the construction history with a series of absolute dates and proposed a date of 3,450–3,385 calBC for the

8 Finds are known from Bourtanger Moor / Bourtangerveen (Nieuw-Dordrecht), Ubbena, prov. Drenthe, De Eese, com. Steenwijkerwold, Dertienhuizen-Musselkanaal, com. Onstweddeof, Midlaren, com. Zuidlaren, as well as Exloërboerkijl, com. Odoorn, Weerdinge, com. Emmen, and 'veenplads no. 3' in the Gasselterboerven, com. Gasselte; cf. Van der Waals 1964, 90–95, 136–137,141; Rostholm 1977, 211; Vosteen 1996, 25–26 fig. 10; 1999 Nr. 33–34.

9 *Inter alia*: Van der Waals 1964; Vosteen 1996; Bakker 1999; 2004; Burmeister 2004b.

10 For instance at the bog road VII (Pr) near Diepholz-Vechta, where two axles from a prehistoric wagon were found, one of them ^{14}C-dated to 3,100–2,875 calBC, the second axle to c. 3,021–2,891 calBC (Burmeister 2004b, 329), from the vicinity of Tannenhausen-Aurich, where several well-dated wagon parts are known, among them two wooden axles (C820 [D] and C821 [D]), radiocarbondated to c. 3,100–2,900 calBC (Burmeister 2004b, 329; Fansa 2004, 35 fig. 44), and from the Teufelsmoor near Gnarrenburg, where an axle connected to a disc wheel yielded a ^{14}C-date of 3,100–2,400 calBC (Vosteen 1999 Nr. 35; Burmeister 2004b, 322, 329 fig. 8).

11 The Teufelsmoor find (Vosteen 1999 Nr. 35; Burmeister 2004b, 322, 329 fig. 8), was recently re-evaluated and is now considered to be significantly younger at 2,580–2,479 calBC (Hesse 2011, 240). – Mid-3rd millennium dates have also been published for bog road and Le 15 (Vosteen 1999, 74–75).

12 A single find of a disc wheel from Bjerregaard Mose, former Studsgård-Havnstrup sogn, reg. Midtjylland, dated to c. 2,900–2,400 calBC (Rostholm 1977, 210–211; Vosteen 1996, 23 fig. 3; 1999 Nr. 26); two disc wheels from Kideris, south of Herning, reg. Midtjylland, that were found relatively near to each other but do not derive from the same context; one of them was ^{14}C-dated to c. 2,900–2,600 calBC (Rostholm 1977, 210; Vosteen 1996, 25; 1999 Nr. 39), and a disc wheel from Pilkmose bog, Vejle amt, radiocarbon dated to c. 2,900–2,500 calBC (Vosteen 1999 Nr. 46).

13 Two multi-part disc wheels from Skorshevo (Skorschewo), Kartuzy distr., have been assigned to the Neolithic / Bronze Age transition by most commentators (Vosteen 1999 Nr. 135 Taf. 83), while the chronological position of the disc wheels from Kowale remains unclear (Van der Waals 1964 A,67; Vosteen 1999 Nr. 130–131). Furthermore, the wheels from Kühlungsborn, even though of Late Bronze Age date, demonstrate the possibility of prehistoric wooden finds being preserved (Heussner 1986).

14 While it is normally argued that a certain type of compression beneath wheel tracks resulting from the pressure of wheels can be discerned from a track mark of a sledge, Burmeister (2011, 216) has pointed out that the same type of compression can be expected of a travois track.

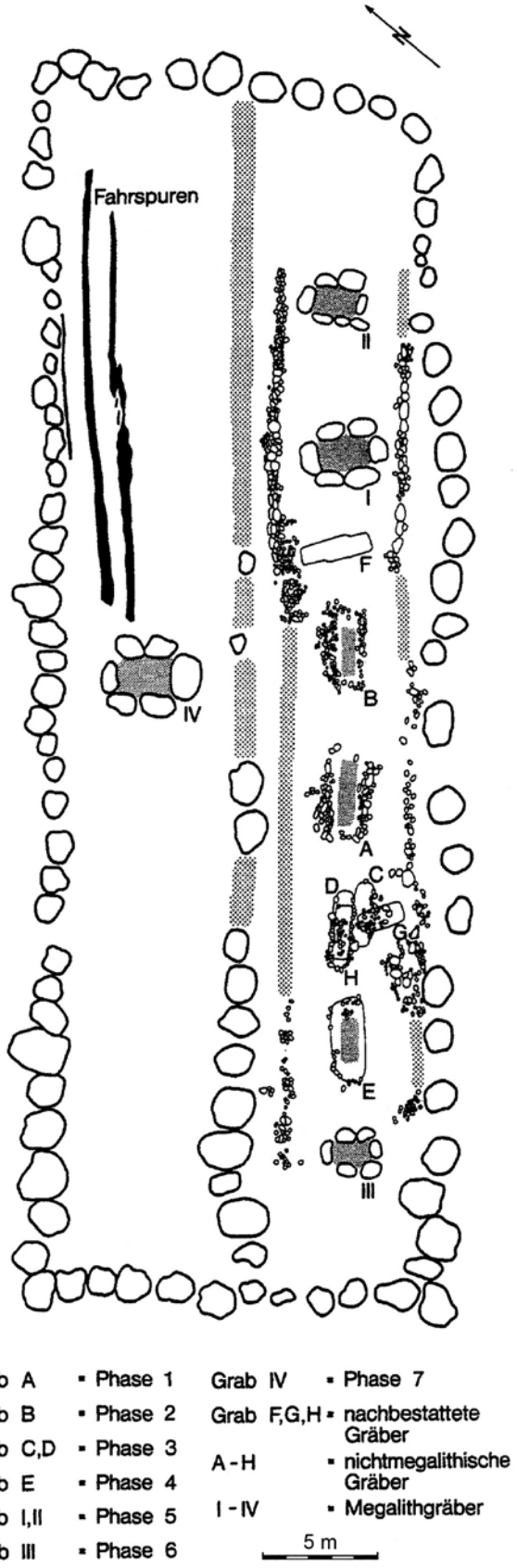

Fig. 2 Wagon tracks discovered under a megalithic grave at Flintbek dated to the Fuchsberg phase (after Vosteen 1996, 34 Abb. 24).

wheel tracks (Mischka 2011).[15] Tracks of a wagon with disc wheels were also found next to a megalithic grave at Helvesiek, distr. Rotenburg (Wümme), Lower Saxony (Vosteen 1999 Nr. 66). At the end of the 4th millennium calBC, wheel tracks are also known in relation with stone heap graves in northern Jutland (Bakker 2004, 288; Johannsen / Laursen 2010).

Two-dimensional depictions

Two-dimensional depictions of wagons are known from pottery and megalithic slabs (Fig. 3). The prehistoric cultures of Central Europe and the North European Plain seem to have been averse to figurative depictions, and the very small number of such pictures thus does not reflect a sparse use of the wagons, but rather a cultural taboo. This is well reflected by the placing of depictions into positions where they could not be seen, as at the Warburg I grave, distr. Höxter in the Warburg Börde, where yoked cattle-pairs were portrayed as fork-shaped signs (Günther 1990; 1997). These pictures were not meant for everyday use or view, but instead seem to have had a magical quality. The Warburg grave is important because it is securely dated into the Wartberg culture, c. 3,400–3,050 calBC. The placing of the depictions into a position where they were invisible after the grave was build excludes the possibility that they were created significantly later. Even though they do not show wagons, but only cattle under a yoke, they are of great importance, because they allow connecting the date with other petroglyphs, like those from a grave from Züschen, city of Fritzlar (North Hesse), with a wagon shown in the same style (Günther 1990, 50 fig. 7,1–4), and the famous rock carvings of two-wheeled wagons from the Kamenaja Mogila near Myrne, rai. Melitopol, Ukraine (Günther 1990, 53 fig. 9). The modern administration districts mask the close vicinity of Züschen and Warburg. From one site to the other it is merely 36 km as the crow flies, while the linear distance between the Wartberg culture burials in Lower Saxony and Züschen is c. 120 km.

Further wagon depictions are found on pottery sherds from the southeastern TRB groups. A rather ambiguous picture derives from a ceramic

15 It is necessary to point out, however, that the laboratory responsible for the radiocarbon dating in Kiel at that time had severe problems concerning the precision of their datings; cf. Menennga 2017, 50–53 with a critical discussion.

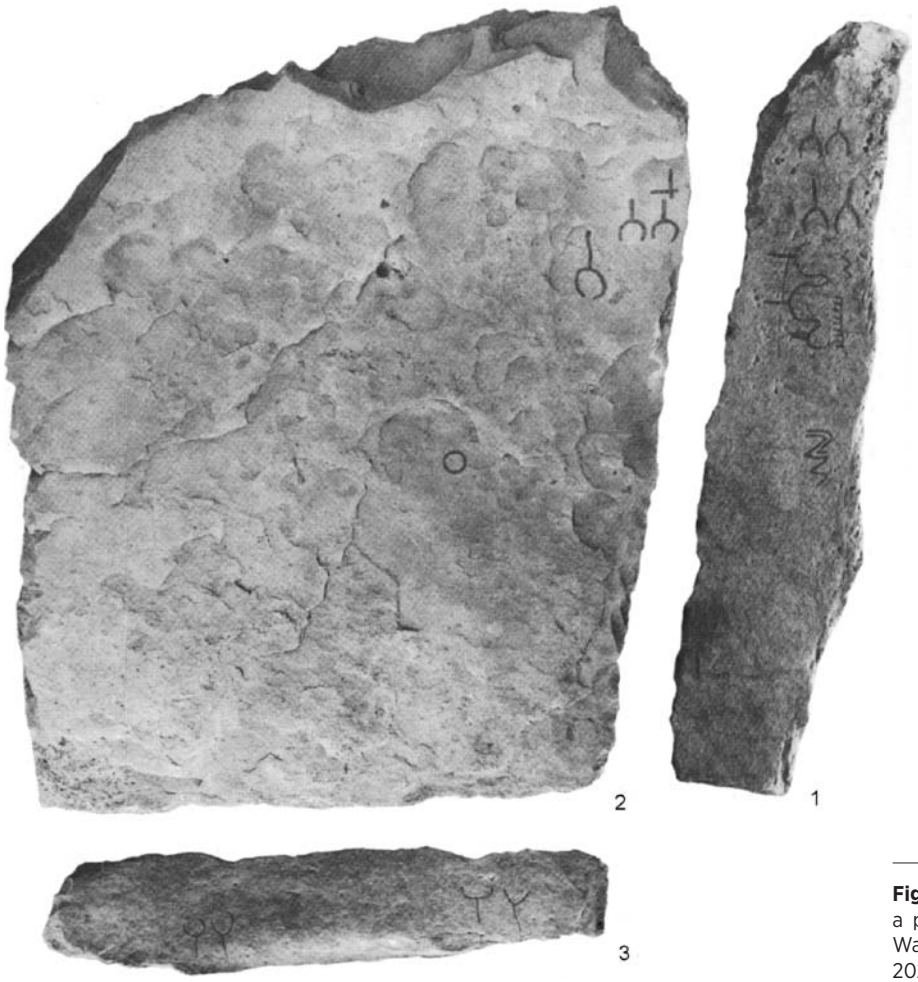

Fig. 3 Fork-shaped signs pecked into a pseudo-megalithic gallery grave at Warburg I, stone B3 (after Günther 1997, 202 Abb. 144).

vessel from Ostrowiec, woj. Kielce (a.k.a. Ostrowca Świętokrzyskiego), Poland, found in a storage pit of a TRB settlement together with Lengyel and Globular Amphora culture remains (Bakker 2004, 289). It is dated relatively late, because of the association with a globular amphora, suggesting a *terminus post quem* of c. 3,100 calBC. The depiction is very abstract, and its interpretation as a wagon is not definite. The other decoration on a TRB vessel from Bronocice, Poland (Fig. 4) is better understandable as a wagon with a surrounding landscape of rivers and fields (Milisauskas / Kruk 1982, Taf. 8; cf. also Milisauskas / Kruk 1977). Each wagon is shown as a box with four appendices to which circles are attached. A fifth circle is placed within the box. Two lines converge to form a triangle on top of which a Y-shaped sign is placed. The depiction is rather abstract and can only be understood as a wagon with appropriate prior knowledge. The fork-shaped signs from Züschen and Warburg representing cattle must thereby be seen as analogous to the Y-shaped sign on the Bronocice pot. Furthermore, the depiction of the wagon from a bird's eye view with the wheels shown from the side is well known from later petroglyphs. Typologically the vessel belongs into the phase Bronocice III (Milisauskas / Kruk 1982, 143) that is nowadays seen as starting c. 3,500–3,300 calBC (cf. Kruk / Milisauskas 2018). The Bronocice depiction has good analogies within rock art from central Germany. Günther (1997, 206 plate 49,1) already referred to several menhirs as well as the pottery drums from the Bernburg and Walternienburg cultures as analogies for the Züschen and Warburg graves: The 'style'

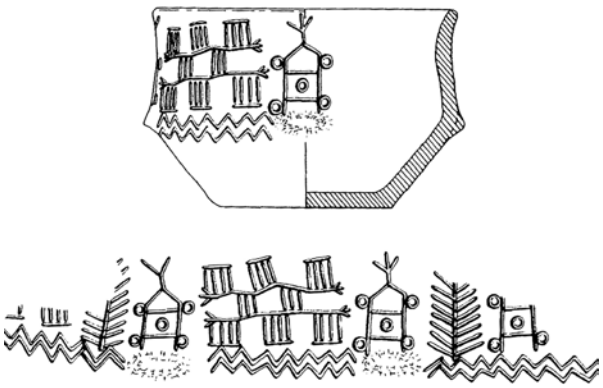

Fig. 4 Wagon depiction on a pottery vessel from Bronocice (after Milisauskas / Kruk 1982, Taf. 8).

used on these monuments uses a limited number of elements that describe a geographically distinct area.[16] It might be assumed that the distribution area of the style can be read as a proxy for the knowledge of early wagons (cf. Günther 1997, 157 fig. 125). The latest date for its spread can be seen with the Bernburg culture, i. e. *before* 3,200/3,100 calBC, while the earliest possible date can easily be connected with the upper limit of the phase Bronocice III and within the early Wartberg culture: Raetzel-Fabian (1997, 175) discusses a more or less simultaneous erection of the Warburg necropolis around 3,400 calBC, based on the available ^{14}C-dates and typological arguments, and this would also apply to the depictions.

An early dating of the Wartberg signs is also strengthened by new research on the huge corpus of rock art in the Alps. There are two major concentrations of depictions, one in the Val Camonica and the neighbouring Valteline and Val Venoste valleys, and the other in the region of Mont Bégo (cf. Arcà 2011 for an overview). The chronology of the images is established by defining stylistic units, which are dated by the association with datable artefacts depicted in them (Fedele 2006, 48 fig. 1). Altogether 21 depictions of ploughs and one of a wagon with a Remedello or Bell Beaker date are reported from Val Camonica. [17] The situation is similar at Mont Bégo: While ploughs are very numerous, wagons occur rarely (De Saulieu / Serres 2006, 76 fig. 7). Most scenes were not created in a single event, but clear associations are existent though rare. A key-position within this sequence is given to those depictions associated with specific axe, dagger, or halberd types.[18]

The most recent study on dating the Alpine rock art relies heavily on horn-shape and classifies such depictions as type C1a or C3 horned figurines (Huet 2016, 12–13).[19] Type C1a figurines can be placed into a sequence with C2 and C3 horned figurines. The styles have been dated by the association with weapons – in these cases daggers – as well as archaeological finds in the vicinity. This results in correlating C3 with the phase 'Chasseen recent', c. 4,050–3,500 calBC, while C2 signs are assumed to begin at 4,000 calBC, and C1a signs are contemporary with halberd depictions (Huet 2016, esp. 13 fig. 12). The superimposition of daggers by C3 horned figurines is crucial in this respect. Huet (2016, 9–11) describes the daggers shown as resembling shapes of the Italian Eneolithic, which Huet / Bianchi (2016, 114) suggested as contemporary with the Rinaldone phase. For the dating of the rock art it is relevant that the triangular Remedello daggers and the axes with low flanges both date to 3,300–2,700 calBC (Dolfini 2013, 39 tab. 2), while scenes including halberds with midrib should be even older, as recently proposed by Horn / Schenck (2016, 18) while discussing the chronological position of Rinaldone, prov. Viterbo, grave 3. This would suggest a date of 3,600–3,300/3,200 calBC, which is supported independently by Dolfini's (2010, 711–715) ^{14}C-datings of grave 21 from Pietro, prov. Viterbo.[20] Accordingly, Horn's type 2 halberds, characterised by a prominent central rib and relatively long blades, can be found associated with cattle teams pulling ploughs in the Mont Bégo region (De Lumley 2003, 381 fig. 129), thereby dating them to 3,600–3,300/3,200 calBC. This would result in a *terminus ante quem* of 3,300–2,900 calBC for type C1a.[21] At this point, it seems appropriate to return to the dating of the Wartberg culture, which, if the analogy with the sign group of type C2 is accepted, should be older than or contemporary to sign group C1a (3,600–3,300/3,200 calBC; cf. Huet 2016, esp. 13 fig. 12). This, in turn, would support Raetzel Fabian's hypothesis of a rather simultaneous erection around 3,400 calBC. While the data from the Alpine rock art are still not conclusive, it is possible to date the appearance of the earliest two-wheeled vehicles contemporary to early halberds, i. e. around or before the middle of the 4th millennium calBC (cf. Matuschik 2006).

16 Described further above already as comprising North Hesse, Warburg Boerde and southern Lower Saxony, complemented by finds from the low mountain range border in Saxony-Anhalt.

17 These were found on the statue menhirs of Borno 1, Ceresolo / Bagnolo 2, Ossimo 7, and Ossimo 8, the larger rocks of Cemno Masso 1 and 2, as well as on the surfaces of Naquane R.99, Campanine R.8, and R.X, and Dos Cuì; cf. Fedele 2006, 49 fig. 2.

18 The finds in question are flat axes with low flanges, daggers with a central rib of the Remedello-type as well as halberds. Cf. esp. Dolfini 2010; Klimscha 2010; Horn 2014. For an example see De Saulieu / Serres 2006, 78 fig. 9,80.

19 This same sequence has been published in another paper, where the fork-shaped signs have been named A(=C2), B(=C3), and C(=C1a): Huet / Bianchi 2016, 106 fig. 2.

20 From the same typological horizon, Horn / Schenck 2016, 18–20 further add the halberds from Rinaldone, grave 5; Poggio Aquilone, prov. Terni; Poggio delle Sorche, prov. Grosseto; Casanuovo, prov. Perugia; Villafranca-Veronese, prov. Verona.

21 According to Huet 2016 this happened after 2,500 calBC. From the information published it seems as if the work by Horn (2014; 2012–2021) was not taken into account.

Plough marks

Plough marks are known from the whole North European Plain. The assumed plough marks from under barrow no. 8 at Sarnowo, com. Kozłowo, are problematic due to the discrepancy between the ^{14}C-date (4,459–4,343 calBC; GrN-5035: 5,570±60 BP) and the archaeological expectation for the dating of the Wiórek-phase (around 3,800 calBC) to which they are assigned (Wiklak 1980, 72–73; Tegtmeier 1993, 25). Their interpretation has also been challenged with plausible arguments, for instance the lack of the typical criss-cross pattern, and it was proposed that they rather represent a burnt timber structure (Niesiolowska-Sreniowska 1999). Further evidence is known from Zarębowo, distr. Gmina Zakrzewo, Kuyavia, dated to the later part of the Wiórek phase around 3,400 calBC by a ^{14}C-date (GrN-5044: 4,624±40 BP, 3,521–3,338 calBC, 94.3 %; cf. Sherratt 1981, 270; Tegtmeier 1993, 25).

Plough marks from Groningen-Oosterpoortwijk, the Netherlands, have been dated by a small series of radiocarbon analyses to around 3,000 calBC. A possibly earlier date was published recently for plough marks under a barrow at Højensvej, Egense sn., Syddanmark, Fyn (POZ-28068: 4,900±40 BP, 3,770–3,637 calBC; cf. Thrane 1982; Mischka 2013, 298 fig. 4). These are contemporary to the plough marks discovered at Flintbek, distr. Rendsburg-Eckernförde, Holstein (Befund 50 and 59), which have been dated to 3,700–3,450 calBC (Mischka 2013, 298 figs. 3; 4,2), and Aldersro, Zealand, which were dated to 3,650–3,535 BC (Mischka 2013, 298 fig. 4). Finally, one early date for Avebury, Wiltshire, England, needs to be mentioned, where plough marks have been discovered that might be older than 3,700–3,370 calBC (Tegtmeier 1993, 25; Vosteen 1999, 36). Apart from the examples associated with radiocarbon datings, there is considerable evidence linked to graves of the Fuchsberg/EN II phase substantiating an assumed beginning around 3,600 calBC.[22] While this is even before the earliest evidence for wagons, it should be kept in mind that the sparse evidence of wheel tracks is also associated with the Fuchsberg phase; therefore new research might push their beginning back to the same date as that for ploughing.

Wooden ploughs

The oldest ploughs known in Central Europe, classified as type Asterlagen, are yet poorly understood; this type requires more and better preserved finds for a clear interpretation. The two known finds are dated to around 3,000 calBC and to the second half of the 3rd millennium calBC (cf. Hecht 2007). The construction of ploughs of type Walle, on the other hand, can be inferred from the completely preserved find of such a plough from the Tannhäuser Moor at Aurich-Walle (Eastern Frisia, Lower Saxony; Precht 1998; cf. also Tegtmeier 1993). Type Walle ploughs are made from a single piece of trunk wood with a branch. The sole is made from the trunk, while the branch in its natural shape and angle is the foundation for the beam. The mentioned find is radiometrically dated to 1,940–1,510 calBC, but the type it represents is considerably older, as a recent late 3rd millennium dating of a fragment of a type Walle plough from Mehlbergen-Balge, distr. Nienburg/Weser (middle Weser) demonstrates (Drenth / Lanting 1997, 54; Hecht 2007, 197). This is also confirmed by a fragment of a type Walle plough from layer XIII–XII of Ezerovo II-Tell Dipsis, Varna prov., Bulgaria, dated to around 3,000 calBC (Pétrequin et al. 2006; Horvath 2015), and the petrogylphs on Cimbergo, rock 8 ('de la baita'), in the Val Camonica, where cattle are shown under a yoke, pulling a plough in the style already encountered at Warburg and Züschen (Tegtmeier 1993, 117; Fedele 2006, 51).[23]

Copper figurines of yoked cattle

Two metal figurines of cattle under a yoke derive from a hoard found at Bytýn, near Poznán, Greater Poland, a third one from the Lisková cave, Slovakia; yet another find (bought from an arts dealer) is thought to come from Dieburg, southern Hesse. The hoard from Bytýn (Fig. 5; cf. Wislanski 1979, 237 fig. 136) was originally explained as an import from Anatolia (Kopacz / Tunia 1978, 196–199), but this interpretation has changed during the last four decades. Matuschik (2002; 2006) has convincingly dismissed the idea of the Bytýn finds belonging to the Early Bronze Age, by dating their metal composition as well as the accompanying axes from the hoard.

22 Classified as FN C or 'dolmenzeitlich' in the older literature; cf. Thrane 1982, 21; 1989, 122–124; Tegtmeier 1993, 24–25; Vosteen 1999, 35–36; cf. also: Louwe Kooijmans 2006, 199 fig. 10; Mischka 2013, 298 fig. 4 no. 8.13–15.

23 The identification of the sign with a plough of type Walle is based on the prominently displayed technical details of the depiction, i.e. in the construction of the beam, the sole, and a handle. If this analogy is accepted, type Walle ploughs likely already emerged before the middle of the 4th millennium calBC.

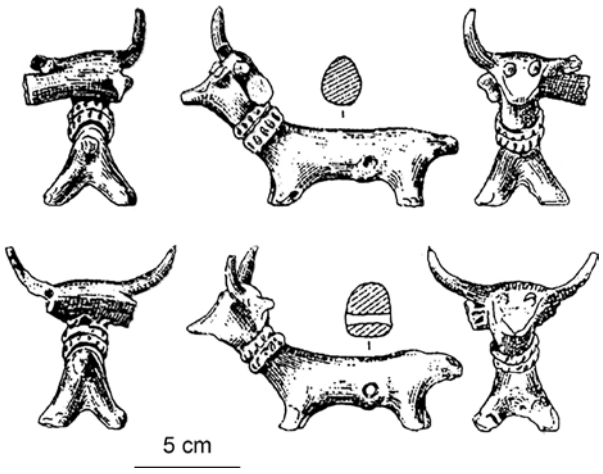

Fig. 5 Two cattle figurines made from copper from a hoard found at Bytyn (after Matuschik 2002, 111 fig. 1).

The figurines are made from an arsenic-copper alloy (Mondsee copper) which is known from the early 4th millennium to around 3,400 calBC.[24] The axes from Bytýn have good analogies in objects from the hoard from Riesebusch, Schleswig-Holstein, currently dated to around 3,500/3,400 calBC (cf. Matuschik 2002, 117). The copper figurine from Dieburg (Fansa 2004, 91 fig. 125; cf. Matuschik 2002, 111 fig. 1; 2006, fig. 8,1) can be loosely typologically associated with the Bytýn hoard (Matuschik 2002, esp. 112). In contrast to the latter, however, the horns of the cattle are aligned lower and the legs are less massive. If the dating is accepted, though, the curved shape of the horns is interesting and might signify the same horn shape as depicted in the signs at Warburg and Züschen ('C-shaped') in another medium.

The Lisková figurine was found at the entrance area of a cave, together with human bones, ceramics, and copper finds. It is attributed to the Pre-Boleráz horizon (Struhár 2010). Klassen (2000, 125–128) argued for a similar age when he discussed the Bytýn find, thereby suggesting the production of small copper figurines in Central Europe already in the 36th century calBC. A similar motive is indeed known from the handle of a TRB beaker found at Krežnica-Jara, south of Lublin, Lesser Poland,[25] which belongs to the phase Bronocice II, currently dated to c. 3,650–3,400 calBC. The handle is connected to the Bytýn figurines only via its motive, not by its production technique or style, but it does not date the hoard. However, as both the dating of the metal-composition as well as that of the associated flat axes are acceptable, the only argument that could force a later date would be the technical complexity of the Bytýn finds. Not only the comparability with the axes from Riesebusch, but also the arsenical copper composition as well as the motive of two pairs of cattle under a yoke all indicate an age of 3,650–3,400 calBC. Usually, the figurines from Liscová, Bytýn, and Dieburg are interpreted as having been part of wagon models.[26] The best analogies for contemporary copper figurines cast in the lost wax-technique are known from the Caucasus, where cattle figurines – however, without a yoke – were discovered in the princely burial of the Majkop kurgan (cf. Hansen 2009 for good illustrations). These can probably be dated to around 3,800 calBC. Miniature wheels from Majkop contexts have shown that the possibility of wagon models exists (Klimscha 2018), and the use of cattle-traction has recently been supported by the discovery of cattle burials with nose-rings (Reinhold et al. 2017). From 3,800–3,600 calBC onwards yoked cattle-pairs were used to pull vehicles in the northern Pontic area, and the dating is also confirmed by the very early existance of sledge models and assumed wheeled ceramic vessels from the transition phase of Tripolye B2 and C1 (around 3,600 calBC; cf. Гусев 1998, 23 fig. 5; Matuschik 2006, 281 fig. 3,1).

Early copper in the north

Imports of copper axes, shaft-hole axes, and axe-adzes are already known for the Ertebølle culture. Both typology and chemical analyses suggest that the earliest finds were imported from either the Carpathian Basin or the Balkan region (Klassen 2000). The metallurgy of both regions has received great attention in the scientific community due to spectacular finds of gold and copper, which are considered as indicators of the earliest stratified societies. Such finds are unknown in the North European Plain, and often the introduction of metal there is disregarded, because the number of finds is low and objects are notoriously

24 However, it is still accounted for in southeastern Europe until the early 3rd millennium calBC, which might challenge Klassen's (2000) argument for a date of Bytýn between 3,800 and 3,400 calBC.

25 Vosteen 1999 Taf. 107,62; Milisauskas / Kruk 1982, fig. 2,2; Fansa 2004, 85 fig. 114; Bakker 2004, 283 fig. 1,284; Vosteen 1999 Nr. 62 Taf 107; Dinu 1981, fig. 9,1.

26 Such figurines must have been cast in the lost-wax-technique, and it was supposed to be unthinkable that metallurgy was practiced to such an extend in Europe before the Early Bronze Age. Because of the rather short chronology used during the 1970s, a deduction from Anatolia seemed very possible.

difficult to date. The impact of metal artefacts in Late Mesolithic and Early Neolithic societies in the north is usually downplayed.[27] Many misconceptions of the role of metal artefacts are the result of a flawed chronology. New ^{14}C-datings as well as excavations in the core areas of early metallurgy are difficult to correlate with the local Mesolithic and Neolithic sequences of northern Europe. Still, the rather precise chronology of the North European Plain (Müller et al. 2012) can be linked loosely with the record of copper finds: As there are no indications for a local metal production during the Neolithic so far, all finds are assumed to be imports (but see Klassen 2000; Gebauer / Sørensen this volume), and can thus be dated by analogies in their areas of origin. Since most copper artefacts do not come from contexts that can be dated otherwise, typological dating and, to a lesser degree, the chronological assessment of the copper type used are the only ways to establish their ages. This is especially the case for the earliest finds, i. e., generally speaking, anything before 3,500 calBC. Nevertheless, the time lag between the use of such objects in their areas of origin and their final deposition remains unclear.[28]

Finds with a typological age earlier than 4,300/4,000 calBC can be regarded as potentially used by Mesolithic (but possibly also Early Neolithic) communities. Within the Neolithic sequence two horizons can be differentiated, namely 4,300/4,000–3,600/3,500 calBC and 3,600/3,500–3,300 calBC.[29] The earlier horizon represents the EN I, including the phases Oxie and Siggeneben-Süd, the later horizon represents the Fuchsberg phase or EN II, and therefore also the typologically related phases Brindley 1/2.

Potential Late Mesolithic copper finds

The earliest copper artefacts in the north are imports from the southeast European Copper Age. Hammer axes of Pločnik type and axe-adzes of Jászladány type have been found in small numbers. Govedarica (2016) recently re-analysed the stratigraphy of the eponymous site Vinca-Pločnik and concluded very plausibly that type Pločnik axes were in use between 4,650 and 4,250/4,200 calBC (cf. also Govedarica 2001; 2010). This is supported by a radiocarbon date from a settlement pit from the periphery of the distribution of these axes in Weitendorf, Styria (Wilding 2011, 39–41). Based on this chronological framework, all finds which are known in the north should be considered as having been imported by Late Mesolithic groups. The dating of the axe-adzes is more challenging as some of them might have been in use as late as during the transition into the Baden culture around the middle of the 4th millennium calBC (Zápotoký 1996, 189–190; Klimscha 2016, 114 fig. 144, 115, with further references). However, their production started around 4,500 calBC, and with the recent re-dating of the later stage of the Bodrogkeresztúr culture to the end of the 5th millennium, the evidence to date axe-adzes *before* 4,000 calBC becomes very strong.

How did these objects reach the North European Plain? Klassen (2000; 2004) is responsible for major advancements on the topic of early metal in this area, and his studies on the western Baltic area have become a handy source to access the material (cf. also Klassen / Pernicka 1998). But Klassen did not process the finds from the North Sea region, and the apparent emptiness of his maps in this regard has to be seen as a lack of research rather than prehistoric reality. Klassen had originally proposed down-the-line trade, and his distribution maps do indeed suggest thin lines spreading out of the Carpathian Basin and into the north (e. g. Klassen 2004, 269 fig. 145). The finds are very scarce, but have received some attention following the realisation that it must have been Mesolithic and Early Neolithic communities, i. e. groups without metallurgical proficiency, who acquired these goods.[30]

Such finds are known not only from the North European Plain, but prominent examples were found as far to the west as in the princely tomb of Pauilhac, dép. Gars, France (in the historical Gascogne

27 Recent studies have, for example, advocated autochthonous models to explain the introduction of stone battle axes without connections to archetypes from southeast Europe, or went so far as to deny any practical use for all pre-Bronze Age metal finds: Vandkilde 2007. Cf. also Vandkilde 1996; Klassen 2000; 2004; Turck 2010.

28 Two arguments, however, speak strongly against this caveat. Firstly, we do have good evidence of many finds after 3,500 calBC, and there are no associations with significantly earlier material. Therefore, we simply have no indications from the archaeological record that metal indeed circulated long enough to significantly blur our conclusions. Secondly, we can identify influences on stone artefacts, and these in turn can be dated much better. Thus, even if we cannot rule out that metal finds were handed down within a social group, we assume that the inherent fuzziness – which is typical for prehistoric chronologies – allows us to disregard errors of one or two generations.

29 These two horizons were not defined beforehand, but simply reflect the dating precision of metal objects.

30 *Inter alia* Klassen 2004; Turck 2010; Frieman 2012; Govedarica 2016.

province).[31] Within this assemblage two boar tusks, several now lost metal beads, and two jadeite axes of extraordinary quality were found together with four very long flint blades, but the most impressive piece is a gold foil object interpreted as a diadem that has its best analogies in the Carpathian Basin (Klassen 2004, 266 fig. 142). A nearly identical gold diadem is known from the famous Romanian hoard of Moigrad in Transylvania (Makkay 1976; cf. also Parzinger 1992, 246 fig. 3). Diadems of that type are assigned to the Bodrogkeresztúr culture, and this brings us back to the north.

The identification of Bodrogkeresztúr pottery at Dąbki in western Pomerania strengthens the possibility that the appearance of hammer axes and axe-adzes was a result of an interregional exchange of Mesolithic communities. Several sherds of Bodrogkeresztúr pots unearthed at Dąbki 9 (Czekaj-Zastawny et al. 2011; 2012) allow drawing parallels between the Late Mesolithic in the north and the Early Copper Age in the southeast of Europe. We do not have any find of a securely contextualised copper artefact at a Late Mesolithic site yet, but at least the knowledge of Mesolithic communities in the north about copper axes is plausible: The link via the pottery at Dąbki is one strong argument, and the dating of the finds in their areas of origin, predating the neolithisation of the north, the other. This might suggest that finds like an axe-adze from 'southern Scandinavia', another such find from Steinhagen near Stralsund, distr. Vorpommern-Rügen, Germany and the hammer axe from Frankfurt/Oder, Brandenburg, Germany were indeed used by Mesolithic people (cf. Klassen 2004; Govedarica 2010). These artefacts did not have a lasting impact, though. Copper shaft-hole axes and axe-adzes might reflect a similar fascination as the Danubian stone tools which hunter-gatherer-fisher groups imported from neighbouring Rössen and Stroke-ornamented Pottery culture groups (cf. Müller / Schirren, this volume): heavy tools made from exotic materials. Neither the raw material nor the know-how to make such tools was available in the North European Plain.

Late Mesolithic or Early Neolithic copper finds

It has been thought that a group of flat axes with chunky bodies ('Beile mit stämmigem Körper') might be contemporaneous to the heavy copper tools of the Pločnik and Jászladány types (cf. Laux 2000). These axes show morphological relations to the axes found in the famous Stollhof hoard from Lower Austria (Angeli 1967).[32] Klassen assigned the axes to his type Kaka and saw their origin in the Jordanów group. On a typological basis and because of their material composition, they were dated to the time around 4,000 calBC. Regarding their typological relation to southeastern types, this is indeed possible, but it lacks any contextual or radiometric support so far, since they were exclusively found as single depositions.[33] From Lower Saxony only one find of an axe with a chunky body is known, and its findspot Salzgitter (southern Lower Saxony) can indeed be casually connected with the Jordanów group (cf. Turck 2010, 53–54 figs. 58–64 for typical finds). Contemporaneous or even slightly older are the famous finds from Brześć Kujawski in Kujawia-Pomerania (Czerniak 1980). Similar objects are known from the lake dwellings of the Alpine region (cf. Heumüller 2009).[34] A connection can be seen along the Vistula river – a route that has been argued for because of the distribution of specific flint axes and pottery connecting the early TRB with the Cucuțeni-Tripolye culture (Dumitrescu 1955; Klimscha 2007). A newly discovered copper axe from Steinbergen, distr. Schaumburg, may be assigned to the same chronological horizon (Lehmann / Wulf 2013). It can be placed next to trapezoid axes with slightly bulged rectangular sections that are well documented in southern Scandinavia and are commonly dated to the EN I.

Early Neolithic II and Middle Neolithic copper finds

While evidence for early copper objects is very sparse, there are impressive finds from the following centuries (Fig. 6). A hammer axe from Müsleringen, distr. Nienburg, from the middle Weser region represents a different type than the pure copper shaft-

31 Eluère 1987; Guilaine 1996, 130–131; Klassen 2004, 266 fig. 142; Hansen 2009, 290 fig. 11.

32 Hansen (2012, 147–149) recently re-examinded the evidence and proposed a dating around 4,000 calBC or into the early 4th millennium with reference to the new dating of Bodrogkeresztúr. Cf. also Neumann 2015, 90–103.

33 For a further discussion of type Kaka, see Klassen et al. 2008/2009. To our knowledge, type Kaka axes are not known from Swifterbant contexts.

34 Cf. also Turck 2010, 56 figs. 66–69 for further analogies from Baalberge contexts in central Germany. Copper jewellery has an even longer tradition, finally also reaching Lower Saxony: cf. Schlicht 1973; Czerniak 1980.

Fig. 6 Copper axes from **1** Müsleringen, distr. Nienburg (© Lower Saxony State Museum Hannover), **2** Reiffenhausen, distr. Göttingen (after Grote 2004, 322 Fig. 1) and **3** Cuconeştii Vechi II, distr. Edineţ, Moldova (after Dergačev 2002 Pl. 18,R).

hole axes and has very good parallels in Moldova and the Caucasus. A similar axe with a cast copper shaft still attached was found in Reiffenhausen, com. Friedland, in the Leine uplands in the region around Göttingen (southern Lower Saxony; cf. Grote 2004; cf. also Jacob-Friesen 1971). According to the most convincing analogies from the princely burials of Majkop and Klady in the Black Sea area and the Caucasus, a dating of these finds to around 3,500 calBC or even earlier was proposed (Hansen 2009; 2013). Assigning these axes to a horizon before the Corded Ware culture as well as an origin in the Carpathians or Caucasus is backed by the metallurgical analyses which show for the Reiffenhausen and Müsleringen axes regular, but low amounts of arsenic (Kronz et al. 2004).

A typologically different copper axe from Scania represents a very good archetype for the TRB stone battle-axes (Klassen 2004, fig. 50A). This object might have a similar age as the finds from Reiffen-

hausen and Müsleringen. Compared to the preceding time slot, there is a great difference between the sporadic exchanges of exotic goods with little impact on the societies in the North European Plain and the massive imitation of foreign copper goods in local stone[35] from the early 4th millennium BC.

The recently discovered hoard from Lüstringen, city of Osnabrück, drew new attention to the topic of early metal in northwestern Europe (Hassmann 2018). The hoard is an exceptional case in the archaeological record, as here for the first time an axe of the type of Müsleringen / Reiffenhausen was part of a larger material assemblage. The axe from the Lüstringen hoard is hardly distinguishable morphologically from the axes of Reiffenhausen and Müsleringen. Furthermore, it has been likewise cast from copper with low amounts of arsenic (Lehmann et al. 2018). The pectorals from the hoard are strikingly similar to a find made of arsenic copper found in the richly furnished cist grave from Velvary, Bohemia (Moucha 1960; Pleslová-Štiková 1993), as well as to a pectoral from Villafranca Veronese[36] in northern Italy made from silver. Although the assemblage of Lüstringen is still in the process of examination, it may be chronologically assigned to approximately the same horizon as the axes – *antedating* the Corded Ware. Their distribution patterns indicate that they have bypassed southern Central Europe and the traditional Danubian communication routes: Besides the aforementioned interregional connections, it is striking that the axes have no analogies in the southern regions of Central Europe. There is only one axe of type Şiria, found in Überlingen at Lake Constance (Matuschik 1997). Type Şiria axes, however, are dated to the late Bodrogkeresztúr culture.

Especially, during the Fuchsberg phase (EN II, or Brindley 1/2, respectively) between 3,600/3,500 and 3,300 calBC, spectacular find concentrations of copper objects are known across the North European Plain. According to Klassen, the weight of the finds from Denmark taken together is higher than that of all finds from the Alps from 3,800–3,300 calBC. The pottery sherd found with the Bygholm hoard also dates this find to the Fuchsberg phase. It is thus contemporary with the hoards from Riesebusch and the aforementioned hoard from Bytýn. The typological relations of both finds with type Altheim axes also suggest eastern influences (cf. Klimscha 2016, 166–167 with further references). Two axes of trapezoidal type from the area of Bremen can be brought forward; these also belong to the Fuchsberg phase.[37]

The metal objects of the 4th millennium calBC are characterised by the first use of arsenic copper. The shift from the use of pure copper to the use of copper with distinct impurities may be considered as an important improvement and innovation. The alloy increases the artefacts' hardness and creates a shiny gloss on the surface.[38] It is still a matter of debate if some of these types of copper may be the result of an increasing use of fahlores or an intentional alloying of copper with arsenic. Nevertheless, the metallurgical data reveals a strong correlation between the emergence of blades and arsenical copper[39] during the 4th millennium calBC. In contrast to that of the 5th and the 3rd millennium, the metallurgical landscape of the 4th millennium calBC is still only vaguely understood, and rivalling classifications of copper types were introduced during the past years, e.g. Bygmet (Liversage / Liversage 1989), Mondsee (Matuschik 1998), or Riesebusch copper (Klassen / Stürup 2001). Recent analyses emphasise that the conceptions of the metal cycles of the 4th millennium hardly correspond with the archaeological record so far as the evidence of lead isotope analyses shows that Mondsee copper does not match any known copper source from the Alpine area as previously supposed, and at the moment, an origin from southeastern copper sources seems more plausible (Frank / Pernicka 2012).[40] Copper finds from the Nordic Middle Neolithic are rare. The axe from Mellendorf, com. Wedemark (Hanover region), has been associated with the axes from the Bygholm hoard (Laux 2000, no. 8), but in contrast to the published drawing it has low flanges. Therefore, it can

35 We are referring to the battle-axes of the TRB culture. With the exception of the axes from Müsleringen, Reiffenhausen, and Lüstringen, none of the assumed copper archetypes for the TRB stone axes have been found. For a different view cf. Frieman 2012.

36 This pectoral is part of a burial assemblage of the Rinaldone culture and is among other things associated with a halberd made of arsenic copper (Ghislanzon 1932; Salzani 2011, 50–51 Tab. 1).

37 Find locations 'Aus der Weser' (out of the river Weser) between the cities of Bremen and Nienburg (Laux 2000, no. 11), and Okel, city of Syke, Lower Saxony (Laux 2000, no. 9).

38 Northover 1989; Budd / Ottaway 1991; 1995; Lechtman / Klein 2002.

39 Matuschik 1998; Horn 2014, 149 fig. 80; cf. also the dynamic map created by Horn 2012–2021 for the different time periods.

40 The traditional idea of an alpine raw material source is for instance referred to in Lefranc et al. 2012.

be compared very well to the axe of the Ice mummy from the Alps also known as 'Ötzi' (Egg 1992, 262 fig. 2, 263 fig. 3; cf. also Klimscha 2010). Similar axes have also been published from the Remedello culture and recently from Zug-Riedmatt and correspond in their radiocarbon dating between 3,250 and 3,100 calBC (Gross et al. 2017).

The innovation cluster of cattle traction

The early evidence for wheels and wagons depends very much on the wagon tracks from Flintbek. Shortly after the middle of the 4th millennium, wagons were regularly used in the area of southern Scandinavia, Schleswig-Holstein, and Lüneburg,[41] central Germany, Poland, and possibly also within the former Swifterbant area, northwest Germany and the Netherlands. We still lack positive evidence from the latter, but the erection of megalithic graves (assumedly making use of cattle traction) as well as the inclusion into the TRB *koine* during the phases Brindley 1/2 (the relation of the early Tiefstichkeramik and Fuchsberg phase has been frequently commented on) strongly suggest that wagons were in regular use there, too.

The question remains: does this date represent the arrival of the innovation, or can it be read as a *terminus ante quem* for the arrival? The latter idea is based on several lines of evidence. First of all, the technical complexity has to be considered. Wagons require the domestication of cattle, the ability to produce a wagon box as well as wheels, and the means to attach the cattle to the box and make use of their power (i. e. a yoke and reins). This necessitates a Neolithic economy that regularly breeds cattle and is able to feed animals beyond the age at which they can be butchered for meat production. We can hardly expect a technology as complex as the wagon to be invented *ex nihilo*, and therefore should expect experimental steps on the way towards its invention. The use of cattle traction in the form of sledges, sleds, and plows might therefore be understood as a preparing stage that was essential for wagon construction. These preconditions were not necessary developed in the North European Plain, but could either have been brought there by people who had the know-how of wagon construction or by people who had seen wagons in lands far away and were able to copy a wagon from local know-how.

In this regard, the close relationship of evidence for ploughing and wagons needs to be stressed. At the moment, there is no clear sequence in which the wagon is developed from more simple technology, but the available data rather suggest a wide distribution of both ploughing and wagon driving within the horizon EN II – Fuchsberg – Brindley 1/2 – Bronocice III. There is no experimental phase visible in which both technologies are being developed or in which precursor technologies can be identified. They appear fully functional in the north and quickly spred through the complete area settled by the Funnelbeaker groups. This suggests the origin of both technologies outside the TRB phenomenon and their diffusion as a package (assumedly as variations of the innovation-process of yoke and cattle teams) into the north.

Copper objects during the Fuchsberg/ Brindley 1/2 phases

Early stages of the diffusion of copper metallurgy were made possible by the high esteem in which Mesolithic communities held large and heavy axes. This created the dilemma that while the finished products were well known to Mesolithic communities, it was completely impossible to reverse-engineer an imported copper axe – the *chaîne opératoire* was complex and could not be 're-invented' by trial and error. With the introduction of the Neolithic economy this changed slowly. New types of pottery required higher firing temperatures, and this was the first step towards pyrotechnological proficiency. The slowness with which the regular but not very numerous imported copper artefacts were adapted into local forms in the North European Plain likely results from the lack of established substructures. Metallurgy relied on long traditions of pyrotechnical expertise, for instance with annealing and heating metals as well as with pottery making and kiln building since the Neolithic (Hansen 2017). Around the middle of the 4th millennium calBC the earliest conclusive evidence of local re-melting of copper has been documented (Klassen 2017, 211–216, 235–238).[42] It is during this

41 Which seems loosley connected to the Baden culture according to the burial from Oldendorf (cf. Burmeister 2004a).

42 This did not include the mining and smelting of ores (and thus the full metallurgical cycle).

time that new types of alloys also arrive in the form of shaft-hole axes.

Technical innovations and the neolithisation of the north

While the Mesolithic societies in the North European Plain remained economically conservative for most of the 5th millennium calBC (with exception of the Swifterbant culture; cf. Raemaekers 1999; Ten Anscher 2012), products from their southern neighbours nevertheless fascinated them. Danubian stone tools were imported in high numbers, and some of them might even have been brought to the north by expeditions of farmers searching for new land (cf. Müller / Schirren, this volume). Small axes and adzes were known in the North European Plain during the Mesolithic, but these were of significantly smaller size and weight. Their functions must have differed from the Danubian stone tools, which not only show a different morphology, but also far greater size-ranges. In addition, the possession of such exotica would have been very prestigious in itself and thus might have been a way to distinguish oneself from others. The same conclusions fit to the earliest copper items. These, however, were not made by neighbouring Neolithic communities, but originated in the Carpathian Basin and the Balkans. The distribution of copper items during the 5th millennium calBC suggests that Mesolithic groups had access to exchange networks that connected them with southeastern Europe, but bypassed the Danube. Yet, the frequency of contacts with groups sustained on Neolithic economies dramatically contrasts with the hesitation to adopt this way of life in the North European Plain. The great appeal of axes is still existent during the neolithisation of the north, but now it was sated by local production. The axe hoards of the TRB culture continued a tradition which began in the Mesolithic. Copper axes were still prized among the early TRB communities, but they seem to have declined in numbers. It is *not* possible to draw a direct line from import to imitation to local production. The re-melting of imported copper items was only possible in the very long run, after having been 'translated' into Neolithic technical and organisational capabilities.

In a certain way, the axe paved the way for metallurgy. The symbolical dimensions of stone axes were essential for the TRB ideology. Hoards of polished flint axes as well as the later types of flint axes themselves connect the TRB with the Black Sea area at the same time as the copper shaft-hole axes. The Majkop culture and the late Tripolye culture currently provide the earliest evidence of wagons (Hansen et al. 2017; Klimscha 2017a; 2018). The early use of wagons in the North European Plain is therefore more than mere coincidence. Long distance communication lines between the north and the Carpathian Basin and Black Sea area have been known since the 5th millennium calBC (Czekaj-Zastawny et al. 2011; Klassen 2000).[43] During the TRB this was perpetuated into networks transmitting regular information, artefacts, and know-how. The time span 3,600–3,300 calBC seems to be a plausible window for the diffusion of the wagon technology. The wagon tracks from Flintbek are placed into the late Fuchsberg phase of the TRB, and it is definitely possible that future research might push back the emergence of the wagon to the beginning of Fuchsberg, arguing that the beginning of the TRB proper is the result of the application of a bundle of innovations coming from the Black Sea area. The grave inventory from Oldendorf IV with its cups with looped handles also points into exactly the same direction (Körner / Laux 1980).[44] From the available data it is currently impossible to argue for a chronological priority of the plough over the wagon, or *vice versa*. The similarity between the *chaîne opératoires* of both technologies and their reliance on trained cattle teams, for which there is no earlier evidence in the north, make it very plausible that both were adopted together as a package.

The wheel might have reached the north in the same way as the copper axe-adzes did five hundred years earlier. We suggest that the record of metal finds in Lower Saxony and the Netherlands reflects the communication network spanning the Baltic region. The copper finds originated in the Black Sea area. The very early appearance of both arsenic copper artefacts and evidence for the use of wheeled vehicles is important in this regard. While the imported goods might also have been transported via several overlapping, smaller exchange networks, the adoption of wagons suggests that people actually at least saw these vehicles and were able to describe them precisely enough to have them replicated.

43 At this stage of the argument, we need to stress that this narrow dating of the copper finds is supported by the finds from Dąbki as well as typology. Some finds, if taken by themselves, might even be older.

44 Any further discussion on the interrelation of Brindly 1/2 and Fuchsberg on the one hand and the southeastern TRB, Bernburg, Cucuteni-Tripol'e and Baden on the other hand would at this point severely overburden this paper.

The diffusion of the cattle traction technology cluster was, however, not the result of people migrating *en masse*. The wheels recorded for the TRB culture are of a different technological tradition than those of the Alpine (cf. summaries of finds by Woytowitsch 1978; Schlichterle 2004; cf. also Burmeister 2012, 84) or the Black Sea region (cf. Fansa / Burmeister 2004; Matuschik 2006): the wide distribution of wheel technology could also be a case of stimulus diffusion (Kroeber 1940).

Ploughing is essential for any long-term agriculture. From at least 4,000 calBC agricultural fields in the Swifterbant culture were worked with hand-held tools (cf. Raemaekers, this volume). The shift to cattle-drawn ploughs must have had economic consequences. Apart from the technical know-how to build a plough, a cattle-team trained to pull it was necessary. Owning a cattle-drawn plough allowed greater efficiency in agriculture and certainly made the work easier. This had important long-term consequences. Even small amounts of surplus (resulting from either the ability to work larger fields, or to work faster) would have led to significant differences in wealth in the long run (Bogucki 1993). The most prominent positions according to the introduction of the plough into northern Central Europe can be summed up with Sherratt's innovation-cluster of traction, plough, wagon, and woolly sheep (Sherratt 1981; 2004) – and its vehement rejection (*inter alia* Vosteen 1996; Bakker et al. 1999; Bakker 2004) – on the one hand, and models of successive technological improvement starting with the LBK on the other (Lüning 1979/1980; 2000; Lüning et al. 2001).

The necessary skills for creating both wagon and plough were available in the LBK with regard to the craftsmanship displayed in longhouses and wells.[45] This shifts the focus to the availability and training of cattle teams. Indeed, it is convincing from a technical point of view that once a society used cattle traction to plough its fields, the necessary step in the development to use cattle to move vehicles is minimal. The components 'cattle team + yoke + plough' can be exchanged into 'cattle team + yoke + sled / travois'. A wagon would need the additional construction of an axle and wheels, and a way to fix both to the chassis. While it is reasonable to assume that ploughing is older than wagons, this cannot be demonstrated for northern Central Europe and the North European Plain. The development of the wagon must have happened somewhere else.[46] The plough appears more or less abruptly in the archaeological record of Central Europe around the middle of the 4th millennium calBC, and it is associated with wagons in Alpine rock art, in the Wartberg culture, and at the Flintbek site. Ploughing and wagon driving likely arrived as an innovation cluster.

Conclusion

During the 5th millennium calBC, various Late Mesolithic groups maintained different levels of contact networks: there was obviously relatively frequent exchange with neighbouring farming groups and also sparser interaction with Copper Age societies in the Carpathian Basin and the western Black Sea area. During this time these contacts had no measurable effect but set the stage for an axe-ideology. When the original Mesolithic societies were transformed into Neolithic economies, this had a delaying effect.[47] The high esteem of large axes was raised even more by the irreplaceable role axes now had in the routines of chopping trees and building houses.[48] Hunter-gatherer-fishers did affect their environment considerably by clearing habitation areas and nourishing specific plants (*inter alia* Out 2009; Colledge / Conolly 2014), and the primeval forest did not disappear with the Early Neolithic.[49] Nevertheless, the thinning out of the forest becomes visible in pollen diagrams from around 4,100 calBC onwards.[50] In other words, there was a significant change that correlates with the shift from Mesolithic to Neolithic economies, and, depending on the region, the changes within the Swifterbant culture and from the Ertebølle to

45 Unless it is argued that the construction of wheels might have been too complex for LBK craftsmen. Assessing this problem would greatly benefit from experimental data using different stone tools to produce disc wheels.

46 Early evidence for cattle traction is currently limited to the southern Levant and southeastern Europe: Hill 2001.

47 From 4,100 calBC, on the Cimbrian peninsula and in the western Baltic (Hartz et al. 2000; Müller 2009), from 4,300 calBC onwards within the Swifterbant culture (Cappers / Raemaekers 2008; Raemaekers 1999).

48 The archaeological record also has good evidence that large axes were used for the slaughtering and/or sacrifice of cattle: Klimscha 2010.

49 Deforestation seems to have had its peak during the Single Grave culture, or even later: Kirleis et al. 2012; Behre / Kučan 1994. For the Alps a similar picture can be drawn with dense forestation until the Younger Neolithic: Rösch 1993; 2013; Lechterbeck et al. 2014.

50 *Inter alia* Hartz et al. 2000; Dörfler 2001; Behre 2008; Kirleis et al. 2012.

the Funnelbeaker culture between 4,300–4,100 calBC.[51] Modern research has identified two major episodes within the opening of the forest, during the erection of megalithic graves, c. 3,400–3,100 calBC, and during the Single Grave culture, c. 2,800–2,500 calBC (Müller 2009; Brozio et al. 2019).

Successively opening up spaces for agriculture had two side effects in that it allowed small-scale travel on cattle-pulled vehicles, but also allowed far greater lines of sight within the landscape. Therefore, it is not by accident that the erection of megalithic tombs and the earliest evidence of wheel and wagon fall into the same chronological horizon around 3,400 calBC.[52] Both the latter might have depended on each other, and both also depended on the flint axe and the opened forest. Economy, environmental change, ritual, and technology were closely interlinked (cf. Brozio et al. 2019).[53] The copper axes from Müsleringen, Reiffenhausen, and Lüstringen support the idea of a diffusion of wagon technology from the Black Sea. The opening of the landscape did result in prehistoric communities choosing new ritual sites (Knitter et al. 2019a; b; cf. Brozio 2016), but was also crucial for more extensive agriculture and thus essential for adopting the 'traction innovation cluster' (cf. Klimscha 2017a; b).

Our paper has summed up several arguments concerning the relationship between diffusion of technology and socio-economic change. Networks of hunter-gatherer-fishers established two communication channels that were crucial for the neolithisation process in the north: contacts with the LBK successors on the one hand, and with the world of the Copper Age of the Carpathian Basin and the western Black Sea area on the other.

The latter one was intensified during the late 5th and early 4th millennium calBC, resulting in the diffusion of a technological package of cattle traction, plough, and wheeled vehicles. The network did not end in the Baltic region, though. A preliminary typological study of the available copper axes strongly suggests that Lower Saxony and the Netherlands, i. e. the former area of the Swifterbant culture, were participating in networks reaching to the Black Sea. The chronological horizon of these finds correlates well with the earliest evidence for wheeled vehicles, and it is suggested to translate the early dates available from Flintbek and the rock art also to the TRB West group.

Furthermore, this allows rethinking the neolithisation process in the North European Plain. As others have made clear, western influences and the role of the Swifterbant culture are still underestimated (cf. Ten Anscher / Knippenberg this volume; Raemaekers this volume). Currently, we have the oldest evidence for agriculture and animal husbandry in the late Swifterbant culture, and can also draw a plausible typological connection from Swifterbant pots to the typical A/B pottery of the EN I phase of the TRB culture (cf. Demirci et al. this volume). An important break is visible with the shift to EN II that is not only contemporary with the appearance of the TRB West group, but also with the aforementioned innovation cluster, the start of megalithic burials, and the shift from a mixed farming / hunting subsistance to a full agrarian society. It seems therefore plausible that this new world of the classical TRB is primarily the result of a new economic strategy made possible by the wide adoption and regular use of cattle traction.

Technical take-offs and new questions

Crucial changes in the neolithisation of the North European Plain are strongly founded in different technologies. When taking such a perspective, however, it is important to acknowledge that we can understand it best from a modern retrospective that was unavailable to the prehistoric communities living through these changes.

The technologies pushing the neolithisation could not simply be invented autochthonously. They required specific resources, organisation, and technical know-how. None of it was available to the Late Mesolithic communities in the north. They did establish contacts with other societies possessing such know-how relatively early, but these contacts did not result in drastic changes. Nevertheless, this is not due to incompetence or ignorance, but due to the lack of sociotechnical substructures. Metallurgy required kilns that were able to produce temperatures of over 1,000 °C, technical ceramics that survived such heat, access to copper ores, and an explicit idea about the very error-prone smelting and melting processes. Ploughing and wagon necessitated domesticated cattle in large enough quantities to be able to remove

51 If ten Anscher's brilliant work on the typological analogies between the later phases of Swifterbant and the earliest TRB is accepted, this might be the same phenomenon (cf. Ten Anscher 2012).

52 It is important to note that archaeologically this might have been as early as 3,600 calBC (see above).

53 The evidence for the wagon is linked closely to megalithic tombs, but this is not a taphonomic relation (as suggested by Burmeister 2011; 2012; 2017). Finds from bogs demonstrate that earlier evidence would have been preserved.

animals from the meat production and use them as a 'motor', as well as tools and knowledge about how to build yokes, reins, wheels, and a chassis.

Mesolithic hunter-gatherer-fishers lacked many of these preconditions and the necessary experimentation with new technologies to adopt them to their own necessities. For a long time they also lacked any context in which both experimentation and production, which did require considerable labour and reorganisation (i.e. investment), could be backed[54]. The import of exotic axes (and possibly many other objects and ideas) from the south might have been motivated by struggles for status, but the more cost-intensive developments of ploughing, wagon construction, and metal casting all took place within the later stage of the Early Neolithic, as well as the distribution of battle-axe types from the North Sea to the Black Sea (Klimscha 2016, 115). Here new research needs to focus on.

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The Schöningen group and the cultural development around 4,000 calBC

Alexandra Philippi

Abstract This article presents the results of the author's bachelor thesis on the finds of the Schöningen group from the eponymous site Schöningen 9, distr. Helmstedt, in Lower Saxony, Germany. The main focus of the paper is the evaluation and classification of the ceramic finds within the Neolithic, as the latter has caused considerable problems in the past. The vessels show different characteristics in their form as well as in their decoration, which can be traced back to different strong influences from the Michelsberg and the late Lengyel cultures during the Late Neolithic.

Zusammenfassung *Dieser Beitrag legt die Ergebnisse der Bachelorarbeit der Verfasserin zum Fundmaterial der Schöninger Gruppe vom namensgebenden niedersächsischen Fundplatz Schöningen 9, Ldkr. Helmstedt, Deutschland, vor. Der Fokus des Beitrages liegt auf der Auswertung und der Einordnung des keramischen Fundmaterials innerhalb des Neolithikums, da letztere in der Vergangenheit erhebliche Probleme bereitete. Die Keramikgefäße weisen sowohl in ihrer Form als auch in ihrer Verzierungsweise verschiedene Merkmale auf, die auf unterschiedlich starke Einflüsse aus der Michelsberger und der späten Lengyel- Kultur zurückgeführt werden können.*

Introduction

The site of Schöningen 9 is situated in a lignite mine area on the eastern border of Schöningen, distr. Helmstedt, in Lower Saxony (Fig. 1). In spring 1985 rescue excavations began at the site in the northern mining area (Maier 1995, 134). The finds from an almost round pit (feature 31; Fig. 2) attracted special attention. It contained unmodified stones and animal bones as well as a few stone artefacts and numerous pottery fragments (Maier 1995, 137). The pottery recovered from this pit did not have good analogies in the archaeological record of Lower Saxony. About 65 m east of feature 31 similar pottery could be recovered from another pit (feature 74). Therefore Maier (1995, 139) assigned these finds to the same context. In feature 74 there was also a layer of charred fibres, which were identified by Körber-Grohne (1987, 463) as fruit stalks and awns of a feather grass (*Stipa pennata L. s. Str.*).

Because of missing parallels the classification of the pottery caused considerable problems, and subsequently a scientific dispute developed. Already in May 1985 Maier presented the features and their finds for the first time on a congress. Because of the presence of arcade rims and a clay disc there was no doubt about a Neolithic classification. Maier (1987) referred on the one hand to an influence of the Lengyel culture and emphasised the more structured vessel shapes. On the other hand, he saw influences of the Rössen culture in the Schöningen vessels. However, the Late Neolithic elements like arcade rims or the fragment of a clay disc led him to consider the Schöningen finds to be later than the Rössen culture (Maier 1987, 115). A classification to the Michelsberg culture was rejected because of the more rounded vessel shapes of the carinated bowls and their shoulder decoration; a connection with the early Funnel Beaker culture or the Baalberge culture of Central Germany was also denied (Maier 1987, 115–116).

In 1991 J. Beran completed his investigation of the site Salzmünde-Schiepzig, distr. Saalekreis, and discussed the position of the Salzmünde culture in the Neolithic of the Saale region (Beran 1993). He discovered that the finds from Salzmünde-Schiepzig had little in common with the Salzmünde culture and had been erroneously placed in such a cultural context by former authors (Beran 1993, 43). Beran found convincing parallels for his pottery in the ceramics form the site Schöningen 9 (features 31 and 74) and proposed the name 'Schöningen group' for this type of ceramics (Beran 1993, 43–46). He placed the Schöningen group at the beginning of the Late Neolithic and confirmed its similarities to the cultural

Fig. 1 Location of the site Schöningen in eastern Lower Saxony (graphic: A. Philippi; map based on Bundesamt für Kartographie und Geodäsie).

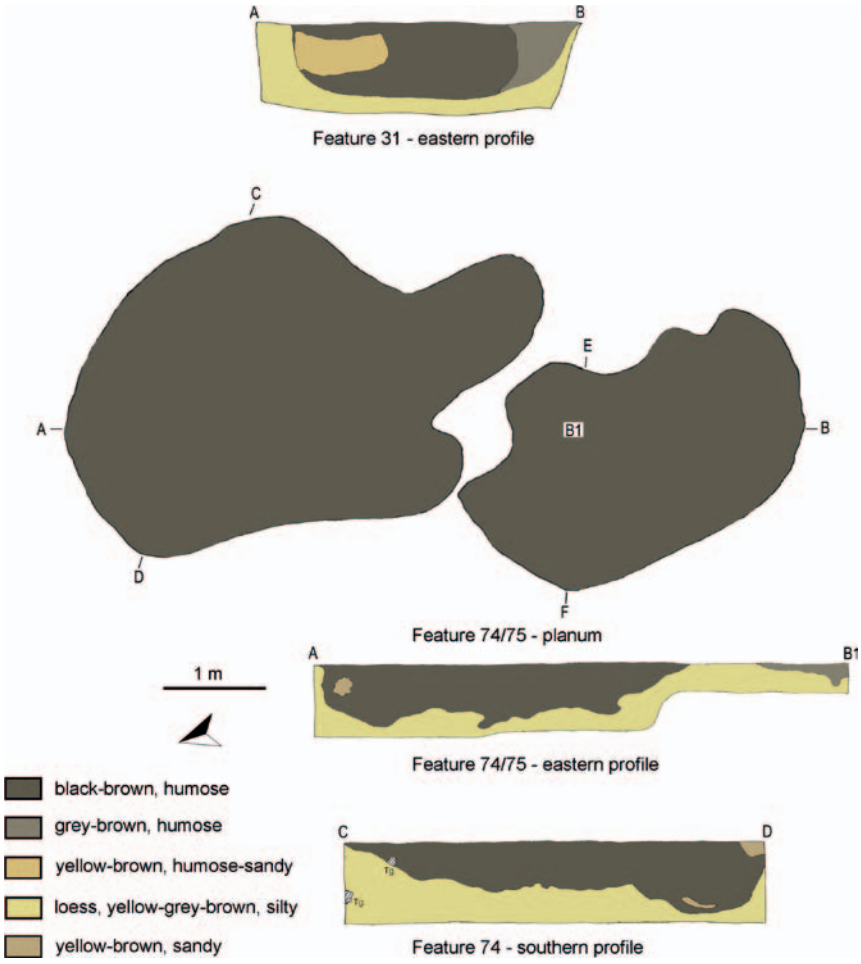


Fig. 2 Schöningen 9, distr. Helmstedt. Plan and profiles of the features 31 and 74 (graphic: A. Philippi).

complexes already mentioned by R. Maier (Beran 1993, 44; see also Beran 1998, 74–78; 2009, 84; 2012). D. Kaufmann (1994, 88) criticised the term Schöningen group and, on the basis of a personal review of the finds of Schöningen 9 (features 31 and 74), he referred to differences to the ceramic of Salzmünde-Schiepzig without explaining these differences in detail. Kaufmann also pointed out that the middle Elbe-Saale region was located on the periphery of archaeological and cultural centres in the south-east and south-west and that therefore pottery sometimes cannot be clearly assigned to a specific archaeological unit. He favoured a connection with a horizon of 'Epi-Rössen/Lengyel of middle German impact' (Kaufmann 1994, 89–90) and introduced the new term 'Schiepzig group' (Kaufmann 2007). In recent years, T. Schunke and P. Viol published further material of this pottery-type and suggested an absolute dating around 4,000 calBC on the basis of radiocarbon dates (Schunke / Viol 2014, 121; see also Damrau et al. 2014; Moser 2014). A chronological reference to Rössen is therefore no longer given. Pottery from the Schöningen group was thereafter also excavated at Hundisburg-Olbetal, distr. Bördekreis. On the basis of the evaluation of these finds, K. Schmütz formulated the hypothesis that the deviations in the pottery spectrum of Schöningen 9 and Salzmünde-Schiepzig could be explained by a Michelsberg influence of varying strength (Schmütz 2017, 136), which led to different local variants (see also Kaufmann 1994, 88–91).

Features

During the excavations in Schöningen an area of 22,000 m^2 was archaeologically examined. Two features (no. 31 and no. 74) provided finds of a new type of pottery.

Feature 31 is situated in the western part of the excavation area. The pit was almost circular in shape and had a diameter of about 2.5 m and a depth of about 0.6 m (Fig. 2*)*. The pit appeared trough-shaped in profile. From the black-brown humous filling 1,305 fragments of pottery have been uncovered, together with cattle bones as well as an adze.

In the planum, feature 74 was irregularly black-brown humous, and greasy discoloration became apparent. It had an extension of approximately 4.5 × 3.6 m and a max. depth of approximately 0.65 m (Fig. 2). Particularly noteworthy is a layer of charred feather grass about 0.3 m below the excavation level.

Finds

The material discussed in this article encompasses the finds from Schöningen 9, features 31 and 74.

Pottery

Nearly 2,200 fragments of pottery have been uncovered. Some vessels were already reconstructed in the 1990s. All vessels were flat-bottomed. The surface of the pottery is usually well-preserved and has been carefully spread or smoothed; in rare cases it is lightly polished. The Schöningen vessels are mostly tempered with crushed granite and white and red feldspar.

The most characteristic vessel shape is the decorated funnel-shaped bowl of the Schöningen type (Fig. 3.1,3), which is represented by 16 specimens. An assignment to this vessel type is probable for a further twelve decorated wall sherds. The vessels have an S-shaped profile. Immediately on the shoulder they are decorated with an all-round ornament, which usually consists of one to three rows of an indented decoration. In rare cases, this is supplemented by a further, parallel band on the neck of the vessel. In a few cases, an indented decoration is added at the base (Fig. 3.6). From feature 31 ten vessels can be assigned to this type with certainty. Three specimens, which resemble the Schöningen bowls in their decoration, were recovered in feature 74. One piece is decorated with at least two circular rows of rounded punctures on the neck of the vessel. In addition, the pottery contains undecorated funnel-shaped bowls that resemble the Schöningen type. The complete profile of a small, undecorated vessel could be reconstructed. Some further vessels have an arcade rim (Fig. 3.2). Altogether 21 arcade rims could be detected among the finds of both features. These could be assigned to storage vessels. The material includes also 18 perforated lugs. Seven such specimens are from feature 31 and eleven from feature 74. The perforated lugs from both features are rounded and have a horizontal perforation with a max. diameter of 1.0 cm. Furthermore there are 19 knobs (Fig. 3.5), all from feature 31. They are mostly round in profile. Within feature 74 one handle fragment was obtained. To complete the interesting pottery sequence of Schöningen a fragment of a clay disc has to be mentioned as well (Fig. 3.7). The fragment has a fingertip impressed decoration at its rim and on one side a mat impression.

Most interesting are five wall sherds with remains of (black) painting from feature 31 (Fig. 4).

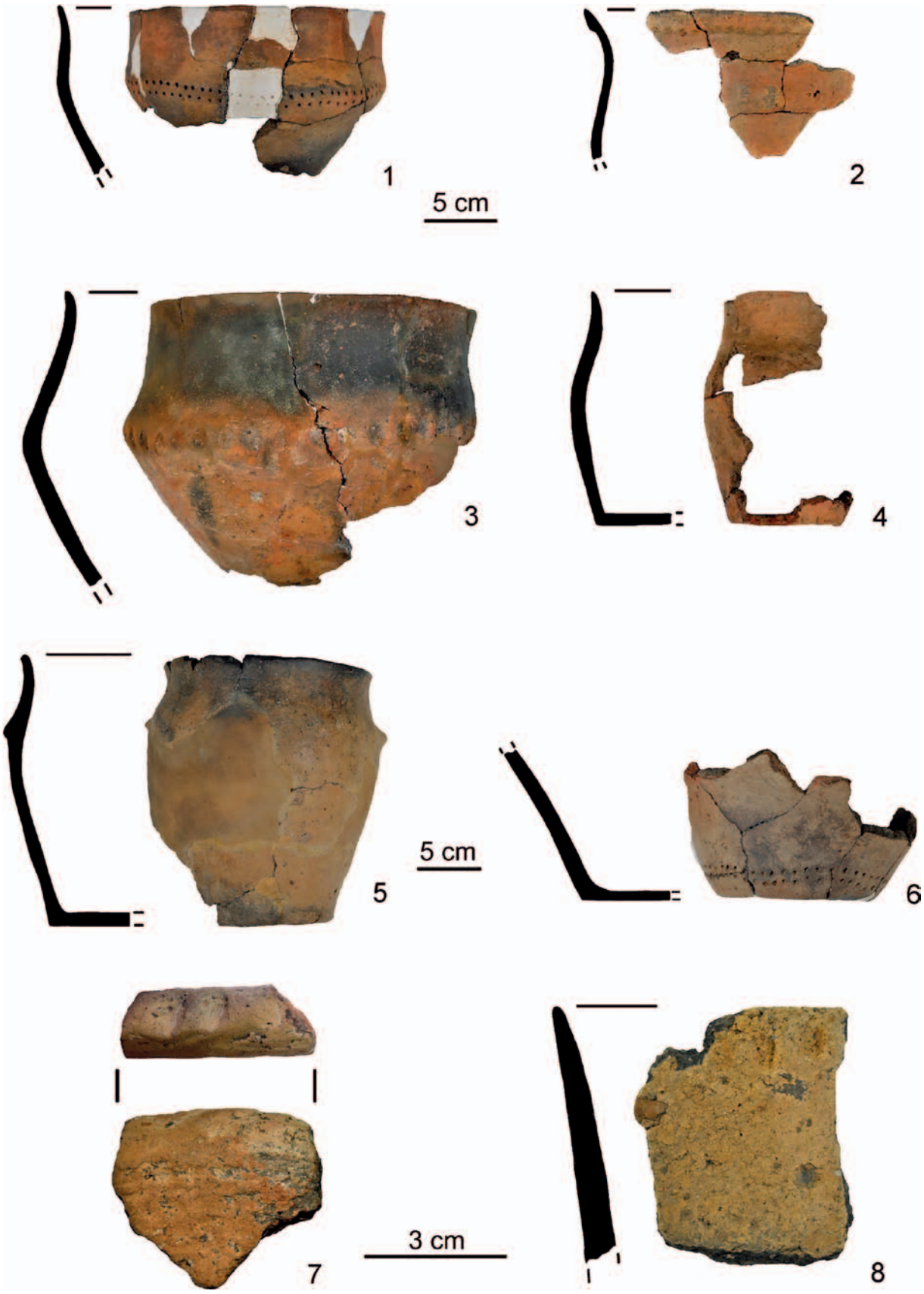


Fig. 3 Schöningen 9, distr. Helmstedt. Examples of important pottery from the features 31 and 74 (drawing and photos: A. Philippi).

Fig. 4 Schöningen 9, distr. Helmstedt. Painted pottery from feature 31 (photos: A. Philippi).

An analysis of the painted pottery fragments with a µ-RFA (X-ray fluorescence analysis) was not able to show clearly elevated element values. Since carbon cannot be proven by this method, painting with a carbon substance might be possible. The black substance marking the decoration could also be a remnant of an adhesive for applications (e.g. made of bark). In very rare cases remains of vessel painting have been preserved on pottery from Michelsberg context. For example, two vessels form the Baumannshöhle near Rübeland in Saxony-Anhalt show remains of painting (Behrens 1969, 298; 1973, 82, 84; Schunke 1994, 130–131). South-eastern cultural connections might be expressed in the painted pottery,[1] suggesting contact with the Lengyel culture. From the site Dąbki in Poland similarly painted fragments with wider lines are known from an early Funnel Beaker context (Czekaj-Zastawny / Kabaciński 2015, 210 fig. 7.7, 212).

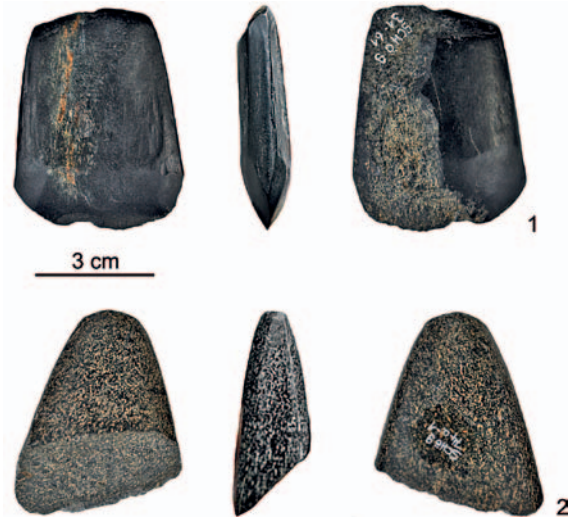


Fig. 5 Schöningen 9, distr. Helmstedt. **1** adze (feature 31), **2** axe with oval section (feature 74) (after Philippi 2018).

Rock stone artefacts

Feature 31 yielded an adze (length 6.0 cm, width 4.4 cm, thickness 1.2 cm; Fig. 5.1) made of amphibolite. The adze shows various damages on the neck and on the cutting edge. Such trapezoidal adzes were common during the 5th and 4th millennium calBC, including the Michelsberg culture (e.g. Seidel 2008, 164).

Furthermore there is a fragment of an axe with an oval cross section (preserved length 5.8 cm, width 4.4 cm; Fig. 5.2) probably made of vulcanite stone (determination by H.-P. Koch, Göttingen). Feature 74 also yielded a possible rubbing stone (length 10.5 cm, width 7.5 cm, weight 450 g).

Finally, 15 unmodified stones (including granite) with a total weight of 895.4 g can be mentioned.

Flint artefacts

All in all 80 flint artefacts with a total weight of 590.4 g are related to the features 31 and 74. There are only two flint scrapers from feature 31. The 37 flints from feature 74 partly show heat influence.

1 Umbreit 1937, 48; Jazdzewski 1965, 75, 83; Bräunig et al. 2016, 49 fig. 38; Seger 1919, 8–9.

Feather grass

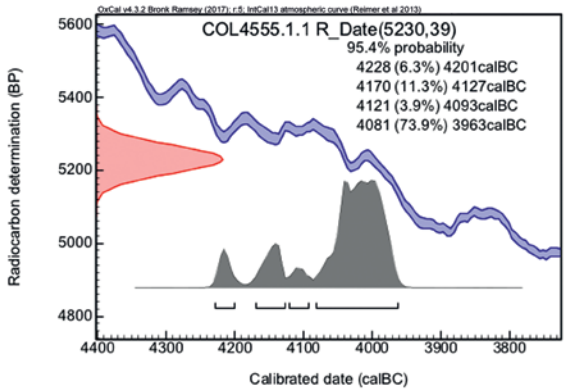
In feature 74 a layer of charred (bundled) feather grass was found (Körber-Grohne 1987). The layer was c. 30 cm long, 30 cm wide and about 5 cm thick.

Today feather grass is a rare plant. Together with its fruit stand, it reaches a height of 40 to 70 cm. Feather grass belongs to the vegetation of the Eurasian steppe and primarily grows in sunny, dry places. In central and western Europe it is present in limited areas such as the Thuringian Basin, the valleys of Elbe and Saale, in the foreland of the Harz and on sun-exposed slopes in southern Germany (Körber-Grohne 1987, 483). Feather grass is therefore an indicator of naturally woodless or only sparsely wooded areas (Körber-Grohne 1990, 90).

Since only the fruit stands with the awns were in the pit (as ordered bundles), Körber-Grohne (1987, 465) concludes that they were collected as raw material. She refers to their possible use as needles for piercing holes or a use as arrowheads for hunting smaller birds because the spelt fruits are very sharp and hard. Scheibner (2016, 124) states that wild plants and wild fruits were also collected in the Neolithic to supplement food resources (see also Kreuz 2010, 55). Feather grass has edible seeds and might have served as a wild cereal. Sites in Kuyavia (Poland) provide evidence of larger amounts of edible wild plant seeds (see Bieniek 2002), including feather grass. It is remarkable that feather grass remains in central Europe are known only from Neolithic sites (Körber-Grohne 1990, 90; Bieniek 2002, 36). According to Bieniek (2002, 36), feather grass should also be considered as a material for covering roofs, mattress fillings, wickerwork or as an isolating material. Probably feather grass was used as a multifunctional material in the Neolithic. Feather grass is also known from a pit of the Schöningen group from Salzmünde-Schiepzig (Hellmund 2014, 262–264; 2017, 86–87).

The Schöningen group and its position in the Neolithic

In the second half of the 5th millennium calBC, the Michelsberg culture developed in the Paris Basin and then spread eastwards. Around 4,000 calBC its range extended from the Seine to the Weser Basin and to Bavaria (Jeunesse 2010, 46). What is remarkable is the regionally different development of the Michelsberg culture, which is to be explained by the influence of the late Lengyel culture, as it shows a



Lab.-no.	^{14}C age BP	^{14}C age calBC	δ^{13}C ‰	Material
Schöningen 9				
COL4555.1.1	5230±39	4067±71	-19,0	cattle tooth

Fig. 6 ^{14}C-date from Schöningen 9, distr. Helmstedt.

comparable dynamic in its distribution at that time.[2] Above all, Lengyel and Michelsberg influences meet in south-eastern Bavaria, Bohemia and the middle Elbe-Saale area; they are decisive for the local formation of various Neolithic groups in these regions. Thus, at this time it is hardly possible to speak of a uniform Michelsberg culture, since numerous regionally different groups of a Michelsberg complex were formed during this period, especially in the peripheral regions, for whose differentiation individual elements are used (Lichardus / Lichardus-Itten 1993, 65; on the problem of the concept of Neolithic cultures see also Lüning 1972). The central German area in particular appears as a border region of archaeological cultures. At the end of the 5th millennium calBC the Gatersleben group appeared in this region, whose distribution area stretches from the middle Elbe-Saale area to the northern Harz foreland. Its vessel shape spectrum shows that it is part of a late Lengyel tradition (Steinmann 1994, 98). To the west of this eastern cultural stream lies the eastern fringe of the Michelsberg culture with ceramics in western tradition.

The pottery of the Schöningen group from the eponymous site shows that Epirössen and late Lengyel vessel shapes are supplemented by Michelsberg elements. Michelsberg influences are evident in the shaping of the arcade rims, the clay disc and the carinated bowls as well as in the relative lack of decoration. Lengyel influences, on the other hand, can be seen in the flat-bottomed vessels, in the handles, knobs and

2 Klassen 2004, 273; see especially Ruttkay 1984, 221–246; Neugebauer 1992, 110–160; Stadler et al. 2006, 53–81.

perforated lugs. A new ^{14}C-date from Schöningen confirms the chronological position of this pottery type (Fig. 6): A cattle tooth from feature 31 yielded a result of 4,228–3,963 calBC (2σ; COL-4555.1.1: 5,230 ±39 BP; calibration by Oxcal v4.3.2, Bronk Ramsey 2017; r:5 IntCal13 atmospheric curve: Reimer et al. 2013). The date corresponds to the expected time frame and fits well to the data from Salzmünde-Schiepzig (e.g. Schmütz 2017, 135).

In the northern Harz foreland and in the middle Elbe-Saale area around 4,000 calBC we see regional differences which can be traced back to different innovation dynamics and varying degrees of influence of western and eastern cultural influences (see also Müller 2001, 424). Due to the dominant Michelsberg elements, the Schöningen group can be understood as a variation of the Michelsberg culture. It is a precedent for cultural structures that are rather unstable and dynamic phenomena that can appear in various forms.

The time around 4,000 calBC and the origin of the early Funnel Beaker culture

In the context of the Schöningen group, the question of the formation of the Funnel Beaker culture arises. In the second half of the 5th millennium calBC, the north and parts of the North German Plain were still inhabited by late Mesolithic hunter-gatherer communities with pointed-bottom pottery: the Ertebølle culture (s. Hartz 2010, 132–140; this volume). In the Netherlands, Lower Saxony and possibly also Westphalia (cf. Stapel, this volume), it is the Swifterbant culture which documents a Mesolithic tradition (e.g. Raemaekers 1999; Ten Anscher 2012). At the transition from the Ertebølle culture to the early Funnel Beaker culture from c. 4,100 calBC onwards, a change in the agricultural subsistence, but also in the pottery inventory, can be observed in the Baltic Sea region (Sørensen 2015, 385). Apart from new vessel shapes and techniques, other types of decoration also appear. Therefore the question of possible external origins of these early Neolithic ceramics arises.

Hypotheses on the origin of the Funnel Beaker culture

First of all, the south-eastern Europe theory of Becker (1947) should be mentioned, according to which the south Scandinavian Funnel Beaker culture people migrated from an unspecified area in south-eastern Europe (Becker 1947).

Furthermore, a central European origin was postulated, which assumes an acculturation of local Mesolithic hunter-gatherers. Two research approaches can be distinguished: On the one hand there is the idea of the origin of the Funnel Beaker culture pottery based on the copy of older organic vessels. This acculturation is suggested to go back to contacts with Danubian groups (Childe 1949, 129–135; Klassen 2004, 151). V. Gordon Childe was the most important representative of this idea. On the other hand, the Rössen and Baalberge cultures were considered to be decisive for the development of Funnel Beaker pottery. However, today numerous ^{14}C-dates prove the end of the Rössen culture some time before the beginning of the Funnel Beaker culture, and further ^{14}C-dates verify the beginning of the Baalberg culture in Central Germany not before c. 3,750 BC (Müller 2001, 51–52). According to this information, they both had no significance for the development of the Funnel Beaker culture.

Other theories are still relevant today. According to them, the Michelsberg culture and the late Lengyel culture have been involved in the formation of the Funnel Beaker culture around 4,000 calBC (Klassen 2004, 152–154). Recent research suggests that the area of southern Lower Saxony played an important role in the development of the early Funnel Beaker pottery (see Grohmann 2010, 418; Müller 2011, 294–296). In southern Lower Saxony and also in the neighbouring regions of Westphalia and Thuringia, a strong presence of late Lengyel elements in the Michelsberg pottery spectrum can be observed (Klassen 2004, 288). In these areas, vessel forms appear which differ from those of the Michelsberg culture and give the various cultural complexes a different character. The Lengyel influence can be seen here not only in the form of decorated rims and isolated flat-bottomed vessels, but also in the regular appearance of a number of other flat-bottomed vessels with typical Michelsberg profiles, of which the funnel beakers are the most characteristic. In addition, many of these vessels have rim ornamentation in the form of fingertip impressed decoration, the origin of which may also be attributed to the fusion of Michelsberg and late Lengyel elements, and which is also one of the characteristics of the early Funnel Beaker culture (Klassen 2004, 288).

Expansion of the Michelsberg culture

With the further expansion of the Michelsberg culture in the early 4th millennium calBC, a large amount of Michelsberg pottery finds can be found in the middle

Elbe-Saale area as well as in Bohemia. They prove the increasing Michelsberg influence further east. It is worth noting that especially in the middle Elbe-Saale area a decrease of the Lengyel influence can be observed at the same time. There only a small representation of the Jordansmühl group and a higher number of Michelsberg finds can be observed (Klassen 2004, 290). This fusion of western and eastern cultural influences may therefore have influenced the formation of the Funnel Beaker culture.

For the formation of the northern group of the Funnel Beaker culture the regional group of the Michelsberg culture in southern Lower Saxony (see Leiber 1983, 189–213) is of high importance, as ceramic finds of the Oxie and Wangels groups (c. 4,100–3,900 calBC), especially from Schleswig-Holstein, show (Mischka et al. 2015, 468–469; Glykou 2016, 199–201). There not only clay spoons and ladles can be traced back to influences of the Michelsberg culture, but large storage vessels with decorated rims also show parallels. Arcade rims and rims with finger-nail impressions, fingertip impressed decoration or simple punctures are typical of the funnel beakers of the Oxie group, which the large storage vessels of the Michelsberg culture resemble quite closely in their profile. The complex of Flintbek, distr. Rendsburg-Eckernförde, also provided numerous fragments of large storage vessels (dated to c. 3,985 calBC; Klassen 2004, 169; Mischka 2011; Müller et al. 2012, 30–31).

Early Funnel Beaker pottery in Schleswig-Holstein

The Michelsberg influence also becomes clear when looking at the funnel beakers of the Oxie group. Similar vessels occur further south in Michelsberg contexts in Westphalia, southern Lower Saxony and the middle Elbe-Saale area. The Schöningen pottery also shows decorated rims in the form of impressions typical for the early Funnel Beaker culture. Also relatively short vessel necks find their equivalents. The origin of this form in the Lower Saxony regional group of the Michelsberg culture, including the Schöningen group, can be taken for certain (see Klassen 2004, 174).

The 'Ösenkranzflaschen' of the Oxie group have also to be included in this discussion. Their necks are short and cylindrical, and the lugs are perforated horizontally. The latter element is characteristic for lugs of the Michelsberg culture, and the lugs from Schöningen are also horizontally perforated without exception. However, it is uncertain in this case whether these originally belonged to 'Ösenkranzflaschen' or amphorae. Early Funnel Beaker pottery, e. g. from Wangels LA 505, distr. Ostholstein (see Klooss 2015, 36; Glykou 2016, 199–201), or Flintbek, distr. Rendsburg-Eckernförde, illustrate the connection between the earliest Funnel Beaker culture in the western Baltic Sea area and the Michelsberg regional groups in southern Lower Saxony. At the site of Wangels the data for pointed-bottom vessels or oval lamps are earlier than 4,100 calBC, and thus the end of the Ertebølle culture in Holstein can be identified. The Early Neolithic vessel forms, on the other hand, date between 4,100 and 3,900 calBC and mark the beginning of the Funnel Beaker culture in this area (Hartz et al. 2000, 134; cf. Hartz, this volume). A ^{14}C-dated pit (4,233–3,969 calBC; KIA 3072: 5,280 ± 115 BP) is known from Flintbek, which included numerous Early Neolithic sherds that show parallels to Michelsberg culture pottery (Zich 1992/1993, 20; Hartz et al. 2000, 132; Mischka et al. 2015). Also to be mentioned in this context is the site of Lübeck-Genin in Schleswig-Holstein. There, early pottery of the Funnel Beaker culture could be dated between 4,050 and 3,700 calBC (Hartz 2015, 459; see also Hartz 2011, 258–270).

Early Funnel Beaker pottery in Mecklenburg-Western Pomerania

Other inventories, which can be assigned to the find spectrum of the Oxie group and the Wangels phase, also originate from two sites in Mecklenburg-Western Pomerania (for the earliest Funnel Beaker culture in the southern Mecklenburg bay see Hartz / Lübke 2004, 119–143). From the site Baabe on the island of Rügen undecorated pottery is known, which can be assigned to the earliest Funnel Beaker culture (Hirsch et al. 2007, 11–51; Kotula et al. 2015, 492–494). The vessels have flat bottoms and strongly protruding rims. Pointed bottoms characteristic for the Ertebølle culture are missing. Only two sherds of oval lamps are represented, which, nevertheless, still occur in the early Funnel Beaker culture (Meurers-Balke 1983, 55).

Among the decorated pieces of early funnel beakers is a rim sherd with impressions on the folded rim, and several times decorations in the form of punctures below the rim appear (Hirsch et al. 2007, 30–31; Glykou 2016, 175 fig. 18.6). Based on ^{14}C dates, a settlement phase between 4,100 and 3,800 calBC could be verified (Hirsch et al. 2007, 13–14; Kotula et al. 2015, 492–494). Another coastal settlement of the Funnel Beaker culture is situated near Parow on the southern Baltic Sea coast on the Strelasund north of Stralsund. The spectrum of finds indicates a

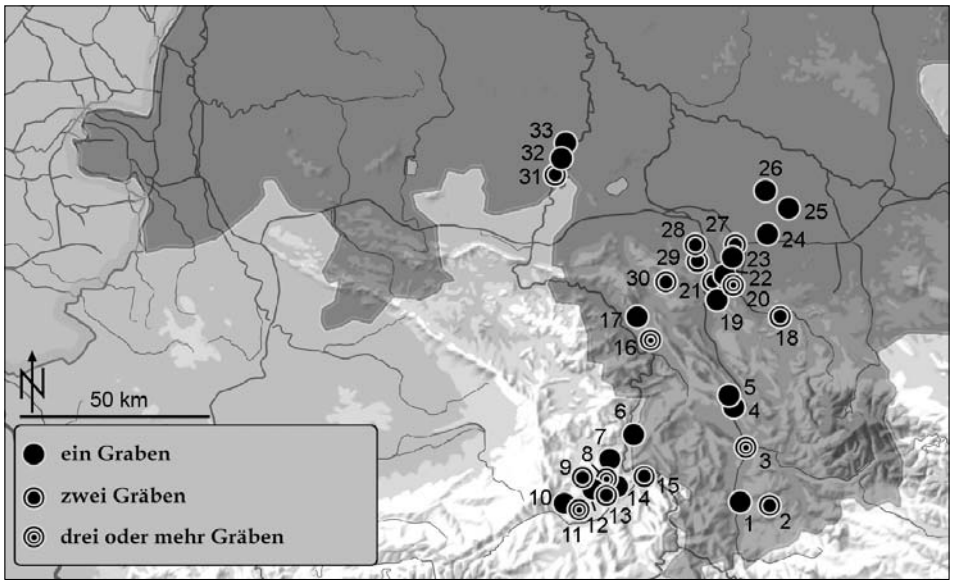


Fig. 7 Enclosure landscapes in the Leine-Weser area (graphic: A. Philippi; map based on Bundesamt für Kartographie und Geodäsie).

use of the coastal zone from the Late Mesolithic to the Neolithic and into the Bronze Age. Apart from Ertebølle pottery, the site also yielded funnel-shaped rims with impressions below the rim. Food crusts of this pottery date between 4,100 and 3,800 calBC (Lübke et al. 2000, 440; Glykou 2016, 201; see also Terberger / Seiler 2004 fig. 18.1–2). A further site which yielded ceramics of an early phase of the Funnel Beaker culture is Brunn 17, distr. Mecklenburgische Seenplatte (Vogt 2009). Here similarities to the Michelsberg culture can be observed in the tulip-shaped beakers. If one supposes that southern Lower Saxony, Westphalia and the middle Elbe-Saale region are the probable areas of origin of the early Funnel Beaker culture, it could be concluded that certain elements were spread northwards or northeast via present-day Schleswig-Holstein. This assumption is underlined by the distribution of individual elements such as arcade rims (Glykou 2016, 205).

Contact zones of Neolithic groups

Numerous contacts of Mesolithic hunter-gatherers in northern central Europe with Neolithic groups can be documented especially by imports, e. g. of characteristic stone tools (Schirren 1997, 245–246; Klassen 2004, 50–53). An adoption of ceramic technologies from western Europe would therefore be quite conceivable. Moreover, this area was connected to the Neolithic cultures of central Europe via the Elbe and Weser (Schirren 1997, 248), so it is possible that it is a matter of an expansion of individual elements, e. g. decoration or vessel forms, such as the clay discs, while at the same time a dynamic development of regional groups is taking place. Regional differences in the ceramic inventory might thus be explained (Glykou 2016, 205). If we assume that the local group of the Michelsberg culture in southern Lower Saxony had been involved in the formation of the Funnel Beaker culture, it is quite likely that the Schöningen group was part of this development.

In addition, in Lower Saxony above all the enclosures of Müsleringen, distr. Nienburg (Weser), and Walmstorf, distr. Uelzen, are of particular importance as contact points to the groups of the North German Plain (Richter 2002; Freese 2010; Ramminger et al. 2013a; 2013b). They are part of a large number of find complexes of this time period in Lower Saxony, which include both forms of the Michelsberg and an early phase of the Funnel Beaker culture. Over the last two decades a series of studies on the Late Neolithic and the enclosure between the Rhine and Elbe rivers have been published. In particular, the area of southern Lower Saxony has always played a recognisable role in the question of the south-north transfer of the enclosure idea and other Late Neolithic elements. In contrast to the north Harz foreland, where a regional analysis of the enclosures has already taken place, the state of research in the neighboring area of Lower Saxony to the west is still disparate. The main focus of the research is the presentation and analysis of the features and finds of new research conducted on the enclosures of Rössing, distr. Hildesheim, and Müsleringen, distr. Nienburg (Weser). Further enclosures have been identified by surface finds and aerial photographs in the area. The project aims at the processing of the

enclosure landscapes in the Leine-Weser area and the question of the neolithisation of the north.

Find complexes from sites such as Rössing or Müsleringen are particularly qualified for these questions. Above all, the site Müsleringen is in the focus of research, since its find material – quantitatively and qualitatively most extensive of this region – so far allows an evaluation that goes beyond a mere sampling character. In a whole series of find complexes of Lower Saxony, elements of the Michelsberg and early Funnel Beaker cultures can be proven. They have a completely different character than those of the Michelsberg main group. A clear attribution does not seem possible, but a correlation with the Funnel Beaker culture is often mentioned.

The work carried out so far has given the image of the enclosure landscapes in the Leine-Weser area a significantly new character (Fig. 7). An accumulation of potential enclosures in the Hanover region is becoming apparent, which needs to be verified by further studies. The region on the middle Weser, where three enclosures have been detected, can be considered a promising starting point for future research into the Late Neolithic enclosures in this area. The northern relations of this region in the Late Neolithic – located directly on the Weser corridor – are also moving into the focus of research, as is the associated neolithisation of the north. The construction of the Müsleringen enclosure happened during a period of social upheaval with new forms of interrelationships, which become apparent in the typological changes in the pottery spectrum from 4,100 BC at the latest.

Swifterbant culture

While in northern Europe there is a shift from the Ertebølle to the early Funnel Beaker culture and the introduction of an agrarian way of life, from the Scheldt to the Elbe river a late Mesolithic society that is also in a state of change can be ascertained (Raemaekers 2015, 322). The early Swifterbant culture is a phenomenon that has not yet been sufficiently researched (Raemaekers 2005, 29; Ten Anscher 2015, 336). Its earliest pottery dates back to around 5,000 calBC (Raemaekers 2015, 322; on the earliest pottery see Raemaekers 2008). In its middle phase (4,600–3,900/3,800 calBC), rim decorations of the vessels occur more frequently and in more variation. The vessels show an S-shaped profile, and their bottoms are pointed or rounded. They are decorated on the neck or shoulder, more rarely on the rim or below the rim. The decorations consist of one or more rows of vertical impressions or finger spots. Sometimes the vessels may also be decorated all over with impressions or fingertip impressed decorations (Raemaekers 1999, 108, 111). The late phase (3,900/3,800–3,400 calBC) ends with the beginning of the western group of the Funnel Beaker culture (Raemaekers 1999, 112). While the subsistence economy of the earliest phase consisted of hunting and fishing, in the middle phase agricultural activities were partly carried out, probably due to contacts with Neolithic cultures (Raemaekers 1999, 113, 115).

Throughout the entire period, a frequent interaction with the neighbouring farming culture is noticeable in the pottery spectrum of the Swifterbant culture, probably due to contacts with the Linear Pottery culture and the subsequent societies. Furthermore, there are ceramics, including elements from the Bischheim and Michelsberg culture as well as round and flat bottoms.

Although a direct influence of the Swifterbant culture on the development of the early Funnel Beaker culture is thus not unlikely, it cannot be excluded that individual elements of the middle phase of the Swifterbant culture or the Pre-Drouwen phase (Ten Anscher 2015, 335–336) were transferred, for example, from the neighbouring Michelsberg. Pre-Drouwen phase pottery is also found at the site Hüde I at the Dümmer lake in Lower Saxony and shows clear references to the Michelsberg culture (Ten Anscher 2015, 349–353). The site Hunte 3, distr. Vechta, during recent excavations also yielded flint artefacts which indicate a still Mesolithic tradition, while the few decorated pottery fragments can be assigned to the horizon of the Swifterbant culture (Heumüller et al. 2017).

An interaction of the Michelsberg culture and the Swifterbant culture probably played a role in the formation of the early Funnel Beaker culture in the area of the North German Plain.

Conclusion – Michelsberg as a source of inspiration

In summary, based on the current state of research, especially with regard to the findings of the early Funnel Beaker culture in northern Germany, it can be concluded that the formation of the early Funnel Beaker culture is obviously an autochthonous development under the influence of agricultural societies from the south, especially the Michelsberg culture. Numerous Michelsberg elements such as clay discs, arcade rims, round-bottomed funnel-beakers, bottles or bowls underline this hypothesis. On the other hand, there are elements that are rather untypical

of the Michelsberg culture. Flat bottoms, fingertip impressed decoration below the rim and knobs show represent elements the origins of which are to be found in external influences (Lüning 1968, 17). Influences of the late Lengyel complex should be mentioned here, which is represented by the Gatersleben culture, especially in the middle Elbe-Saale area. The pottery of the Schöningen group takes up these influences and thus shows clear parallels to the pottery of the early Funnel Beaker pottery. Together with the Michelsberg culture of southern Lower Saxony, it can be regarded as the stimulating agent for the development of the Funnel Beaker culture. To what extent the Swifterbant culture is involved in this process will have to be clarified in future research.

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Some remarks on the expansion of the Younger Neolithic causewayed enclosure phenomenon towards northern Germany

Benedikt Knoche

Abstract The onset of the causewayed enclosure phenomenon in Schleswig-Holstein and Jutland is becoming increasingly apparent as early as the 38th and 37th centuries calBC. New information demand a re-evaluation of the relations between the traditional Neolithic landscapes at the northern edge of the low mountain range zone and the Early Neolithic phenomena north of the river Elbe. This paper deals with the significance of the enclosure phenomenon as an indicator of socio-cultural processes in the geest landscapes of Lower Saxony during the Younger Neolithic (c. 4,200 – 3,600 BC). Indirectly, the habit to build or not to build causewayed enclosures reflects the existence of specific socioeconomic and demographic structures in this area which are associated with Late Mesolithic to Early Neolithic cultural groups such as Swifterbant / Hüde I, or part of an early Funnel Beaker complex. In this context, the significance of the Weser river as a communication corridor between southern central and northern Europe is emphasised.

Keywords Neolithisation, Lower Saxony, causewayed enclosures

Zusammenfassung *Der Beginn des Phänomens der Erdwerke kann in Schleswig-Holstein und Jütland mit wachsender Verlässlichkeit in das 38.–37. Jh. calBC datiert werden. Die neue Datenlage lässt eine Neubewertung des Verhältnisses zwischen den neolithischen Gebieten am Nordrand der Mittelgebirgszone und dem Frühneolithikum nördlich der Elbe lohnenswert erscheinen. Der Beitrag beschäftigt sich mit der Bedeutung des Erdwerk-Phänomens als Indikator für sozio-kulturelle Prozesse in der Geestlandschaft Niedersachsens im Jüngeren Neolithikum (ca. 4200 – 3600 calBC). Indirekt reflektiert die Entscheidung, solche Erdwerke zu errichten oder nicht, die Existenz bestimmter sozio-ökonomischer und vor allem demographischer Strukturen in dem Gebiet der spätmesolithischen / frühneolithischen Gesellschaften wie Swifterbant / Hüde I oder Teilen der frühen Trichterbecherkultur. In diesem Zusammenhang wird die Bedeutung der Weser als Kommunikationskorridor zwischen dem südlichen Mitteleuropa und Nordeuropa deutlich.*

Introduction

Until recently, no Younger Neolithic enclosures (pre-3,500 calBC) were known in the area north of the Elbe river, in contrast to regions further south. Only during the last few years it has become clear that the beginning of the construction of causewayed enclosures here dates back to the 38th/37th centuries calBC (Klassen 2014; Müller 2017). In particular with L. Klassen's comprehensive work on 'Causewayed Enclosures in South Scandinavia and Beyond', a reassessment of the southern Scandinavian enclosures and their European context is available, especially with regard to their early dating (Klassen 2014). Therefore the causewayed enclosures in continental Europe can be roughly assigned to two essential construction horizons (Fig. 1): Coming from the western European region during an older phase of about 4,200–3,900/3,750 calBC, this mainly ritually driven phenomenon spread relatively quickly within a few decades from the river Seine in the west to the Harz foreland (Urbach) and even Bohemia (Kly) in the east. Although in general a supra-cultural phenomenon, this happened in connection with the spread of a certain ceramic style (Michelsberg), specific lithic technologies, and probably also expansive livestock systems. Initially, causewayed enclosures were restricted to areas that had already been inhabited by Neolithic communities since the end of the 6th millennium calBC. To the north, Final Mesolithic hunter-gatherers continued to live. The first sporadic scattering of causewayed enclosures further to the north took place in the Münsterland

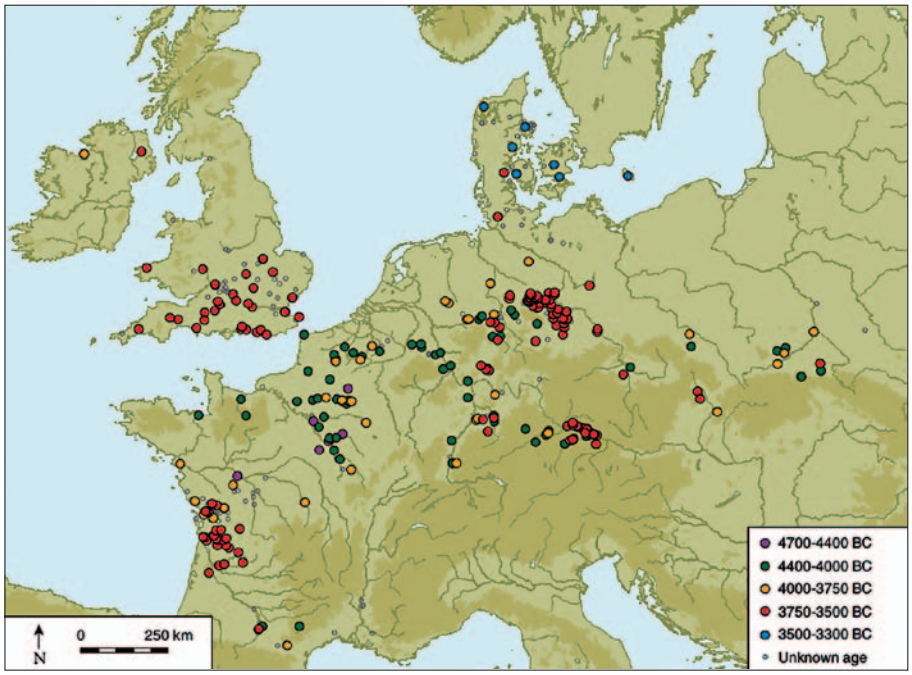

Fig. 1 Distribution of causewayed enclosures in Europe (after Klassen 2014, fig. 123).

(Nottuln, probably also Rosendahl-Osterwick) and parts of Lower Saxony (Müsleringen, possibly Walmstorf) from about the 39th century calBC. With a later construction wave from approx. 3,750 calBC onwards, it also expanded to northern Europe (Denmark) and northwestern Europe, with a real 'construction boom' of causewayed enclosures in the British Isles from approximately 3,750 calBC onwards.[1] With this later construction wave, it also expanded to the eastern part of central Germany (Baalberge). Most of the causewayed enclosures excavated so far in southern Lower Saxony (Hildesheim and Hanover regions) date to this horizon. The same applies to the West French Vendée and Charent Maritime (Klassen 2014, 206 fig. 123). The expansion phase from 3,750 calBC onwards indicates a widespread phenomenon documented in central, west, and northwest Europe and – as Klassen showed – is to be understood as a coherent process.

In the following, the state of causewayed enclosures research from Westphalia to southern Lower Saxony is outlined and evaluated with a view to the adjacent zone of the north German plain. Subsequently, models of the relationships between the enclosure landscapes on the northern edge of the low mountain range and the early causewayed enclosure evidence further north are discussed. Since a number of studies have dealt with this question in recent years,[2] this only needs to be done in an overview manner. It summarises the author's various preliminary papers, which are only available in German language. On this basis, an assessment of the cultural dynamics is then carried out.

Causewayed enclosures in Westphalia and Lower Saxony

In recent years, a number of studies on the Younger Neolithic and the question of causewayed enclosures between the Rhine and Elbe rivers have been published.[3] While evidence of enclosures is available in the Lower Rhine region, there is a gap in the western Hellweg area (probably due to the state of research), which only ends in the Soester Börde. Causewayed enclosures are present in considerable numbers in east Westphalia as far as the Weserbergland. Of particular interest in the Münsterland are the Michelsberg culture (MK) III-complexes in the area of the 'Baumberge', a hilly landscape in the middle of the otherwise flat Westphalian Bay: Nottuln-Uphoven and probably also Rosendahl-Osterwick. Both appear with unusual, linear ditch courses. According to the current

1 This time horizon saw the construction of 145 new enclosures. As Klassen 2014 evaluates, this was more than four times as many as in the preceding horizon of equal length with 58 enclosures per century.

2 Knoche 2008a; 2013; 2018; 2019; cf. also Andersen 1997; 2017; Geschwinde / Raetzel-Fabian 2009; Klassen 2014.

3 Raetzel-Fabian 2000; Knoche 2008a; 2013; Geschwinde / Raetzel-Fabian 2009; Knoche / Schyle 2015; Rinne 2017; Geschwinde 2018; for the Netherlands and Belgium see Vanmontfort 2007, 111 fig. 3.

Fig. 2 Pattensen-Vardegötzen. Very likely a causewayed enclosure with two ditches (image: GoogleEarth; after Knoche 2018).

state of research these seem to be regional features in their time period (see below; cf. Knoche 2008a; 2013). Nottuln-Uphoven also yielded Middle Neolithic pottery in form of vessels in the Rössen, Bischheim, and Funnel Beaker styles, all remains of a pre- and a post-enclosure occupation of the place (Groer 2010). Structural constructions, for example in the form of typical Middle Neolithic longhouses, have, however, not yet been documented.

In southern Lower Saxony, the enclosures of Nordstemmen-Rössing and Betheln 'Beusterburg' (both in the district of Hildesheim) as well as most of the enclosures around Braunschweig fall into the later construction horizon, further north probably also Walmstorf (in the district of Uelzen). In contrast to the Hildesheim and Braunschweig regions, where regional investigations of the enclosures have already taken place (Geschwinde / Raetzel-Fabian 2009; Geschwinde / Grefen-Peters 2017), the state of research in the adjoining western parts of the country, in particular in the Hanover area and in the Weserbergland region, is still disparate. New discoveries in recent years show, however, that a similar density of enclosures as in the Braunschweiger Land can be expected there, especially in the southern part of the region. There are, for instance, aerial photographs of a presumed enclosure of Pattensen-Vardegötzen (Ldkr. Region Hannover; Fig. 2), consisting of two ditch courses (Knoche 2019). A further, probably Younger Neolithic causewayed enclosure with three ditch courses at Emmerthal-Börry (Ldkr. Hameln-Pyrmont) was recently identified by H.-D. Freese on aerial photographs (Fig. 3; pers. comm. H.-D. Freese).

Along the Weser river, north of the Porta Westfalica, several new enclosures were identified by voluntary research activities of the Freundeskreis für Archäologie in Niedersachsen (F.A.N.). Here, the causewayed enclosures of Stolzenau-Müsleringen (Fig. 4) and Steyerberg-Wellie (both Ldkr. Nienburg/Weser; Fig. 5) led to a significant expansion of Younger Neolithic sites of this type in the region (Freese 2010;

Fig. 3 Emmerthal-Börry. Causewayed enclosure in an aerial photograph, ditches marked (FSt. 10, aerial photo, 09.07.1999, by Otto Braasch, FM: Otto Braasch, 41089387; coloured markings added by H.-D. Freese).

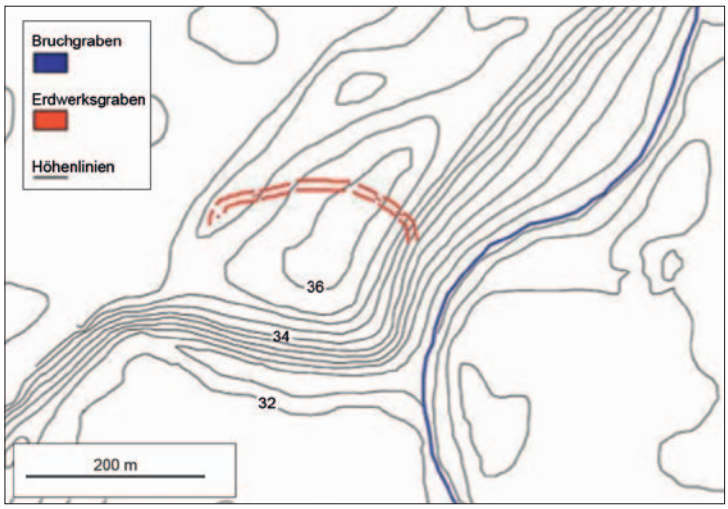

Fig. 4 Stolzenau-Müsleringen. Causewayed enclosure (after Ramminger et al. 2013, fig. 2).

2019; Ramminger et al. 2013; Knoche 2018; 2019). Between these two enclosures there is probably another one near Anemolter (Ldkr. Nienburg / Weser). According to ^{14}C-results, the Stolzenau-Müsleringen enclosure dates from between 4,110–3,800 calBC (Raminger et al. 2013, 20 table 1). Steyerberg-Wellie and Anemolter have not yet been dated, and nothing is known about their exact chronological relationship to Stolzenau-Müsleringen. Müsleringen proves an earlier apperance of causewayed enlosures in the Weser region compared to the Hannover/Braunschweig region – at least according to the data available so far.

The causewayed enclosures of Stolzenau-Müsleringen, Steyerberg-Wellie, and Anemolter lie linearly at intervals of about one hour's march along the river Weser. The three enclosures are located within a distance of about ten kilometers on the west side of the Weser. It is worth mentioning that one of the most important medieval long-distance routes, the so-called 'Frankfurter Weg' ('Frankfurt way'), ran parallel to the river banks (Fig. 6). In historical times, this way connected Frankfurt in middle Hesse via east Westphalia and parts of Lower Saxony with the Hamburg area. There further routes towards Jutland and northern Europe were available (Knoche 2013). The importance of the Weser vector and the 'Frankfurter Weg' has been confirmed recently by the discovery of causewayed enclosures at Meißen near Minden, and Petershagen (both Kr. Minden-Lübbecke) on the east side of the Weser (Song / Pollmann 2020, 183 fig. 1.2, and information by H.-O. Pollmann, Münster [Westphalia], March 2020). It can be assumed that along the Westphalian part of the Weser river south of Stolzenau-Müsleringen and

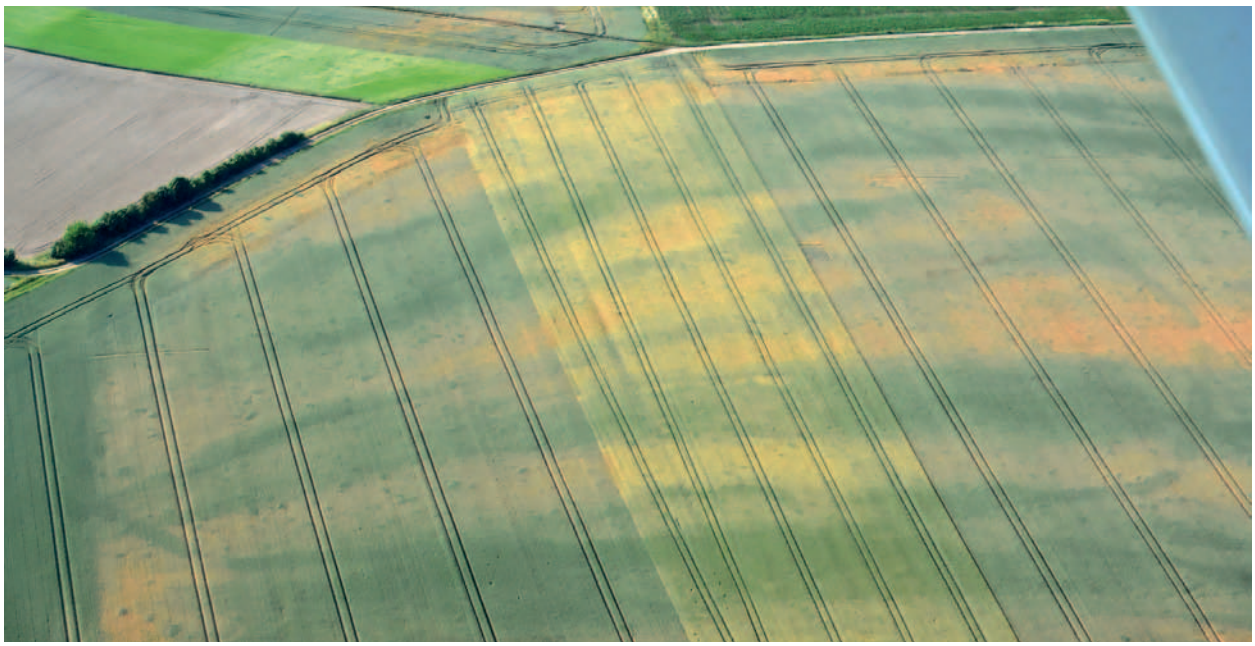

Fig. 5 Steyerberg-Wellie. Causewayed enclosure in an aerial photograph, June 2018 (photo: H.-D. Freese).

the Porta Westfalica / Minden there are further, yet undiscovered causewayed enclosures.[4] Fords crossing the river Weser at Minden, Hameln, Höxter, and Beverungen are already marked by Younger Neolithic causewayed enclosures, reflecting – in addition to the south-north-routes – the predominant importance of the west-east Hellweg / Deiweg-route-system between the rivers Rhine and Elbe. Historic long-distance routes and causewayed enclosures have a strong link, as has been demonstrated for a number of regions in Europe. Causewayed enclosures are therefore route-affine elements (Geschwinde / Raetzel-Fabian 2009; Knoche 2013; Klassen 2014).

The significance of the Weser river as a vector to the north and north-west is relatively well visible from Müsleringen towards the northwest, as relevant vessels have been found in the river Weser at Bremen (Brandt 1969, 82 fig. 3; Knoche 1998, 62; 2008a, 131 fig. 5.11). Against this background, further causewayed enclosures in or along the Weser valley extending north can be strongly assumed from the evidence so far available. According to the situation in northeastern France (Aisne valley) and in Denmark (Kolindsund Fjord), theoretically a distance of 4–5 km between enclosures is to be expected (Klassen 2014, 155 fig. 9). Therefore, it is very likely that further causewayed enclosures will be found to the north of Steyerberg-Wellie, especially at the confluence of the Aller and Weser rivers. From this junction and river crossing (Verden), the traffic coming from the south continued in historical times along the river to Bremen, or it branched off northeast towards Hamburg, where it was possible to crossing the river Elbe towards Jutland and the Baltic Sea region. In the Hamburg area, impulses from south-central Europe will have come together with impulses from the middle Elbe-Saale area coming along the Elbe river (cf. Knoche 2008a). At the Elbe crossing, evidence of a Neolithic enclosure would not be surprising.

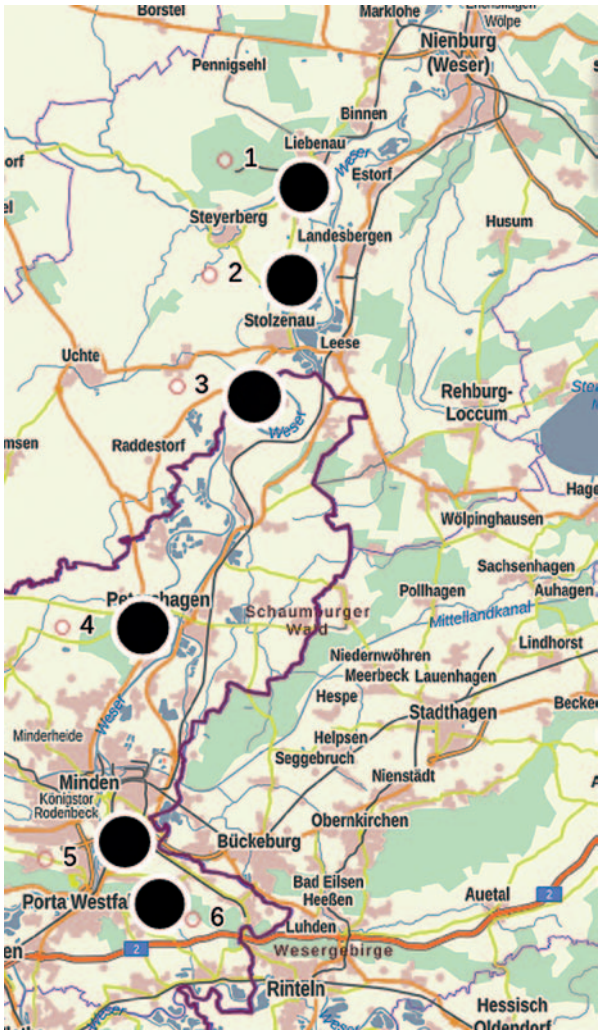

Fig. 6 Causewayed enclosures north of the Porta Westfalica, streched along the western bank of the river Weser within a few kilometres, i.e. in distances of about an hour's walk. South of the Porta Westfalica, the newly discovered causewayed enclosures of Minden-Meissen and Petershagen follow at a distance; these are also oriented towards the river Weser. It remains to be seen whether there are still undiscovered causewayed enclosures immediately west and east of the Weser. So far, there are no reliable indications of this. **1** Steyerberg-Wellie; **2** Anemolter, a highly probable causewayed enclosure; **3** Stolzenau-Müsleringen; **4** Petershagen; **5** Minden-Meißen; **6** Minden 'Nammer Burg'; a highly probable causewayed enclosure (map basis: TIM-online).

The northern perspective

The causewayed enclosures situated relatively far north along the Weser river raise questions about the relations of the southern Lower Saxony Late Neolithic to the north. The situation north of Steyerberg-Wellie is in fact still largely unclear. Those enclosures in Denmark (Lystrup Kildevang I) and Schleswig-Holstein (Büdelsdorf, Albersdorf-Dieksknöll) built as early as the 38th (perhaps even the 39th) century calBC reveal connections to southern central Europe, which can only be described to a limited extent at present (Klatt 2009; Klassen 2014; Müller 2017). Isolated enclosures in northern Lower Saxony (Walmstorf) and in Brandenburg (Potsdam, Gädebehn) probably began at the same time as the early constructions in Denmark and most causewayd enclosures in the Braunschweig region. They show that the eastern part of the north

4 It is noticeable that many hill-enclosures are superimposed by later, mostly Iron Age to Early Medieval structures (e.g. Betheln 'Beusterburg', etc.). For the Westphalian region, this was already shown for a large number of 'Wallburgen', or it was at least made very probable (e.g. Minden 'Nammer Burg', Porta Westfalica 'Wittekindsburg', etc.): cf. Knoche 2008a, 139, 151; 2013, 171, 177.

German plain was basically included in the world of the enclosures. However, since the end of the 5th millennium BC (MK II), there has been influence from the Michelsberg and Jordansmühler ceramic traditions further south upon Brandenburg as well as the western Baltic area (cf. Beran / Wetzel 2014). But this is dated to the end of the 5th and the beginning of the 4th millenium calBC and thus not connected with causewayed enclosures. The same is true for the Holstein area in the far north of Germany (cf. Hartz et al. 2000). The western part of Lower Saxony also remains free of enclosures, even in the subsequent Later Neolithic. As a communication route, the Weser river must have played a major role in the transmission of the enclosure idea during the younger Neolithic, and probably also in a further neolithisation process.[5]

But how can we characterise the relationships between the enclosure builders of Müsleringen to any remaining Final Mesolithic populations? As Terberger et al. (2018) pointed out on the basis of stable isotope results ($^{13}C/^{15}N$) of human remains from northern central Europe, a farming economy was introduced in all parts of the lowlands during the early 4th millennium BC. But it was not before the 3rd millennium cal BC that it became fully established on a general scale (Terberger et al. 2018, 66). Even if the data are more scarce here, this was probably also the case in northwestern Germany. The situation in the northern forefield of the traditional Neolithic settlement areas in Westphalia and the southern part of Lower Saxony remains unclear. An occupation by Final Mesolithic / Subneolithic communities similar to Swifterbant in the Netherlands can be assumed for western Lower Saxony at any rate (Hüde-Swifterbant), where corresponding pottery is found selectively (Hüde I near Diepholz).[6] However, Swifterbant is only vaguely visible in western Lower Saxony. The reason is to be found in a mainly foraging way of life, which leaves relatively few archaeological traces. Compared to Westphalia, for example, the lack of causewayed enclosures has a particularly negative effect to our knowledge. Comparably, relatively little would be known of Michelsberg further south without its habit of building causewayed enclosures.

The period in question here between 4,100 and 3,500 calBC (EN I) was a transitional phase between a foraging and an agrarian economy, between a Mesolithic and a Neolithic lifestyle (cf. among others and with further literature: Knoche 2008a, 129; Klassen 2004). According to current knowledge, northwest Germany north of the Wiehengebirge was a kind of 'mixed cultural area' between a Mesolithic foraging way of life and economy, enriched with Neolithic elements (lithic heavy tools, pottery, but in its own tradition). In addition, there are apparently specialised complexes such as Hüde I (Ldkr. Diepholz), which may well have been hunting stations of indigenous populations as well as of Neolithic groups further south (Möller 2004, 40). M. Furholt characterises this phase as a 'Virtual Neolithic', where all elements of the 'Neolithic Package' are present and used, but their limited use does not yet effectively change social reality and human identities. This happens only after 3,500 calBC, with the 'Realised Neolithic' (Furholt 2010, 12 fig. 9). In the light of recent studies, the neolithisation process in northern Europe was among other factors the result of migrations from central Europe, and less of an acculturation of Late Mesolithic populations (Brace et al. 2018). These populations present at the transition from the Mesolithic to the Neolithic apparently formed the demographic basis for the subsequent Funnel Beaker culture / EN II, c. 3,500–3,300 calBC onwards (Ten Anscher 2015). The situation in the north German lowlands east of the Elbe river seems to be quite comparable (cf. Beran / Wetzel 2014, 81), perhaps complemented by stronger northerly oriented early Neolithic traditions (EN I), similar to the western Baltic region.

It has been shown elsewhere by the author that no far-reaching impulses seem to have come from the Younger Neolithic in the Münsterland (Michelsberg) to the adjacent north German lowlands. This is not only demonstrated by the absence of causewayed enclosures in western Lower Saxony during the Younger Neolithic, but also by the absence of Maas flint (especially of pointed axes made of Maas flint) as well as of leaf-shaped arrowheads (Knoche 2008a; b). Jade axes are also present only sporadically in this area, compared to southern central Europe.[7] Late

5 Knoche 2008a, 131; Klassen 2014, 167, 226, 228 fig. 140; cf. the 'north-south communication route' („Nord-Süd-Kommunikationsroute") of Müller 2017, 93 fig. 47, fig. 86. For Gädebehn see http://krg.htw-berlin.de/studium/studienschwerpunkte/grabungstechnik-feldarchaeologie-gfa/studienprojekte/lehrgrabung-gaedebehn/, last accessed 08.12.2019.

6 Kampffmeyer 1983; 1991; Stapel 1991; Kotula 2019, 7. For Swifterbant see Raemaekers 1999; Raemaekers / De Roever 2010. See also Nachr. Niedersachsen Urgeschichte Beiheft 2, 1999, 89 fig. 58,2.

7 Klassen 2004, 83; Pétrequin 2012, fig. 3; Pétrequin et al. 2017, fig. 1. Only in the western Baltic region they can be found in certain numbers; there they also provoked formal flint imitations, as Klassen points out.

Neolithic remains, however, are known in relatively large numbers, and the described Younger Neolithic gap of sites is not just a source problem.

This border situation between Westphalia / the Hellweg zone and the adjacent parts of western Lower Saxony stands in contrast to the situation further east, where south-north interactions along the Weser river can actually be detected (Knoche 2008a; Klassen 2004; 2014). This corridor-like role of the Weser river can also be traced by the distribution of clay discs with fingertip prints mapped by J. Müller, and perhaps by the transmission of tetraploid free threshing wheat to the north (Kirleis / Fischer 2014, 81; Müller 2017). Prestige goods such as jade axes may also have been transmitted via the Weser vector. The communities located in these parts of the north German plain (Hüde-Swifterbant) thus obviously behaved structurally conservative towards the Younger Neolithic associations of Westphalia or the Rhineland with their Michelsberg tradition. In contrast, they themselves seem to have radiated impulses to the western Münsterland. Isolated evidence for such dynamics is represented by an aurochs scapula from Greven-Bockholt (Kr. Steinfurt) with circular cutouts. Such production waste (from making bone rings) is known from the Ertebølle area and, partly, also from Swifterbant (Spoolde, Hüde I; cf. Stapel 2014; this volume; for the distribution of bone rings: Andersen 1998, 37). For Klassen, bone rings and shoulder blades with cutouts are part of the same distribution mechanisms as T-axes made of deer antlers. He considers them to be a genuine 'innovation of the northwestern central European Mesolithic' (Klassen 2004, 127 [author's translation]). According to radiocarbon measurements, the specimen of Greven-Bockholt is dated to c. 4,350 calBC, i. e. the transition phase from the Middle to the Younger Neolithic. Thus, via the Ems river, elements from the north German plain reached southwards into the Münsterland. In the Münsterland Bay north of the Lippe, a spatial coexistence of Neolithic (e. g. Nottuln-Uphoven: Rössen, Bischheim) and Final Mesolithic groups becomes tangible for this period – a real borderland in its time. The 'multi-cultural' local situation of Hüde I is replicated here on a regional scale; this proves both areas to be part of a broader socio-economic structure in northern central Europe. Little is currently known about the exact relationships between the two traditions. The artefact of Greven-Bockholt with its orientation to the Ems river thus refers to the same north-south vector also connected to the stone hammer axes in the 38th/37th centuries calBC, again with links to the north (cf. Knoche 2008a, 185 fig. 5.44).

The coexistence does not only refer to the dichotomy between the Neolithic areas in the loess boroughs and the adjoining geest areas to the north and north-west of Germany which has been known for a long time (Kabaciński et al. 2015). The same dichothomy of Neolithic people and hunter-gathers can be observed for the Belgian Younger Neolithic (cf. Vanmontfort 2007, 112). In the southern Westphalian region, i. e. the low mountain range landscapes to the south of the loess boroughs, a longer coexistence of groups with and without a farming lifestyle up to the Late Neolithic is now also cautiously outlined. Thus, a persistence of hunter-gatherer populations in the mountain range of southern Westphalia ('Blätterhöhle' near Hagen) can be seen until about the middle of the 4th millennium calBC (Orschiedt et al. 2015; 2017). Apparently, the use of different landscape types made it possible to reconcile the two concepts of life and economy in the longer term, for example in the sense of a 'Paramesolithic'. These concepts may even have formed partially socio-economic complementary phenomena. In this context, the occurrence of some flint artefacts in the MK III-complex of the Soest causewayed enclosure (Kr. Soest), which have formal Final Mesolithic parallels and might easily represent a reflection of this coexistence, should only be pointed out in general terms (Knoche 2008a, 80; 128). The Late Mesolithic site 'Retlager Quellen' (Kr. Lippe), on the other hand, yielded unspecific ceramic fragments that might theoretically be Younger Neolithic, assuming that there is no admixture of finds (Knoche 2008a, note 709). Possibly, a comparable 'multicultural' situation of Mesolithic and Neolithic populations can also be expected in southern Lower Saxony with its juxtaposition of lowlands and low mountain ranges (Weserbergland, Deister, Süntel, Solling, Harz, etc.).

Models of the northern dissemination of the causewayed enclosure phenomenon

On the basis of the current state of research at least four partially merging models of the dissemination of the causewayed enclosure phenomenon to northern Germany and Jutland can be discussed (Knoche 2019):

(1) Comprehensive and gradual extension of the causewayed enclosure phenomenon to the north along the northern edge of the low mountain range zone east of the Weser river (Fig. 7,1),

(2) Selective exclaves in the north German plain: Targeted migrations from the Neolithic border landscapes into single regions of the north German plain form hotspots of a Neolithic concept of life, which function as crystallisation cores for habitually and economically delimited (isophenomenological) Younger Neolithic settlement pockets (Fig. 7,2),

(3) Linear, dynamic spread to the north along the valley of the Weser or a parallel land-bound vector, at least into the areas of Bremen and Hamburg, crossing the Elbe river to Schleswig-Holstein towards the western Baltic Sea area. A comparable vector can be assumed for the Elbe from the southeast (cf. Müller 2001 on the chronological and spatial dynamics of the middle Elbe-Saale area). At the same time, a gradual expansion from the traditional Neolithic settlement areas across a broad front towards the north can be expected, possibly also in the sense of the exclave model (no. 2). This would result in two different velocities of spread with a fast impetus along the Weser corridor and a slower land-take further east (Fig. 7,3),

(4) Complementary dynamics: First a linear expansion along the Weser valley to the northern Elbe region and Jutland almost like a kind of 'pincer movement'. Here the causewayed enclosure phenomenon was intensively established with a subsequent southern extension towards the north German plain and the Hannover / Braunschweiger Land region (Fig. 7,4).

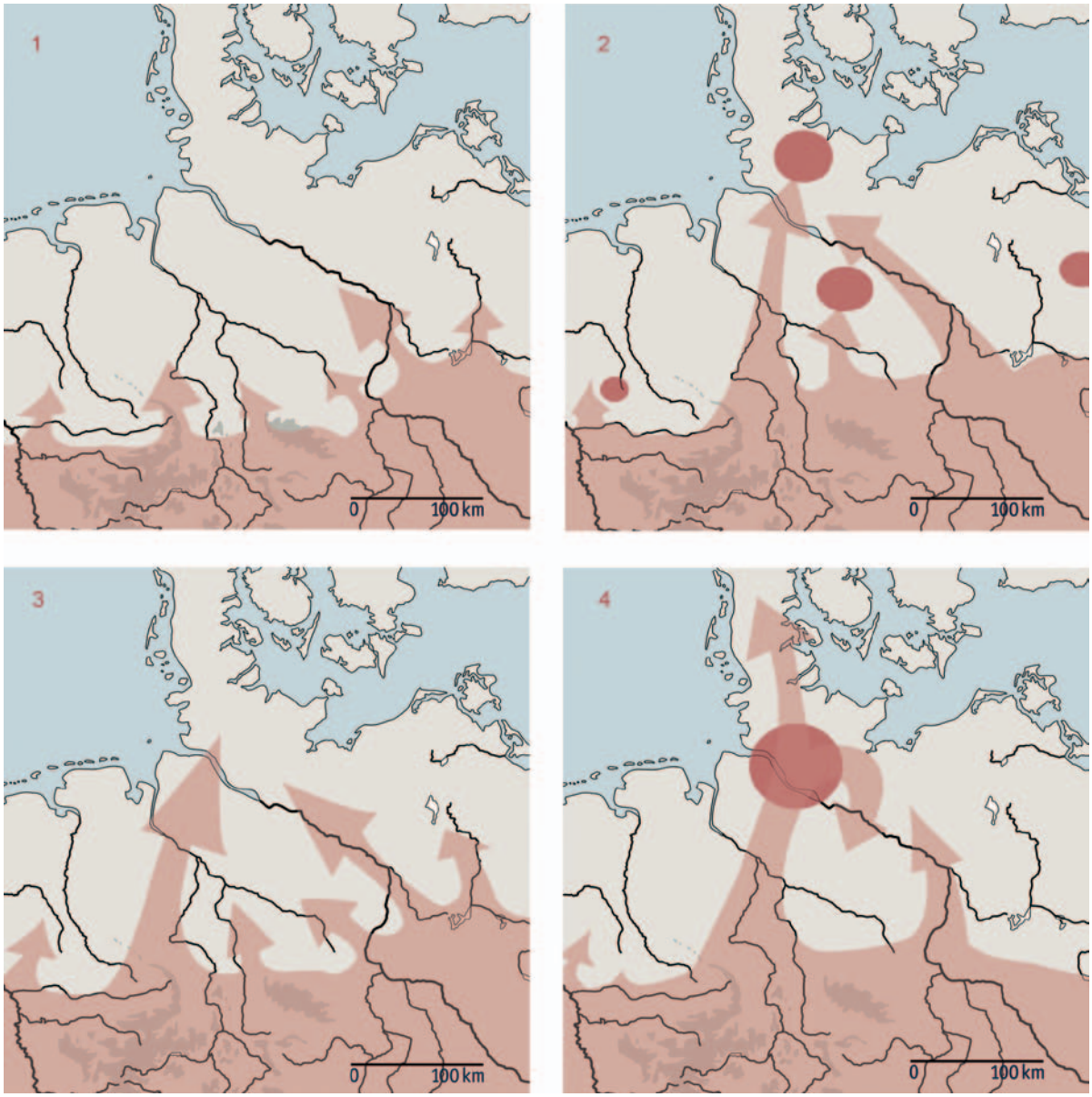

Fig. 7 Models of the enclosure phenomenon's spread across northern Lower Saxony to the area north of the river Elbe, c. 3,900–3,700 calBC.

For all these models, arguments and counterarguments can be cited, just as gradual modifications and additions are conceivable. It may even be possible to combine different models over time. At first glance, *model 1* appears to be most likely, i. e. a 'broad front' extension beyond the existing causewayed enclosure landscapes into the north German plain, which had apparently been occupied by Mesolithic to Early Neolithic groups so far. This also implies the possibility that this process might have taken the form of small-scale intrusions. However, there is still a lack of connecting finds north of the Hannover-Braunschweig area. *Model 2* initially contains only an exclave-like establishment of 'avant-garde' populations with subsequent spatial and habitual effects. A comparable process might have manifested itself in causewayed enclosures such as Walmstorf (Ldkr. Uelzen; Richter 1998) in Lower Saxony, or Nottuln-Uphoven (Kr. Coesfeld) in Westphalia (cf. Knoche 2008a; but rather sceptical: Geschwinde / Raetzel-Fabian 2009, 192). In both cases, Neolithic populations might have occupied distinct fertile loess areas outside the traditional Neolithic settlement areas. Observations by L. Klassen on the construction elements of various causewayed enclosures distributed over large parts of Europe also argue for the possibility of long-range migrations of at least smaller groups of people. Thus Klassen assumes a derivation of early Neolithic causewayed enclosures such as Büdelsdorf (Kr. Rendsburg-Eckernförde; cf. Hassmann 2000; Hage 2016; Müller 2017, 88) from the Neckar region. He considers migrating groups of people as 'founder populations' in the north to be the most plausible scenario (Klassen 2014, 150; cf. Klassen / Knoche 2019, 95). This is accompanied by a spread of north Alpine pottery and probably also copper axes far to the north and west of continental Europe, soon to be followed by tetraploid free threshing wheat and copper daggers.[8] Further specific elements (or variants) of the causewayed enclosure phenomenon, such as the linear earthworks or linear ditch systems (which are strictly speaking no causewayed enclosures!) only found in the Münsterland (Nottuln-Uphoven, probably also Rosendahl-Osterwick) and in one case in Denmark (Vilsund; Klassen 2014, 185–186, 189 fig. 107), suggest such a punctual and disjointed character. A recently identified linear arrangement of pits and ditch segments connecting two Funnel Beaker culture causewayed enclosures on Djursland in Denmark ('ritual superstructure' between Skærvad, Kainsbakke IV) also falls within the range of 'ritual linearity' (Klassen et al. 2020, 468 fig.7). In terms of linearity of ditch and parallel rows of wooden post settings Nottuln-Uphoven in fact resembles linear stone rows, as they appear slightly earlier or simultaneously next to the megalthic grave 'Table des Marchand' (Dép. Morbihan) in Brittany, with the 'Grand Menhir Brisé' as its relocated main component (cf. Klassen / Knoche 2019, 87; for the stone row at the side of the 'Table des Marchand' see e. g. Cunliffe 2001, 146; Bonniol / Cassen 2009). In this case an ideological interaction between the materials wood and stone can be assumed. However, rows of wooden posts accompanying trenches are a common feature of Younger Neolithic causewayed enclosures in central Europe (cf. Raetzel-Fabian 1999; 2000), although not in the specifically linear arrangement present in Nottuln-Uphoven. Furthermore, not every section of an causewayed enclosure must have been in use at the same time. In addition, there are so-called recuttings, i. e. re-openings of filled ditches. Taking this into account, the post settings can even have been the primary constituent and most constant element of a causewayed enclosure in terms of time as a (magical) membrane ('Bannkreis') of a certain place.

A variant of this dynamic would be *model 3* with its linear extensions along infrastructural vectors as 'main routes of intrusion'. The newly discovered causewayed enclosures of Stolzenau-Müsleringen and Steyerberg-Wellie (both Ldkr. Nienburg/Weser; cf. Freese 2010; Knoche 2019) show the essential importance of the Weser corridor as a Younger Neolithic vector. About eight kilometres further north from Müsleringen, Steyerberg-Wellie also gives reason to suspect that further earthworks might be found along the Weser to the north, possibly at intervals of five to ten kilometres. The specific significance of the river Weser as a transmission axis of Younger Neolithic impulses to the north has already been discussed (Klassen 2004; Knoche 2008a). In addition to a targeted spatial dynamic along the Weser and Elbe rivers, this model also assumes a kind of avant-garde-population, which brought the north into contact with the causewayed enclosure phenomenon and the underlying ideology. In contrast to the exclave model, this linear expansion then led to the establishment of a coherent corridor of causewayed enclosures. In this linear model, direct spatial contact with the traditional Neolithic settlement areas on the northern fringe of the low mountain range further south was always maintained. The background of such mobility might perhaps be the existence of extensive livestock farming systems and the associated driving of stock (Knoche 2013).

8 Klassen 2004; 2014; Knoche 2008a; Müller 2013; 2017; Kirleis / Fischer 2014.

As an extension of this model, *model 4* then takes into account that in the aftermath of the establishment of the causewayed enclosure phenomenon in Jutland and Schleswig-Holstein, the neolithisation of the north German plain then might have proceeded *essentially from north to south* – and not so much from south to north on a broad front. However, the radiocarbon dates do not support a compelling approach in this sense. Arguments for this model can be seen in the flat hammer axes with their connection from north Germany to Jutland, which penetrated as far as Westphalia, southern Lower Saxony, and even further south (Knoche 2008a, 185 ff., fig. 5.44). The chrono-typologically somewhat ambivalent complex of Walmstorf (Geschwinde / Raetzel-Fabian 2009, 191) might also be traced back to these reciprocally detached relationships. Overall, the significantly higher density of causewayed enclosures in Denmark compared to Schleswig-Holstein indicates that Jutland may well have had a structural significance in the expansion of these structures, i. e. as a secondary expansion core. However, the current state of research may have a distorting effect here (Müller 2017, 81). The integration of the entire north German plain into the area of the so called Trichterbecher complex (cf. Furholt 2014, 17; Hinz 2014, 207 for a discussion from different angles) with its megalithic constructions in the subsequent Late Neolithic ('Spätneolithikum') from approx. 3,500 calBC onwards indirectly suggests such a north-south connection already for the late Younger Neolithic. These temporal dynamics of diverse material elements from the Younger to the Late Neolithic might then be understood as a coherent cultural-historical process. This model would also best explain why vessel remains from the causewayed enclosure of Walmstorf show stronger connections to EN I ware than to the ceramic traditions further south. In my opinion, model 4 fits best to the current state of research.

The models presented here can only display theoretical approaches to the issue. Only a specifically focused research strategy can contribute to further elucidating the historical south-north dynamics during the Younger Neolithic in Lower Saxony and beyond. By the way, it should *not* be an *a priori* assumption that the entire Lower Saxony area east of the Weser river had been covered by causewayed enclosures, especially in the area north of the traditional Neolithic settlement areas. Looking at other parts of Europe, a mosaic pattern of regions with and without causewayed enclosures is to be expected. In the British area there were regions intensively filled with causewayed enclosures, while at the same time neighbouring regions did not practise this phenomenon or at least only at a significantly lower level of intensity (Oswald 2011, 2). The reasons for these regionally different behaviours are still unknown. It can only be assumed that ideological differences in ritual experience and action were responsible for the difference, or that there were also forms of enclosures which cannot be proven by archaeological methods, for example by hedges, clearings, superficial ground carvings, etc. But even in such a scenario regional differences in ritual expression would remain. In any case, the propagation of the causewayed enclosure phenomenon is a non-linear process, which cannot be sufficiently conceptualised with a simple broad-front area extension.

Not only spatially, but also temporally the causewayed enclosure phenomenon is represented in a nuanced way among users of Michelsberg ceramics: Several sites with an earlier version of Michelsberg pottery (MK II/III) in Schleswig-Holstein and Brandenburg appear as isolated spots in their surroundings, almost like isolated offshoots far beyond the closed distribution area of this pottery (cf. e. g. Hartz et al. 2000; Beran / Wetzel 2012). The extent to which these specific neolithisation hotspots achieved a widespread effect cannot yet be estimated, but it may have remained quite limited. In any case, during this earlier phase of the Younger Neolithic around 4,000 calBC they do not seem to have been associated with causewayed enclosures.

At present, no conclusive statements can be made about the exact mode of transmission of Neolithic elements from central to northern Europe. These early ceramic ensembles probably reflect acculturative impulses towards the western Baltic region, whereby the Michelsberg ceramics apparently provided a higher adaptability for the Ertebølle ceramics, which were also largely undecorated and non-flat-bottomed. In addition to the assumption of extensive livestock farming systems with transhumance, etc., a ritually / ancestor-driven concept exists, which assumes migrations from the southwest of Germany to at least Schleswig-Holstein (Büdelsdorf) with good reasons (Klassen 2014, 167). Ancestor worship and associated long-distance routes may have kept the link between the region of origin and the target region at least ideally, especially since migrations are now assumed to be a noticeable factor in the neolithisation of the north (Klassen / Knoche 2019, 95; on migrations to the north see Sørensen 2014). As with the economic approach (cattle driving, transhumance), however, the route affinity of the causewayed enclosures would also remain an essential factor in this model (Fig. 8). Systematical regional research on historical routes in the Braunschweig region and Westphalia might provide further clarity here.

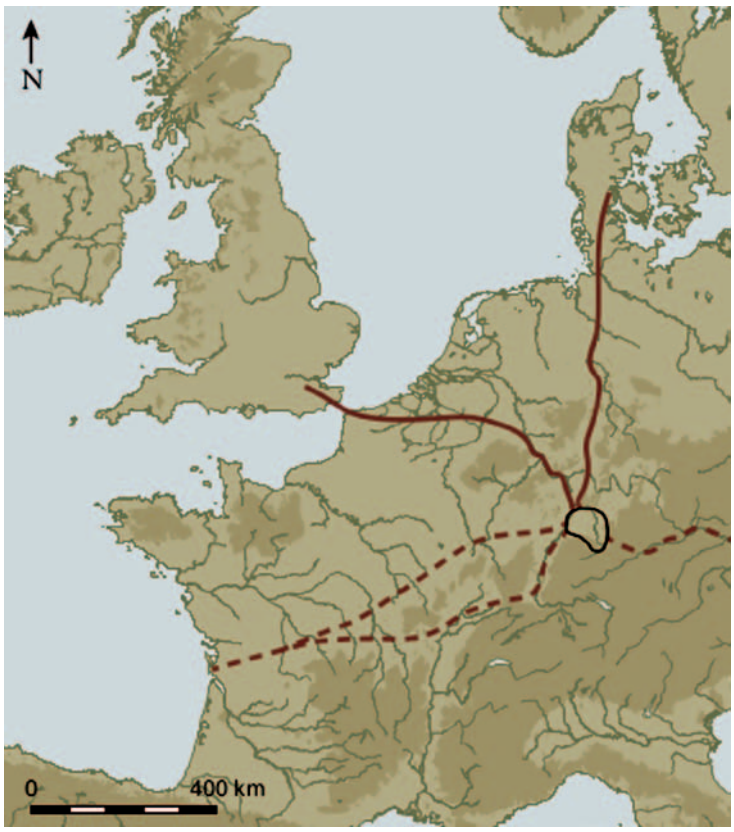

Fig. 8 Long-distance routes connected the Neckar Valley and the Kraichgau region in southern central Europe with south Scandinavia and the British Isles in the late 5th and early 4th millennia BC, as pointed out by L. Klassen. An extension towards Bavaria (and further on to the Black Sea) as well as the French Atlantic coast is also likely. These connections may have played a decisive role in the local development of causewayed enclosure construction in the western Baltic region between 3,750 and 3,500 BC (cf. Klassen 2014, fig. 140).

As mentioned before, this period is a phase of serious change also in the British Isles. It was not until the 38th/37th or the 35th–33th centuries calBC, respectively, that Neolithic communities established themselves on a broad basis there, after only sporadic and ephemeral approaches had taken place in the previous centuries (Sheridan 2010; Oswald 2011; Whittle et al. 2011).

In addition to the causewayed enclosures, the construction of long barrows also began during this phase (from c. the 38th century calBC) as another aspect of monumental architecture in northern Germany and Westphalia, followed a little later or even simultaneously by the first gallery graves in east Westphalia and possibly in the Hellweg zone (Knoche 2008a, 187 fig. 5.47).[9] This close connection is visualised by the arrangement of a gallery grave in a causewayed camp of Warburg-Rimbeck 'Weißes Holz' (dist. Höxter), constructed around 3,700 calBC (cf. Knoche 2003).

Deductions

If the above-mentioned 'model 4' actually reflects historical reality to some degree, this leads to various inferences on the general socio-cultural conditions and dynamics north of the traditional Neolithic settlement areas during the Neolithic, especially for the 38th/37th centuries calBC:

(1) North of the Münsterland and southern Lower Saxony, causewayed enclosures are only detectable from the 38th century calBC, possibly from the 39th century calBC, onwards. Up to this time the causewayed enclosure phenomenon came to a halt in these (so to say) borderlands. According to the current state of research, causewayed enclosures – as a western to central European phenomenon – expand only in a limited way from the northern foothills of the low mountain ranges into the north German lowlands. The phenomenon did not cover the entire north German plain, but was apparently only selectively taken up by the local populations. Some causewayed enclosures in the north might even be traced back to migrating colonists from the south. Differences between the regions west and east of the Weser river are recognisable, since in the northwestern part of Lower Saxony no

9 On the probable start of the gallery graves in the late Younger Neolithic see Knoche 2008a, 179. Meanwhile, in addition to this typological derivation, there are ^{14}C-data from Westphalian gallery graves available which support this view (c.f. Schierholt et al. 2012).

causewayed enclosure is detectable at all for the first half of the 4th millenium calBC. Exceptions are only the causewayed enclosures along the Weser river itself, which can be detected further north, apparently as evidence of an expansion along traditional communication and traffic corridors. It remains to be clarified whether there are still undiscovered causewayed enclosures immediately west and east of the Weser.

(2) The regionally different preparedness for the integration of causewayed enclosures indicates different attitudes to this ritual phenomenon, probably in the sense of different social or cultural groups. In western Lower Saxony, this would be Swifterbant-Hüde I, in the eastern part some sort of Swifterbant as well or another early ceramic tradition roughly north of the area Hannover-Braunschweig. In the latter case, it can only be assumed that they represent derivations of an early Funnel Beaker tradition.

(3) Michelsberg ceramics in the north German lowlands are sporadically known since the end of the 5th millenium calBC, but there were still no causewayed enclosures until the 39th to 37th century calBC. So in this region Michelsberg ceramics do not necessarily have to go together with causewayed enclosures. The Early Neolithic populations in northern central and northern Europe tended not to be causewayed enclosure builders. According to Müller (2014, 187) the 'emergence of causewayed enclosures represents social transformations', and if this is true, it can be assumed in the reverse conclusion that an appropriate social infiltration of these parts of northern Germany was not strong enough at the beginning of the 4th millenium calBC. Apparently there was initially no broad demographic basis for such a social transformation in form of the lifestyle of the enclosure builders. In this regard, causewayed enclosures indeed are veritable markers of the existence (and acceptance) of a full Neolithic lifestyle in northern Germany and the western Baltic region. This delayed start of enclosure building is not an isolated case: According to J.-P. Bocquet-Appels and J. Dubouloz, the demographic changes (higher birth rate, increase in population density) in the course of the neolithisation in large parts of Europe also led to an increased construction of causewayed enclosures. While the so-called Neolithic Demographic Transition (NDT) reached its peak demographically and anthropologically about 500 years after the beginning of each regionally based neolithisation, archaeologically detectable reactions to it in the form of an intensified construction of enclosures (or maybe other monumental buildings) did not become noticeable until 600–900 years later (Bocquet-Appel / Dubouloz 2004). The observations for northwest and northern Germany fit well into this pattern and emphasise above all the demographic dimension within this process (cf. in general also Knoche 2013, 149).

(4) The neolithisation (early Funnel Beaker complex) north of the river Elbe starting on an Ertebølle basis (up to approximately 4,100 / 4 ,000 calBC) led to the establishment of a monumental architecture in the western Baltic Sea area from the 38/37th century calBC, to which – besides causewayed enclosures – also non-megalithic long mounds belong (Müller 2017). These early (Younger Neolithic) causewayed enclosure phenomena are not yet documented in the western part of Lower Saxony north of the Westphalian Bay or the Wiehengebirge. Swifterbant thus proves to be a largely enclosure-resistant socio-economic and cultural phenomenon. Here an already long-existing cultural disposition, in form of a habitual distinction between Michelsberg to the south and Swifterbant to the north, seems obvious. This also applies to the distinction between Swifterbant south of the river Elbe and Ertebølle north of it, where causewayed enclosures definitely appeared later on during the EN I (prior to those in northwest Germany). The construction of the first causewayed enclosures in the western Baltic Sea region can already be expected in the 39th century calBC (Klassen 2014; Müller 2017). If this is true, it will put the causewayed enclosures at the Weser river, such as the early dated Stolzenau-Müsleringen example, even more into focus as links for the causewayed enclosures north of the river Elbe. The early construction phases of causewayed enclosures are generally problematic to determine. However, the starting 'perceptibility' of causewayed enclosures in southern Lower Saxony (in the Braunschweig and Hanover region) and the area north of the river Elbe until the 38th century calBC may be no coincidence. Most likely there is a convergence of the underlying socio-economic dynamics of this time period, which also affected the traditional Neolithic regions of southern central Europe and western (France) as well as northwestern Europe (Britain). Strong impulses for these dynamics

seem to have come from southern Germany, where from the 38th century calBC a complex with copper metallurgy, flat-bottomed ceramics and innovations in arable farming became recognisable ('Nordalpines Jungneolithikum').[10]

(5) Thus it seems that the northern boundary of the causewayed enclosure phenomenon up to the time around 3,750 calBC and even beyond was a relatively constant line of equilibrium between the traditional Neolithic settlement areas in the south and the directly adjoining Mesolithic to Early Neolithic areas in northern Germany. In this term, the Middle to Younger Neolithic complex of Nottuln-Uphoven is probably not something like an offset piece of a 'pioneer-like' movement into new areas in the Münsterland or even the bordering north German plain. Rather, it was probably a targeted expansion or 'rounding off' of regionally already existing settlement areas (in this case from the Hellweg zone south of the river Lippe, probably around Haltern am See). First of all, the regional situation favours such an interpretation: the 'Baumberge' on the slopes of which the Nottuln causewayed enclosure is situated, represent a prominent elevation that can be seen from a great distance in the otherwise flat Münsterland, and so seem predestined as a ritual focal point. Furthermore, there are smallpockets of loess soil, which corresponds to the Hellweg loess zone and favours the model of a targeted frequentation of the site. Finally, the Younger Neolithic causewayed enclosure with its rows of posts parallel to the ditch is very likely to be understood as a ritual installation, maybe in the form of a 'sacred mountain'. The location on a hilly slope, with the spring of the Stever river at its feet, may well have been an essential motivation for a local reach of Neolithic groups into the Münsterland as early as the end of the Middle Neolithic and the Younger Neolithic. From the top of the hill in Nottuln-Uphoven one can actually look up to the edge of the Hellweg zone further south as the traditional Neolithic landscape in the region. The river Stever may even have been something like a 'connecting line' to the Neolithic settlement areas further south, as it flows into the river Lippe at Haltern am See.

(6) Furthermore, the distribution of younger Neolithic hammer axes demonstrates that from the 38th/37th centuries calBC onwards there were noticeable impulses from the north German plain into the Münsterland, east Westphalia, the Weser region, and southern Lower Saxony. With one exception (Gofeld), all typologically determinable specimens from Westphalia belong to the typological groups FIC, FIIA, and FIVB according to Zápotocký (1992), which have their major distribution areas in eastern Germany, especially in Mecklenburg-Western Pomerania and Brandenburg, partly up to the middle Elbe-Saale region. These axes were obviously strongly bound to the rivers Ems and Weser, and at least in the case of the Ems / Münsterland a continuation of final Mesolithic structures is recognisable. This means that while the Weser vector was charged strongly south-north, the Ems vector remained consistently directed from north to south. This situation also explains the inability of the Westphalian enclosure builders to expand further northwards – among other reasons. In general, it must be understood against the background of the Swifterbant/Hüde I-complex and/or some sort of early Neolithic populations in the subsequent west Lower Saxon lowlands. In the longer term these early Neolithic/Submesolithic populations in western Lower Saxony prepared the field for the forthcoming later Neolithic development of the passage graves in the second half of the 4th millenium calBC, very probably also via the river Ems. The rivers Ems and Weser form a kind of opposite system, with the Weser transmitting south-north impulses, while the Ems simultaneously vectored impulses in the opposite direction towards the south. This 'spin' is the result of a specific cultural-geographical charge in Westphalia and northwest Germany between diverging Michelsberg, Swifterbant, and Early Neolithic traditions, or, so-to-say, 'energy fields'.

(7) The importance of the river Weser as a central transmission axis northwards becomes increasingly clear for the Younger Neolithic (e.g. causewayed enclosures, jadeite axes, copper, pottery, crops). The same relationship can be seen for the river Elbe further to the east, connecting the Saale region (Baalberge) with northern Germany. Both vectors (or accompanying routes)

10 'Nordalpines Neolithikum' (see Knoche 2008a, 166), with impacts from as far away as the west of France (see Klassen 2014, 236): The copper flat axe from Pont-de-Roide (Doubs, France) and a flat hammer axe of serpentinite from Héricourt (Haut-Sâone, France) 'testify to relations between southern central Germany and areas west at the time of major enclosure construction between 3,750 and 3,500 BC' (Klassen 2014, fig. 139).

conveyed Neolithic impulses towards northern Germany and southern Scandinavian regions. In the wider Hamburg area, the impulses converged via the Elbe and Weser vectors (cf. the site of Hamburg-Boberg as a reflection of several Neolithic impulses; Laux 1986; Thielen 2020). At this crossroad a further causewayed enclosure might theoretically be expected. A separate consideration of this bi-directional setting would certainly be of importance for the further understanding of the neolithisation process in the north. L. Klassen explained the concept of causewayed enclosures with more than two ditch circuits in southern Scandinavia in particular by contact with enclosure building populations in east Westphalia and southern Lower Saxony. There is even some evidence suggesting 'that migration from the southern parts of Lower Saxony and (possibly) eastern parts of Westphalia was a potential cause for south Scandinavian neolithisation' (Klassen 2014, 167).

(8) As far as the role of the rivers Weser and Elbe as propagation paths for Neolithic populations, stock, ideas, and techniques towards the western Baltic region and northern Europe is concerned, the study of K. Davison et al. (2006) for population dynamics along major waterways during the Neolithic might be helpful for further investigations. The authors developed a mathematical model for population spread of early Neolithic farmers (LBK) along rivers such as the Danube or the Rhine that stresses the importance of anisotropic forms of diffusion, which might lead to an effective advection of the connected attributes. As seen in the case of the Younger Neolithic in northwest Germany (as pointed out above), cultural reasons may have prevented a linear and isotropic neolithisation process towards the north German plain until the middle of the 4th millennium calBC. It may be, however, that it was precisely this inhibition that favoured a relatively rapid anisotropic advance of younger Neolithic elements, such as causewayed enclosures, along the river Weser (perhaps as a 'left-open corridor'), influencing the north German plain up to the western Baltic region.

(9) The high number of causewayed enclosures in relatively limited regions (as around Braunschweig / Hildesheim) or along the river Weser makes a 'central place' function for each enclosure unlikely. Rather, they display with their aggregation and their linear arrangement (as along the Weser) the character of a regional 'mass phenomenon', which tends to be a model of temporally restricted and decentralised ritual activities. One or even both aspects can also be found in many other regions, as Westphalia, southern Lower Saxony, and north Hesse, up to the British Isles. This strengthens Klassen's hypothesis of relatively uniform ideas behind the construction of the enclosures throughout Europe. As primarily ritual complexes, causewayed enclosures indicate ancient routes,[11] possibly well comparable to crossroads, pilgrimage stations, or devotional chapels along medieval to submodern routes. Recently, L. Klassen and B. Knoche demonstrated a possible function of the trenches as 'magical circles' ('Bannkreise'), to protect or enclose magical / ritual / ancestral activities within the causewayed enclosures. Ritual travels may have been associated with this (Klassen / Knoche 2019).[12] Incidentally, this does not exclude mundane purposes such as stops along routes for cattle drive, trade and exchange; the magical and the mundane spheres were certainly inseparable dimensions in a premodern execution and perception of life (Knoche 2013, 226). Here comparisons to the *wak'a* (or *huacas*) of the Andes region are possible, which already existed in pre-Columbian times and are still revered today. These *wak'as* are local deities or special places themselves as divine entities. Integrated in pilgrimages and pilgrimage routes along these sacred places of worship are ceremonial and ritual spots (ceque-lines, ceque-system). Catholicism (which itself knows ritual routes with chapels, churches, and pilgrimages) in Columbia has incorporated these *wak'a* system into its ritual texture (Zuidema 1964).

Conclusion

Causewayed enclosures can be understood as indicators of the neolithisation process as early as the 38th century calBC, regarding the early dating of some Danish and north German examples. The north German plain with its traditional geestland and partly peatland landscapes, which borders Westphalia, the

11 Cf. the route-affinity of Younger Neolithic enclosures in central and northern Europe: Raetzel-Fabian 2002; Knoche 2003; 2008a; 2013; Geschwinde / Raetzel-Fabian 2009; Klassen 2014.

12 Some years ago Cummings 2007 presented similar ideas of moving around in monumental spaces of Neolithic western Britain.

central Weser region, and southern Lower Saxony to the north, is archaeologically so far largely still *terra incognita*. However, it is not probable that Neolithic elements, including the causewayed enclosures, spread linearily throughout the whole area, but rather that the dynamics will have varied from region to region. While the Westphalian Middle and Younger Neolithic (Rössen, Bischheim, Michelsberg) had hardly any deep entanglements with Lower Saxony to the north (where a partly expanding Swifterbant obviously inhibited any dissemination), the situation to the east of the Weser river was probably different. The reasons for this can be attributed to varying social and demographic causes. Above all, the Weser itself must be regarded as a first-class vector for the northern relations of the Younger Neolithic causewayed enclosure builders. Via the Weser and the Elbe, the causewayed enclosure idea most likely was transferred to Jutland (and maybe Schleswig-Holstein), where an independent (secondary) distribution centre developed, which then in turn radiated impulses to the south.

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Subsistence change? Diversification of plant economy during the Neolithic in northern Germany

Wiebke Kirleis

Abstract From an economic perspective, the neolithisation can be described as a growing together of multiple arrays of food supply strategies. In the north of Germany, there is no strict division into either a Mesolithic or Neolithic way of life observable in the diet after 4,000 calBCE. Instead, the Neolithic subsistence economy there merges multiple methods of food acquisition, with the contribution of wild resources depending on availability in specific ecological niches and on culinary preferences. Changes in plant use from the uptake of agrarian practices towards the establishment of fully-fledged crop cultivation between c. 4,000 to 1,700 calBCE are presented here, based on archaeobotanical data from 21 Neolithic settlement sites in northern Germany. For the northern German Neolithic, a diversification in the crop spectrum from the Early towards the Late Neolithic can be observed, contrary to southern Scandinavia. Hence, it can be inferred that the Funnel Beaker plant economy shows clear regional differentiation. As a new interpretative approach, it is proposed that the Neolithic plant economy was organised alongside different modules with adaptation to specific environmental constraints and specific needs of individual plant species. These modules included plant gathering as well as (labour) intensive and (labour) extensive crop cultivation, mutually interlinked with specific technological and cultural innovations, each with variable relevance through time and space.

Keywords Plant economy, Neolithic, northern Germany, archaeobotany

Zusammenfassung *Die Neolithisierung kann aus wirtschaftlicher Sicht als ein Zusammenwachsen verschiedener Strategien der Nahrungsmittelversorgung beschrieben werden. Nach 4000 v. u. Z. ist im Norden keine strikte Trennung zwischen mesolithischen und neolithischen Ernährungstraditionen zu beobachten. Stattdessen führt die neolithische Wirtschaftsweise verschiedene Strategien des Nahrungserwerbs zusammen, wobei der Beitrag der Wildressourcen von deren Verfügbarkeit in bestimmten ökologischen Nischen und von kulinarischen Vorlieben abhängt.*

Veränderungen in der Pflanzennutzung von der Übernahme agrarischer Praktiken hin zur Etablierung eines vollwertigen Pflanzenanbaus zwischen ca. 4000 und 1700 v. u. Z. werden hier basierend auf archäobotanischen Daten von 21 neolithischen Siedlungsplätzen in Norddeutschland vorgestellt. Für das norddeutsche Neolithikum ist eine Diversifizierung des Kulturpflanzenspektrums vom Früh- zum Spätneolithikum zu beobachten, ein gegenläufiger Trend im Vergleich zum südlichen Skandinavien. Daraus lässt sich ableiten, dass die Pflanzenwirtschaft der Trichterbecherzeit eine deutliche regionale Differenzierung aufweist. Als neuer interpretativer Ansatz wird vorgeschlagen, die neolithische Pflanzenwirtschaft als modulares System zu betrachten, dessen verschiedene Module an spezifische Umweltbedingungen angepasst waren und die spezifischen Bedürfnisse einzelner Pflanzenarten berücksichtigten. Die Module umfassten das Sammeln von Nutzpflanzen sowie den (arbeits-) intensiven und den (arbeits-) extensiven Kulturpflanzenanbau, die jeweils wechselseitig mit spezifischen technologischen und kulturellen Innovationen verknüpft waren und unterschiedliche zeitliche und räumliche Relevanz hatten.

Introduction

The discussion on the transition from hunter-gatherer-fisher communities towards the establishment of a fully Neolithic way of life within Europe is very much driven by the idea of a dualistic concept of lifestyles of either (semi-)mobile Mesolithic or of sedentary agrarian Neolithic groups, accompanied by a perspective of directional one-way development. The general perception is that northern hunter-gatherer-fishers were confronted with early central European farmers and adapted their economies.[1] The northern European plain is generally considered as a region where hunting, fishing, and the gathering of wild plants were the

1 Klassen 2004; Müller 2013; Price / Gebauer 2017; Gron / Sørensen 2018.

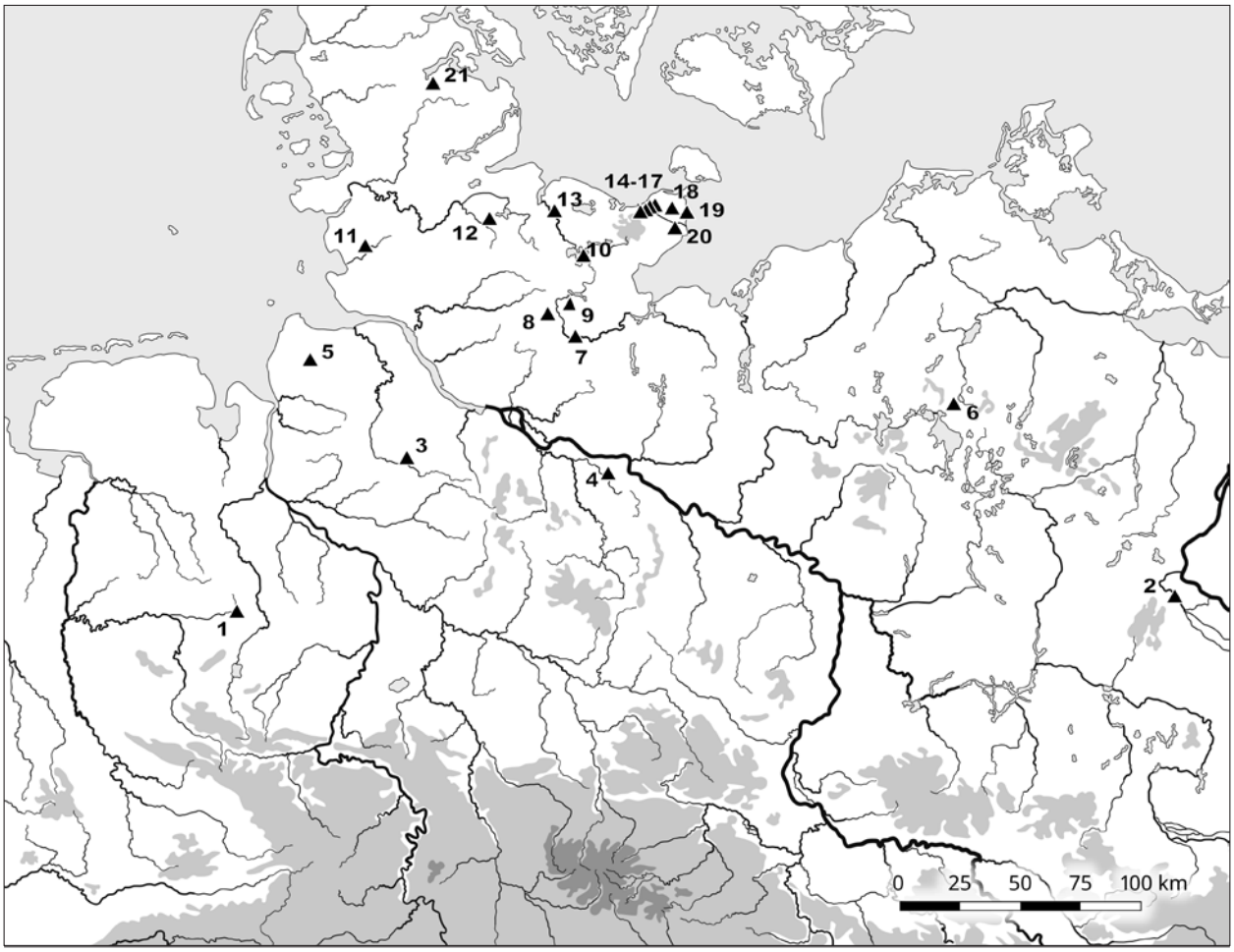

Fig. 1 Geographical distribution of the 21 Neolithic sites with archaeobotanical investigations in northern Germany (site no. according to Table 1).

preferred economic activities of the Mesolithic groups living there, and where agriculture and livestock breeding became the basis of livelihood with a time lag of about 1,400 years.[2]

However, recent studies showed that in the late 6th and 5th millennium calBCE both groups co-existed in the northern European plain for quite some time (e.g. Kirleis et al. in prep.; cf. Gerken / Nelson 2016; Ismail-Weber 2017). Since settlements belonging to the Linear Pottery (LBK) and subsequent Neolithic groups (e.g. Rössen) have recently been discovered outside the main loess regions, the separation of the living environments of Mesolithic and farming groups along natural boundaries is partly obsolete (Ismail-Weber 2017). In contrast, natural transition zones are of particular importance as border regions between different habitats. They represent direct contact zones between Mesolithic and Neolithic lifestyles and act as catalysts for cultural exchange.

In contrast to the interrelations between LBK or post-LBK farmers and the Nordic Mesolithic, we can observe a direct adoption of pastoral and agricultural practices by southern Scandinavian and northern German groups from 4,100 calBCE onwards. Even though it is often argued that sub-Mesolithic groups were found at certain sites until about 3,000 calBCE (e.g. the cemetery of Ostorf), dietary calculations showed that a primarily Neolithic society had been developed that practiced varied combinations of different nutritional strategies (Lübke et al. 2007; Olsen / Heinemeier 2007; Fernandes et al. 2015). A comparison of archaeobotanical inventories in particular indicates that on the one hand, there are basic trends, but on the other hand there are differences in the ways in which plants are included, e.g. with respect to the integration of gathered wild plants and the like.

The aim of this study is to present archaeobotanical data from 21 Neolithic settlement sites in northern Germany, with the highest site density in Holstein (Fig. 1; Table 1), using this as a basis to identify how plant use developed over time, from the uptake of agrarian practices towards the establishment of fully-

2 E.g. Hartz et al. 2007; Müller 2011; Kirleis et al. 2012; Terberger et al. 2018.

No.	Site name	Site type	Feature types (if applicable)	Archaeological period	„No. of features“	„No. of samples“	„No. of cereal grains“	Reference
1	Vechta Fst. 10	settlement	pit	LN	1	3	101	Kirleis 2019
2	Altgaul Fpl. 2	settlement	pit, palaeosoil, layer	LN	29	40	0	Lehmphul 2000
			layer	LN I	15	20	14	
			diverse	LN II	1	1	0	
3	Lavenstedt Fpl. 178	settlement	well	MN Ib	3	5	35	Kirleis 2019
			pit, cultural and natural layer, profile, fireplace, bank	MN I/II	545	683	245	
4	Rullstorf Fst. 8	settlement	pit, cultural and natural layer, posthole	EN II / MN I	46	136	37	Kirleis 2019
5	Flögeln-Eekhöltjen	settlement	diverse	MN I-IV	7	111	1085	Behre /Kučan 1994
6	Gädebehn Fpl. 10	fortified settlement	diverse, pit	EN Ib	3	4	9	
7	Bad Oldesloe-Wolkenwehe LA 154	settlement	cultural layer	EN I	2	5	1	Kirleis et al., 2012
			cultural layer	EN Ib	2	4	5	
			cultural layer	EN II	2	3	12	
			cultural layer	EN II-MN II	11	28	34	
			cultural layer	MN V / YN 1	7	16	39	
			cultural layer	YN 1	2	4	1	
			cultural layer	YN 2	2	3	5	
8	Todesfelde LA 31	settlement	floor	YN 3	1	1	4	Effenberger 2017, 2018
			burnt horizon, pit, posthole	LN	4	4	697	
			posthole, silo	LN I	3	3	7110	
			floor, burnt horizon	LN II	2	2	818	
9	Bad Segeberg LA 94	fortified settlement	pit, ditch system	EN Ib / EN II	6	22	5	Kirleis 2019
			diverse	MN I	17	112	98	
10	Bosau	settlement	pit	LN	2	2	6145	Kirleis 2019; Kirleis 1981
11	Hemmingstedt LA 2	settlement	pit, posthole, diverse	EN II / MN I	28	32	226	Kirleis 2019
12	Büdelsdorf LA 1	fortified settlement, settlement	pit, ditch system, cultural layer, diverse	EN Ib	6	6	0	Hage 2016
			pit, ditch system	EN Ib / EN II	5	5	0	
			pit, ditch system, cultural layer, fireplace	EN II	4	4	0	
			pit, ditch system, fireplace, posthole	MN I	6	10	53	
			pit, ditch system, posthole	MN II	5	5	2	
			diverse	LN	1	1	0	
13	Rastorf LA 6 a/c	settlement	pit	EN Ib / EN II	1	1	8	Kirleis 2019
			pit, fireplace, occupation layer	EN II	3	18	56	

Table 1 21 Neolithic sites with archaeobotanical investigations in northern Germany (No. 1–12).

No.	Site name	Site type	Feature types (if applicable)	Archaeological period	„No. of features“	„No. of samples“	„No. of cereal grains“	Reference
14	Oldenburg LA 77	settlement	pit, inhumation, posthole	MN I	12	12	1254	Kirleis 2019; Brozio 2016
			well, pit, pit complex, posthole	MN II	59	143	7716	
			pit, posthole, cultural layer	MN III/IV	37	37	817	
			diverse	MN I-II	1	1	0	
			well, pit, inhumation, cultural and natural layer, posthole, diverse	MN I-IV	290	337	3771	
			pit, posthole, diverse	MN II-IV	16	16	63	
15	Oldenburg LA 191	settlement	cultural layer	EN II-MN Ia	1	1	3	Kirleis 2019; Filipović et al., 2019
			diverse					
			diverse					
			diverse					
			diverse					
		settlement	cultural layer	MN I-IV	17	17	3350	
16	Wangels LA 505	settlement	cultural layer	EN Ib	1	1	1	Kirleis 2019; Kroll 2001
			diverse	MN V	2	13	70	
17	Oldenburg LA 232	settlement	cultural layer	MN	1	1	106	Brozio et al. 2019b; Filipović et al., 2019
			pit	MN I	1	1	2338	
			pit, ditch, posthole, cultural layer	MN I-II	32	32	658	
18	Göhl LA 142	settlement	pit, fireplace, posthole, diverse	MN I-II	43	48	11	this publication
			diverse	YN 1	1	1	0	
			diverse	LN	1	1	2	
19	Heringsdorf-Süssau LA 38	settlement	pit	EN Ib	1	1	0	Kirleis 2019
				MN I/II	5	5	2	
20	Grube LA 65	settlement	pit	EN Ib / EN II	1	1	26	Kirleis 2019
21	Tastrup LA 29	settlement	well	EN Ib / EN II	4	17	2	Bock 2016
			diverse	EN II-MN Ib	1	1	1	
			diverse	MN II-V	1	1	0	

Table 1 21 Neolithic sites with archaeobotanical investigations in northern Germany (No. 13–21).

fledged crop cultivation between c. 4,000 to 1,700 calBCE. Focusing on domestic rather than burial sites allows us to get insight into the routine practices of a plant economy that may have varied between different regions and social groups, and also into a diachronic perspective of the uptake of sedentary agrarian lifestyles from the Early Neolithic all way through to the Late Neolithic (Kirleis / Klooss 2014).

Material and Methods

Data on charred plant assemblages from 21 northern German Neolithic sites comprise the baseline for this evaluation, including published as well as unpublished data, all stored in the ArboDat database at Kiel University.

The sites date to 4,000–1,700 calBCE, and only such sites that cover at least two archaeological sub-periods / combined sub-periods are considered (Table 2). Plant assemblages that can only be dated to more general units, e.g. the Funnel Beaker period as such (4,000–2,800 calBCE), are excluded to avoid background noise. Only data on charred plant remains are considered. Data on water-logged plant material are not included, as only two sites provided such material: Bad Oldesloe-Wolkenwehe LA154 with selective preservation conditions due to recurrent desiccation of the peat matrix (Kirleis et al. 2012), and the Middle Neolithic V (3,000–2,900 calBCE) site Wangels LA505 with sound and reliable water-logged plant assemblages (Kroll 2001; Kirleis 2019a, 125); the latter one is referred to for comparison in the discussion. The archaeobotanical records are mostly related to domestic sites, but for the sites Büdelsdorf LA1, Bad Segeberg LA94, and Gädebehn 10, ditch systems are recorded for certain periods that might also account for ritual plant depositions.

The data included had to fulfill certain requirements to ensure a reasonable degree of comparability and representativeness. Finds had to originate from sites with a Neolithic domestic context, comprising at least twenty-five charred cereal grains, ideally from a minimum of three features. 25 cereal grains from at least three features per site may seem to be a weak criterion. However, this reflects the generally low find concentrations of botanical remains for Neolithic sites on the north European plain (Kirleis et al. 2012; cf. Regnell / Sjögren 2006; Bogaard / Jones 2007). The site Heringsdorf-Süssau LA38 was included despite comprising only 13 cereal grains. For five other sites, mass finds originating from only one or two features were considered, since e.g. the Early Neolithic site Rastorf LA6a/c provides evidence of only rarely preserved charred linseeds, while the remaining four other sites were included to ensure coverage of archaeological periods that otherwise would have been fully excluded (e.g. the Late Neolithic site Bosau LA242). Not all periods are covered with a comparable number of sites. Particularly from the Younger Neolithic Single Grave culture there are only very few sites known at all, from which very few were archaeobotanically investigated.

For the database presented here, an application of frequency measurings is not appropriate. Instead, absolute numbers of cereal grains were considered and included for calculations at each site. This site data provide the baseline for the application of an aoristic approach to allow for a diachronic perspec-

Archaeological sub-periods	absolute dates BCE
Early Neolithic, EN I	4000–3500
EN Ib	3800–3500
EN II	3500–3300
Middle Neolithic, MN	3300–2800
MN I	3300–3100
MNIb	3200–3100
MN II	3100–3000
MN III/IV	3000–2900
MN V	2900–2800 (2600)
Younger Neolithic, YN 1	2850–2600
YN 2	2600–2450
YN 3	2450–2250
Late Neolithic, LN	2250–1700
LN II	(2350) 2250–1950
LN II	1950–1700

Combined archaeological sub-periods	absolute dates BCE
EN II-MN Ib	3500–3100
EN Ib/EN II	3800–3300
EN II-MN Ia	3500–3200
EN II/MN I	3500–3100
EN II-MN II	3500–3000
MN Ib-MN IV	3200–2900
MN I-II	3300–3000
MN II-IV	3100–2900
MN II-V	3100–2800 (2600)
MN I-IV	3300–2900
MN V/YN 1	2900–2600
EN/MN	4000–2800 (2600)

Table 2 Archaeological periodisation for the north European plain (after Müller et al. 2012).

Archaeological period	EN Ia	EN Ia	EN Ia	EN Ia	EN Ib	EN Ib	EN Ib	EN Ib	EN Ib	EN Ib	EN II	EN II
cal BCE	4000 – 3950	3950 – 3900	3900 – 3850	3850 – 3800	3800 – 3750	3750 – 3700	3700 – 3650	3650 – 3600	3600 – 3550	3550 – 3500	3500 – 3450	3450 – 3400
Crop seeds and fruits												
Papaver somniferum x 10												
Linum usitatissimum x 10					2	2	2	2	2	2	2	2
Triticum cf. *spelta*												
Triticum aestivum s.l.											3	3
Triticum monococcum												
Hordeum vulgare, hulled												
Hordeum vulgare var. *nudum*					3	3	3	3	3	3	157	157
Triticum dicoccum					1	3	3	3	3	3	22	22
Threshing remains												
Cerealia indet., culm fragment												
Cerealia indet., glume fragment												
Cerealia indet., rachis segment												
Hordeum vulgare											0,5	0,5
Triticum aestivum s.l.												
Triticum durum s.str.												
Triticum dicoccum					3,9	4,2	4,2	4,2	4,2	4,2	54,4	54,4
Triticum monococcum					0,4	0,4	0,4	0,4	0,4	0,4	0,7	0,7
Triticum cf. spelta												

Archaeological period	EN II	EN II	MN Ia	MN Ia	MN Ib	MN Ib	MN II	MN II	MN III/IV	MN III/IV	MN V	MN V-YN 1
cal BCE	3400 – 3350	3350 – 3300	3300 – 3250	3250 – 3200	3200 – 3150	3150 – 3100	3100 – 3050	3050 – 3000	3000 – 2950	2950 – 2900	2900 – 2850	2850 – 2800
Crop seeds and fruits												
Papaver somniferum x 10							5	5			10	10
Linum usitatissimum x 10	2	2	1	1	1	1	1	1	1	1		
Triticum cf. *spelta*												
Triticum aestivum s.l.	3	3	2	2	3	3	8	8	2	2	1	1
Triticum monococcum			7	7	7	7	12	12	5	5	1	1
Hordeum vulgare, hulled			66	66	71	71	66	66	66	66		
Hordeum vulgare var. *nudum*	157	157	901	901	909	909	2394	2394	620	620	51	51
Triticum dicoccum	22	22	1431	1431	1435	1435	2829	2829	889	889	133	133
Threshing remains												
Cerealia indet., culm fragment			3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0		
Cerealia indet., glume fragment			0,4	0,4	0,4	0,4	75,9	75,9	0,4	0,4		
Cerealia indet., rachis segment			6,3	6,3	6,3	6,3	110,8	110,8	10,8	10,8		
Hordeum vulgare	0,5	0,5	89,5	89,5	89,5	89,5	251,8	251,8	91,8	91,8	49,9	49,9
Triticum aestivum s.l.			0,1	0,1	0,1	0,1	5,6	5,6	0,1	0,1	2,0	2,0
Triticum durum s.str.											1,0	1,0
Triticum dicoccum	54,4	54,4	750,6	750,6	752,1	752,1	7702,9	7702,9	794,1	794,1	220,4	220,4
Triticum monococcum	0,7	0,7	19,6	19,6	19,6	19,6	24,1	24,1	7,6	7,6	1,1	1,1
Triticum cf. spelta			0,7	0,7	0,7	0,7	0,7	0,7				

Archaeological period	YN 1c	YN 1c	YN 1c	YN 1c	YN 2a	YN 2a/b	YN 2b	YN 3a	YN 3a	YN 3b	YN 3b	LN I
cal BCE	2800 – 2750	2750 – 2700	2700 – 2650	2650 – 2600	2600 – 2550	2550 – 2500	2500 – 2450	2450 – 2400	2400 – 2350	2350 – 2300	2300 – 2250	2250 – 2200
Crop seeds and fruits												
Papaver somniferum x 10												
Linum usitatissimum x 10												
Triticum cf. *spelta*												261
Triticum aestivum s.l.												486
Triticum monococcum												23
Hordeum vulgare, hulled												17
Hordeum vulgare var. *nudum*	5	5	5	5	1	1	1					171
Triticum dicoccum	1	1	1	1	1	1	1	1	1	1	1	860
Threshing remains												
Cerealia indet., culm fragment												
Cerealia indet., glume fragment												
Cerealia indet., rachis segment												
Hordeum vulgare												1,8
Triticum aestivum s.l.												
Triticum durum s.str.												
Triticum dicoccum												976,8
Triticum monococcum												
Triticum cf. spelta												31,9

Archaeological period	LN I	LN I	LN I	LN I	LN I	LN II	LN II	LN II	LN II	LN II
cal BCE	2200 – 2150	2150 – 2100	2100 – 2050	2050 – 2000	2000 – 1950	1950 – 1900	1900 – 1850	1850 – 1800	1800 – 1750	1750 – 1700
Crop seeds and fruits										
Papaver somniferum x 10										
Linum usitatissimum x 10										
Triticum cf. *spelta*	261	261	261	261	261	27	27	27	27	27
Triticum aestivum s.l.	486	486	486	486	486	486	486	486	486	486
Triticum monococcum	23	23	23	23	23	2	2	2	2	2
Hordeum vulgare, hulled	17	17	17	17	17	13	13	13	13	13
Hordeum vulgare var. *nudum*	171	171	171	171	171	112	112	112	112	112
Triticum dicoccum	860	860	860	860	860	154	154	154	154	154
Threshing remains										
Cerealia indet., culm fragment										
Cerealia indet., glume fragment										
Cerealia indet., rachis segment										
Hordeum vulgare	1,8	1,8	1,8	1,8	1,8	1,5	1,5	1,5	1,5	1,5
Triticum aestivum s.l.										
Triticum durum s.str.						0,2	0,2	0,2	0,2	0,2
Triticum dicoccum	976,8	976,8	976,8	976,8	976,8	88,4	88,4	88,4	88,4	88,4
Triticum monococcum										
Triticum cf. spelta	31,9	31,9	31,9	31,9	31,9	1,9	1,9	1,9	1,9	1,9

Table 3 Absolute data for Figs. 2 and 3, aoristic approach. Diachronic perspective on the Neolithic crops in northern Germany, 4,000–1,700 calBCE.

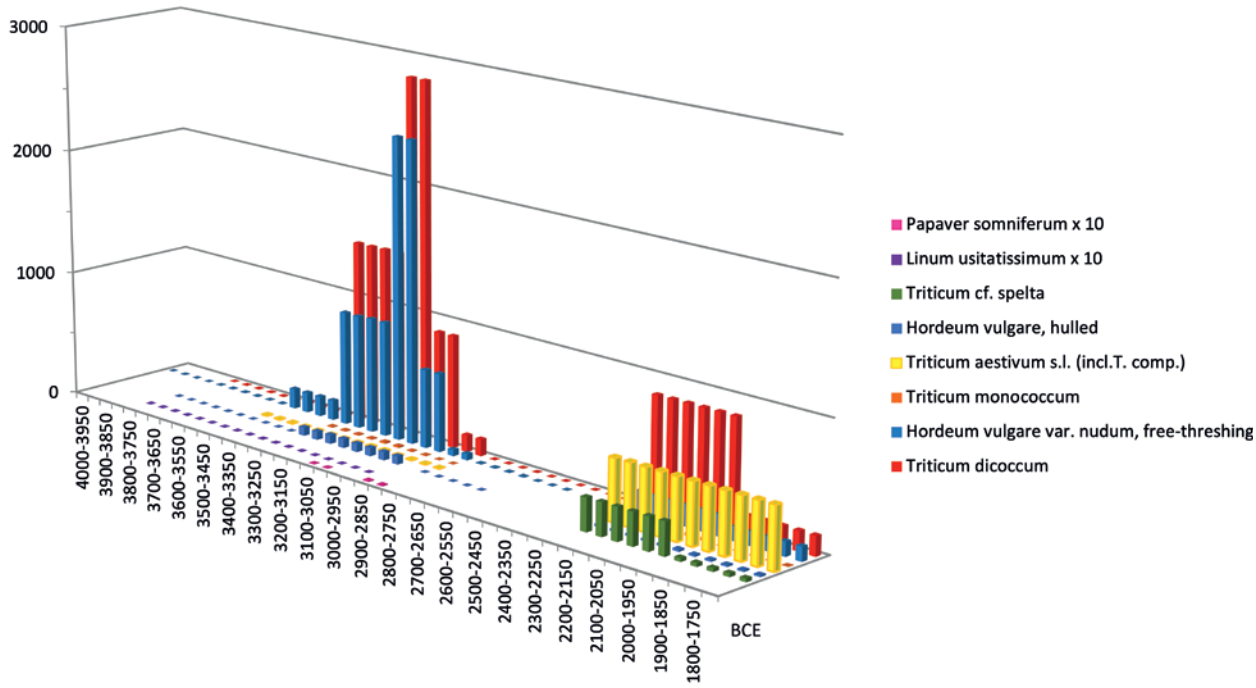

Fig. 2 Diachronic perspective on the Neolithic crops in northern Germany, 4,000–1,700 calBCE: cereals and oil plants (data as listed in Table 1. Note that the hulled variety of barley is only identified at one FBC site (Flögeln) – all other FBC sites show the free-threshing variety of barley.).

tive on the data, calculating the species relevance in 50-year time slices for the period 4,000–1,700 calBCE (Fig. 2). The aoristic method is used successfully in criminological studies to calculate the probability that an event took place in a certain period (Ratcliffe / McCullagh 1998; Ratcliffe 2000; 2002). Eventually, longer periods of, for example, occupancy of sites are subdivided into 100-year steps or 50-year steps and result in a uniform statistical distribution of the probabilities of the individual objects and monuments (Mischka 2004; Müller 2015).

Only cereal grains definitely identified to species level are recorded, except for the identification of *Triticum* cf. *spelta*. For barley, we differentiate between *Hordeum vulgare*, the hulled variety, and *Hordeum vulgare* var. *nudum*, which is the free-threshing one. Within the area of the Funnel Beaker culture the hulled variety of barley is only identified at the site of Flögeln with numerous findings (Behre / Kučan 1994). All other Funnel Beaker sites show evidence for the free-threshing variety of barley, *Hordeum vulgare* var. *nudum*. It would be worth re-visiting the Flögeln barley to verify if this is simply a matter of different use of nomenclature, or if the Flögeln barley grains indeed show the distinct impressions from glumes and glume remains sticking to the grain surface.

Results

Diachronic perspective on cereals and oil plants in northern Germany, 4,000–1,700 calBCE

The overall picture of the northern German plant assemblages shows clear differences between two periods (Figs. 2–3). The crop assemblages from the Early to Younger Neolithic (4,000–2,250 calBCE) are dominated by two main cereals, emmer (*Triticum dicoccum*) and barley (*Hordeum vulgare*). For these periods, socio-cultural changes have only a minor impact on preferences in nutrition and plant economy. In contrast, the Late Neolithic (2,250–1,700 calBCE) crop assemblage is clearly different from the previous time, since two new cereal species, spelt (*Triticum* cf. *spelta*) and free-threshing wheat (*T. aestivum* s.l.), gain relevance and widen the cereal spectrum.

In the narrow crop assemblage of the Early Neolithic I (4,000–3,500 calBCE), with only marginal evidence for the Early Neolithic Ia and the main data belonging to the Early Neolithic Ib, emmer and barley show equal shares. In addition, the oil and fibre plant linseed/flax is present. When oil rich seeds get in contact with fire, they usually immediately burn to ash. The probability for the preservation of oil-rich

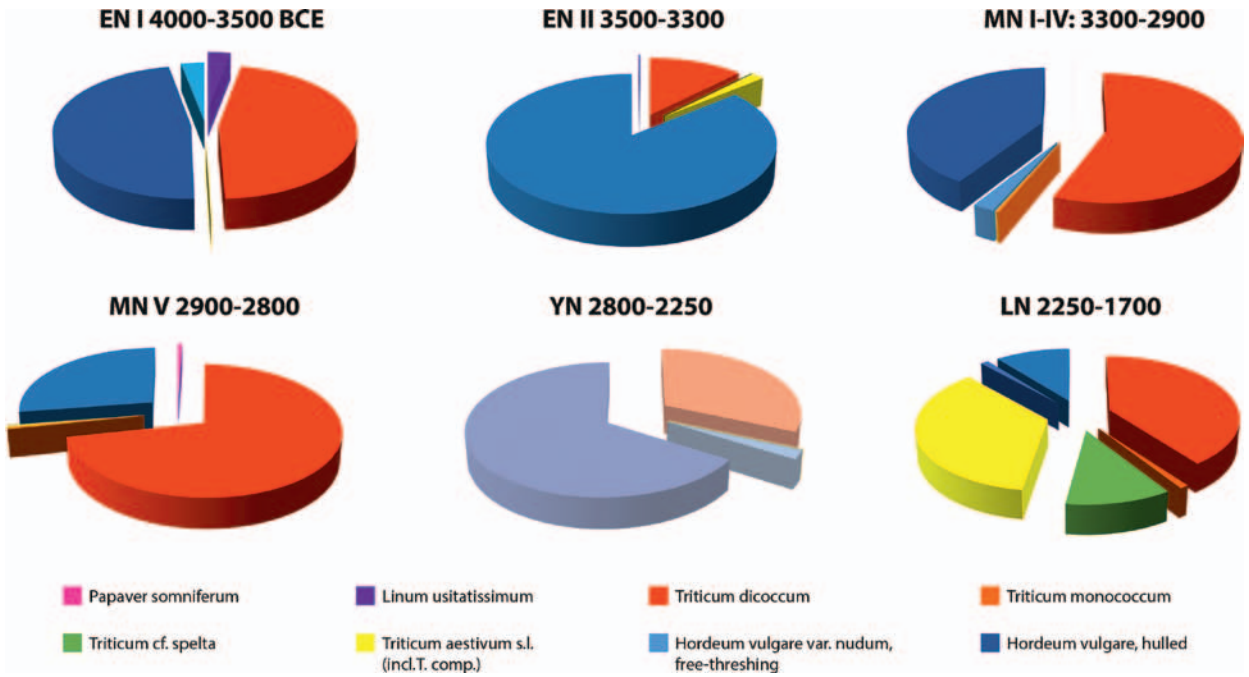

Fig. 3 The Neolithic crop assemblages in northern Germany in six archaeological periods between 4,000–1,700 calBCE (data as listed in Table 1. Note that the hulled variety of barley is only identified at one FBC site (Flögeln) – all other FBC sites show the free-threshing variety of barley.).

seeds in charred conditions is extremely low. The linseed/flax finds from Rastorf 6a/c included here – although low in absolute find numbers – are to be considered as evidence for a fully-fledged cultivation of the species. The charred seeds originate from a pit fill with an extraordinary texture that is described in the excavation report as 'greasy' (Steffens 2009), a texture that most probably reflects the burning of a linseed assemblage or storage (Kirleis 2019a, 79). In the Early Neolithic II (3,500–3,300 calBCE) free-threshing barley predominates over emmer, but together both remain the dominant cereal species. For emmer, there are numerous additional findings of chaff indicating emmer processing activities. Barley and emmer are supplemented by minor contributions of free-threshing wheat (*T. aestivum* s.l.) and linseed. The Middle Neolithic (MN) I–IV (3,300–2,900 calBCE) again shows emmer and free-threshing barley as the main cultivars, with emmer dominating this time. The cereal spectrum is supplemented by minor contributions of einkorn and free-threshing wheat. Among the numerous threshing remains there are single glumes, possibly from spelt (*Triticum* cf. *spelta*), originating from the site Göhl LA142. Single finds of linseed/flax and opium poppy seeds (*Papaver somniferum*), both from the site of Oldenburg LA77, indicate the oil plants. The charred plant assemblage of the short period of MN V (2,900–2,800 calBCE) resembles the composition of the MN I–IV. Emmer and free-threshing barley comprise the main cereal components, with emmer dominating, as supported by numerous finds of glume bases. Single finds of einkorn, free-threshing wheat – the latter at site Wangels LA505 identifiable as *T. turgidum/durum* (Kirleis 2019a, 128) – and opium poppy supplement the crop spectrum. Data for the plant assemblages of the Younger Neolithic (2,800–2,250 calBCE) are extremely sparse and hardly reliable. The assemblage consists of barley and emmer, the main components thus similar to those of the preceding periods. A sound database for the Late Neolithic (2,250–1,700 calBCE) reveals clear changes in crop cultivation. A diversification of domesticates is observable. Now four species, emmer, free-threshing wheat (including *T. turgidum/durum*), spelt, and free-threshing barley, are the main cereals, supplemented by einkorn and hulled barley.

Diachronic perspective on the tradition of plant gathering in northern Germany, 4,000–1,700 calBCE: gathered plants versus cultivars

The relevance of gathered plants in the northern German Neolithic in a diachronic perspective is depicted as z-scores of the ratio of gathered plants/crops (Fig. 4). A wide definition is used for gathered plants, including next to the common important

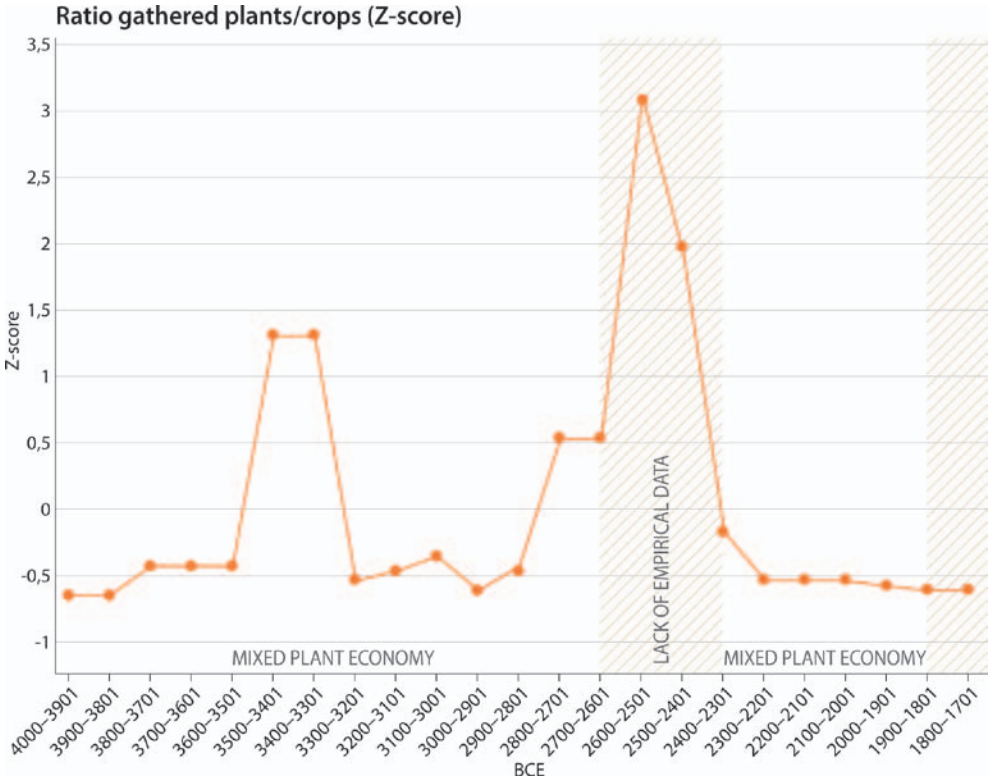

Fig. 4 Diachronic perspective on the tradition of plant gathering. Ratio of gathered plants/crops (z-score standardization, after Kirleis 2019b, 465, fig. 3).

staples such as hazelnuts, berries or crab apples with high caloric impact, as well such wild plants and weedy herbs – like white goosefoot – that provide edible fruits and seeds. The graph shows that a mixed plant economy was applied throughout the Neolithic, and this to variable extent. Interestingly, the Early Neolithic II (3,500–3,300 calBCE) was the phase with the highest relevance of plant gathering, a phase when crop cultivation was consolidated as a second mainstay alongside animal husbandry and hunting game. There were multiple reasons for integrating wild plants into the subsistence in Neolithic societies. First of all, it is a strategy of diversification that increases food security and provides an extra supply of additional nutrients and special flavours. Next to such economic and dietary reasons, gathered plants played an important role in the ritual sphere of Neolithic societies and are often overrepresented in burial contexts (Kirleis / Klooss 2014). That Neolithic ways of life included foraging traditions to a variable extent is not only shown in the use of plants, but also in the hunting of game.[3]

Diachronic perspective on subsistence strategies in northern Germany, 4,000–1,700 calBCE: intensive versus extensive cultivation

Subsistence regimes can follow different types of cultivation strategies. Two main strategies, intensive and extensive cultivation (Fig. 5), can be inferred for prehistoric crop cultivation (Van der Veen 2005). In order to identify past human activities and to gain an understanding of social organisation, it is crucial to define the cultivation strategies with utmost clarity and to bring into focus the farmers' investment. Thus, labour input, among the several, often interrelated aspects, is decisive in defining intensive and

	Intensive cultivation	Extensive cultivation
Labour input per area	high	low
Yield per area	high	low
Yield per person	low	high
Example	Small scale cultivation, gardening	Large arable fields, shifting cultivation
Archaeobotanical indication	Dominant annual weeds	Dominant perennial weeds
Archaeological indication (material culture)	Digging stick / hoe	Animal draught ard

Fig. 5 Characteristics for intensive and extensive cultivation strategies (after van der Veen 2005).

3 Steffens 2005; Hinz 2018; Brozio et al. 2019a; Knitter et al. 2019.

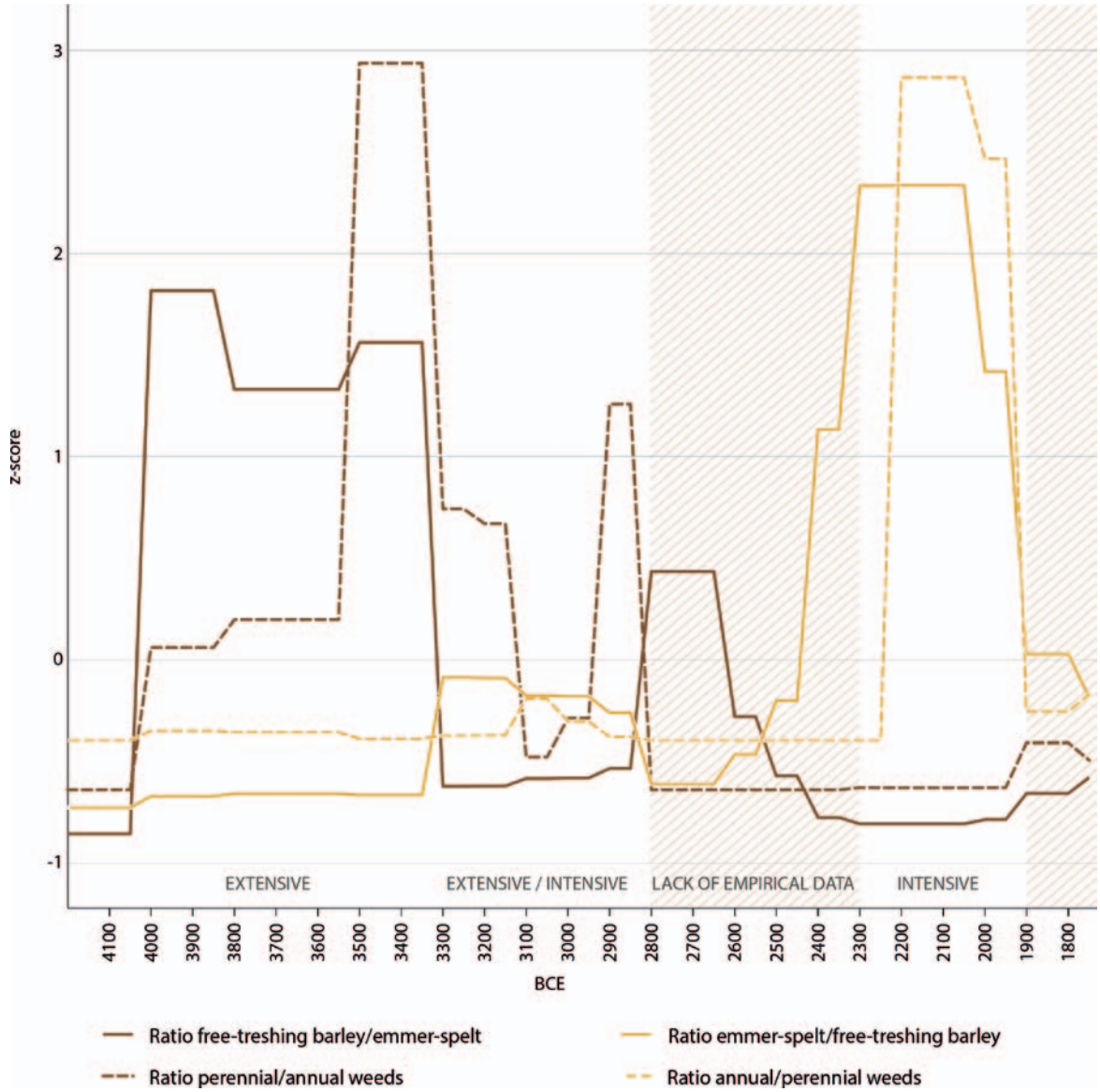

Fig. 6 Diachronic perspective on cultivation strategies in northern Germany, 4,000 – 1,700 calBCE (after Brozio et al. 2019a, fig. 4).

extensive cultivation strategies. This is in contrast to a definition relating to palaeo-ecological reconstructions that often refers to consolidated agriculture – as proven by large-scale woodland opening – as 'intensified' agriculture. This nomenclature is misleading and should be avoided, since the large-scale woodland opening – seen from the work force perspective – goes along with the application of extensive cultivation strategies on expanded arable fields.

Intensive cultivation is characterised by high labour input per area, the yield per area is high, but the yield per person is low. This cultivation strategy applies for small-scale cultivation on garden-like plots. In contrast, extensive cultivation builds upon low labour input per unit of arable land, low yields per area, but accounts for high yields per person. Extensive cultivation strategies are practised on large arable fields as well as in shifting cultivation.

Specific tools and technologies are used for either strategy. Intensive crop growing is carried out with the digging stick and the hoe, often as a collective activity (Kirleis 2019b). In the archaeological record, both tools are rarely encountered. Traces indicating the possible use of a digging stick were unearthed only in a Swifterbant context in the Netherlands, dating to the second half of the 5th millennium calBCE (Huisman / Raemaekers 2014). Extensive crop cultivation is mainly carried out with the ard, a simple plough that scratches the soil before seeding, invented in the 4th millennium calBCE. Earliest ard marks on Fyn, Denmark, date to about 3,700 calBCE; they are commonly preserved below megalithic tombs that were erected between

3,600 and 3200 calBCE (Beck 2014; Müller 2014; Sørensen / Karg 2014). The 'boom' of ard marks directly predates the erection of megalithic tombs (Mischka 2013). It is often overlooked but important that the ard is a tool that can be pulled either by humans or by draught animals. To differentiate both, systematic measurements of the depth of ard marks are a desideratum that might reveal the depth of ground penetration which supposedly is deeper when animal traction was applied. To date, animal traction is proven to have taken place on a regular basis only since the Middle Neolithic, i. e. from 3,300 calBCE onwards (Johannsen 2006). The full adoption of animal traction for plowing coincides with the introduction of wheel and wagon or cart in the mid 4th millennium calBCE, another technological innovation that accounts for animal traction (Mischka 2011; Klimscha 2017; Klimscha / Neumann this volume).

From an archaeobotanical point of view, the documented weed spectrum allows for the identification of differences in the subsistence regime. The weeds can be grouped into annual and perennial species, each linked with a variable degree of disturbance and thus a specific mode of arable practice. The occurrence of annual weeds is linked with a high disturbance regime, intensive earthwork and weeding. In contrast, the perennial weed species dominate in cultivation regimes that are managed extensively, e. g. with the ard, just scratching furrows in the ground for seeding, leaving undisturbed patches between the ard marks and later rows of plants.

To infer tendencies in crop management strategies regarding intensive versus extensive cultivation in the northern German Neolithic and how it relates to specific crop plants, the ratios of emmer plus spelt/free-threshing barley and annual/perennial weeds are calculated (Brozio et al. 2019a). For the periods 4,000–2,800 and 2,250–1,900 calBCE, sound background data on cereal and weed seeds and fruits are available. They show that the ratio of free-threshing barley/emmer-spelt for the Early Neolithic period (4,000–3,300 calBCE) is linked with the ratio of perennial to annual weeds, indicating that in this period in particular free-threshing barley may have been grown extensively (Fig. 6). However, emmer and annual weeds are present as well and show that intensive crop growing was a complimentary part of the agricultural system. In contrast, for the Late Neolithic period (here: 2,250–1,900 calBCE) the ratio of emmer-spelt/free-threshing barley matches the ratio of annual to perennial weeds. Since annual weeds dominate, it can be assumed that intensive agriculture was the practice applied to emmer and gained even more importance when spelt entered the crop spectrum in the Late Neolithic. The Middle Neolithic (3,300–2,800 calBCE) is a period with more or less balanced extensive and intensive agricultural practices.

Informed crop cultivation: adaptation to plant traits and ecological niches

The Neolithic dwellers lived in a widely forested environment (Feeser et al. 2019; Knitter et al. 2019) with small-scale clearings for farmsteads. Further opening of the dense woodland cover was triggered by livestock browsing in the vicinity of the farmsteads, thus facilitating the establishment of plots for crop cultivation. While cultivation on freshly cleared plots is highly beneficial with respect to plant nutrients, depletion of soils becomes relevant if plots are periodically under cultivation (Schier et al. 2013). It is assumed that intensive garden plots were in use over long time periods over the course of the Neolithic, possibly for several generations. The recurrent crop cultivation on the same plots changed the soil properties. Intensive use and biomass removal by harvesting of crops may have led to a severe leaching of soils, accounting for the application of manure to sustain high yields. The stable isotopic composition of cereal grains can indicate the use of livestock manure and hint at water management strategies that enhance crop yields. Whether or not manuring was implemented as a cultivation strategy in the northern German Neolithic, is currently being investigated.

First results from stable isotope studies applied on charred material from the northern German site Oldenburg LA77, distr. Holstein, have shown a high degree of variation (Filipović et al. 2019a). Crab apple provides a signal of natural soils with $\delta^{15}N$ values below any manuring regime (Fig. 7). The emmer grains group with consistent values in the range of natural soils and a low level of manuring (resulting in $\delta^{15}N$ values between 3–6 ‰). The individual grains of barley however show a high variety in the range of $\delta^{15}N$ values. This may be explained by differences in the incorporation of nitrogen in the living plant, or taphonomic reasons, like the effects of charring and the state of grain preservation. The narrow range of emmer $\delta^{15}N$ values, when compared with barley, might also be interpreted as a consequence of stable growing conditions for emmer, with cultivation on similar plots and consistent treatment, perhaps in the dry upland zone near to the settlement. The high degree of variation in barley may, in contrast, reflect the wide ecological amplitude of this species, regardless of the presence/absence of manuring, that allows for success-

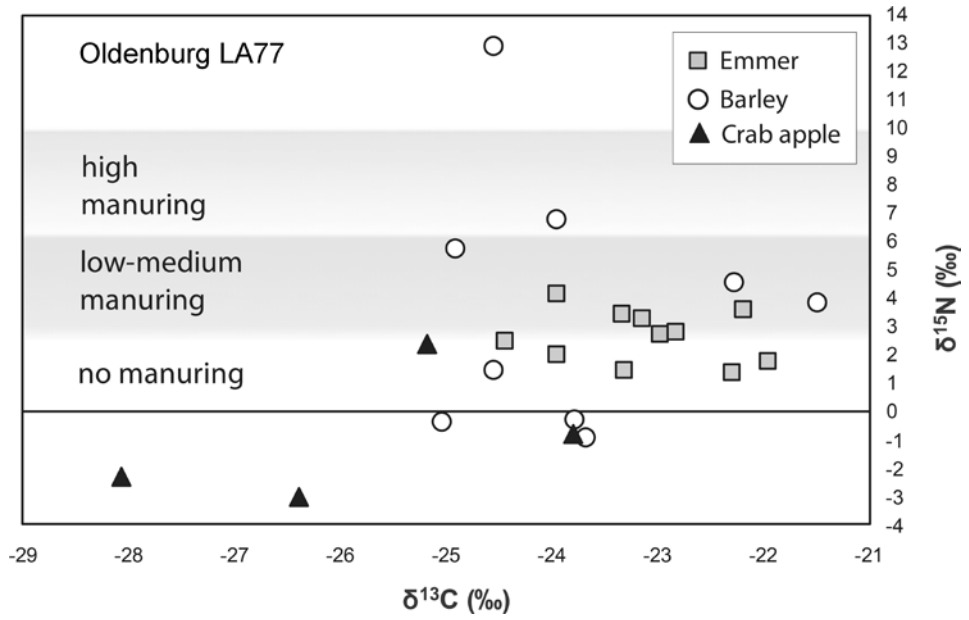

Fig. 7 Stable carbon and nitrogen isotope measurements on plant remains from the site Oldenburg LA77 (after Filipović et al. 2019a, fig. 7).

ful cultivation on different plots including those with poor soil properties (e.g. Klassen 2005). Furthermore, archaeological contexts affect the signals; a high input of manure was deduced in cereal grains deposited at domestic sites, while cereal deposits at ritual sites revealed non-manuring signals (Bogaard et al. 2013; Kanstrup et al. 2014; Styring et al. 2016).

The $\delta^{13}C$ values for most of the emmer and barley samples at Oldenburg LA77 fall into a range that indicates a well-balanced hydrological regime. This can be expected in a temperate zone, which fits with the situation of site Oldenburg LA77 in the Oldenburger Graben, a wetland area with tiny islands that was cut off from direct access to the Baltic Sea during the Middle Neolithic (Filipović et al. 2019a; b).

To sum up, emmer and barley may have been grown on soils of different quality and moisture status in the vicinity of the site Oldenburg LA77. The emmer cultivation plots received perhaps greater care, whereas barley cultivation may have been less intensive, or less demanding than that of emmer, and it was therefore grown on any ground, spreading out into areas less suitable for emmer cultivation. An in-depth knowledge of Neolithic farmers about environmental conditions as well as crop traits and needs might entail such an adaptation to local conditions. The application of manure varied over time and space. The data from the Oldenburg LA77 site fit nicely with the reported nitrogen values for emmer and barley grains from Neolithic sites in southern Scandinavia that range from between unmanured and low to medium manuring regimes (Bogaard et al. 2013; Gron et al. 2017). The values for the Neolithic are far lower than values that have been reported for barley and emmer from several Bronze Age sites in the Netherlands, where increased $\delta^{15}N$ values reached above 6 ‰ (Bakels 2018). This indicates that the maintenance of soil fertility was not a focal point of Neolithic cultivation strategies, but became relevant when animal husbandry gained further importance in the Bronze Age and animal dung was a widely available resource.

Summarising diachronic developments in northern German Neolithic crop cultivation

The cereal spectrum in northern Germany in the Funnel Beaker period (4,000–2,800 calBCE) is narrow. It comprises free-threshing barley and emmer as the main crops; einkorn and free-threshing wheat occur as minor components only, and whether they were intentionally cultivated or a random admixture remains unclear. From the Early Neolithic onwards, the cereals are accompanied by the oil plant linseed/flax, and from the Middle Neolithic by opium poppy as well. Towards the Late Neolithic a drastic change occurs. The number of main cereal staples is doubled. Now four cereal species become main staples: emmer, barley, spelt, and free-threshing wheat. In particular, the newcomer spelt indicates new exchange networks (Effenberger 2017; 2018). Gathered plants accompany the cultivars throughout the Neolithic, but to a varied extent. The overall picture for the northern German Neolithic shows a diversification of plant use over time, a widening of the plant components relevant for economy and diet that reaches its highest diversity in the Late Neolithic.

A similar picture arises when looking into agrarian strategies. Stable isotope analyses show an elaborate treatment of the different cultivars: no massive manuring, but directed care for such species that were esteemed valuable. The spectrum of cultivation technologies widened during the Neolithic when the ard was introduced (cf. also Klimscha / Neumann this volume). An animal-drawn ard allows for tilling large fields. Our investigations show that this new technology of extensive cultivation on large arable fields did not take over, but complemented already consolidated horticulture strategies, whereever suitable and beneficial. Intensive crop cultivation by use of the hoe continued on small garden-like plots. The opening of woodlands can be traced in the regional pollen records and indicates the enlargement of arable fields, most probably by means of extensive cultivation, but near-site and on-site archaeobotanical studies are necessary to give a complete picture, highlighting plant gathering and the continued small-scale cultivation practices (Feeser et al. 2012; Feeser / Dörfler 2015; Kirleis 2019a).

To sum up, the diachronic development of crop cultivation in the northern German Neolithic shows one main pattern: It is the pattern of diversification that applies for the cultivars as well as for the socio-technological management of crop cultivation. The early Neolithic starts off with a narrow spectrum of crops that is widened towards the Late Neolithic and all the way through accompanied by gathered plants to a variable extent. The cultivation strategies applied can be described as a modular system. The first farmers grew their crops on small plots. With the invention of the animal-drawn ard, large arable fields as a new module supplement the widely consolidated crop cultivation on garden-like plots. Plant gathering may even have benefitted from the large-scale woodland opening, since the number of woodland edges increased. Woodland edges are the favourable habitat of many of the gathered plants, such as crab apple, hazel or blackberry. Resource availability was most probably amplified (Kirleis 2018).

Discussion

Subsistence change in the archaeological context of the northern German Neolithic

For the northern Neolithic, a stepwise adoption of subsistence strategies is indicated (Hartz et al. 2007; Sørensen 2014; Kirleis 2019b). In the subsistence of Early Neolithic groups in southern Scandinavia as well as in northern Germany domestic animals, next to game, played an important role. The adoption of animal husbandry indicates the commencement of farmers' activities, with pastoral activities contributing to the opening of the woodland canopy (Hartz et al. 2007; Feeser / Dörfler 2019a). The woodland opening was further triggered by direct human activities, i. e. the foundation of farmsteads, but also ritual sites with different expressions of monumentality. Such open areas in the densely forested environment served as main precondition for crop cultivation based on free-threshing barley and emmer in northern Germany. From joint palaeo-ecological and archaeological studies it is already known that the phase of the highest intensity of monument building activities and the highest rate of land opening overlap (Feeser / Furholt 2014; Müller 2019). Particularly during the Funnel Beaker period, economic and ritual activities were closely interrelated (Brozio et al. 2019a). Palynological investigations show that the megalithic tombs in the northern and western Funnel Beaker region were often erected on former arable land and former settled areas. In particular, clumped pollen grains of cereals, ribwort plantain, and wild grasses, often together with ard marks, prove local cereal cultivation in the Early Neolithic (Feeser / Dörfler 2019b). The first consolidation of an economic and cultural landscape is expressed by a massive, relatively stable openness in the landscape and by intensive monument building, especially from 3,600 to 3,200 calBCE (Müller 2019). It reflects a newly established economic system that was now, next to animal husbandry, building on cereal cultivation as a second important pillar of subsistence economy, with the growing of free-threshing barley and emmer. The agrarian technological innovations (ploughing with the ard, the use of draught animals) widened the arable practices applied. Extensive cultivation strategies complemented intensive crop growing and show that diversified cultivation techniques were established from 3,300 calBCE onwards. The crop spectrum, however, remained basically the same all throughout the Early and Middle Neolithic, with emmer and barley as the main cultivars. This also accounts for the MN V that is archaeologically characterised by the 'Store Valby phenomenon', which is now interpreted as expressing socio-cultural changes in the area of the Cimbrian Peninsula / southern Scandinavia, with Funnel Beaker societies declining, while at the same time the rise of the Globular Amphora phenomenon with its own coarse ware, axe and adze types, as well as cattle burials is observed (Brozio et al. 2019c). From an archaeobotanical

point of view, it is noteworthy that there are continued indications for the cultivation of opium poppy, and that – for the first time in northern Germany – there is evidence of grains from the tetraploid variety of free-threshing wheat *Triticum durum/turgidum* in a domestic context at the MN V site Wangels LA505.

The phenomenon of the Younger Neolithic Single Grave culture groups developed with a low spatial representation of domestic sites, with their own forms of social organisation and their own symbols that are expressed in a new monumental boom (Brozio 2019a). The Younger Neolithic subsistence economy is perceived as primarily relying on animal husbandry, the plant component being difficult to trace. But the sparse evidence for cereal cultivation shows a continuation of previous traditions, with cultivation strategies being adapted to specific environmental constraints when necessary (Klassen 2005). This is in contrast to the Late Neolithic period, beginning around 2,250 calBCE, when an emphasis is placed on intensive crop cultivation strategies and new specific storage systems. The pattern of diversification in subsistence economy becomes evident. It finds its expression in a wider crop spectrum and in new subsistence management strategies, indicating possibly new networks, wherein spelt and hulled barley are encountered as new cultivars, and the cultivation of free-threshing wheat is consolidated (Effenberger 2017; 2018). At the same time, massive changes in the archaeological record concern the declining relevance of monuments, which are replaced by high deposition rates of status symbols in the form of flint daggers and metal objects, reflecting supra-regional metallurgy exchange systems (Klassen 2004; Vandkilde 2017). The new Late Neolithic economic growth features a strong plant component. It is reflected in a highly variable, but strongly increasing human impact on the environment with maximal indications for soil erosion around 1,900 calBCE, with the transformations further influenced by a regional abrupt cooling event that is evidenced in the Skagerrak palaeo-climatological records (Butruille et al. 2017; Brozio 2019a).

Comparison of the diachronic developments in crop cultivation in the southern Scandinavian and northern German Neolithic

The diachronic development of crop cultivation in the northern German Neolithic, as presented in this paper, is characterised by the pattern of diversification in the crop spectrum as well as seen in the socio-technological management of crop cultivation. The onset of crop cultivation started with a narrow set of main cultivars, namely free-threshing barley and emmer. This cereal assemblage is then widened with an off-set of about 1,500 years into the Late Neolithic when spelt and free-threshing wheat become two additional main staples. If we compare this regional picture with data from southern Scandinavia, in particular from southern Sweden, but also from Denmark (as compiled by Kirleis / Fischer 2014, fig. 6), a different pattern is observed. The crop spectra of the sites Almhov, Kvärlöv, Hjulberga, Limensgård, and Frydenlund show a notable contribution of free-threshing wheat as early as in the Early Neolithic I. Based on this compilation, it is concluded that the finds of free-threshing wheat support the scenario of a chronological separation of different agricultural systems that were implemented within different Funnel Beaker phases. The evidence for tetraploid free-threshing wheat shows that the tradition of the early Funnel Beaker groups is linked to southwestern agricultural developments, for example, of the Michelsberg culture. In southern Scandinavia, the Early Neolithic I shows a substantial cereal spectrum with emmer, barley, and free-threshing wheat as main staples. It is separated from the agricultural system of the Middle to Late Neolithic that built upon a standardised narrow cereal spectrum with only barley and emmer as main staples. The change was supported by the introduction of the new ard technology during the late Early/Middle Neolithic transition. The ard was most probably in use on a regular basis with a draught animal system since the Middle Neolithic (Johannsen 2006). The standardised narrow cultivar package, combined with extensive cultivation strategies, may have allowed for surplus production and at the same time furthered population growth. Such agricultural change most likely mirrors transformations in the organisation of Funnel Beaker societies, with a new burial attitude emerging, in connection with intensive monument building about 3,600–3,200 calBCE that required increased labour input.

The different phasing of agricultural systems in the Funnel Beaker period as described in Kirleis and Fischer (2014) remains valid, but when compared with the improved evidence for northern Germany, it has to be seen as a specific regional expression for the onset of crop cultivation in southern Scandinavia. In contrast, cereal cultivation in northern German Funnel Beaker groups focused on barley and emmer from the beginning. Free-threshing wheat was known as well, but did not become a main staple food until the Late Neolithic.

A modular system of subsistence management after 4,000 calBCE – an archaeobotanical perspective

The neolithisation (in an economic sense) in northern Germany is seen as a process of adaptation that lasted for several generations; it is considered a slow and gradual sequence of changes towards agrarian subsistence. The introduction of domestic animals and crop cultivation took place between 4,000–3,700 calBCE. However, culinary practices that originated in pre-agricultural societies continued (Hinz 2018; Kirleis 2019b). This accounts for wild plants and wild terrestrial animals and is further indicated in the stable isotope records from samples of human remains ($^{13}C/^{15}N$) from northern central Europe, showing the importance of aquatic food ressources far into the 4th millennium calBCE (Terberger et al. 2018). With respect to wild plant consumption, both individual and cultural preferences will have played a role. Moreover, edible wild plants provide nutrients, vitamins and minerals in high concentrations. Wild plant use implies subsistence diversification as a strategy for risk-management (Jacomet / Schibler 2010, 116). For the Neolithic in northern Germany, a modular system of subsistence management is suggested, where multiple plant use practices co-exist to variable extent. Farming and plant gathering are identified as the main activities. The gathering of plants can even be incorporated into farming activities, e. g. as a family task, when fruits are gathered as 'by-products' on the way to remote arable fields.

Conclusion

Plant economy is discussed for the northern German Neolithic, with emphasis on the period from 4,000–1,700 calBCE. Based on data from the plant assemblages from 21 sites, three main topics occur that characterise the plant-based subsistence economy:

In a diachronic perspective, a diversification can be observed in multiple aspects of plant economy. The transition towards sedentary ways of life goes along with a widening of subsistence strategies. With respect to plant economy, plant gathering was supplemented by crop cultivation carried using a multitude of different strategies. Plant economy as such was organised alongside different modules, including plant gathering, (labour) intensive and extensive crop cultivation, with adaptation to specific environmental constraints and specific needs of individual plant species. Each module had a variable relevance throughout time and space and was influenced by technological and cultural innovations. Furthermore, when looking into the crop spectrum, Funnel Beaker groups, and possibly also Single Grave groups, had a narrow set of cultivars, building upon two main staples, barley and emmer. Only in the Late Neolithic the crop spectrum widened, and emmer, barley, spelt, and free-threshing wheat comprised the cereals that served as main plant staples then.

While a diversification in the crop spectrum from the Early towards the Late Neolithic can be observed for the northern German Neolithic, an opposed trend is visible for southern Scandinavia. Thus, the Funnel Beaker plant economy shows clear regional differentiation.

The neolithisation from an economic perspective can be described as a 'growing together' of multiple arrays of food supply strategies. There is no strict division into either a Mesolithic or a Neolithic way of life observable in the diet after 4,000 calBCE. Instead, Neolithic subsistence economy was organised as a modular system, combining multiple methods of food acquisition, the relevance of each component underlying a non-linear fluctuation. The contribution of wild resources depended on availability in specific ecological niches, and on cultural preferences.

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Neolithic landscape under the bog – new investigations in the Ahlen-Falkenberger Moor, dist. Cuxhaven, Germany

Anja Behrens, Moritz Mennenga, Steffen Wolters and Martina Karle

Abstract The neolithisation process in northern Lower-Saxony (4,000 – 3,500 calBC) is still not very well understood, as there are hardly any known sites from this time period. This is due to, on the one hand, an intense bog growth, commencing c. 7,000 calBC and covering vast areas of the coastal region, concealing especially the late Mesolithic and Neolithic cultural landscape. On the other hand, preservation conditions in the dry and sandy Pleistocene ground are rather poor. Only few Neolithic settlements and almost no Mesolithic features have been found so far, and undisturbed structures are rare. As the cultural developments in northern Lower-Saxony in the 4th millennium calBC are diverse (and still need to be untangled in the Elbe-Weser triangle), this is very unfortunate. However, as an exception to these conditions, continuous bog drainage over the last 100 years and the resulting severe desiccation of peat have partly revealed a hidden Funnel Beaker culture landscape in the Ahlen-Falkenberger Moor north of Bad Bederkesa, dist. Cuxhaven. This particularly rich 'time capsule' is currently examined within the new project 'Preserved in the Bog', which seeks to uncover Funnel Beaker culture relics in the peat through a large-scale examination of the bog area. Based on the combination of archaeological, botanical and geological methods, the project aims to reconstruct the landscape development during the Funnel Beaker period – a period with a sharp rise of sea as well as bog level – and to evaluate environmental impacts affecting the Neolithic societies as well as the other way around. This approach also allows to draw further important conclusions about cultural processes in Lower Saxony during that period.

Keywords Neolithisation, Elbe-Weser triangle, bog landscape, Funnel Beaker culture, state of preservation, geomagnetic survey, landscape development, megalithic graves, settlements

Zusammenfassung *Die Neolithisierung in Niedersachsen (4000 – 3500 v. Chr.) lässt sich nach heutigem Forschungsstand kaum nachvollziehen, da Fundstellen aus dieser Zeit weitgehend fehlen. Einerseits ist dies auf ein flächenhaftes Moorwachstum zurückzuführen, welches ab dem 7. Jahrtausend v. Chr. bis in die Eisenzeit weite Küstenbereiche und somit vor allem mesolithische und neolithische Landschaften verdeckte. Zum anderen sind die Erhaltungsbedingungen in den zugänglichen sandigen Geestgebieten schlecht, so dass nur wenige Fundstellen und zudem kaum ungestörte Befunde bekannt sind. Dies ist besonders bedauernswert, da die kulturellen Entwicklungen in Niedersachsen im 4. Jahrtausend v. Chr. sehr vielfältig gewesen sein müssen und es Strukturen sowie Vernetzungen noch zu entschlüsseln gilt. Hier kommt dem Ahlen-Falkenberger Moor, nördlich von Bad Bederkesa, Ldkr. Cuxhaven, gelegen, nun eine besondere Rolle zu, da aufgrund intensiver Drainagemaßnahmen der letzten 100 Jahre und der damit verbundenen Torfsackung eine erhaltene trichterbecherzeitliche Landschaft zu Tage tritt. Im Rahmen des Projektes "Relikte im Moor" werden diese besondere "Zeitkapsel" und damit das Gebiet selbst sowie die darin befindlichen Hinterlassenschaften der Trichterbecherkultur interdisziplinär untersucht. Basierend auf archäologischen, botanischen sowie geologischen Methoden ist es Ziel des Projektes, die Landschaftsentwicklung zur Zeit der Trichterbecherkultur zu rekonstruieren sowie Aussagen über die damals herrschenden Umwelteinflüsse und ihre Auswirkungen auf die Gesellschaften und umgekehrt zu treffen. Mit diesen Analysen sollen zudem wichtige Erkenntnisse zu den kulturellen Prozessen in Niedersachsen im 4. Jahrtausend v. Chr. ermöglicht werden.*

The Neolithic in northwestern Germany – state of research

During the early 4th millennium calBC, the Neolithic way of life began to emerge in northern central Europe. In the area of the Mesolithic hunters and gatherers of the Ertebølle culture, this transition came to its climax with the appearance and development of the Funnel Beaker culture (TRB). In the region of the present Netherlands and neighbouring areas, the neolithisation began with the adoption of agriculture and livestock farming already in the later phases of the Swifterbant culture (Ten Anscher 2015). There is evidence for close connections between the traditions in northwest Germany and the Netherlands during the Mesolithic (Mahlstedt 2015a, 150) as well as for the later TRB.[1] First traces of a defined Neolithic culture are present around 3,470 calBC (Mennenga 2017, 91–96). As there is hardly any evidence for the period between 3,900–3,400 calBC (Mahlstedt 2015b, 72; Mennenga 2017, 15–21), little is known about the changes of the human way of life between the rivers Elbe and Ems. Current interdisciplinary research on the changing lifestyle in northern central Europe is limited to the areas east (Terberger et al. 2018) and west (most recently: Raemaekers 2019) of northern Lower Saxony. However, palynological studies show that in northwestern Germany first anthropogenic impacts on the closed mixed oak forests are detectable around 4,000 calBC (Behre / Kučan 1994; Kramer / Bittmann 2015a, 103). For the successive centuries, the settlement indicators and the changes in tree pollen spectra imply small-scale arable farming in combination with forest pasture and pollarding (Behre 2001). During the period between 3,500 and 2,600 calBC, which coincided with the main phase of the erection of megalithic tombs (Müller 2011, 18), intensive human intervention in the environment caused an opening of the landscape (Behre / Kučan 1994; Kramer / Bittmann 2015a). On the other hand, the landscape was changing very much during the middle Neolithic – caused by a rise of sea as well as bog level which made large areas no longer usable as before (Behre 2005). Although this implied a shifting of habitation and cultivation to higher grounds, the continuous agricultural use from the Neolithic to the Common Era is well established in the Elbe-Weser triangle (Behre / Kučan 1994; Nösler / Wolters 2009).

1 Bakker 1979; 1992; Brindley 1986; for new research cf. Mennenga 2017; Lorenz 2018; Menne 2018.

The Elbe-Weser triangle – preservation of cultural material

The Elbe-Weser triangle represents an area of its own importance throughout nearly all (pre-)historical times, forming a zone of intense interactions between northern, western, and southern archaeological cultures. Evidence on cultural affiliations in the Mesolithic and early Neolithic is missing, as the archaeological record for this time in the region in particular is very poor (see below; cf. synopsis: Mahlstedt 2015b, 72–73).

Preservation conditions

The fragmentary record can be explained with the diverse landscape – a mosaic of Pleistocene plains ('Geest'), Holocene clay districts ('Marsch'), as well as bogs and fens – and its highly variable preservation conditions, for which the southern North Sea shore region is particularly well-known. This contrast becomes most clear when comparing the landscapes of clay districts and Pleistocene ground (detailed description: Behrens et al. 2019): Clay districts are commonly known for excellent organic preservation, allowing extensive conclusions to be drawn on former living conditions (Strahl 2004). However, access to archaeological deposits in this type of landscape depends on local accumulation rate and resulting coverage with marine sediments (Behre 2008). The neighbouring moraine ranges, on the other hand, are characterised by very poor preservation conditions due to their dry, aerated, lime-poor soils (Jacomet / Kreuz 1999). Still, many sites from all periods are known, but erosion and soil formation processes steadily diminish the archaeological record (cf. Schwank 2017). This is reflected by the state of Stone Age settlements. The Lower Saxony Institute for Historical Coastal Research (NIhK) carried out the latest investigations within the project 'Settlement and land use in Neolithic northwestern Germany', as part of the priority program (SPP) 1400 'Early monumentality and social differentiation', which was funded by the German Research Foundation (DFG). Regarding the conservation conditions, it was concluded that undisturbed cultural layers and features represent exceptions on Pleistocene ground (Mennenga 2017, 293–294).

Chances for the preservation of cultural remains are increased in areas where there is protection by covering layers of Medieval 'Eschboden' (plaggen soil overlays), colluvium or non-erosive clastic sediment deposits, and, last but not least, peat.

	Mesolithic	Neolithic (TRB)
Total number of sites	31	393 (133)
Burials	–	144 (101)
Settlements / camp sites	3	33 (7)

Table 1 Archaeological sites in the area between the rivers Geeste and Schwinge, as listed in the database of the State Agency for Cultural Heritage of Lower Saxony (ADABweb; report: November 2020). Surface finds in brackets.

The archaeobotanical and archaeological evidence

First Neolithic activities in the Elbe-Weser triangle are evident by palynological profiles from various micro-regions, including the Ahlen-Falkenberger Moor (Kramer / Bittmann 2015b, 442) and its surroundings, the Dorumer Moor in the north (Kramer

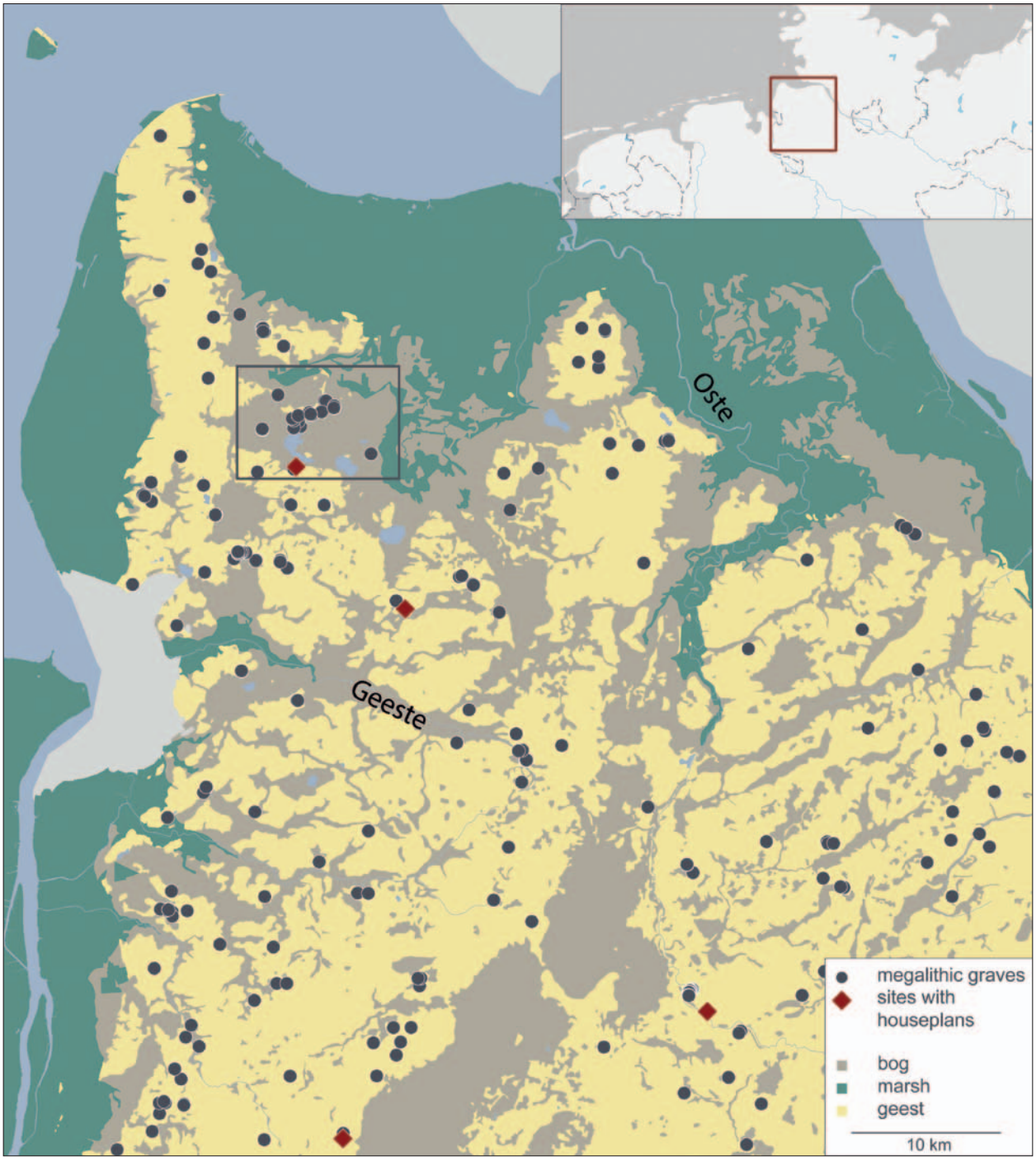

Fig. 1 The area of the Elbe-Weser triangle, with a map of megalithic tombs and Neolithic settlement sites. The black box on the left marks the study area, see Fig. 2 (graphics: M. Mennenga, NIhK; map basis: State Office for Mining, Energy and Geology Lower Saxony [LBEG], Hannover; soil landscapes scale 1: 50.000; mapping of megalithic tombs after data from the Lower Saxony Monument Database ADABweb and Fritsch et al. 2010; of settlements according to Mennenga 2017, 57).

et al. 2012), and the southern Swienskuhle (Behre / Kučan 1994; Kramer / Bittmann 2015a), all dist. Cuxhaven. A few archaeological traces from the Mesolithic are known in this region, excluding finds of early pottery (Metzger-Krahé 1977, 150–160), but in contrast many traces of Neolithic activities have been found in the areas of Wanna and Flögeln, both dist. Cuxhaven – but mostly as surface finds (Nösler et al. 2011; see Table 1). Only on the sites of Flögeln and Hainmühlen, dist. Cuxhaven, Lavenstedt, dist. Rotenburg (Wümme), and Pennigbüttel, dist. Osterholz, early resp. middle Neolithic building structures were found (Zimmermann 2001; Mennenga 2017; 2021). In general, cultural remains of the TRB are much more numerous compared to the Mesolithic record (Fig. 1).

The finds and features of the TRB within the Elbe-Weser triangle are generally assigned to the West Group (Midgley 1992) with its core area of distribution between the river Weser and the Ijsselmeer. Evidence for the development of agricultural practices is still scarce for this region, in particular for the Elbe-Weser triangle (cf. Mennenga 2017, 15–20). The most striking features in the landscape are the megalithic tombs, which were probably built between 3,400 and 3,200 calBC (Müller 2011, 39; Furholt / Mischka 2019, 934), though no ^{14}C dates are available so far for this region. In the area between the rivers Geeste and Oste different architectural styles appear. Beside a few extended dolmens and the supposed polygonal dolmen of Stintstedt, dist. Cuxhaven, passage graves with three to five capstones represent the dominant type (Sprockhoff 1975; Laux 1979, 65; 1991). External constructions around the chambers, such as clay or stone coverings, were observed several times (Sprockhoff / Siebs 1957, 8). So far, there are no further studies on the biographies of these monuments. According to F. Laux (1979, 80), there was – based on the deposits and their composition – only one brief phase of primary use, concluding that new graves were erected for subsequent funerals. However, this seems more doubtful in view of recent evidence for the periods of use of megalithic tombs spanning several centuries, e. g. in neighbouring western Lower Saxony (Menne 2018, 128), Schleswig-Holstein (Brozio 2016, 174–176), and the Altmark (Diers / Fritsch 2019).

In addition to the megalithic tombs, flat graves need to be listed, which also occur in settlement contexts (Kossian 2005, 309–319, Mennenga et al. 2013, van der Velde et al. 2019). Regarding the settlements itself, next to ground plans of houses only few other features are known. Within the above-mentioned SPP 1400, settlement structures could be re-evaluated and in most cases chronologically allocated using ^{14}C data (Mennenga 2017, 93–96). One of the best-known sites of the TRB is located on the sandy island of Flögeln (site Flögeln 48). In the 1970 s and 1980s, remains of three houses were documented there during excavations by the NIhK within the DFG project 'Development of a settlement micro-region [Siedlungskammer] in the Elbe-Weser triangle since the Neolithic' (summarised in Mennenga 2017; 2019). During this time of research the Ahlen-Falkenberger Moor in the north was still mostly regarded as no man's land for the Neolithic period. Over the past decades, however, it has become clear that a Neolithic landscape has been preserved in that area. Due to ongoing desiccation of peat, more and more megalithic graves of the TRB become visible. In order to access and document these magnificent archives, the NIhK started new investigations in 2019 (Behrens et al. 2019).

The Ahlen-Falkenberger Moor – a research history

The bog is located north of Bad Bederkesa, between the Pleistocene ranges of Flögeln (south) and Wanna (north). Within the 40 km^2 wide and flat bog area the small sandy Pleistocene outcrops 'Großer Ahlen' and 'Kleiner Ahlen' are prominently visible (Fig. 2).

The survey and excavations in 2019 were not the first archaeological investigations in the Ahlen-Falkenberger Moor. U. Körber-Grohne, H. Schneekloth, and K.-E. Behre conducted the first research of vegetation history and bog stratigraphy in the area (Körber-Grohne 1967; Schneekloth 1970; Behre 1976). In particular, Schneekloth's work with radiocarbon-dated pollen profiles provided extensive information on bog growth and also revealed a marine transgression south of the Großer Ahlen, which dates back to the Neolithic. Furthermore, the NIhK investigated the history of the bog between 1995 and 2000 as part of the project 'Beginning and spread of large-scale moorland formation in northwestern Germany as an indicator of changed environmental conditions', funded by the DFG (Petzelberger et al. 1999; Gerdes et al. 2003). According to the results of this project, bog-growth in the Ahlen-Falkenberger Moor began in the Mesolithic shortly after 6,500 calBC and continued into the Iron Age, covering the lower-lying megalithic tombs (Behre 2005, 215). Significant influence on the vegetation, presumably caused by human activities, is visible at the earliest around 3,500 calBC (Behre / Kučan 1994; Kramer / Bittmann 2015a, 103). As part of the above-mentioned project 'Settlement and land use in Neolithic northwestern Germany', palynological

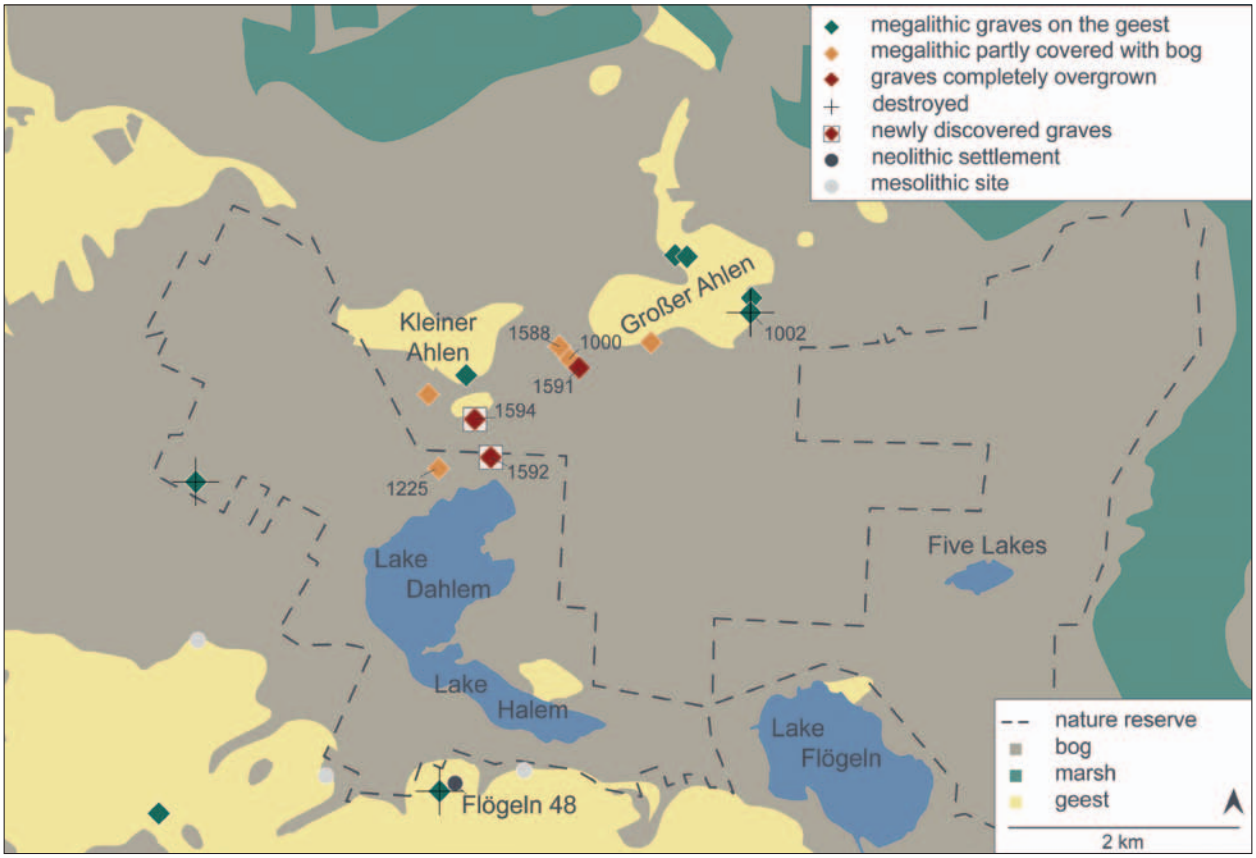

Fig. 2 Ahlen-Falkenberger Moor, dist. Cuxhaven. The study area with known Mesolithic sites as well as Neolithic settlements and burials (graphics: M. Mennenga, NIhK; map basis: State Office for Mining, Energy and Geology Lower Saxony [LBEG], Hannover; soil landscapes scale 1:50.000; mapping of megalithic tombs based on data from the Lower Saxony Monument Database ADABweb and Fritsch et al. 2010; of Mesolithic sites based on ADABweb).

investigations were also carried out on the 'emerged' megalithic graves in the Ahlen-Falkenberger Moor (near sites Wanna 1000 and 1225), as well as near the northern sandy area of Wanna. The ^{14}C-dates from the peat base at the graves suggest a very late onset of peat growth in the 1st millennium calBC (Nösler et al. 2011; Kramer et al. 2012). As the two monuments have been erected on higher ground, the results show that bog growth and expansion continued over millennia with high dynamics and that the graves were finally covered in the Iron Age. By that time, the graves lying lowest were probably totally covered for long. From an archaeological and landscape-historical point of view, they should, therefore, show better conservation conditions. As examples of excellent preservation of features and finds in the northwestern German bog lands, the remains of Stone Age buildings and trackways, documented in the surroundings of Dümmer, distr. Diepholz, have to be mentioned (Fansa / Schneider 1996). Considering the Ahlen-Falkenberger Moor it seems that the research potential is quite similar to that of the famous Irish bogs, where numerous megalithic tombs, field boundary systems, and hearths from the Stone Age to the Iron Age were preserved (O'Connell et al. 2020).

Today five megalithic graves are located on 'Großer Ahlen' and 'Kleiner Ahlen' (Sprockhoff 1975, nos. 636–642; see Fig. 2). Due to intensive drainage measures for cultivation purposes, starting in the early 20th century, the peat thickness decreased, revealing more graves situated within the bog during the 1930s (site Wanna 1225; Sprockhoff 1975, no. 643) and 1970 s (e.g. site Wanna 1000). In 2016 the capstones of two more tombs were found (sites Wanna 1588 and 1591; Hüser 2019, 25), while yet another one was detected in 2019 (see below), a total of twelve monuments are known so far, all of them passage graves. The megalithic tombs of Ahlen-Falkenberg are almost completely unexplored. The few opened graves, 'Kronskark' (Wanna 1215) as well as 'Karlskirche' (Wanna 1222), are located on higher ground 'islands'. No records of those investigations have survived, and thus, the graves were excavated under circumstances unknown to research. The first and, so far, only systematic investigation was carried out in 1963 due to sand extraction at the grave of the 'Hoher Kopf' (Wanna 1002) by the Lower

Fig. 3 The completely overgrown megalithic tomb Wanna 1000 after intervention through cultivation measures. From left to right: Dr. Peter Schmid, Prof. Dr. Haio Zimmermann (both NIhK), and H. Nast (Archaeological Heritage Agency, district of Cuxhaven; photo Dr. H. Aust, Archaeological Heritage Agency, district of Cuxhaven).

Saxony Institute for Clay District and Terp Research (today: NIhK; cf. Schmid 1963; Sprockhoff 1975, no. 641). Since the monument was already severely disturbed at that time, the structures could not be exactly clarified and documented. It was reconstructed as a passage grave with four capstones. Around the tomb, remains of a ring-shaped stone packing, which probably covered the grave, were detected. During the investigation of 'Hoher Kopf' about 400 'Tiefstich'-decorated sherds were excavated, some of them with 'Tvaerstik' ornamentation (Lorenz 2018, 74; for the definition of 'Tvaerstik' see Mennenga 2017, 41), which is characteristic of the TRB West Group ceramics. Moreover, a rudimentary assessment of the architecture of Wanna 1000 was undertaken by the Heritage Agency of the district of Cuxhaven and the NIhK in the 1970s. The monument was already disturbed by agricultural activities, which had uncovered the upper constructions (Fig. 3). Fortunately, the four capstones remained *in situ*, and no intrusions into the chamber were reported. The excavation photograph shows a massive stone packing, slightly perturbed due to the disturbance, but still, it seems, covering the top of the capstones, with the exception of the highest of them. None of the other megaliths located within the bog have been studied in detail so far; in most cases only the capstones of the graves are visible.

New research on a buried landscape

Due to the high research potential in this area the project 'Preserved in the Bog – Relics of Prehistoric Settlement Landscapes in the Elbe-Weser Triangle', funded by the Ministry of Science and Culture of Lower Saxony within the program 'Pro*Niedersachsen', started in 2019. The project is running for four years and is affiliated with the NIhK. Its archaeological focus is on the remains of the TRB and younger Neolithic cultures. Within the project a number of methods are applied, and several fieldwork campaigns will be carried out. Results from the first year of research are presented below.

Geophysical prospection

The majority of the megalithic graves known from the study area were discovered only after they had become visible above ground again due to peat decay. In the course of the preliminary work, however, it has been possible to identify and map further sites in the bog with the use of geomagnetic measurements. For this reason, a large-scale geophysical survey of the study area is part of the project schedule. A total of about 1,300 ha needs to be prospected in the Ahlen-Falkenberger Moor with an 11-probe geomagnetic device available at the NIhK. Until summer 2020 approx. 800 ha have been measured already. Extensive structures, which were investigated through core drilling and smaller exploratory excavations, are recognisable in the measurement images. In this way, characteristic anomalies were examined, supporting the interpretation of the magnetograms. It became apparent that the megalithic graves – and in part also modern structures – can be derived well from the measured values. Megalithic tombs and other aggregations of stones appear prominently in the images – due to the use of very large igneous rocks for building them (Fig. 4). In contrast, the search for

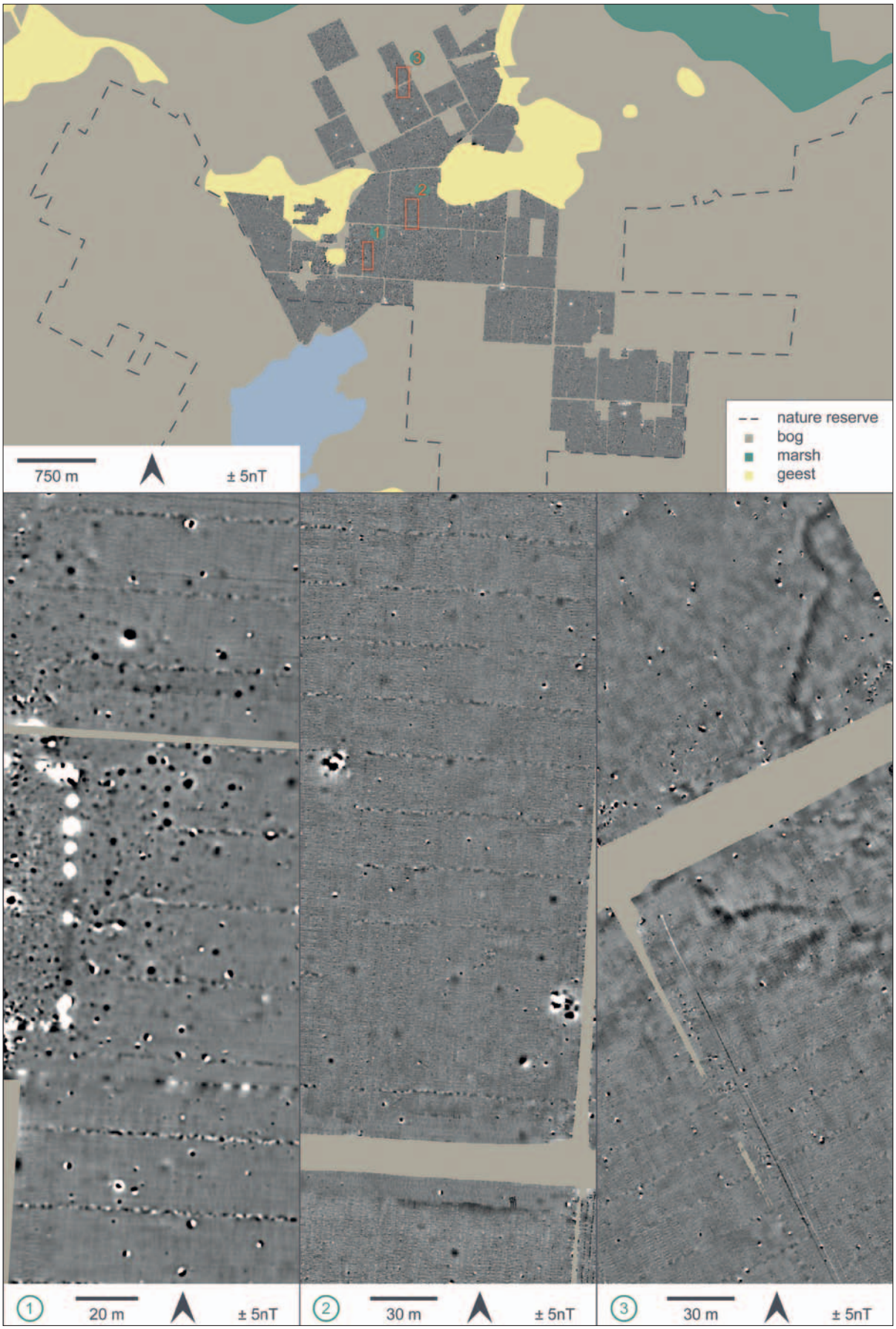

Fig. 4 Overview of results of different geomagnetic measurement conducted in the Ahlen-Falkenberger Moor (top). **1** Natural boulders under the bog (bog depth less than 2.5 m. **2** Megalithic graves Wanna, sites 1000 and 1588. **3** Marine-influenced area in the north of the study area (graphics: M. Mennenga, D. Dallaserra, J. Lühmann, all NIhK; map basis as for Fig. 2).

further findings from settlement contexts in the bog is difficult. In some areas, a large number of anomalies can be observed, suggesting an anthropogenic origin. However, test excavations revealed them to be naturally scattered larger boulders covered by a peat-layer with a thickness of up to 2.5 m. In deeper layers, the bog acts as a filter, so that these large individual stones are no longer visible in measurement images. Where the peat layers are thinner, a differentiation between rocks of the natural Pleistocene landscape and archaeological features – excluding megalithic graves – based on the magnetic values is currently not possible. Further analysis of the measured data compared to the results of test trenches should allow a more differentiated consideration of these anomalies.

Despite the above-mentioned problems, further structures are becoming visible in the north of the study area, which are of great value to the project. Here formerly marine or limnic areas could be detected on the basis of the magnetic data; although dating results of the flooding and the coverage by bog are still pending, it can be assumed that these sediments date to the Middle Neolithic, based on comparisons with datings from other marine transgressions in the study area.

Geological and botanical investigations

Today the landscape in the area is flat and relatively homogenous, but older data and geophysical surveys show that this was not the case in the past. The covered megalithic tombs were erected on different elevation levels – on former small ridges and hills. In order to understand the cultural space, however, it is essential to reconstruct the palaeo-landscape. Therefore, geological and vegetation-historical investigations form another focus of the project. The basis for investigation is the Neolithic land surface, which can be approximated by determining the top of the Pleistocene deposits. Using the data of the Lower Saxony State Office of Mining and Geology (LBEG), a first reconstruction of the palaeo-topography could be obtained. For this purpose, the transition between Holocene deposits and Pleistocene strata was extracted from the digital coring data. The documented depths and the respective data at the coring sites have been used to calculate the elevation of the pre-Holocene surface. A preliminary evaluation yielded basic information about the palaeo-relief of the study area. On the basis of this data, a first assessment of the contact zone between the bog and the Pleistocene ground could be determined, and the relief of the last surface before the onset of peat growth was interpolated. Since the cores were drilled irregularly at lateral intervals of 200–500 m, only a rough reconstruction of the surface was possible (Behrens et al. 2019). However, connecting these data with the mentioned markers of bog growth and the known archaeological sites enabled an estimation of the area of assumed Neolithic land use – settlements, cultivation, graves. The potential use-zone is narrowed down further through the inclusion of new data, allowing a more accurate delimitation of possible areas where Neolithic remains are still covered by peat.

Since the analysed core data were obtained from surveys spanning the past 120 years, in some cases, elevation measurements did not comply with current standards and have been corrected with modern data.[2] In order to compensate for possible discrepancies in elevation values by correlating current measurements of the peat base with pre-existing elevation data, control drillings need to be conducted. First field work for this already took place in 2019. Based on the results of the geophysical prospection as well as the coring data in the database of the LBEG, systematic drilling is carried out in order to increase the density of information for the small-scale recording of the palaeo-topography before the onset of peat formation. A drilling grid of approx. 100 x 100 m is created, and the transition between Holocene and Pleistocene strata is documented. So far over 600 drillings have been made. In addition to the determination of the palaeo-relief, sedimentological evidence of marine sediments is analysed in order to enable the reconstruction of Neolithic shoreline positions. It is also important to identify possible indications of human activities such as cultural layers.

Another key aspect in landscape reconstruction is the dating of the start of bog growth and the determination of peat thickness in the Neolithic and later periods. Previous research on the development of the Ahlen-Falkenberger Moor has shown that the peat growth in the study area depends strongly on the topography. This concerns both the type of peat-forming vegetation at the bog base and the timing of the onset of peat growth. However, the horizontal and vertical dynamics and, consequently, the spatial development of peat formation have been only vaguely known so far. Obtaining temporally and spatially high-resolution information by evaluating all existing data and archives as well as carrying out further coring is therefore one of the priority objectives of the project.

The peat cores are sampled for pollen analysis at the base of the peat as well as at relevant stratigraphical transitions, such as the shift from fen to raised bog, or the boundary between highly and slightly decomposed

2 Written communication Dr. J. Sbresny, LBEG, Hannover.

raised bog peat. Through biostratigraphic correlation the samples can be dated and thus provide a relative chronological framework of peatland growth, which is refined by ^{14}C data and fixed in absolute chronological order. The selection of the ^{14}C samples is based on the preliminary pollen-analytical investigations, and the dating results can thus be validated by the pollen-analytical dating. The material for radiocarbon datings is obtained after careful sieving of the peat samples, which allows the selection of defined terrestrial macrofossils and avoids the contamination by rootlets or other non-contemporaneous material. In addition, the results of the pollen analysis allow for the reconstruction of the terrestrial vegetation at the time of the onset of peat growth.

South of the Großer Ahlen, the occurrence and distribution of old clay deposits over fen bog has been documented in several cores. Schneekloth (1970) dates the deposition of marine clay to the 3rd millennium calBC. However, his age model is rather imprecise, and, therefore, needs to be refined in order to improve the understanding of landscape development. The first new results on plant macro-remains now date the marine ingression between 3,368 and 3,104 calBC (AWI-4382: 4547 ± 30 BP).[3] It is not yet clear how long a direct connection to the North Sea existed, but it is safe to assume that the subsequent gradual turn to brackish and fresh water conditions and the final silting-up of the sea arm were already completed by 2,898–2,678 calBC (AWI-4380: 4206 ± 31 BP).

The analyses of the first cores from the bog confirm the widespread distribution of raised bog peat directly on Pleistocene sand, the so-called 'wurzelechtes Hochmoor'. So far, the vast majority of the basal peat samples date to the 3rd and 4th millennia calBC, indicating that the raised bog growth in the Elbe-Weser triangle accelerated during this period. Older bog areas (see for example Gerdes et al. 2003) could be confirmed for the southern part of the study area. In addition, the dates of the peat base in the vicinity of the 'Kleiner Ahlen' show that the expansion of the bog on the Pleistocene sandy areas lasted at least until the 1st millennium calBC. Accompanying analyses of macro-remains and the determination of loss-on-ignition of the sediment show that proper peat growth is often preceded by a waterlogged period, with thin deposits characterised by leaves, flowers, and stems of heather dwarf shrubs (*Calluna vulgaris*, *Erica tetralix*), few peat moss residues, and a high proportion of sand. In the immediate vicinity of megalithic tombs, charcoal fragments and remains of charred heather species are frequently recorded in this layer, indicating fires during the initial stages of bog growth. Although the close vicinity to the megalithic tombs suggest intentional fires, a natural cause cannot yet be excluded at that stage of research.

On the basis of the results of geophysical and stratigraphical investigations, archaeological excavations are carried out. In addition to surface prospection in the area of the Pleistocene ground, large stone graves and settlements are to be examined. Concerning the megalithic installations, the focus is on the documentation of the architecture, especially exterior constructions, as well as on reconstructing the history of their use. In this way, in addition to answering questions regarding social structure and practices, fundamental statements on grave construction in the Elbe-Weser area – which have so far been quite impossible – can be made. Furthermore, for the detection of settlement sites, promising areas will be identified on the basis of geophysical measurements, pedological mapping and drilling, followed by small test trenches in these zones.

Archaeological investigations

In the summer of 2019 a first larger excavation campaign was carried out on two monuments. The first was a TRB passage grave located approx. 200 m north of the Dahlemer See (Wanna 1592; see Fig. 2). Its orientation is east-west, with the entrance in the south. During ploughing in the 1950s two capstones were removed by farmers. They moved them to a hole directly next to the grave (Fig. 5,1); after this event the location of the grave was forgotten for decades. Due to the geomagnetic survey it could be redetected.

After removing 25 cm of topsoil, three further capstones became visible in the course of the excavation, which indicated that the construction had originally been a passage grave with five capstones, making it the largest monument of the grave group of Ahlen-Falkenberg (6.3 m x 2 m). The further excavations revealed a complex architecture. A massive stone packing around the chamber was documented – up to 2.5 m wide at the base and up to 1.4 m high. The capstones were still visible, the entrance accessible. On top and within the packing numerous burnt pieces of flint were found, which suggests intentional scattering. No other outside constructions, such as a mound, were built here. Of further interest is the shape of the chamber itself, which has slightly angled walls on the west side. This represents a rare

3 All calibrated radiocarbon dates are provided in 2-sigma range, calibrated with OxCal (IntCal13).

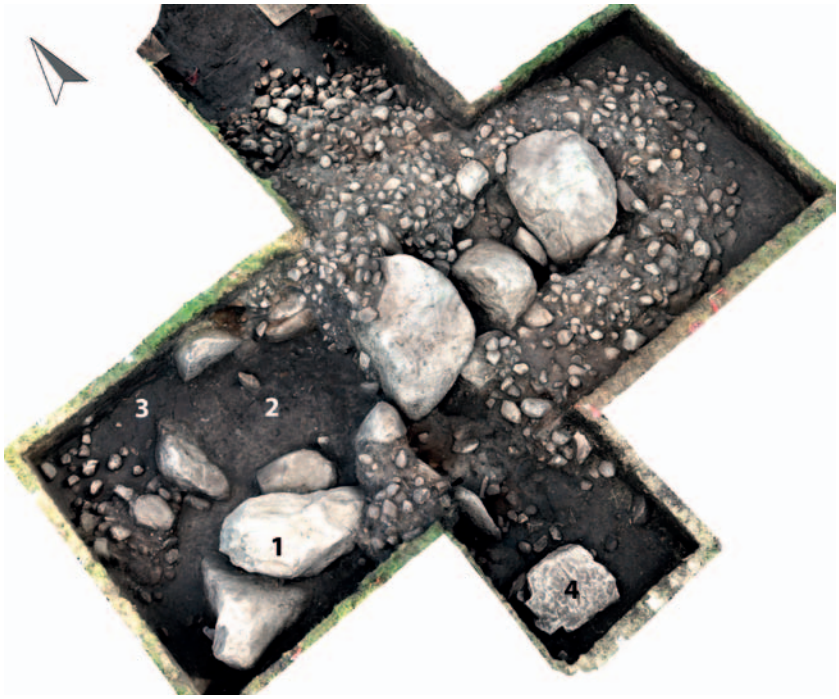

Fig. 5 Wanna 1592, dist. Cuxhaven. Compound structure from motion model after removing 20–30 cm of the top soil around and within the chamber. In the northern part the complete stone packing is visible after removing 1.8 m of peat. Numbers 1–4 refer to text information (graphics: M. Mennenga, NIhK / P. Frederiks, HTW Berlin).

feature[4] among the generally straight-walled, rectangular or trapezoid tombs in the Elbe-Weser triangle (Sprockhoff 1975, atlas pages 1–16).

Grave Wanna 1592 had an eventful history. Inside the excavated chamber area in the west (Fig. 5,2) the remains of a burial were found. On top of a paved chamber floor, covered with a layer of gravel, two slightly broken vessels (a funnel beaker cup ornamented with vertical stripes on the belly [Brindley 1–5] and a one-piece bowl) as well as pieces of two decorated pots and three amber beads were uncovered. The fragmented, mingled and scattered material suggests that the deposition was not *in situ*. As parts of the stone packing on the outside of the western chamber area were removed (Fig. 5,3), indicating a disturbance, this might explain the rearranged contents of the chamber. The burial horizon was covered with a layer of sand, 20–25 cm thick, which must have accumulated after or in the context of the disturbance. The entrance showed also traces of intrusion, as one of the former capstones was found displaced in front of the construction (Fig. 5,4). The boulders on the west side were still in position, forming a 1.6 m long and approx. 0.8 m wide entrance. The construction of the eastern side is unclear, as boulders or traces of removed boulders are missing. At the bottom of the entrance dozens of small broken pieces of pottery were recovered, belonging to several, partially richly decorated TRB vessels. The vessel fragments imply at least one clearing event of the chamber, maybe even more. Interestingly, the entrance had been sealed completely by stones (ø 15–25 cm, c. 1 m^3) in a later phase, probably as the passage was destructed. Maybe we can find here the reason for the disturbance on the western chamber side, as people tried to gain access to the interior once again after the entrance had been closed.

Beside this megalithic tomb, a second site, detected through geomagnetic survey and located south of the village Ahlen-Falkenberg, was examined (site Wanna 1594; see Fig. 2). After removing up to 1 m of peat around the structure an almost circular mound of compact stones with a diameter of approx. 6 m and up to 0.9 m height became visible (Fig. 6). In the centre, underneath a 20–30 cm thick layer of smaller stones, one huge boulder (2.1 m x 1.1 m) was located. Around this erratic a standing stone slab in the east as well as two slightly displaced flat stones in the north form a sort of chamber on top. Within this area, broken and very badly preserved pottery was recovered, unfortunately allowing no conclusions on the vessel type.

Due to time constraints, it was not possible to remove the boulder and uncover what lies beneath during the 2019 campaign. Further investigations in 2021 revealed a Late Neolithic / Early Bronze Age cult site.

4 A very similar construction is known from Axstedt, dist. Osterholz: cf. Sprockhoff 1975, no. 620.

Fig. 6 Wanna 1594, dist. Cuxhaven. Final planum of the excavation campaign 2019 (photo: A. Behrens, NIhK).

So far only archaeological material allows a chronological statement about the excavated sites. However, ^{14}C dating of the bog growth is currently in progress, also including samples from the peat directly overlaying the monuments and adjacent palaeo-surfaces. Thus, *termini ante quem* for the erection of the monuments can be expected. Furthermore, excavations on two more passage graves were carried out in 2020, giving more detailed information on the grave constructions and their history.

Conclusions and outlook

The project 'Preserved in the Bog' makes use of the excellent preservation conditions prevailing in the prehistoric landscape of the Ahlen-Falkenberger Moor and aims to arrive at far-reaching insights about the effects of environmental processes on the societies settling there at that time. The focus is on the remains of the TRB culture, which is evidenced in the region from about 3,470 calBC (Mennenga 2017). Due to variable preservation conditions for material remains in this region, the neolithisation process is not well documented here. The diversity of material heritage, e.g. tools and implements, vessel forms and ornamentation, and later in the design of houses and megalithic graves, testifies to the integration into a far-reaching communication and exchange network of the TRB (cf. Müller 2019). Here, the Elbe-Weser triangle probably plays a decisive role due to its proximity to Ertebølle and Swifterbant as well as the succeeding TRB North Group.[5] However, the question still remains as to why it is not until the middle of the 4th millennium BC that a cultural transition becomes apparent in the archaeological record, while in the Baltic Sea region, as well as in some southern areas of Lower Saxony, this transition can be traced some 500 years earlier. This issue will not be discussed here (cf. Klassen 2004, 297–299); rather, the research potential in the exploration of the hidden landscape at Ahlen-Falkenberg shall be highlighted. It is only possible to gain important answers by obtaining new data. For example, the detailed recording of building structures and the dating of megalithic tombs will allow important conclusions about spatial and cultural factors to be drawn. High-resolution pollen analyses as evidence for landscape development, as well as archaeological investigations of the settlement and burial landscape provide insights into the economic and cultural use of space by humans. This approach not only allows to draw extensive conclusions about human-environmental relations in the Ahlen-Falkenberg area, but also provides a basis for comparative supra-regional studies.

5 Currently investigated by Svea Mahlstedt (Mahlstedt et al. this volume).

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List of authors

Dr. Theo J. ten Anscher
RAAP
Pollaan 48 E/F
NL-7202 BX Zutphen
t.ten.anscher@raap.nl

Dr. Luc W.S.W. Amkreutz
National Museum of Antiquities
Papengracht 30
Postbus 11114
NL-2301 EC Leiden
L.Amkreutz@rmo.nl

Drs. Steffen Baetsen
ADC ArcheoProjecten
Nijverheidsweg-Noord 114
NL-3812 PN Amersfoort
s.baetsen@archeologie.nl

Dr. Andreas Bauerochse
Lower Saxony State Service for Cultural Heritage
Scharnhorststraße 1
D-30175 Hannover
andreas.bauerochse@nld.niedersachsen.de

Dipl. Prähist. Anja Behrens
Lower Saxony Institute for Historical Coastal Research
Viktoriastraße 26/28
D-26382 Wilhelmshaven
behrens@nihk.de

Mirjam Briel M.A.
Lower Saxony State Service for Cultural Heritage
Ofener Straße 15
D-26121 Oldenburg
mirjam.briel@nld.niedersachsen.de

Prof. Dr. Oliver E. Craig
Department of Archaeology
University of York
Wentworth Way
UK-YO10 5DD York
oliver.craig@york.ac.uk

Prof. Dr. Agnieszka Czekaj-Zastawny
Institute of Archaeology and Ethnology
Polish Academy of Sciences
Sławkowska 17
PL-31-016 Kraków
aczekajzastawny@gmail.com

Erwin Cziesla
Martin Wurzel Archäologie und Umwelttechnik GmbH
Fasanenstraße 25b
D-14532 Stahnsdorf
Wurzel-Archaeologie@t-online.de

Dr. Özge Demirci
Groningen Institute of Archaeology
University of Groningen
Poststraat 6
NL-9712 ER Groningen
o.demirci@rug.nl

Walter Dörfler
Institute of Prehistoric and Protohistoric Archaeology
Christian-Albrechts-University
Johanna-Mestorf-Straße 2–6
D-24118 Kiel
wdoerfler@ufg.uni-kiel.de

Dr. Anne Birgitte Gebauer
Danish Nationalmuseum
Ny Vestergade 10
DK-1471 Copenhagen
anne.birgitte.gebauer@natmus.dk

Klaus Gerken
Hohes Ufer 10
D-31535 Neustadt
klaus@gerken-archaeologie.de

Dr. Sönke Hartz
Stexwigfeld 5a
D-24857 Borgwedel
soenke.hartz66@gmail.com

Dr. Marion Heumüller
Lower Saxony State Service for Cultural Heritage
Scharnhorststraße 1
D-30175 Hannover
marion.heumueller@nld.niedersachsen.de

Dr. Daniela Hofmann
Department of Archaeology, History, Cultural Studies and Religion
University of Bergen
Øysteinsgate 3, Postboks 7805
N-5020 Bergen
daniela.hofmann@uib.no

Dr. Christian Hülsebusch
christian.groer@t-online.de

Prof. Dr. Albrecht Jockenhövel
Am Biederlackturm 7
D-48282 Emsdetten
jockenh@uni-muenster.de

Prof. Dr. Jacek Kabaciński
Institute of Archaeology and Ethnology
Polish Academy of Sciences
Rubież 46
PL-61-612 Poznań
jacek.kabacinski@interia.pl

Dr. Martina Karle
Lower Saxony Institute for Historical Coastal Research
Viktoriastraße 26/28
D-26382 Wilhelmshaven
karle@nihk.de

Dr. Jan F. Kegler
Ostfriesische Landschaft
Archäologischer Dienst & Forschungsinstitut
Hafenstraße 11
D-26603 Aurich
kegler@ostfriesischelandschaft.de

Prof. Dr. Wiebke Kirleis
Institute of Prehistoric and Protohistoric Archaeology
Environmental Archaeology/Archaeobotany
Christian-Albrechts-University
Johanna-Mestorf-Straße 2–6
D-24118 Kiel
wiebke.kirleis@ufg.uni-kiel.de

PD Dr. Florian Klimscha
Lower Saxony State Museum
Willy-Brandt-Allee 5
D-30169 Hannover
Florian.Klimscha@landesmuseum-hannover.de

Dr. Sebastiaan Knippenberg
ARCHOL
Einsteinweg 2
NL-2333 CC Leiden
S.Knippenberg@archol.nl

Dr. Benedikt Knoche
Kanalstrasse 46
D-48147 Münster/Westf.
benedikt.knoche@web.de

Dr. Andreas Kotula
Brandenburg Authorities for Heritage Management and Archaeological State Museum
Wünsdorfer Platz 4–5
D-15806 Zossen (Ortsteil Wünsdorf)
andreas.kotula@bldam-brandenburg.de

Dr. Hanns Hubert Leuschner
Department of Palynology and Climate Dynamics
Albrecht-von-Haller Institute for Plant Sciences
University of Göttingen
Wilhelm-Weber-Straße 2a
D-37073 Göttingen
hleusch@gwdg.de

Dr. Alexandre Lucquin
Department of Archaeology
University of York
Wentworth Way
UK-YO10 5DD York
alexandre.lucquin@york.ac.uk

Clemens Ludwig M.A.
Lower Saxony State Service for Cultural Heritage
Scharnhorststraße 1
D-30175 Hannover
clemens.ludwig@nld.niedersachsen.de

Dr. Svea Mahlstedt
Lower Saxony Institute for Historical Coastal Research
Viktoriastr. 26/28
D-26382 Wilhelmshaven
mahlstedt@nihk.de

Dr. Moritz Mennenga
Lower Saxony Institute for Historical Coastal Research
Viktoriastr. 26/28
D-26382 Wilhelmshaven
mennenga@nihk.de

Dr. des. Ann-Katrin Meyer
Wakenitzstraße 39
D-23564 Lübeck
akmeyer88@aol.com

Helle M. Molthof M.A.
RAAP
Le Pooleweg 5
NL-2314 XT Leiden
h.molthof@raap.nl

Prof. Dr. Johannes Müller
Institute of Prehistoric and Protohistoric Archaeology
Christian-Albrechts-University
Johanna-Mestorf-Straße 2–6
D-24118 Kiel
johannes.mueller@ufg.uni-kiel.de

Michael Müller
Hausotterstr. 91
D-13409 Berlin
mueller_michael3@gmx.de

Dr. Hildegard Nelson
Hohes Ufer 10
D-31535 Neustadt
hildegard.nelson@googlemail.com

Dr. Daniel Neumann
Lower Saxony State Museum
Willy-Brandt-Allee 5
D-30169 Hannover
Daniel.Neumann@landesmuseum-hannover.de

Dr. Hans Peeters
Groningen Institute of Archaeology
University of Groningen
Poststraat 6
NL-9712 ER Groningen
j.h.m.peeters@rug.nl

Alexandra Philippi M.A.
Lower Saxony State Service for Cultural Heritage
Scharnhorststraße 1
D-30175 Hannover
alexandra_philippi@web.de

Prof. Dr. Daan C. M. Raemaekers
Groningen Institute of Archaeology
University of Groningen
Poststraat 6
NL-9712 ER Groningen
d.c.m.raemaekers@rug.nl

Dr. Michael Schirren
State Office for culture and preservation of monuments of Mecklenburg-Western-Pomerania
Dienststelle Stralsund
Badenstraße 16
D-18439 Stralsund
M.Schirren@lakd-mv.de

Reinhold Schoon
Johannisstraße 27
D-37073 Göttingen
r.schoon@t-online.de

Dr. Bernhard Stapel
LWL-Archäologie für Westfalen
Außenstelle Münster
An den Speichern 7
D-48157 Münster
Bernhard.Stapel@lwl.org

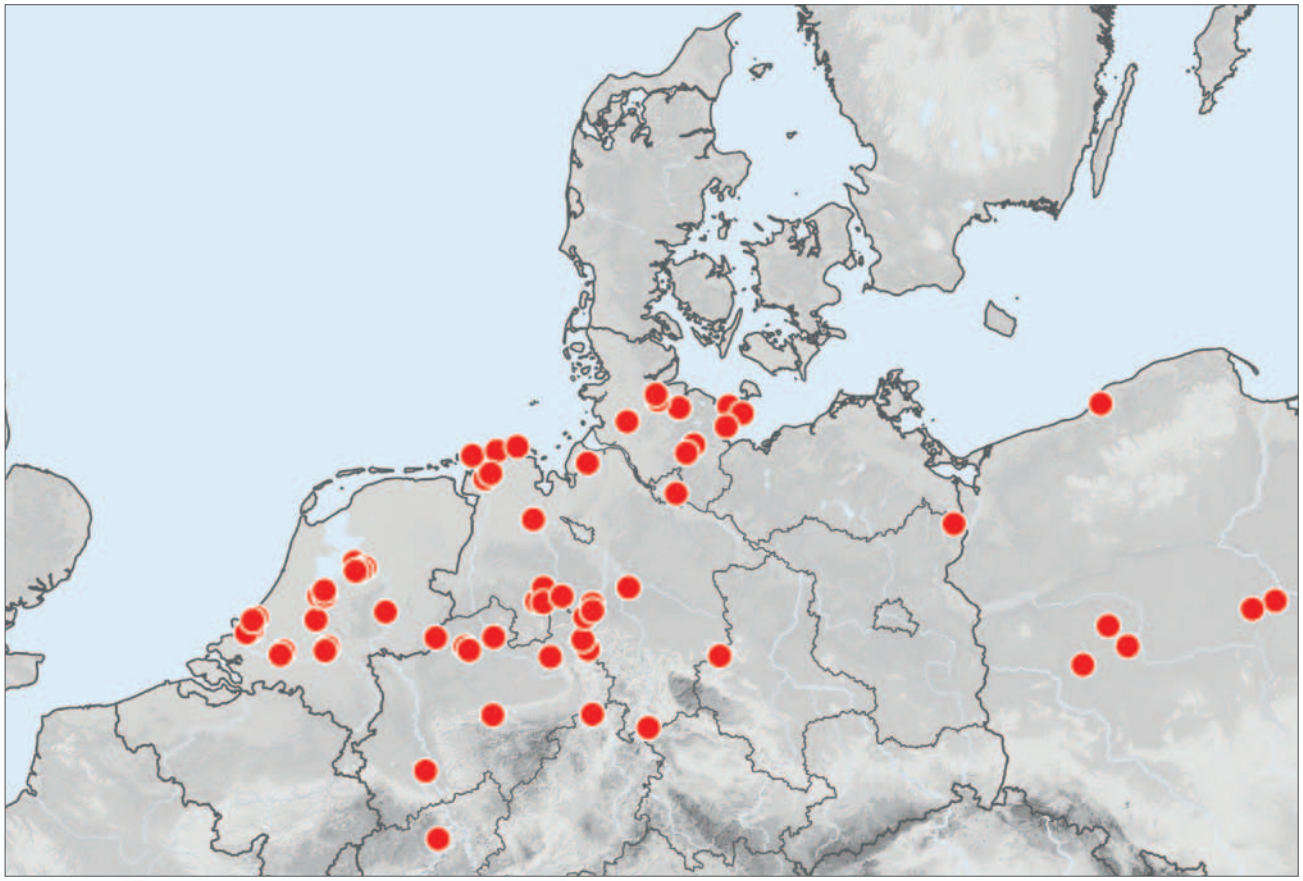
Dr. Lasse Sørensen
Danish Nationalmuseum
Ny Vestergade 10
DK-1471 Copenhagen
Lasse.Sorensen@natmus.dk

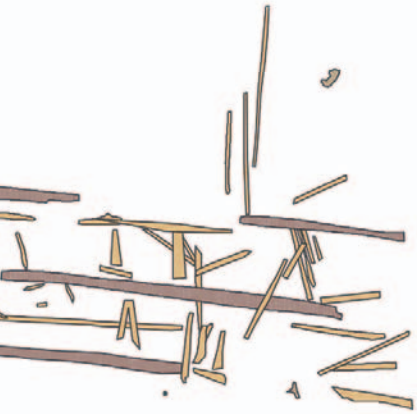
Prof. Dr. Thomas Terberger
Lower Saxony State Service for Cultural Heritage
Scharnhorststraße 1
D-30175 Hannover
Thomas.Terberger@NLD.Niedersachsen.de

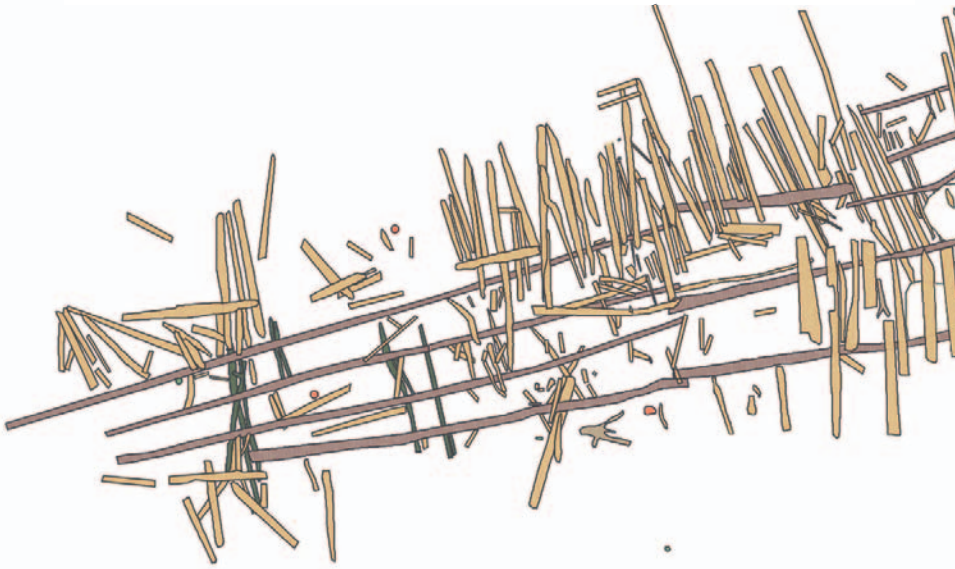
Dr. Laura Thielen
laurathielen@gmx.de

Dr. Steffen Wolters
Lower Saxony Institute for Historical Coastal Research
Viktoriastraße 26/28
D-26382 Wilhelmshaven
wolters@nihk.de

Dr. Tanja Zerl
Archaeobotanical Laboratory of the Department of Prehistoric Archaeology
University of Cologne
Weyertal 125
D-50923 Köln
tzerl@uni-koeln.de







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