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ARCHAEOLOGY IN THE ŽITAVA VALLEY I

The LBK and Želiezovce settlement site of Vráble

SCALES OF TRANSFORMATION IN PREHISTORIC AND ARCHAIC SOCIETIES | 9

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Preface of the editors

With this book series, the Collaborative Research Centre Scales of Transformation: Human-Environmental Interaction in Prehistoric and Archaic Societies (CRC 1266) at Kiel University enables the bundled presentation of current research outcomes of the multiple aspects of socio-environmental transformations in ancient societies. As editors of this publication platform, we are pleased to be able to publish monographs with detailed basic data and comprehensive interpretations from different case studies and landscapes as well as the extensive output from numerous scientific meetings and international workshops.

The book series is dedicated to the fundamental research questions of CRC 1266, dealing with transformations on different temporal, spatial and social scales, here defined as processes leading to a substantial and enduring reorganization of socio-environmental interaction patterns. What are the substantial transformations that describe human development from 15,000 years ago to the beginning of the Common Era? How did interactions between the natural environment and human populations change over time? What role did humans play as cognitive actors trying to deal with changing social and environmental conditions? Which factors triggered the transformations that led to substantial societal and economic inequality?

The understanding of human practices within often intertwined social and environmental contexts is one of the most fundamental aspects of archaeological research. Moreover, in current debates, the dynamics and feedback involved in human-environmental relationships have become a major issue, particularly when looking at the detectable and sometimes devastating consequences of human interference with nature. Archaeology, with its long-term perspective on human societies and landscapes, is in the unique position to trace and link comparable phenomena in the past, to study human involvement with the natural environment, to investigate the impact of humans on nature, and to outline the consequences of environmental change on human societies. Modern interdisciplinary research enables us to reach beyond simplistic monocausal lines of explanation and overcome evolutionary perspectives. Looking at the period from 15,000 to 1 BCE, CRC 1266 takes a diachronic view in order to investigate transformations involved in the development of Late Pleistocene hunter-gatherers, horticulturalists, early agriculturalists, early metallurgists as well as early state societies, thus covering a wide array of societal formations and environmental conditions.

Included among the main CRC field projects are the excavations and field surveys that were conducted in the Žitava Valley of West Slovakia. The research provides a new puzzle piece for the reconstruction of human history with a specific insight into the living together of early farming communities. The impressive results from the Neolithic site of Vráble are presented in this volume, whereas results on the entire area will be the theme of another volume. We are very thankful to Ivan Cheben,

Martin Furholt, Nils Müller-Scheeßel, Alena Bistáková, Robert Staniuk and Maria Wunderlich for their extraordinary engagement within this project and for graphic editing support from Carsten Reckweg. Without them, this book would not have been possible.

Wiebke Kirleis and Johannes Müller

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Section 6: Synthesis

Preface

This book presents the research project on the Neolithic settlement south of Vráble (2012-2020). The main excavation and survey activities took place within the Kiel CRC 'Scales of Transformation: Human-environmental Interaction in Prehistoric and Archaic Societies', in which the subproject 'The Dynamics of Settlement Concentration Processes and Land Use in Early Farming Communities in the North-western Carpathian Basin' constituted one of the main archaeological field projects. This research is embedded into the basic concept of the CRC to structurally compare different case studies with respect to transformative changes.

From the start, the project has been conceptualized as a regional study, whereby research on the Neolithic settlement of Vráble is seen in the context of the overall diachronic interest in the settlement history of the Žitava Valley (with a second focus on the Bronze Age settlement of 'Fidvár' explored by the team of Rassmann and Bátora). The volume presented here focusses on the Neolithic site of Vráble ('Veľké Lehemby' and 'Farské'), while the results of our regional research on the Neolithic will be included in a second volume.

Locally, the history of the Vráble LBK project goes back to the idea of a diachronic research strategy combined with Early Bronze Age research, which was conducted by the Slovakian Academy of Sciences in Nitra and the Romano-Germanic Commission of the German Archaeological Institute Frankfurt/Main in a different DFG project from 2009-2019 at the nearby Bronze Age site of Vrable-'Fidvár'. The initial idea for a diachronic research perspective was developed together with Jozef Bátora and Knut Rassmann, for whose support we are very thankful.

Many people took part in this project and contributed to its publication. The discovery of the site resulted from the first geomagnetic plan, which was produced during the Kiel Geophysical Summer School in 2012 by Christoph Rinne and Wolfgang Rabbel. Main geomagnetic mapping was later provided by Knut Rassmann and his team, for which we are very thankful. In most years, fieldwork in 'Fidvár' and 'Veľké Lehemby'/'Farské' was carried out in tandem, which ensured a pleasant neighbourhood with mutual support, including common goulash meals on the field.

We would also like to thank a number of further colleagues who were actively involved in the work in Vráble and the development of the project. In 2012, Peter Tóth was the project's 'obstetrician' and a pleasant, constructive colleague. Since 2013, Michal Cheben has actively taken part in the successful implementation of the field campaigns. Stefan Dreibrodt has been a regular collaborator since 2014, contributing his geoarchaeological and pedological expertise to a fruitful broadening of horizons. Since 2017, Natalie Pickartz, Erica Corradini and Diana Panning have considerably expanded the range of geophysical methods. In the beginning, they were supported by Ercan Erkul. In 2012, Helmut Kroll, and later also Dragana Filipović, were on site several times to coordinate archaeobotanical sampling. In 2016, Peter

Gábor took part in the excavations for several weeks. In 2017 and 2018, Kata Szilágyi supported us in processing the stone artefacts. Zooarchaeological work was carried out by Rebekka Eckelmann, supervised by Cheryl Makarewicz, and Sarah Pleuger, supported by Ulrich Schmoelcke. Zuzana Hukeľová contributed physical anthropological analyses. Isotope analyses were carried out by Rosalind Gillis and Cheryl Makarewicz and the modelling of 14C data was carried out in collaboration with John Meadows. We are also indebted to Agnes Heitmann for the professional photographs of the finds from the 2018 campaign. Robert Staniuk, who assumed a position as a scientific project employee in late 2019, contributed extensively to the organization and writing of many parts of this book. The work on language corrections, image processing and editorial work on the layout included many people and helping hands to whom we would like to express our gratitude. These include Susanne Beyer, Agnes Heitmann, Anna Carina Lange, Carsten Reckweg, Karin Winter (all graphics), Suzanne Needs (language correction) as well as our colleagues Eric van den Bandt, Corné van Woerdekom and Karsten Wentink from Sidestone Press. Hermann Gorbahn and Julian Laabs supported this publication in their role as scientific coordinators of CRC 1266 during the course of the entire publication process. Finally, we would like to thank Matej Ruttkay, Director of the Archaeological Institute in Nitra, for his kind support of the project.

Looking back at the modest beginning of this project in the spring of 2012, with a low budget and a small number of extraordinarily motivated students, it is a pleasure to be able to present here, eight years later, the first results of an interdisciplinary research project, which has been supported by the strong interdisciplinary research infrastructure at the Archaeological Institute of the Slovakian Academy of Sciences in Nitra and the Institute of Pre- and Protohistoric Archaeology at Kiel University, as well as the Institute of Archaeology, Conservation and History at the University of Oslo. From 2012-2014, we received start-up financing for a pilot project from the Romano-Germanic Commission, the Graduate School 'Human Development in Landscapes', Kiel University, and the Institute for Pre- and Protohistory, Kiel University. Since 2016, this project profited especially from the close integration of interdisciplinary archaeological research in the context of CRC 1266 'Scales of Transformation: Human-Environmental Interaction in Prehistoric and Archaic Societies' at Kiel University. This research was funded on a large-scale by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation, project number 2901391021, CRC 1266). Funding for the Slovakian side of the project was provided by the VEGA project 2/0107/17.

One aspect that cannot be emphasized enough is the input of a large number of students, many of whom took part in excavations and prospections multiple times over the years, forming a strong community, which made all fieldwork campaigns extremely pleasant social experiences. Many of these students have become professional researchers themselves and some have contributed to chapters of this book.

We hope that this volume will contribute to a better understanding of early farming communities, in general, and the communities connected to LBK material culture in Central Europe, in particular, and make the fascinating Neolithic settlement site of Vráble in southwest Slovakia better known to an international audience.

Kiel, Nitra and Oslo, March 2020
Martin Furholt, Ivan Cheben, Johannes Müller, Alena Bistáková,
Maria Wunderlich and Nils Müller-Scheeßel

Section 1: Introduction

1.1. The research project at the LBK and Želiezovce settlement site of Vráble

Ivan Cheben, Martin Furholt

Abstract

Despite being one of the largest LBK-sites in Europe, the site of Vráble ‚Veľke Lehemby'/‚Farské' remained unknown until 2009, when in the course of investigations of the Bronze Age settlement Vráble 'Fidvár' extensive geophysical prospection took place. The investigation of the site started in 2012 with small-scale excavation and archaeological prospection and led to the establishment of a joint research project by the University of Kiel and the Archaeological Institute of the Academy of Sciences in Nitra. After the first years of investigation, the project was embedded into the newly formed CRC 1266 'Scales of Transformation' in 2016. Within this context, the project profited from a close cooperation with various other disciplines, thereby achieving far reaching and multifaceted results which can be used to explain the history and character of the settlement site. The site of Vráble was revealed to consist of three distinct village parts, or neighbourhoods, which altogether cover an area of ca. 50 ha and comprising a minimum of 313 houses. Within the course of the project work, questions concerning the spatial organisation, the chronological development, subsistence strategies, the development and altering of the environment, as well as the material culture stood in the foreground. With the help of the application of targeted excavations, extensive geophysical and geomagnetic methods and prospections, as well as the development of a site-specific dating-program, it was possible to reconstruct the history of the site. This case study now constitutes a well-researched example of an outstanding LBK-settlement, thus contributing to our understanding of regional developments within the phenomena of Early Neolithic LBK-societies.

Keywords: Magnetic prospections, house orientations, socio-political structures, spatial developments

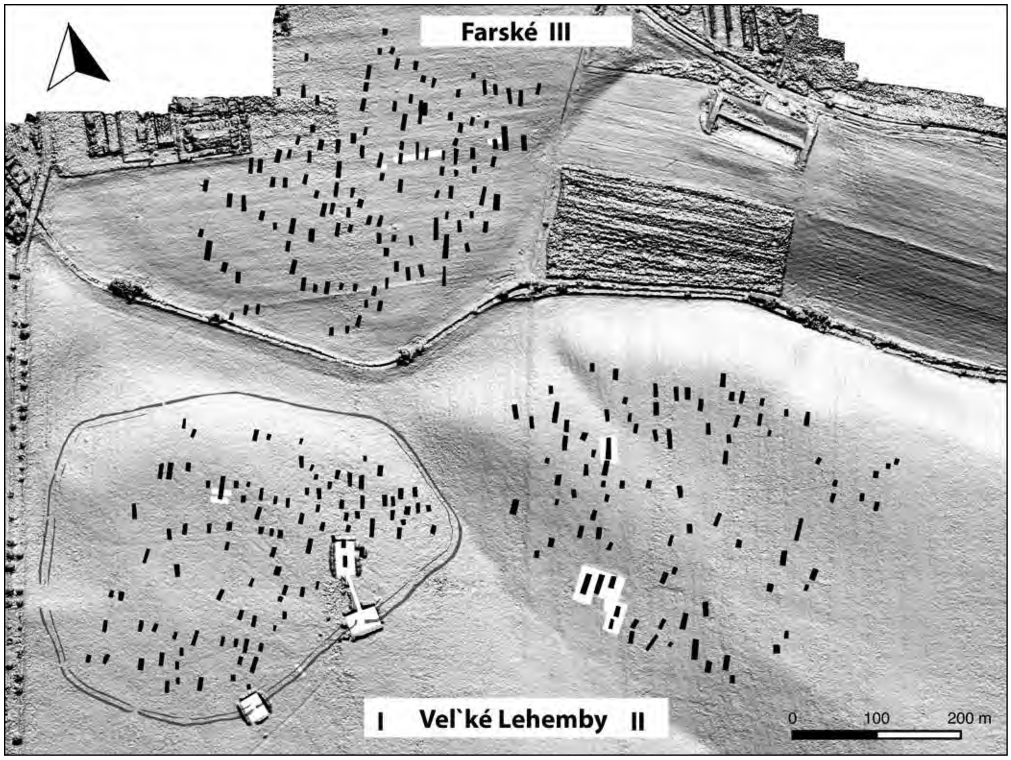

Figure 1.1.1. The three settlement areas of Vráble (I-III), as deduced from the magnetic measurements, showing the position of 313 houses superimposed on a digital elevation model representing the modern landscape in summer 2017.

Introduction

The research project centred around the LBK and Želiezovce settlement complex in Vráble (Nitriansky kraj, Slovakia; Fig. 1.1.1) is part of a larger, diachronical research initiative, started by Knut Rassmann (Romano-Germanic Commission of the German Archaeological Institute Frankfurt/Main) and Jozef Bátora (Archaeological Institute of the Academy of Sciences in Nitra) with their work on the Bronze Age settlement in southwest Slovakia. It was their work in the early and middle Bronze Age settlement in Vráble 'Fidvár' that led to the discovery of the Neolithic settlement, and their invitation to the authors of this chapter to further archaeologically investigate and to use the magnetic prospection data from this site enabled us to establish this project. The idea to diachronically investigate the settlement history and social transformations in the upper Žitava valley, to jointly conceptualize the work of the team RGK/Academy Nitra and the team Kiel/Academy Nitra, to collaborate and exchange data and results, was a main basis of our work from the start. This is reflected, among others in the overall plan of this project within the Collaborative Research Centre (CRC) 1266, which started with the investigation of the early Neolithic LBK settlement and which will proceed successively into younger periods – Late Neolithic and Copper Age – to finally integrate our work with the data and results of the RGK/Academy Nitra group on the Bronze Age settlement in a diachronical perspective on the Žitava Valley and the wider Eastern Central European region.

The project is strongly connected to the application of geophysical investigation methods in archaeology on several levels. First of all, the site was discovered through geophysical prospections (Chapter 2.1).. Although it is one of the largest Linearbandkeramik (LBK) sites in Europe, its existence was unknown until 2008. This is remarkable because the Žitava Valley is one of the areas in which systematic site registrations have been carried out for decades through surveys and surface collections. A field-survey in 2012 indicated a very low density of surface finds in Vráble, which is presumably what caused the LBK settlement to go undetected for so long. The subsequent excavations showed that the pit features are covered by a layer that is thicker than usual, compared with other sites in south-western Slovakia. This means that the pit features were less disturbed by modern agricultural activities. Only at a depth of about 50 cm, and thus mostly below the plough horizon, can significant concentrations of Neolithic finds be observed. The site would probably have remained undiscovered even longer if investigations of the neighbouring Bronze Age site in the plot called 'Fidvár' (further Vráble 'Fidvár') had not taken place. In 2008, for practice purposes and to explore the wider surroundings of the Bronze Age settlement, the neighbouring field was surveyed by the team around Kay Winkelmann (Chapter 2.1), discovering pairs of long pits and parts of a ditched enclosure. In 2009, an 'International course on ArchaeoGeophysics INCA', i.e. an interdisciplinary field course by Slovak and German geophysicists and archaeologists used the fields around Fidvár, again for practice purposes. Christoph Rinne and Tina Wunderlich from the University of Kiel directed a more extended survey on the Vel'ké Lehemby field, and they were the ones who were able to verify the existence of an LBK settlement through a very thorough surface collection that they organized. This survey yielded a small number of LBK fragments that confirmed the initial assumptions about the dating of the site.

In addition to the site's discovery through the application of geophysical methods, the following investigations greatly benefited from the possibilities of geophysics and their large-scale applicability in archaeology. It was a stroke of luck that one of the project leaders of the excavation at Vráble 'Fidvár', Knut Rassmann from the RGK in Frankfurt am Main, had a car-pulled 16-probe magnetometer device (SENSYS MAGNETO®-MX ARCH) at his disposal (see Chapter 2.1). With this device, he prospected an area of 150 ha in the autumn of 2010 and spring of 2012 and discovered a Roman military camp (Bátora *et al.* 2015; Hüssen *et al.* 2016) as well as three LBK settlement areas of about 15 ha each, densely built-up and only disturbed in the north-west by modern buildings. These three Early Neolithic settlement areas side by side (in the fields 'Veľké Lehemby' and 'Farské') on a total area of about 50 ha (Fig. 1.1.1), do not represent the largest known LBK settlement concentration (cf. Petrasch 2012), but one among the largest in the wider European context. Certainly, Vráble is the only LBK settlement of this size class with a complete settlement plan. It thus represents a particularly interesting Early Neolithic site.

Knut Rassmann and Josef Bátora, who were at that time working at the neighbouring Bronze Age site of Vráble 'Fidvár', were then able to interest the authors of this introduction to visit the site in 2012. Martin Furholt from the University of Kiel carried out a test excavation on one of the houses of the south-western settlement in spring 2012, together with Peter Tóth from the Archaeological Institute of the Academy of Sciences in Nitra (Furholt *et al.* 2014). In the summers of 2013 and 2014 (Fig. 1.1.2-3), further excavations were carried out, now by Martin Furholt and Ivan Cheben (Archaeological Institute of the Academy of Sciences). They were headed by the Archaeological Institute in Nitra and had start-up funding from the Institute for Pre- and Protohistory of the CAU Kiel and as part of the Vedecká grantová agentúra of the Slovakian Academy of Sciences (VEGA) project 2/0107/17 'Civilisation Development and Settlement Structure in the Period of LBK in the Lower Žitava River Area'. The purpose of these campaigns was to obtain pilot data for a larger research project. From 2016 to 2018, the 'CRC 1266 'Scales of Transformation – Human-Environmental Interaction in Prehistoric and Archaic Societies' was able to finance a larger and more interdisciplinary project. Each was accompanied by prospection campaigns in spring.

Since 2016, the work in Vráble has been embedded in the infrastructure of the CRC 1266 and has benefited greatly from the expertise of the disciplines and subprojects represented there, such as palynology and geoarchaeology (Project

Figure 1.1.2. The 2013 excavation area in the south-eastern settlement (II). View from the south, in the ploughed area at top left is the northern settlement, 'Farské' (III), to the left (not visible) is the south-western settlement, 'Veľké Lehemby' (I).

F2, led by Walter Dörfler and Hans-Rudolf Bork); Archaeobotany (project F3, led by Wiebke Kirleis); dating and modelling (project G1, led by John Meadows and Thomas Meier); and, last but not least, geophysics (G2, led by Dennis Wilken and Wolfgang Rabbel). Zooarchaeological investigations were carried out at the Institute for Pre- and Protohistory of the CAU Kiel (headed by Cheryl Makarewicz) and by Ulrich Schmoelcke, Schleswig.

The Archaeological Institute in Nitra contributes archaeological expertise in the field of excavation technique, ceramic typology (Ivan Cheben, Alena Bistáková) and lithic analysis (Michal Cheben), as well as logistical and legal support for the work (Ivan Cheben). Zuzana Hukeľová at the Institute in Nitra was responsible for the physical-anthropological investigations of the human skeletal remains.

Regarding terminology, based on our overall social model (Chapter 6.3), we refer to the whole site of Neolithic Vráble as 'a settlement', while the three settlement areas (I-III) are referred to as 'neighbourhoods'. This is a term derived from the research on the Anatolian Neolithic (Düring 2011), which has been increasingly used in LBK contexts, and refers to residential subunits within a larger settlement units (see Chapter 6.3). This was done as a consequence of the dating project, which assessed that all three settlement areas were largely contemporary (Chapter 4.2).

Central research questions

The most striking feature of the settlement plan of Vráble is the concentration of a large number of houses – at least 313 in three settlement areas, or neighbourhoods (I-III) – in a small space, which is remarkable, while not unheard of, in the Early Neolithic context of the LBK. While densely built, large settlement communities are a well-known feature of Early Neolithic societies in the Near East and Anatolia (Kuijt 2000; Banning 2010; Düring 2011), and also frequently occur in south-eastern

Figure 1.1.3. Students during the 2014 excavation campaign.

Europe during the developed Neolithic (Hofmann 2013; Furholt 2016; Schier *et al.* 2004; Hofmann *et al.* 2019), the central European Neolithic, since the LBK, seems to be characterised by smaller settlements and, above all, less densely built settlement areas. Since the 1980s, the so-called 'Hofplatzmodell', or 'yard model' (Boelicke *et al.* 1988; Stehli 1989; 1994; Zimmermann 2012), which emphasises the spatial and economic autonomy of individual households or courtyards, has dominated the field of LBK research (Boelicke *et al.* 1988; Stehli 1989; 1994; Zimmermann 2012). According to this model, even settlement plans that appear very dense should break down into smaller, dispersed units once chronological differentiation is taken into account. For the LBK, this reinforced the concept of a social structure in which the 'Hofplatz' (or 'yard', or 'farmstead' – we use these terms interchangeably) as an autonomous economic unit represents the most important social unit, while the village community is much less important than it is, for example, in the Balkan societies associated with Vinča material. The yard model deconstructs the idea of settlement-wide social principles and of community-wide institutions that determine the position of houses and that would be expressed, for example, in settlement plans arranged in rows of houses. This fits well into the diachronic context of the central European Neolithic, which – with a few exceptions (*e.g.* Ebersbach 2010) – hardly knows the concept of ordered settlement plans or larger settlement concentrations. It also fits well into the idea of a gradient starting in the Orient and going via south-eastern Europe to the north-west, of decreasing settlement size, decreasing settlement concentration (Rosenstock 2009) and increasing autonomy of the household at the expense of the larger settlement community (Furholt 2016; 2017).

However, in the past 10 years, an intensive discussion about the validity, or at least the universal applicability, of the yard model for the entire area of LBK settlements has developed. This was initiated in particular by Oliver Rück (2007; 2012), who formulated a series of sound observations regarding problematic premises of this model and used this criticism to rehabilitate the principle of rows of houses in the LBK. Inspired by this criticism, various principles of spatial order in LBK settlement sites have again been widely discussed in recent years (Link 2012; Lenneis 2012; Lefranc *et al.* 2018), the tenor being that it is hardly convincing to assume a single spatial principle, be it the yard model or the house row model for the entire central European Early Neolithic.

The first approach to the settlement plan of Vráble happened under the precondition of testing different principles of spatial order with an open outcome (cf. Furholt *et al.* 2014, 250-254). The first impression that the magnetic plan gives is that of a stronger settlement-wide order, which is expressed, in particular, in the existence of several parallel rows of houses (Fig. 1.1.1).

The central research question of the project was thus to what extent the concentration of occupation in Vráble represents a process of social integration, that is, a strengthening of settlement-wide social institutions. This might be expressed by a more central or communal organisation of subsistence and social interaction, and a synchronisation of social behavioural patterns, which would show itself not least in a subordination of the household unit to a spatial order encompassing the settlement community – or to what extent it represents a loose accumulation of autonomous units, as suggested by the yard model.

This research question is of particular importance in the context of Neolithic research and beyond because our notions of prehistoric forms of social organisation are far too often dominated by poorly questioned premises, even stereotypes. The notion of culturally and socially homogeneous, closed communities as the standard configuration of agricultural communities usually implicitly, and often explicitly, forms the basis for further reflections on political organisation, economic strategies, regional and supra-regional interaction, and the role of mobility and migration (Furholt 2018). However, both social anthropological literature (*e.g.* Schachner 2012; Cameron 2013; Leppard 2014) and recent archaeological and scientific studies (Bentley *et al.* 2008; Bogaard *et al.* 2011; Zvelebil *et al.* 2013; Brandt *et al.* 2014; Hachem and Hamon 2014) suggest that the social composition of communities without or beyond the reach of state forms of organisation often, if not mostly, is dynamic and fluid. A high degree of individual mobility enables the frequent breaking up or mixing of communities that can lead to socially heterogeneous residence groups.

The assessment of the social composition of residence groups in Neolithic societies is thus a fundamental basis for the understanding of a whole series of important questions and will therefore also be examined in Vráble. One of the most prominent of these questions relates to the already mentioned phenomena of centralisation and communality of social interaction; of subsistence strategies; and of access to, storage and distribution of resources and raw materials. Another closely related research question is that of population size, *i.e.* the number of residents, which can be approximated through the number of houses used simultaneously and their lifespan. This is linked to the question of the extent and form of human influence on the surrounding landscape, and the question of the carrying capacity of the natural environment used for subsistence economic activities. Necessary prerequisites to answer these questions are, first, a chronological differentiation of the settlement plan and, second, the characterisation of strategies of subsistence and traditions of production and usage of material culture, as well as access to raw materials in different parts of the settlement.

Based on these central questions, which concentrate on the settlement group of Vráble, the project seeks to embed these findings in the wider context of the surrounding landscape. Therefore, since 2016, prospections and smaller excavations have been carried out in the Upper Žitava Valley in order to understand Vráble's position in the wider settlement landscape and to investigate to what extent the settlement concentration of Vráble deviates from the regional settlement structure and whether it is a central settlement in a larger settlement system. The monograph presented here concentrates on the Vráble studies themselves, while the regional studies will be published in a second volume.

Within the framework of the CRC 1266 'Scales of Transformation – Human-Environmental Interaction in Prehistoric and Archaic Societies', Vráble is a case study for the overarching question of how population concentration affects social relations, how it is economically organised, and how it is embedded in a changing natural and social landscape. We can draw on the concurrent work of Knut Rassmann and Jozef Bátora on the Early and Middle Bronze Age settlement at Vráble 'Fidvár', and, taking into account the occupation of the same area during the Lengyel period, in order to carry out a diachronic investigation of social concentration and dispersion processes. These processes can be compared with parallel projects, *e.g.* the project on settlement concentrations in Trypilla megasites (CRC 1266, subproject D1, led by Johannes Müller, Wiebke Kirleis and Hans-Rudolf Bork).

Research strategy

In order to answer the project's overarching questions, two essential prerequisites have to be met: a chronological differentiation of the at least 313 houses and a characterisation of subsistence strategies, traditions of material culture and access to raw materials in different parts of the settlement. Traditionally, LBK settlements are investigated by means of large-scale excavations, which completely excavate a substantial part of the former settlement area. This would require extensive excavation campaigns lasting several years, which, even with the generous funding provided by a DFG-funded CRC, are not realistically achievable. On the other hand, the variety

Figure 1.1.4. Aerial photo of the 2016 excavation area, which covered a house cluster in the south-eastern settlement area (II).

of methods available in the CRC offers new opportunities to develop and implement alternative research strategies. In particular, the possibility of having a complete or almost complete settlement plan available at the beginning of the work, due to the extensive magnetometry investigations carried out, enables us to tackle specific problems in a targeted manner by means of smaller excavation campaigns, coring and further geophysical investigations. For this reason, in each of the three settlement areas at Vráble, individual houses, sections through several adjacent houses, and a complete house cluster (Fig. 1.1.4) were excavated. In addition, three different parts of the ditch system enclosing the south-western settlement area (neighbourhood, Area I) were cut by an excavation trench, twice at an entrance and once in the middle of a continuous part of the enclosure[1].

Furthermore, a major coring project was carried out in 2017 (Fig. 1.1.5) to recover datable material (see Chapter 4.2). The interpretation of the large-scale magnetic plan provided by Knut Rassmann was simplified by further pedological and geophysical investigations through the subprojects G1 and F2, in the excavation trenches themselves and at other selected areas.

Introduction to the site

The north-eastern part of the Danubian Lowland forms the geomorphological unit of the Danubian hills. The Neolithic settlement complex of Vráble is situated in south-western Slovakia, at the northern edge of the Danubian Lowland, in the Žitava hills, on the eastern terrace near the Žitava floodplain. The settled area is subdivided into three elevations, south of the modern-day town of Vráble (Fig. 1.1.1; 1.1.3; 1.1.7). The Upper Žitava Valley with all its tributaries represents a closed geomorphological unit. In the northern and north-eastern parts, it is delimited by the pronounced Tribeč and Pohronský Inovec mountains. In the eastern part, the area is surrounded by the hilly Pohronská pahorkatina. The three elevations south of Vráble are separated by a small brook (Kováčovský potok), which flows into the Žitava River to the west of the sites (and of the Bronze Age site at 'Fidvár'). The two southern neighbourhoods (area I and II) of Vráble are separated from each other by a furrow that runs in N-S direction towards the stream. Today, all three neighbourhoods are situated on intensively cultivated agricultural land running from the southern built-up outskirts of Vráble to the commune of Melek. To the west, the settlement is bounded by the road from Vráble to Hul/Dvory nad Žitavou, and to the north, by the road from Vráble to Tehla.

At the end of the older Pleistocene, the formation process of today's Danubian hills, and especially of the lowlands and larger rivers, began. In the middle Pleistocene, terraces along the main river course were formed and loess was deposited on the large area of the Danubian hills. At the beginning of the younger Pleistocene, the present relief formation and sedimentation, which has been preserved in the lowlands of Nitra, Žitava and Gran, was largely completed. Most of the lowlands are filled with fluvial sediments. The majority of loess deposits and deluvia date back to the Early Pleistocene. In the Holocene, deepening of the rivers in the lowlands led to the partial removal of the Late Pleistocene fluvial sediments. Aeolian sediments are dominant in this area. In particular loess and loamy soils cover the largest area in this region, ranging in thickness from 1 to 20 m. In addition to loess, sandy loam, loam, and other soils are found here. The dominant soil type is chernozem, but brown soils and floodplain soils (Harčár and Priechodská 1988) also occur.

Figure 1.1.5 (top left). Students engaged in the coring programme in south-western settlement area (I) during summer 2017.

Figure 1.1.6 (below left). View of the south-western settlement area (area I) from the south during the 2017 excavations. To the north are 'Farské' (area III) (whitish field) and the town of Vráble, and in the background are the foothills of the Carpathians.

1 This trench had been dug in 2010, under the direction of Peter Tóth, before the authors of this introduction began to participate (cf. Furholt *et al.* 2014, 234).

As already mentioned, the three neighbourhoods of Vráble were extensively surveyed via magnetometry (see Chapter 2.1) and could therefore be described in detail before the excavations even began (Fig. 1.1.1). The enclosure around the south-western neighbourhood, area I (Vráble 'Veľké Lehemby' I), encloses an area of 14.7 ha, and the area on which house features can be found covers 10 ha. The northern neighbourhood, area III (Vráble 'Farské') covers at least 12 ha; the north-western part was destroyed by modern building activity. Taking this disturbance into account, it does not seem too far-fetched to state that the northern settlement area (neighbourhood) has essentially similar dimensions to the south-western enclosure. This is all the more remarkable because the south-eastern neighbourhood, 'Veľké Lehemby' II, is also about the same size, at 14.5 ha.

Taking into account the disturbance of the northern settlement area, the three neighbourhoods also appear relatively uniform in form and orientation (Fig. 1.1.1). Both the enclosure and the two other settlement areas are roughly trapezoidal, with a wider half in the north-east and a narrower half in the south-west. Judging only from these parameters – same size, form and orientation – all three neighbourhoods seem to follow a similar mental template with respect to the settlement form. The implications of such considerations will be discussed in Chapter 6.3.

The identification of houses in Vráble via the magnetics plan is essentially indirect. Since in the vast majority of cases postholes could not be identified through the magnetometry investigation, the presence of paired long pits must be used to deduce the existence of houses. In most cases, the picture is very clear and can be interpreted without a doubt. But there are also cases where the magnetic anomalies are relatively unclear, so that it is at the discretion of the observer to register a long pit. In order to eliminate this subjectivity as best as possible, in 2018 the identification of house features was provided through digitalisation by three persons (Martin Furholt, Nils Müller-Scheeßel and Wiebke Mainusch), independently of each other, and only if at least two of the three persons interpreted it as a house was the anomaly registered as a house. This reduced the number of currently counted houses to 313, compared to the 316 that Martin Furholt assigned on his own in 2012 (cf. Fig. 1.1.1; see Furholt *et al.* 2014).

A cluster of 313 houses on an area of about 50 ha is not unheard of in the context of the LBK, but Vráble 'Veľké Lehemby'/'Farské' is certainly among the largest and most densely populated settlement sites of the central European Early Neolithic, comparable with Eythra in Saxony, Germany (Cladders *et al.* 2012a), Bylany in Bohemia (Pavlů 2010) or Gerlingen in Baden-Württemberg, Germany (cf. Petrasch 2012, 57). The ditch system that surrounds the south-western neighbourhood, area I, is also one of the biggest enclosures of the LBK. It is also the first one of this date found in Slovakia. The nearest enclosures are located in Vedrovice, South Moravia, Czech Republic, where 12 hectares of land are included (Ondruš 2002, 13, Fig. 2) and in Asparn-Schletz, Austria (Teschler-Nikola 2012).

Excavation technique

During the excavations the following technique was used in general. First, the trench areas, planned on the basis of the magnetic findings, were pegged out using differential GPS and then the topsoil was removed with an excavator (Fig. 1.1.6-7). Depending on the depth of the ploughing and brunification horizons, 40-60 cm were removed, in order to be able to identify the archaeological features in Planum 1. These features were documented with a tachymeter in the early years and with GPS-supported drone photography in later years and were then sectioned. Postholes were documented with a single profile. Other pits were quartered or, in the case of larger pits, excavated in a chequerboard

Figure 1.1.7. The removal of the plough horizon by means of a mechanical excavator.

pattern in order to obtain a sufficient number of longitudinal and transverse profiles. Especially the long pits accompanying the houses, which also have the highest density of finds, were excavated this way. The quadrants formed by this chequerboard pattern were documented planum-wise approximately every 10 cm. Within these 10 cm spits, natural layers were uncovered and documented if possible, which was particularly viable for burnt clay concentrations. In the years 2012-2014, some feature contents were sifted systematically. This was done primarily to obtain a representative animal bone spectrum in terms of animal size and age for the zooarchaeological analyses. However, it soon turned out that the additional time required for sieving in the loess soil was not worth the effort, as the total amount of bones recovered this way was still not large enough to create meaningful age profiles. Therefore, we discontinued these sieving trials after the 2014 campaign.

During excavation of the features, all finds, including animal bones, were collected and separated by quadrant and archaeological feature. Special finds and bones taken as samples were measured three-dimensionally with a tachymeter or differential GPS. Burnt clay was weighed and stored together with the other finds in the depot for further analysis. In addition, sediment samples were systematically taken for archaeobotanical and geochemical analyses and the former were processed by flotation on site. Transverse and longitudinal profiles of the archaeological features were documented photogrammetrically, but features were also defined, sketched and described on site. Selected profiles were described on site, sampled for geochemical analyses and measured for their magnetic susceptibility. If time allowed, after the profiles had been documented, the remaining quadrants were excavated and plan views were documented.

Figure 1.1.8. Aerial photo of the 2017 excavation areas in the south-western settlement area (neighbourhood I), viewed from the north.

Excavation history

In 2010, a small trench was dug through the enclosure of the south-western settlement under the direction of Peter Tóth. This was done as part of the research activities at the Bronze Age settlement of Vráble 'Fidvár'. The project leaders, Knut Rassmann and Jozef Bátora, then sought Neolithic researchers who might be interested in organising a larger research project around the site. As a result, the first sondages were made in spring 2012 by one of the authors of this introduction (Martin Furholt) together with Peter Tóth and a small group of German and Slovak students. Two sections of 5 × 20 m each were made within a house context (Furholt *et al.* 2014), labelled trenches 2 and 3[2]. In addition, a systematic survey was carried out in the central area of the south-western neighbourhood, area I (cf. Furholt *et al.* 2014). For the 2012 campaign, the first task was to document the conditions of preservation and the structure of the features of a house in the south-western settlement area and to estimate the potential for a larger project. During this exploratory work, the other author of this introduction (Ivan Cheben) joined as a project partner for further work. In the summer of 2013, a complete house context was excavated in the south-eastern part of neighbourhood II, stretching over an area of 30 × 20 m, as well as another house, which was partially overlain by the former (trenches 4-6). In spring 2014, a magnetometry campaign was carried out to extend the settlement plan in all directions and to identify further settlements. After one week of intensive measurements without detecting a single prehistoric anthropogenic anomaly, we

2 'Trench 1' was used to code for all stray finds or finds from systematic surveys in the project database.

were able to establish with great certainty that the three already known neighbourhoods represent the only LBK settlement activities of this site.

The aim of the excavation in the summer of 2014 was to cut as many houses as possible within the, at that time, still small financial budget. Therefore, four trenches were set up close to each other, which produced material from six different houses and a larger pit complex. In trenches 7, 9 and 10, pit contexts were excavated at 5 × 5 m each. Trench 8 was a 5 × 57 m traverse through six paired long pits that belonged to four houses defined on the basis of the magnetic plan.

With the pilot material collected so far, a successful project application could be submitted for funding within the framework of the CRC 1266, within which Nils Müller-Scheeßel could also be employed in the project. In the summer of 2016, a complete house cluster of four houses, which are close to each other and have a similar orientation, was excavated in the southern part of the neighbourhood II. Comprising a total area of 2283 m², these four houses could be excavated either completely or to a large extent (trenches 11-14). In the spring of 2017 and 2018, systematic field surveys and magnetic measurements were carried out at several sites in the Žitava Valley. These are mainly to be presented in a second monograph.

In the summer of 2017, two trenches were dug at two entrance areas of the ditched enclosure complex surrounding the south-western neighbourhood I (Fig. 1.1.8; trenches 21 and 23, 35 × 20 m and 37 × 20 m), and an additional trench was dug which covered large parts of two adjacent houses near the enclosure (trench 22, 26 × 20m). In the summer of 2018, excavations were carried out in two LBK settlements outside Vráble (in Úľany nad Žitavou and Vlkas), which will also be reported on in the second monograph.

Acknowledgements

We would like to thank Knut Rassmann and Jozef Bátora for making it possible for us to work in Vráble in the first place. Knut Rassmann created the fantastic magnetic plan, which is the starting point and heart of the research. Since the beginning of our project, he has helped us time and time again with advice and practical assistance, especially in critical times. In most years, the field work in 'Fidvár' and 'Veľké Lehemby' and 'Farské' was carried out in tandem, which ensured a pleasant neighbourhood with mutual support, up to and including a common goulash meal in the field.

We would also like to thank a number of colleagues who were actively involved in the work in Vráble and in the development of the project. In 2012, Peter Tóth was the project's 'obstetrician' and a pleasant, constructive colleague. Since 2013, Michal Cheben, has been actively involved in the successful implementation of the field campaigns. Stefan Dreibrodt has been a regular collaborator since 2014, contributing his geoarchaeological and pedological expertise to a fruitful broadening of horizons. Since 2016, we have benefited extremely from the involvement of Nils Müller-Scheeßel, who has given the project even more depth and structure through his ideas and organisational talent. Since 2017, Natalie Pickartz, Erica Corradini and Diana Panning have considerably expanded the range of geophysical methods. In the beginning, they were supported by Ercan Erkul. In 2012, Helmut Kroll was on-site to coordinate the archaeobotanical sampling. Later, Dragana Filipović undertook this task several times. We would also like to thank Agnes Heitmann for the professional photographs of finds in the 2018 campaign.

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The zooarchaeological work was carried out by Rebekka Eckelmann, supervised by Cheryl Makarewicz, and Sarah Pleuger, supported by Ulrich Schmoelcke. Zuzana Hukeľová contributed the physical anthropological analyses. Isotope analyses were carried out by Rosalind Gillis and Cheryl Makarewicz and the modelling of ^{14}C data was carried out in collaboration with John Meadows.

The fieldwork has benefited greatly from a large number of extremely committed students. Many of them participated more than once in the field campaigns, which led to the development of a healthy sense of community. We would like to thank all those who have contributed, but especially those who have been part of the team for several years.

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Section 2: Scientific analyses at Vráble

2.1. Revealing the general picture: Magnetic prospection on the multiperiod site of Vráble 'Fidvár'/ 'Veľké Lehemby'/'Farské'

Kay Winkelmann, Jozef Bátora, Isabel Hohle, Johannes Kalmbach, Nils Müller-Scheeßel, Knut Rassmann

Abstract

The large scale magnetic prospection (2008-2012) near Vráble on the sites of 'Fidvár' and Velky Lehmby covered an area of around 150 ha and revealed three Neolithic settlements of the Linear Pottery Culture as well as numerous remains of later periods like the Lengyel Culture, Early Bronze Age and Roman Period. The paper presents an overview of the magnetometer data of the three Neolithic settlements. Thanks to the ongoing excavations that started in 2010 a selection of typical archaeological features like elongated pits of houses, settlement pits and ditches can be compared with the magnetometer data. This context enables us to improve the analysis and interpretation of the magnetometer data and to optimise the estimation of the number of houses and the evaluation of quantitative data like the size of elongated pits and their orientation.

Keywords: Magnetic prospections, LBK, Lengyel, Early Bronze Age

Introduction

The magnetic prospection carried out near Vráble (Nitriansky kraj, Slovakia) was the starting point for a cooperation between the Romano-Germanic Commission (RGK in German) and the Sensys company. Our cooperation, which started in 2008, aimed to evaluate multi-channel magnetometer systems developed and manufactured by Sensys GmbH (Bad Saarow, Germany) in the field of archaeological prospection (Bátora *et al.* 2009). The multiperiod site near Vráble was chosen based on the first, promising results of a magnetic prospection carried out in the context of a Slovakian-German project in 2007 (Falkenstein *et al.* 2008, 42).

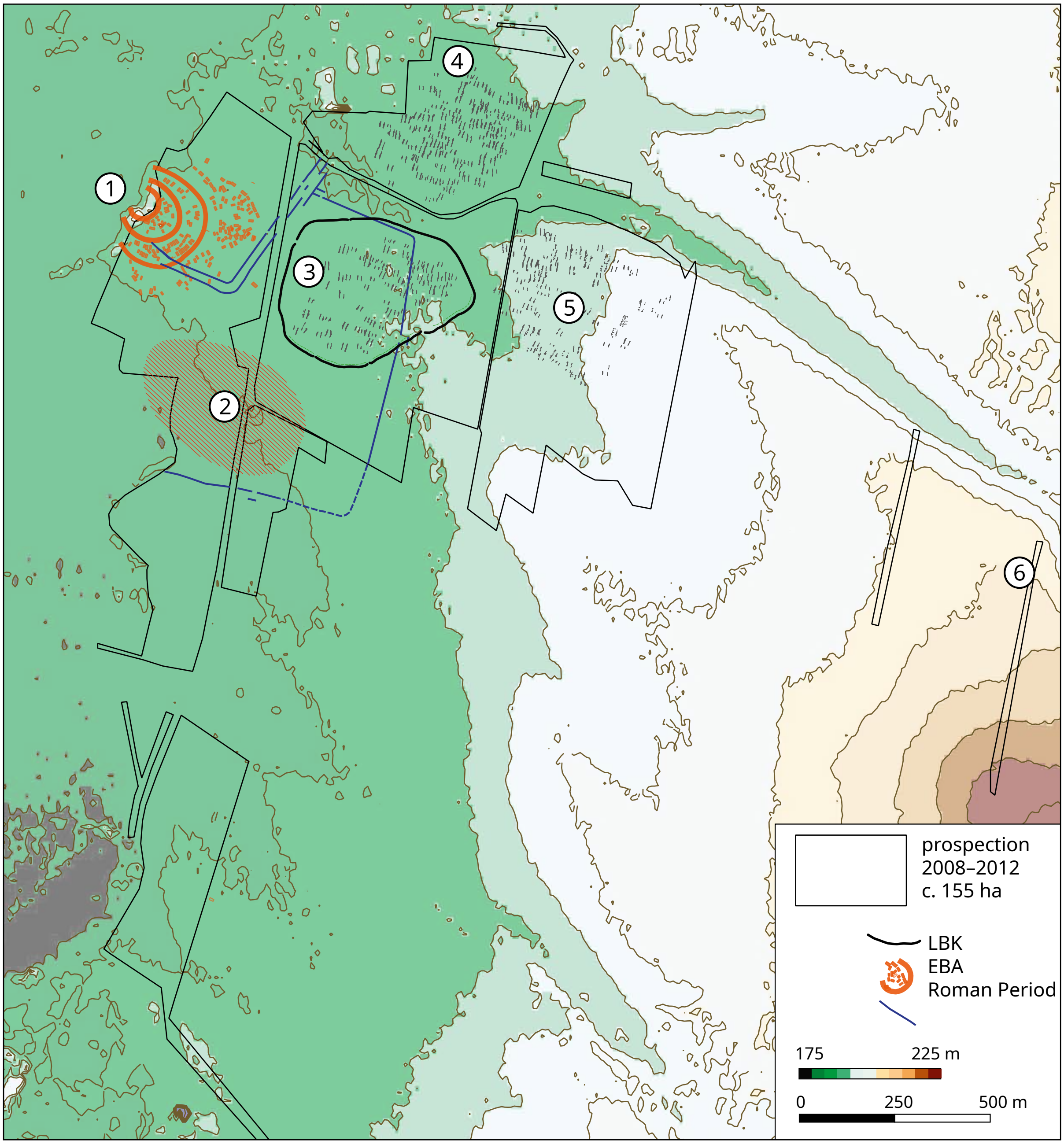


Figure 2.1.1. Map showing location of the prospected area and overview of the crucial archaeological features at the multiperiod site of Vráble 'Fidvár' and Vráble 'Veľké Léhemby'/'Farské'. 1 fortified Early Bronze Age settlement of 'Fidvár'; 2 Early Bronze Age cemetery; 3-6 Neolithic settlement of Veľké Lehemby (© RGK).

During the campaigns of 2008, 2009, 2010, and 2012, three agglomerations of houses of the Linearbandkeramik (LBK) were revealed. Altogether the prospection area covered nearly 150 ha (Fig. 2.1.1). It was the first magnetic prospection of that extent in Slovakia, and it demonstrated the potential of the vehicle-towed, multi-channel system provided by Sensys. This was proven later on other key sites of European prehistory, including at Stonehenge, in the UK (Darvill *et al.* 2013), and at Maydanetske and Talianki, two megasites of the Tripolye Culture in Ukraine (Rassmann *et al.* 2016).

During the formation of this article, we developed the idea to collect information of sites of the LBK that had been prospected with a magnetometer. The idea behind that was to collect data about the technical equipment, the quality of the results, the measured area and so forth. The list is not exhaustive (Fig. 2.1.2). It should be understood more as a starting point for a broader collection of data. Most of the pros-

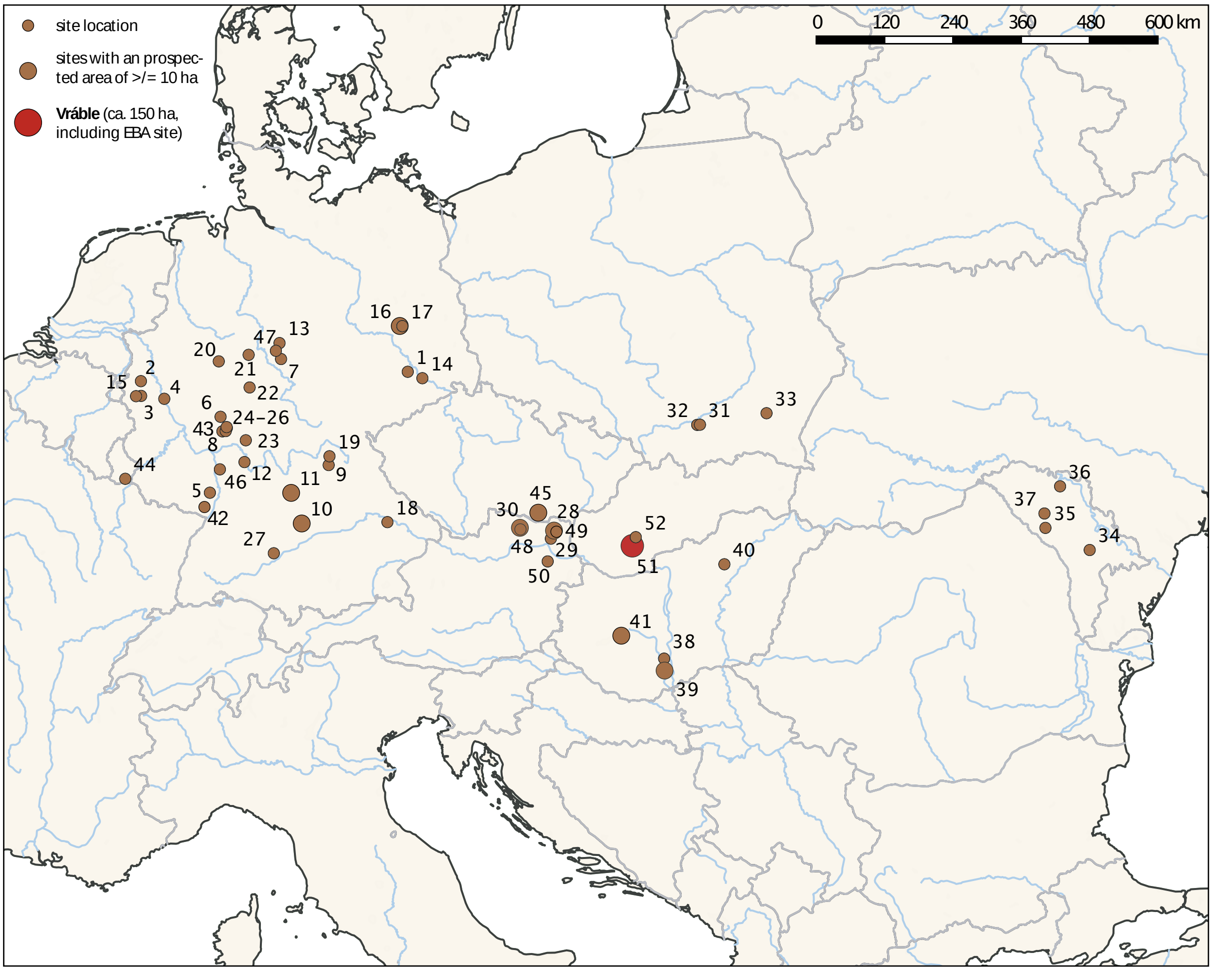


Figure 2.1.2. LBK settlements prospected with a magnetometer (illustration: Isabel Hohle). 1 Salbitz (Kinne et al. 2014); 2 Borschemich (www1); 3 Arnoldsweiler-Ellebach (Balkowski 2018, 14-17); 4 Niederkassel-Uckendorf (www2); 5 Haßloch (www3); 6 Wetzlar-Dalheim (www4); 7 Diemarden (Saile and Posselt 2002); 8 Usingen (www5); 9 Ebermannstadt-Eschlipp (www6); 10 Markt Wallerstein (www7); 11 Neusitz (www8); 12 Mömlingen (Ragger et al. 2016); 13 Hollenstedt (Saile et al. 2018); 14 Clieben (Pers. comm., Harald Stäuble, Heritage Office Saxony, Dresden); 15 Inden-Altdorf (Clare et al. 2014, 7-8 and 182-183); 16 Dennewitz 15 (Mischka and Mischka 2016); 17 Jüterbog 36 (ibid.); 18 Straubing-Lerchenhaid (Pechtl 2012, 137); 19 Königsfeld (www9); 20 Hohlen Stein (ibid.); 21 Borgentreich-Großeneder (Pollmann 2011); 22 Lötzelfeld (Kneipp and Posselt 2005); 23 Rothenbergen Scheiblingsgraben (Kreutzer et al. 2004); 24 Butzbach Hoch-Weisel (Schade and Posselt 1999); 25 Wehrheim-Friedrichsthal (Posselt and Zickgraf 1999); 26 Butzbach-Fauerbach v.d.H. (Posselt 2001); 27 Sonderbuch 8b (Knipper et al. 2005); 28 Asparn a.d. Zaya (Löcker et al. 2009); 29 Grossrussbach-Weinsteig (ibid.); 30 Breiteneich (ibid.); 31 Targowisko (Pers. comm., Joanny Pyzel, University Gdansk); 32 Brzezie (ibid.); 33 Rzeszów-Zieczyca 3 (Dębiec 2014); 34 Găureni (Saile et al. 2016a); 35 Bumbăta (ibid.); 36 Nicolaevca (ibid.); 37 Chişcăreni (Saile et al. 2016b); 38 Tolna-Mözs (Unpublished, RGK); 39 Alsónyék-Bátaszek (Unpublished, RGK); 40 Füzesabony-Gubakút (Whittle et al. 2013, 64); 41 Balatonszarszo (Unpublished, RGK); 42 Herxheim b. Landau (Haack 2016); 43 Kilianstädten (Unpublished, RGK); 44 Frisange/Weiler-la Tour (Buthmann 2015); 45 Těšetice (Milo 2013); 46 Gernsheim-Klein Rohrheim (Becker and Fröhlich 2017); 47 Gladebeck (Saile et al. 2004); 48 Mold (Lenneis and Pieler 2010); 49 Niederleis (Stuppner 2006, 48); 50 Brunn am Gebirge (Stadler 2019); 51 Vráble 'Fidvár'/'Veľké Lehemby'/'Farské' (Unpublished, RGK); 52 Čierne Kľačany (Cheben 2015), Slažany (ibid.), Čifáre (Müller-Scheeßel et al. 2020), Horný Ohaj (ibid.), Maňa (ibid.), Nevidzany (ibid.), Telince (ibid.), Úľany nad Žitavou (ibid.), Vlkas (ibid.), Vráble ‚Drakovo' (ibid.).

pected LBK sites covered an area of 1-5 ha and were prospected using hand-held/hand-pushed magnetometer systems. We highlighted sites with areas larger than 10 ha and at the current state of research, Vráble 'Veľké Lehemby'/'Farské' stands out in terms of its three Neolithic settlements that have been prospected in their complete dimensions. In 2014, additional magnetic prospections in the east and south of the three settlement areas confirmed that there is no additional LBK settlement in the close vicinity.

Figure 2.1.3. 8-channel Magnetometer (SENSYS MAGNETO®-MX ARCH) during survey of the 'Fidvár' site in 2008 (photo: K. Rassmann).

In the case of 'Fidvár', the large-scale surveys delivered enough data to reconstruct the extension of the three settlement units and revealed more than 1,500 elongated pits accompanying the typical longhouses, circular settlement pits, pits for clay extraction, ditches, palisade ditches and entrance situations. Several thousands of relevant archaeological features enable us to reconstruct the spatial structure of this Early Neolithic settlement agglomeration. The quality of the magnetic data was crucial for defining a first research agenda for investigating these settlements, providing precise information on the structure of the archaeological features, their size and their spatial organisation. The five excavation campaigns that were conducted on the basis of the results of the magnetic survey in turn provided a lot of data for a better understanding of the magnetic survey results. The analysed results of the magnetic survey were combined with the excavation data and are embedded in an interdisciplinary research project of N. Pickartz (see Chapter 2.2). Our paper presents an overview of the magnetic data in the context of the excavation results. Additionally, we analysed the magnetic data to quantify features, such as the number of elongated pits and their length, orientation and density, for the reconstruction of settlement development.

Equipment for the magnetic prospection

In 2008 our survey started with an 8-Channel Magnetometer (SENSYS MAGNETO®-MX ARCH, Fig. 2.1.3). During this first archaeological prospection, the system that was hitherto mainly used for the detection of unexploded ordnance demonstrated its potential for the prospection of archaeological sites. From 2009 onwards the prospection was continued with a 16-channel system (SENSYS MAGNETO®-MX

Figure 2.1.4. The 16-channel Magnetometer (SENSYS MAGNETO®-MX ARCH) during a survey in 2008 (photo: K. Rassmann).

ARCH). Whereas with the 8-channel system an area of around 8-10 ha could be covered per day, the 16-channel system increased this to 20-25 ha per day (Fig. 2.1.4).

The 8- and 16-channel magnetometer systems are mounted on a vehicle-towed, non-magnetic trailer array (Fig. 2.1.2-3). The vertical gradiometers are set at 0.25 m intervals on a 2 m or 4 m wide sensor array, itself set at right-angles, with a 6 m long tow bar. With speeds of approximately 6-12 km/h and a sample rate of 20 readings per second (Hertz), the system provided 15 magnetometer readings per square metre on average. The magnetometers used were FGM-650B tension band fluxgate vertical gradiometers with 650 mm sensor separation, a ±3,000 nT measurement range and 0.1 nT sensitivity. For a precise georeferencing of the magnetometer data, Trimble RTK-DGPS systems consisting of a base station and a rover with the DGPS antenna mounted centrally on the magnetometer array were used. The achieved accuracy of the georeferencing is usually ± 0.05 m.

Project planning, milestones of the prospection and the location of the survey area

The starting point for our survey is the site of Vráble 'Fidvár' (hereafter 'Fidvár'), with its remains of an Early Bronze Age settlement (Bátora *et al.* 2009). The first field survey in 2008 covered the area of this Early Bronze Age site of 'Fidvár' and a small section of the site of Vráble 'Veľké Lehemby'/'Farské' (hereafter 'Veľké Lehemby'/'Farské'). In 2009 and 2010, the prospection was continued southwards,

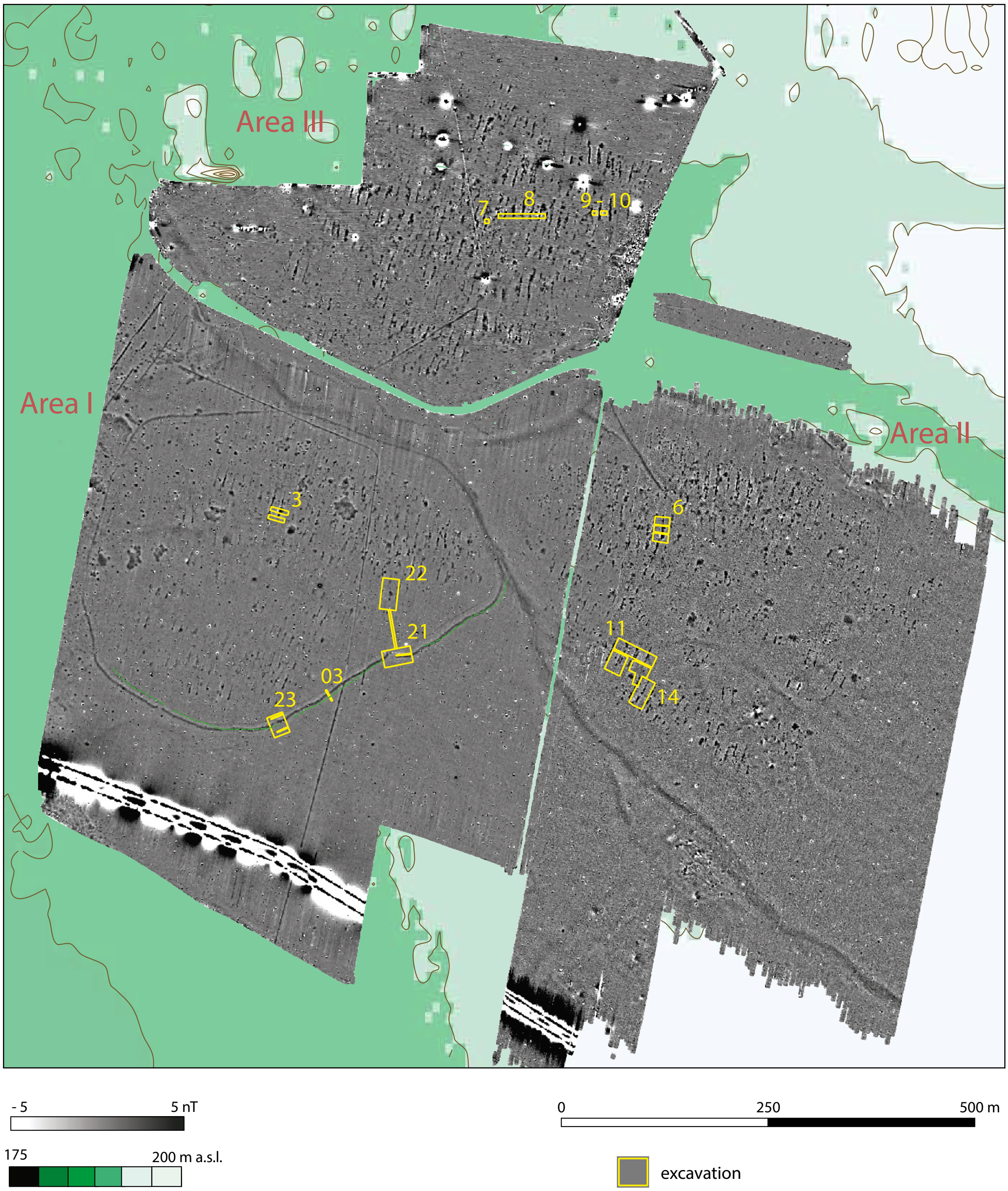


Figure 2.1.5. Overview of the magnetometer prospection at Vráble 'Veľké Lehemby'/'Farské' and the location of the excavation trenches (illustration: K. Rassmann/J. Kalmbach).

following the river terrace of the Žitava river, and was extended to the area east of 'Veľké Lehemby'/'Farské'(Fig. 2.1.1).

The magnetic survey data along the lower river terrace of Žitava revealed no evidence of any impact of the LBK, whereas at 'Veľké Lehemby'/'Farské', three large house clusters (Areas I, II, III) marked a remarkable agglomeration of houses (Fig. 2.1.5). At a distance of 1.2 km farther east, more traces of Neolithic houses where revealed in a small surveyed area (Fig. 2.1.1,6).

The discovery of the LBK settlement in the east demonstrated the potential of the vehicle-towed multichannel systems to enlarge our surveys from the scale of an

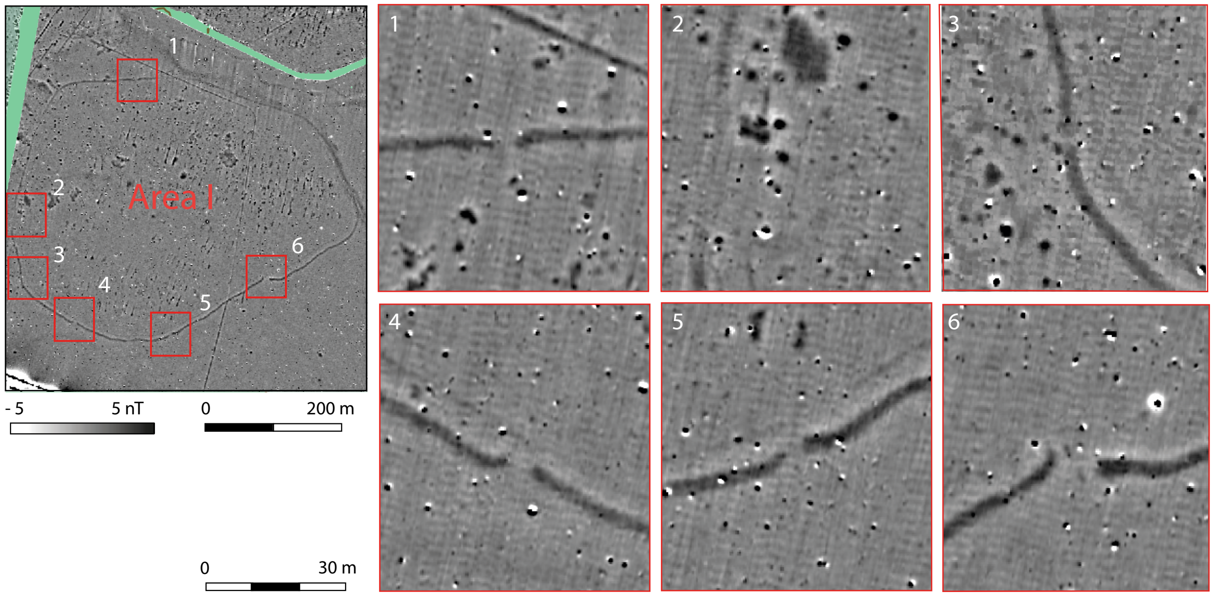


Figure 2.1.6. Magnetometric plan of 'Veľké Lehemby' (I) showing four clear entrance situations (1, 4-6) along the ditch, a further possible entrance (3), and the limited visibility of the ditch in the west (2) because of the survey direction coinciding with the direction of the ditch (illustration: K. Rassmann/J. Kalmbach).

archaeological site up to the scale of complete archaeological landscapes. An appropriate project design, the location of the prospection areas and their shape and size, and the distance between the chosen sections of prospection in the context of the natural landscape are important factors that have to be taken into account considering the specific research questions.

The area of investigation covered around 150 ha of intensively used agricultural land with fertile loess soils that were ideal for the application of the vehicle-towed system. One challenge was to find the appropriate time slot for the prospection campaign. In 2008, 2009 and 2010 our field work took place in autumn, after the harvest. In 2012 dry and sunny weather and a late sowing allowed us to survey the fields with a four-wheel car in spring. The survey direction generally followed the course of the furrows in order to minimize movement-induced noise that is observed in the magnetometers if the ground is uneven and the array starts moving or vibrating because of this.

Generally, a magnetic survey should be designed perpendicular to or at least not in line with longer, linear archaeological features in order to avoid these from being eliminated in the processing of the magnetometer data. This processing generally comprises background removal based on filtering of the raw data (by applying moving average or non-linear filters with filter lengths between 5 m and 30 m and subtracting this from the raw data). During the survey, some of the typical elongated pits of the LBK houses were orientated in the same direction of travel of the car, but this did not minimize their detection rate. However, in the south-western area of the ditch system, the direction of the prospection along the existing furrow direction coincided with that of the ditch. As a result, the ditch in this section has a significantly lower magnetic amplitude after compensation over a length of *c.* 30 m (Fig. 2.1.6,2).

In 2008 and 2009, the prospection was realized with a Ford Ranger, and in 2010 and 2012 with a Land Rover Defender. The use of both cars caused a little noise in the magnetic survey data with respect to the signal-to-noise ratio between the relevant archaeological features and their background.

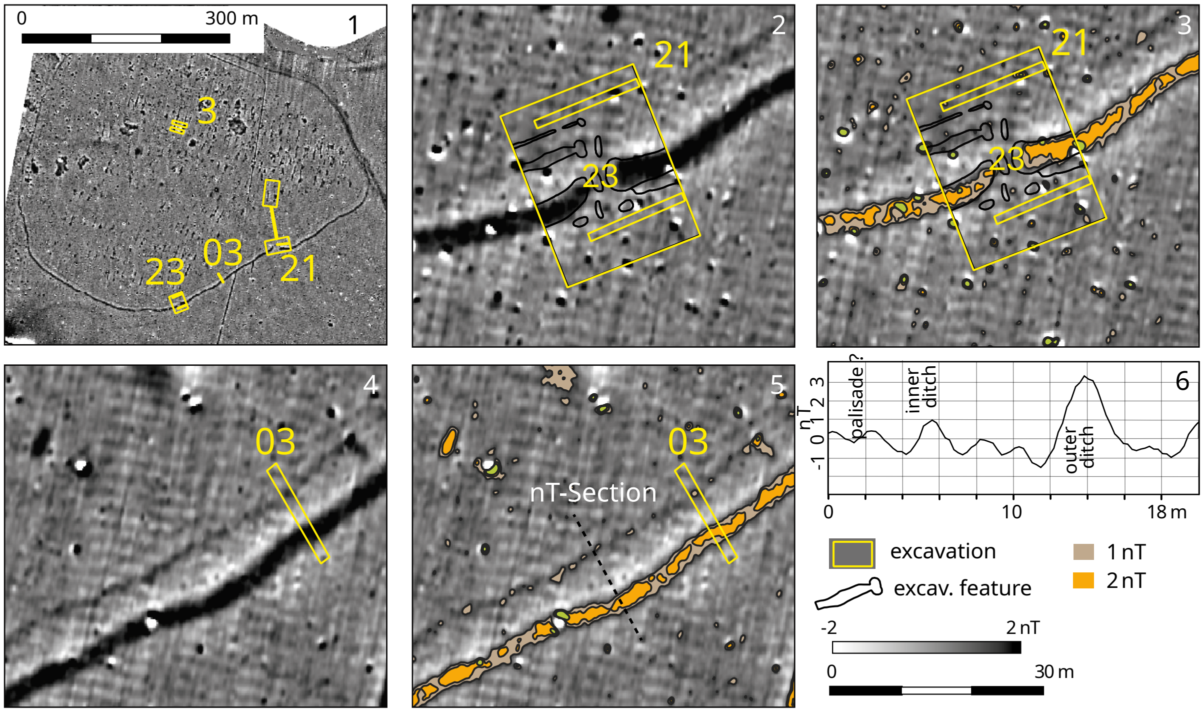


Figure 2.1.7. 'Veľké Lehemby' (I) showing magnetic data and excavation results in Trench 03 and Trench 21 (3) (illustration: K. Rassmann/J. Kalmbach).

Neolithic settlement features and their magnetic signals

Overview of the data

The campaign in 2009 revealed the complete western settlement unit, enclosed by a ditch and palisade enclosure (Area I). Magnetic survey on small test strips in the northern and eastern periphery already indicated a second and third settlement area. Unlike the western settlement, these two are without ditches and palisades. In 2010 and 2012, these settlements were surveyed over their full extent. The size and the more or less oval shape of the settlements can be reconstructed from almost two thousand magnetic anomalies of elongated pits of houses.

The settlements were divided by a little creek, the Kováčovský potok. The recent shape of the terrain does not show any other natural borders. However, the magnetic survey data revealed an erosion gully between the western and eastern settlement that is no longer evident in the topography. The remaining sides of the three settlements are without any clear natural boundaries.

Ditches and palisades and entrance situations

Neolithic settlements of the LBK with surrounding ditch systems occur since the earliest phase of the LBK but are relatively rare compared to settlements without ditch systems, especially in the eastern part of the distribution area (*e.g.* Saile and Posselt 2017, 32-33, Meyer and Raetzel-Fabian 2006, 3-9). Most of the well-known ditch systems date into the later phases of the LBK. There are different types, including ones that surround a settlement or parts of a settlement (such as the type Köln-Lindenthal) and ones that do not. Their course at 'Veľké Lehemby' is clearly visible in the magnetic data. The ditch surrounded the settlement completely. Also clearly visible are four unambiguous entrance situations (Fig. 2.1.6,1.4-6) and one additional possible situation (Fig. 2.1.6,3). The entrances are generally pincer shaped. Only in two cases was the inner ditch visible (Fig. 2.1.6,4-5).

The position of the entrances raises the question why they are missing in the contact zone with Areas II and III. In discussion are different reasons, one could be the topographical situation with the course of the erosion channel between Areas I and II and the Kováčovský potok between I and III, respectively.

The ditch anomaly was explored in 2010 with a small test trench (Furholt *et al.* 2014, 232ff. Abb. 5-6). The width was *c.* 3.8 m. The inner ditch was much smaller, with a width of only 110 cm and a depth of 20 cm. The function of the inner ditch is unclear at the current state of research. It could have been a palisade ditch. Arguments against this interpretation are the shallow depth and the bowl-shaped cross-section of the ditch. Despite its shallow depth, the inner ditch was clear visible in the South but less clear in the West and only weakly visible as a noisy, unclear signature in the North and East.

The excavation in 2017 revealed a third, smaller ditch at a distance of 3.2 m from the inner ditch (Fig. 2.1.7,2). Its V-shaped section argues for an interpretation as palisade ditch. This ditch is hardly visible in the grey-scale map of interpolated magnetic data. Based on a comparison with the excavation results, a weak response was found in the magnetic data that was not observed prior to the excavation. This was because it was not visible in the standard colour scale from −5 nT to +5 nT, but only when scaling to +2 nT to +5 nT. A virtual profile of the magnetic data close to trench 03 emphasizes the magnetic contrast of the ditches. The outer ditch, with a width of 3.8 m and a depth of 0.8 m, produces a magnetic signature amplitude of up to 3 nT, while the inner ditch produces a magnetic signature amplitude of only 1 nT and the palisade (?) ditch produces one of at most 0.5 nT, on the same scale as the noise in the magnetic survey data. The main source of noise in the data was electromagnetic induction by DC currents in the car's electrics and small up and down movements of the spring-suspended magnetometer array. The detection of the palisade ditch shows the limitations of the method. While ±0.5 nT noise in magnetic survey data can be assessed as a very low noise level, it still describes the limitations in terms of detection of archaeological features that should at least have a magnetic signature amplitude of 2 nT at ±0.5 nT noise to have a signal-to-noise ratio of 2:1 that allows clear detection of features in the data.

Houses, pits and elongated pits

The clearest evidence for the LBK settlement are the nearly 2000 elongated pits regularly accompanying the Neolithic houses. The distribution of these features clearly demonstrates the dimensions of II and III, whereas the western settlement, I, is marked by the enclosure surrounding the widely distributed elongated pits. The size of each of the three neighbourhoods (I-III) is similar, at around 14 ha each.

Based on the elongated pits, the first studies presented estimations on the number of houses. Furholt *et al.* estimated 316 houses (Furholt *et al.* 2014, 251), whereas Meadows *et al.* reconstructed slightly fewer, with 305 houses (Meadows *et al.* 2019, 1654). The reasons for these uncertainties are the overlapping of elongated pits in some cases, as there are obviously overlapping house positions. Furthermore, some excavation results show that there are cases where not every house has elongated pits on both sides of the house, as well as houses without any elongated pit (there is also one example in the magnetic data of Area III). A comparison with the excavation data of Vráble illustrates a third problem. In trench 14 (III), a Neolithic house with postholes and two elongated pits was excavated (Fig. 2.1.8,3). The response of the archaeological feature regularly shows a more complex picture of more than one magnetic anomaly. The large, western elongated pit is visible in five individual anomalies, and the two eastern pits

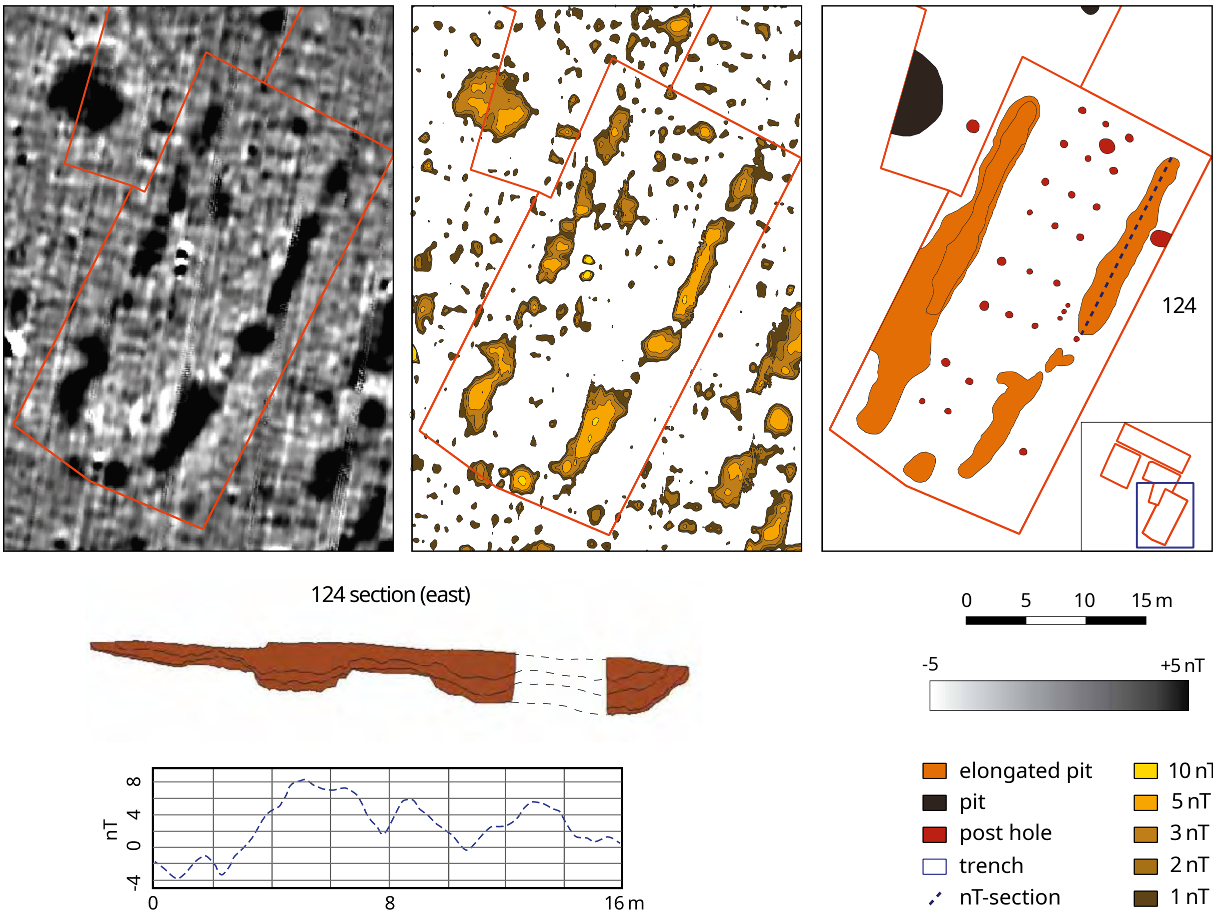
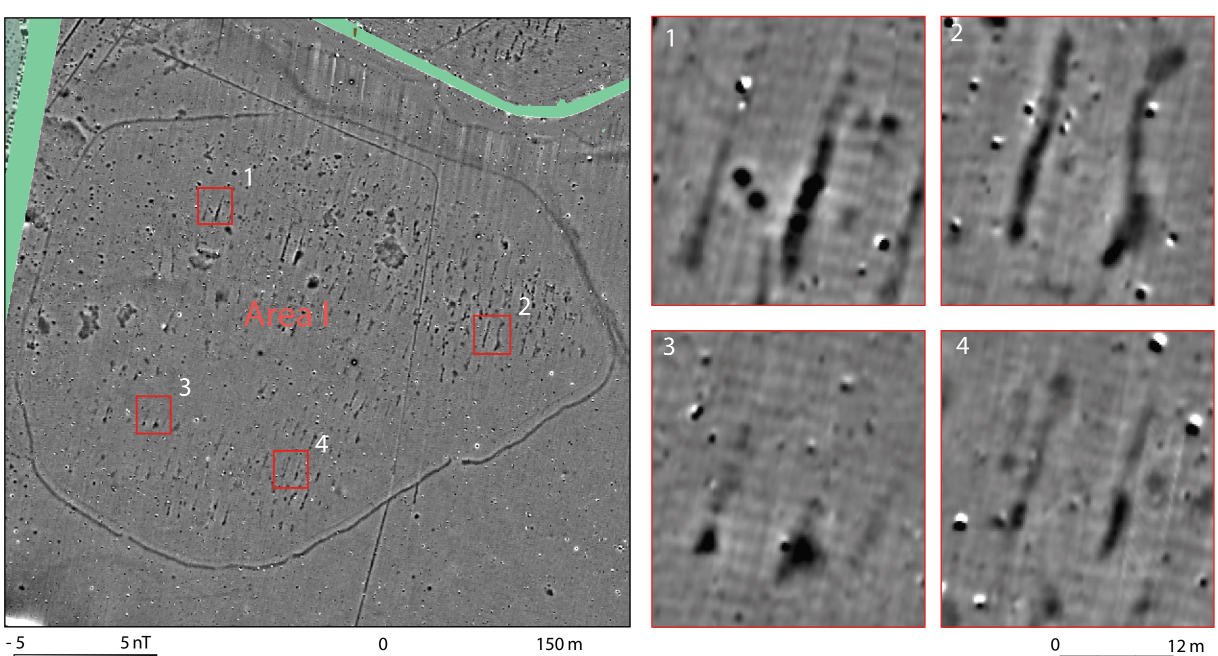


Figure 2.1.8. Vráble 'Veľké Lehemby' (II), Trench 14, comparison of magnetic data and excavation plan. 1 magnetic map; 2 contour map of the selected nT values; 3 generalised archaeological data of house, showing postholes and elongates pits; and 4 section 124.5 nT section following section 124 (position s. Fig. 2.1.5) (illustration: K. Rassmann/J. Kalmbach).



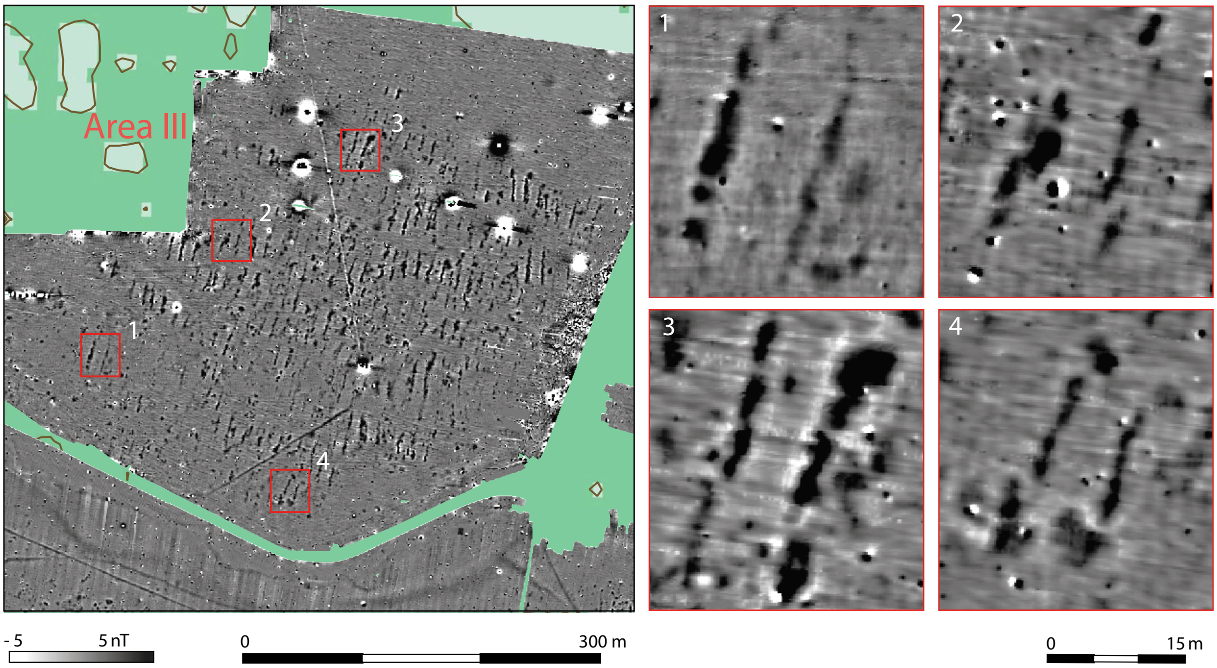


Figure 2.1.10. Vráble 'Farské' (Area III). 1-4 examples of the variation of the magnetic signatures of elongated pits (illustration: RGK).

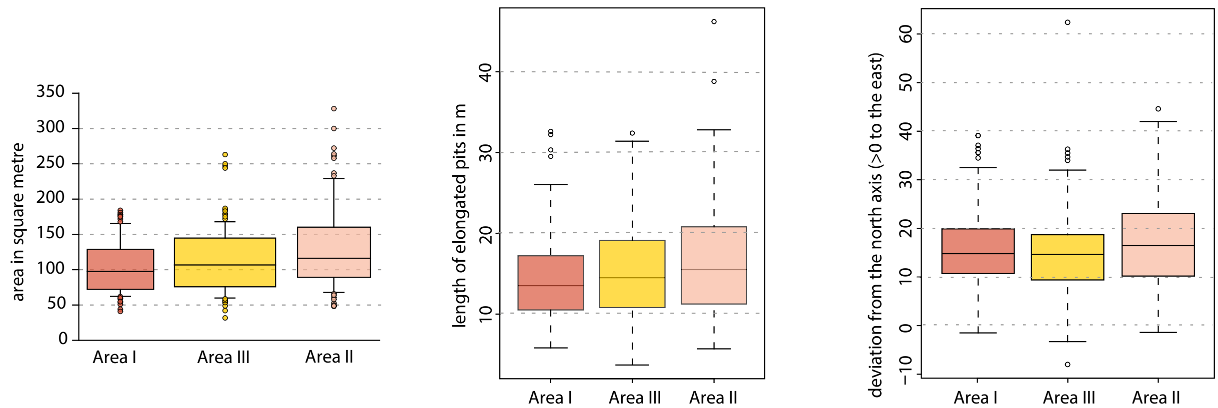
resulted in three magnetic anomalies. The total length of the magnetic anomalies of the eastern and western elongated pits correlate precisely with the excavation results. That the southern parts of the elongated pits are positioned a bit more to the west than the other pits could indicate that they belong to a separate house. A systematic comparison of magnetic anomalies versus excavation results confirms the predictive value of the magnetic anomalies of elongated pits.

Despite the previous optimistic assumption, the appearance of the elongated pits in the magnetic data is highly diverse and varies among the three settlements. In the northern area of I, the anomalies are more obvious, with a higher magnetic signature amplitude than in the southern area (Fig. 2.1.9). Around 550 anomalies were identified at I that can be assigned to 179 elongated pits and 90 houses (s. 82 houses, Meadows *et al.* 2019, 1654).

In comparison to those in Area I, the elongated pits in the northern neighbourhood, III, show a higher magnetic contrast and a higher density (Fig. 2.1.10). The 650 magnetic anomalies at Area III can be assigned to 244 elongated pits and 122 houses. This estimation is a little lower than the former estimation of 130 houses (Meadows 2019 *et al.*, 1654). The magnetic anomalies at Area III are rarely smaller than 5-7 m. They can be assigned to elongated pits, with a length between 12 m and 20 m (Fig. 2.1.11). They are slightly larger than at Area I. This result corresponds with former estimation on the house size (Fig. 2.1.11). The boxplots illustrate that the measured length of the extent of the elongated pits is a good proxy for a rough reconstruction of the length of the Neolithic houses. Apart from some regional variations, the average size of Early Neolithic longhouses is mostly around 20-25 m (*e.g.* Link 2014, 154; Coudart 1998, 49). The interquartile ranges of the length of elongated pits at Vráble scatter between 10 and 20 m.

The number of elongated pits in the eastern settlement, Area II, is 183. Based on that the number of reconstructed houses is 91, which is nearly identical to the number for Area I. Their magnetic contrast is on the same scale as at Area III. The number of digitised anomalies is lower than at Areas I and III (Fig. 2.1.12) with a total of 470. This could be interpreted as an indication for a better preservation of the archaeological features in this area; however, this remains to be further investigated.

Figure 2.1.9 (left). Vráble 'Veľké Lehemby' (Area I). 1-4 examples of the variation of the magnetic signatures of elongated pits (illustration: RGK).



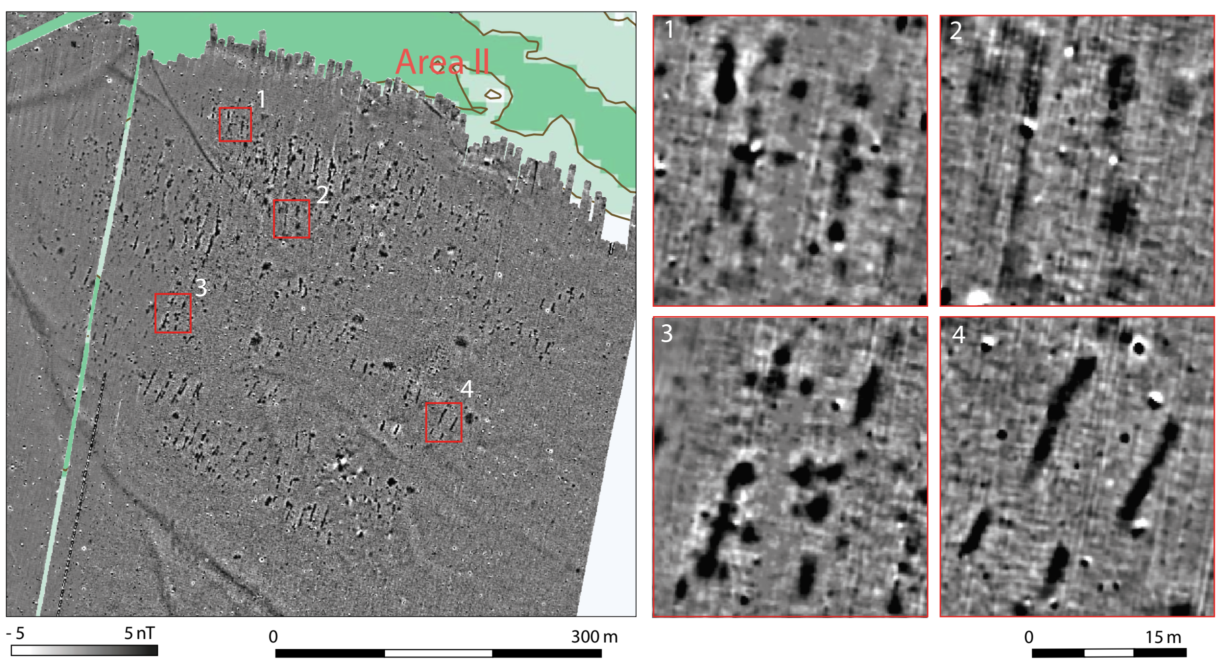


Figure 2.1.11 (top). Boxplots of house and long pit estimations. Left: estimated house areas; centre: estimated length of the elongated pits at Areas I-III; right: deviation from the north axis of the elongated pits (illustration: I. Hohle/N. Müller-Scheeßel).

Figure 2.1.12 (below). Vráble 'Veľké Lehemby' (Area II). Examples of the variation of the magnetic signatures of elongated pits (illustration: RGK).

The elongated pits indicate the number of houses and their distribution, and they are therefore a valuable proxy for reconstructing the general spatial structure of the settlement units of Areas I, II and III. Furholt *et al.* (2014) already tried to apply the 'yard model' for Vráble 'Veľké Lehemby'/'Farské' (see Chapter 6.3). For that, the chronology of the houses is fundamental (s. Meadows *et al.* 2019).

A first attempt to develop a chronological model is based on the observed shift in house orientation (Furholt *et al.* 2014). A more elaborate model is based on a series of radiocarbon dates from samples gathered during a drilling campaign and on excavation data (Meadows *et al.* 2019). Taking these results into account, the house orientation can indeed be used as one indicator for the chronology. We applied this to the elongated pits, which are generally diverse in their orientation. Although most of the elongated pits show a deviation from the north axis between around 10-20° East, with a median of around 15° East, it is striking that a lot of houses fall outside this range (Fig. 2.1.11). Neighbourhood II is the most diverse in its orientation of elongated pits. The variation at Area III, which has the highest number of elongated pits, is lower and hence similar to the variation at Area I.

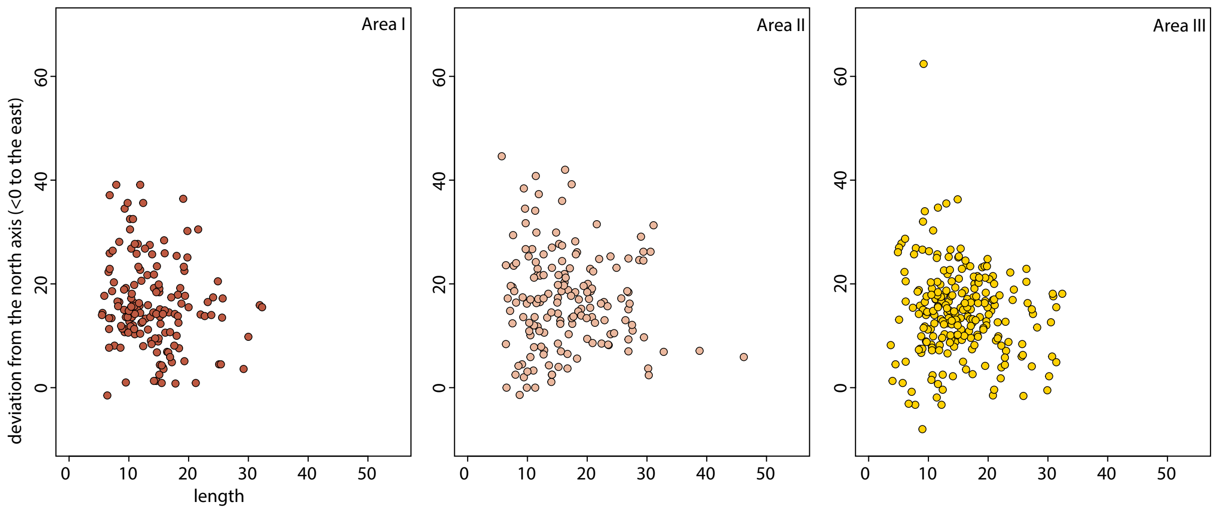


Figure 2.1.13. Length and orientation of elongated pits for each LBK neighbourhood of 'Veľké Léhemby'/'Farské' (illustration: I. Hohle).

Being aware that the combination of circular with metric data is problematic, we plotted the maximum of the measured length of elongated pits with the orientation of the elongated pits for each settlement (Fig. 2.1.13). As has been established recently by Müller-Scheeßel *et al.* (2020), the orientation of houses can be taken as an indicator for chronology. Over time, houses at Vráble tend to be oriented less to the east and closer to a north-south axis.

When it comes to the chronological model, the limitation of the sampling strategy was briefly mentioned in Meadows *et al.* (2019, 1661ff.). So far, the magnetic data of the elongated pits, especially their orientation, seems crucial in order to optimize the sampling strategy and to improve the current chronological model. In a stratified sampling strategy, it is necessary to first define classes of elongated pits based on their orientation and only then select the objects for a drilling campaign that is representative for every settlement and house group within each settlement.

Settlement pits, pits for clay extraction

In addition to the ditches around Area I and elongated house pits at Areas I-III, several other significant magnetic signatures were observed in the magnetic survey data. These magnetic signatures are either circular or ellipsoidal, 1-3 m in diameter, with magnetic signature amplitudes varying between *c.* 20 nT and *c.* 60 nT, or larger, unsymmetrical to fuzzy structures with magnetic signature amplitudes between 15 nT and 20 nT.

The small circular anomalies with signature amplitudes around 20 nT can be interpreted as settlement or storage pits with diameters between *c.* 1 m and 2 m. They are more or less evenly spread across the site. Those small, circular anomalies with higher magnetic signature amplitudes are likely fireplaces with burnt soil.

The large, unsymmetrical to fuzzy structures could possibly be extraction pits for clay to be used for construction or pottery (Fig. 2.1.14). Based on the magnetic data, it is not possible to classify these structures as Early Neolithic ones that belong to the LBK settlement, as there are also Roman structures and an Early Bronze Age settlement in the West. However, no excavation data is yet available from these structures.

But complex pit systems that were probably used for clay extraction are known for LBK sites too. Generally, the typical elongated house pits are interpreted as pits from which clay was extracted for use as wall plaster. That it is generally proven to use loess clay from the elongated pits for house construction has been proved by experimental archaeology (Lobisser 2014, 105). But as the quality and quantity of loess

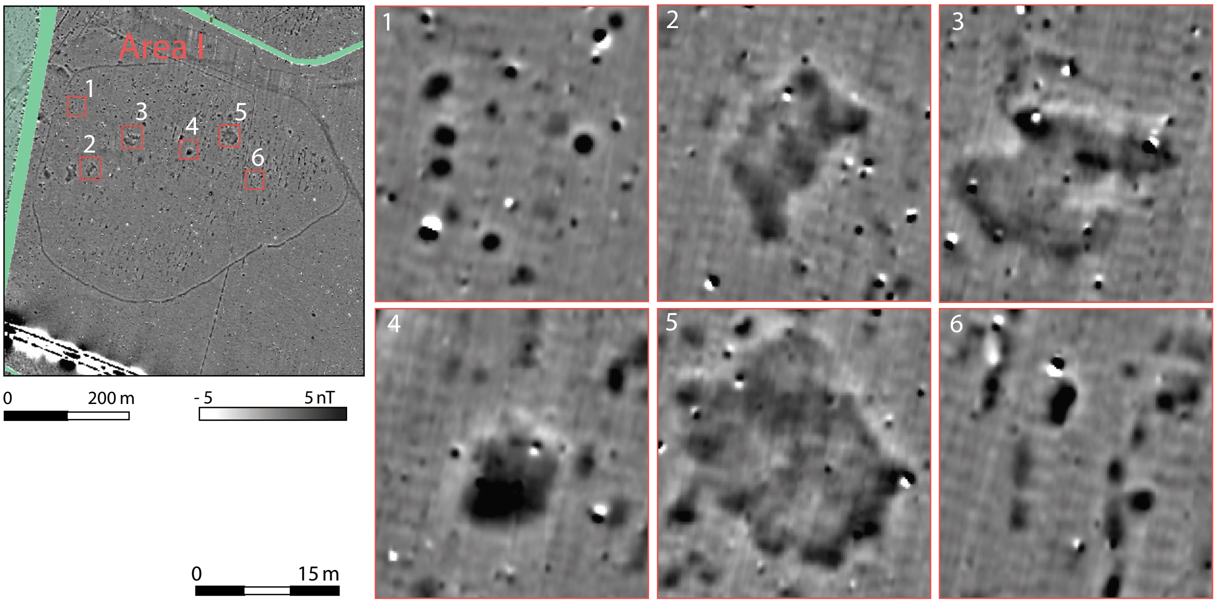


Figure 2.1.14. Vráble 'Veľké Lehemby' (Area I). Examples of further anomalies encountered in the magnetic survey data that could be interpreted as settlement pits (1 left, 6 right), fireplaces (1, right) and clay extraction pits (2-5) (illustration: RGK).

and clay varies from region to region, it is likely that the builders added clay from other pits as well. That is why elongated pits are more accurately interpreted as preparation pits for wall plaster. A possible indication that the inhabitants needed additional clay extraction pits is the volume of the elongated pits. This volume can be used to calculate whether the clay removed from them would have been enough to plaster the walls of the associated house. There are just a few examples in the literature of calculating the volume of LBK pits. Stäuble (1997) takes the often heterogeneous forms of the pits into account, whereas Balkowski (2018, 207-208), based on Kazdová, recently calculated length, width and depth divided by 2 to take account of the often funnel-like shape of the pits. Erosion is another factor that has to be taken into account. That is why only an approximation is possible. In the case of 'Veľké Lehemby'/'Farské', the excavation data can be used for such calculations. Of course, the calculations regarding clay requirements also depend on the size of the house how much clay is needed. For an average longhouse of 20-25 m length and 7 m width (with the typical three-part subdivision), around 100 m^3 is needed for wall plaster. Based on the excavation data of 'Veľké Lehemby'/'Farské', the elongated pits probably provided around 40-80 m^3 of clay. Given that the floor probably also was covered with clay, it is quite likely that the elongated pits were not the only source for clay extraction.

Magnetic susceptibility modelling of archaeological features

In order to better understand the magnetic signatures encountered and to aid interpretation of the magnetic survey data, magnetic anomalies expected were modelled using GEOSS Potent 3-D magnetic modelling software (version 4.15.05). The basis for the modelling were expected geometries of features, literature reference values for magnetic susceptibility of archaeological materials, measurements of magnetic susceptibility in situ during the drilling campaign, as well as magnetic susceptibility measurements on samples gathered during the drilling campaign.

Magnetic susceptibilities observed on relevant archaeological features are reported in the literature (*e.g.*, Tite *et al.* 1971, Jordanova 2001). These values, which were either reported in the CGS system or as mass susceptibility, were converted to

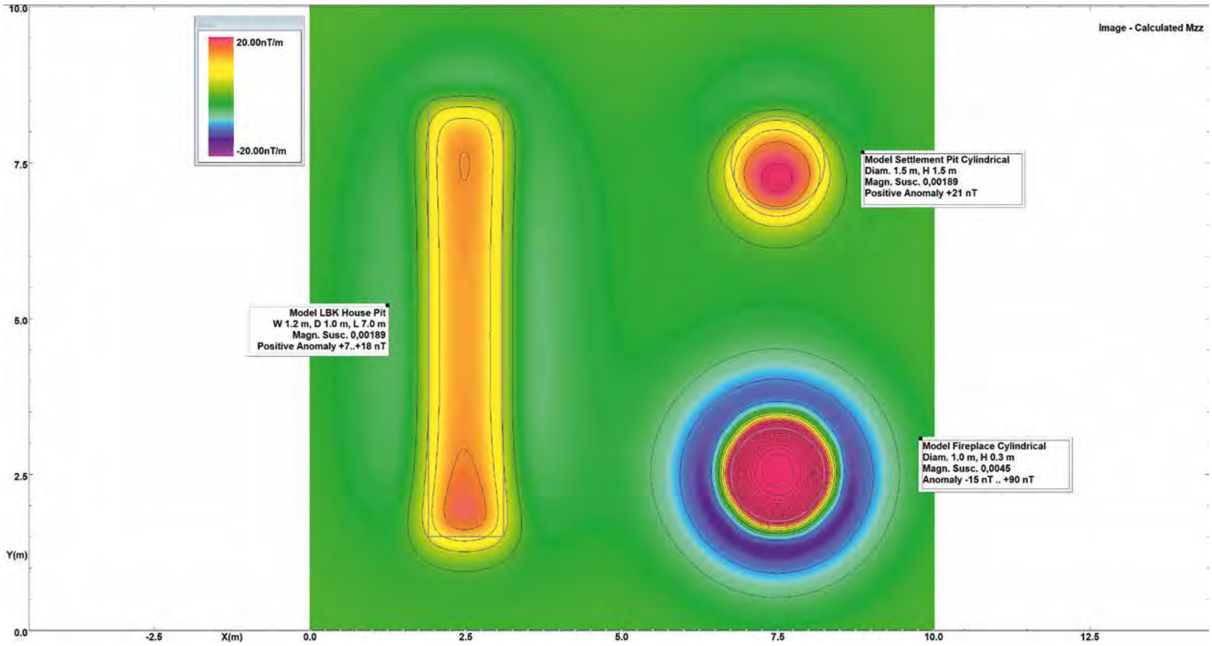


Figure 2.1.15. Vráble 'Veľké Lehemby'/'Farské'. Annotated magnetic susceptibility models (examples) of typical archaeological features expected in the neighbourhoods I-III: elongated house pit (left), settlement pit (upper right), and fireplace (lower right), with 5 nT isolines (illustration: Kay Winkelmann).

volume susceptibility in the SI system (Bennett *et al.* 1977). The following magnetic susceptibility value ranges reported in the literature coincide with the results of measurements in boreholes in situ and on samples acquired from boreholes at Vráble:

- Settlement pits: $1.885\times10^{-3} \leq \chi_{Vol} \leq 1.131\times10^{-2}$ (average *c.* 5.654×10^{-3})
- Ditches: $5.654\times10^{-4} \leq \chi_{Vol} \leq 5.654\times10^{-3}$ (average *c.* 1.885×10^{-3})
- Burnt soil: $2.25\times10^{-4} \leq \chi_{Vol} \leq 1.5\times10^{-2}$ (average *c.* 4.5×10^{-3})

Elongated house pits when modelled as a ditch measuring 1.2 m wide, 1.0 m deep and 7.0 m long, at a depth of 0.4 m below the modern-day surface, with a magnetic volume susceptibility (SI) of 5.65×10^{-3}, resulting in elongated positive magnetic signatures with positive magnetic signature amplitudes between +7 nT and +18 nT (only induced magnetisation), similar to those observed in the magnetic survey data of Areas I-III (Fig. 2.1.15, left).

Similarly, settlement pits modelled as cylindrical pits with a diameter of 1.5 m and a height of 1.5 m at a depth of 0.4 m below surface, with a magnetic volume susceptibility (SI) of 5.65×10^{-3}, resulted in circular magnetic signatures with a positive magnetic signature amplitude of *c.* 20 nT (only induced magnetisation) and hardly any negative signature amplitude. This correlates with a significant number of the circular magnetic anomalies observed at Areas I-III (Fig. 2.1.15, upper right).

Fireplaces, modelled as shallow cylindrical features with a diameter of 1.0 m and a thickness of 0.3 m of burnt soil, with a magnetic susceptibility (SI) of 4.5×10^{-3} and some remanent magnetisation, resulted in circular magnetic anomalies with up to 100 nT magnetic signature amplitude. Only in these models of burnt soil as caused by fireplaces was a significant negative magnetic signature amplitude (up to –15 nT) observed. Also, their positive magnetic signature amplitude (up to +90 nT) was observed to be significantly higher than in the case of pits and ditches. These modelling results appear to correlate with several circular magnetic signatures of higher positive magnetic signature amplitude of up to +80 nT and also with significant, circular negative anomalies of up to –10 nT).

The modelling of archaeological features based on their geometries and expected (literature references) or measured (drilling/sampling campaigns) magnetic susceptibilities assists the interpretation of magnetic signatures observed in magnetic survey data acquired in archaeological prospection and is subject to further investigations (see also Chapter 2.2.).

Outlook

Our large-scale magnetic prospection of the archaeological landscape of Vráble 'Fidvár' and Vráble 'Veľké Lehemby'/'Farské', in western Slovakia, was the starting point for a larger research project on Neolithic, Copper Age and Bronze Age settlements in Hungary, Slovakia, Romania, Serbia, Moldova and Ukraine. The research was embedded in a comprehensive research program including prospections on Vinča settlements in Serbia and Romania, as well as research on Cucuteni-Tripolye settlements in Romania, Moldova and Ukraine. Research focusing on the investigation of Neolithic settlement patterns in the northern part of the Carpathian Basin was carried out in cooperation with the Slovakian and the Hungarian academies of science and the University of Kiel. In this ongoing project, since 2008, we have – among others – investigated five large LBK sites whose settlement layout was largely unknown or, in some cases, only partly known, from rescue excavations.

The research program was focused around the use of large, vehicle-towed magnetometer arrays with 8-16 magnetometers (fluxgate vertical gradiometers) with RTK-DGPS georeferencing that have produced high-resolution magnetic survey data covering hundreds of hectares. The large datasets allow analysing the layout of prehistoric settlements in their landscape, marking a step from small-scale magnetic surveys in archaeological prospections to archaeological prospection of settlements in their landscape (landscape archaeology). During the large-scale surveys, a significant number of hitherto unknown archaeological sites were discovered, including one LBK settlement (Vráble 'Veľké Lehemby'/'Farské' I-III) and Roman camps superimposed on Vráble 'Fidvár' and Vráble 'Veľké Lehemby'/'Farské'.

LBK houses can be best detected from the position of two parallel ditches – normally referred to as clay extraction pits or house pits – along the outer walls that are a common feature of houses of this period. Only in rare cases postholes are visible in magnetic survey data. Therefore, it is possible that some houses may have remained undetected. It is, however, striking at Vráble that there is almost no overlap of house plans based on the location of the elongated house pits. This is even more striking considering the houses are quite densely arranged in the settlements. The excavations (see Chapter 3.1. below) did confirm this general lack of superposition, which is not uncommon within LBK settlements. The orientation of LBK houses can assist in their dating, or at least in planning sampling and excavation campaigns designed to generate information with respect to dating.

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2.2. Extending archaeological documentation from 2D to 3D: The benefits of geophysical on-site measurements in excavations

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Abstract

Ongoing excavations can be supported by geophysical in-situ measurements to analyse and document the unearthed features with measurements characterising them physically beyond visual inspection. Here, we present results of ground-penetrating radar (GPR), electromagnetic induction (EMI) and magnetic susceptibility (MS) measurements performed on an excavation planum of 'house-accompanying pits' at the Linearbandkeramik (LBK) and Želiezovce settlement site at Vráble (Nitriansky kraj, Slovakia). The measurements enable us to extend the documentation of the excavated area from 2D to full 3D beneath the planum in form of data cubes of GPR reflections and electric conductivity derived from EMI. The shape of house pits at the site of Vráble could be determined in 3D by EMI measurements after local calibration through GPR, excavation trenches and downhole magnetic susceptibility (MS) measurements. It turned out that the pits have an irregular bottom, indicating a discontinuous construction over time. In some cases, it turned out that the pit bottom was about 40 cm deeper than archaeologically documented. Vertical depth sections of the pits could also be generated by sequences of MS downhole measurements, which are a proxy of the iron oxide content of the soil. The uppermost soil layer of the planum showed distinct differences in MS and GPR amplitude strength inside and outside the investigated house. These differences could be seen as evidence of a slight compaction of the sediments originating from the usage of the house floor. Soil structures classified as postholes in the archaeological documentation showed no contrast in susceptibility, GPR, or EMI to the surrounding soils, indicating that only a minimal volume of the posthole fill had remained on the planum.

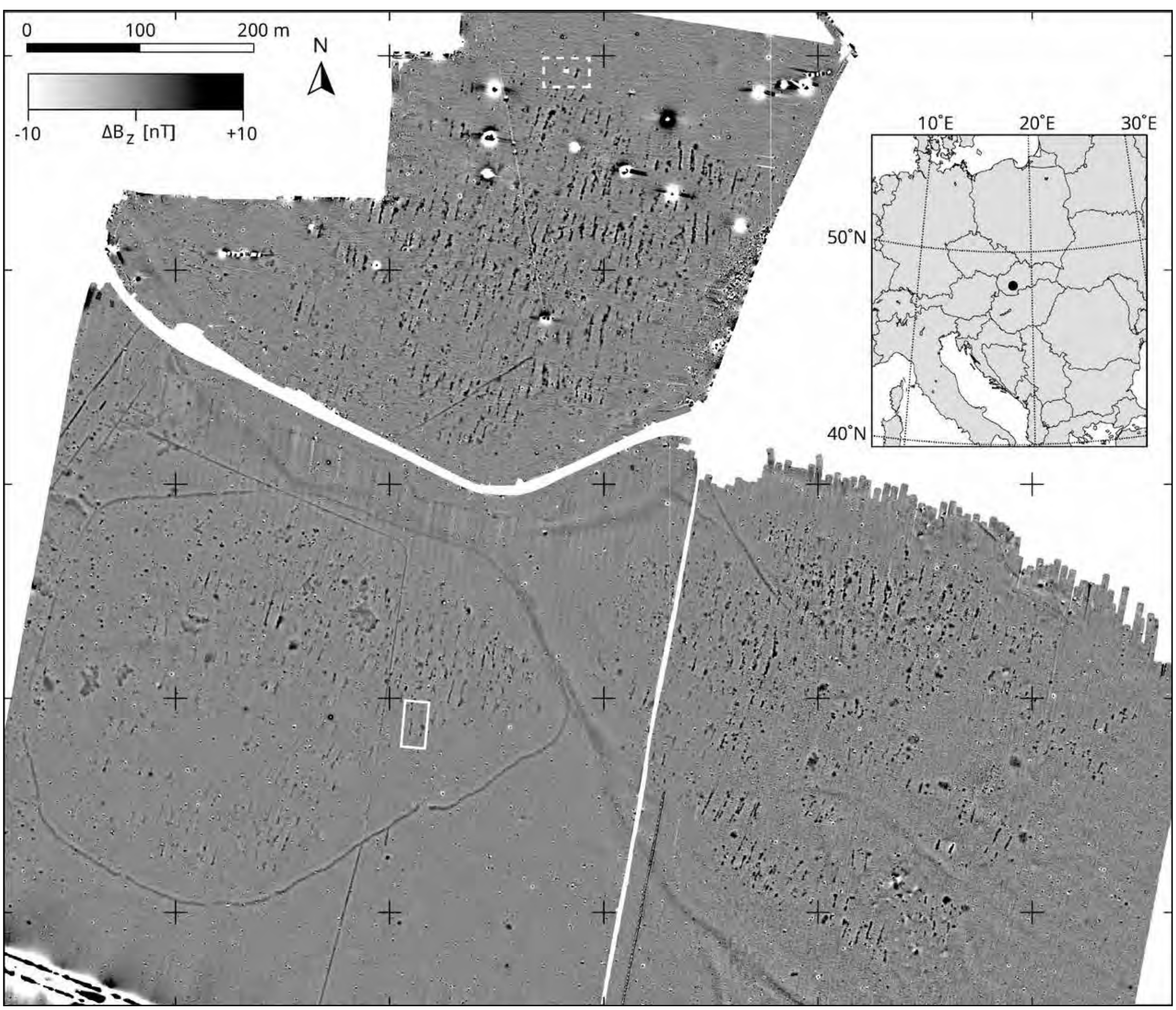
Keywords: Geophysics in excavations, in-situ measurements, geophysical documentation of excavations, ground penetrating radar, electromagnetic induction measurements, magnetic susceptibility

Introduction

Knowledge about archaeological sites is usually derived from key targets, which are excavated and, as part of this process, documented. Soil colour, texture, and finds are visually inspected and used to determine the stratigraphy of the excavated structure, and this stratigraphy defines the relative ages of the included layers.

Geophysical prospection methods are used to determine the spatial distribution of physical soil parameters in 2D or 3D, depending on the chosen method. In contrast to soil sampling and geochemical analysis, they can be applied almost continuously, to cover hectare-scale areas. Many archaeological objects can be identified by their physical parameter contrast with respect to the surrounding soil. Conversely, archaeological objects are often not uniquely distinguishable from the surrounding soil by visual inspection alone. Physical soil parameters serve to characterise geological layers and can help to identify recent and ancient anthropogenic site usage (cf. Verdonck *et al.* 2019). Therefore, we see the determination of geophysical pa-

Figure 2.2.1. Magnetic map after Winkelmann et al. (Chapter 2.1), showing the excavation area in the south-western settlement nucleus (solid box) and the area investigated with corings in the northern nucleus (dashed box). Insert: Location (dot) of the site in Slovakia.



rameters on plana (plan views) and sections and along boreholes as an additional diagnostic tool, one that complements the archaeological documentation.

Against this background, the basic objectives of our study are (1) to investigate to what extent geophysical measurements accompanying excavations can support identifying and characterising underground structures uncovered in plana and trenches beyond optical visibility, and (2) to show how the information gathered on plana can be extended into 3D.

We used the Linearbandkeramik (LBK) and Želiezovce settlement site of Vráble (for location, see inset Fig. 2.2.1) as a case study, whereby we investigated the physical properties of archaeological objects on-site in comparison to the surrounding soil. In this chapter, we demonstrate which geophysical methods can be applied successfully as a complement to excavation, and we evaluate how the geophysical results match the standard excavation documentation and corings.

We conducted measurements in excavation area 22 on planum 1 (approximately 60 cm beneath the modern-day ground surface). Figure 2.2.1 shows the magnetic map (see also chapter 2.1) of the LBK site, which has three settlement nuclei. Excavation area 22 is located in the south-western nucleus (indicated by the solid box). The excavation encircles two long pits that flanked one of the house, one along each side wall. North of these features, a second pair of pits is visible, and these were partly excavated. During the excavation, several postholes were also found. We applied ground penetrating radar (GPR), electromagnetic induction (EMI) and magnetic susceptibility (MS) measurements.

The measurements were conducted directly on the first excavated planum. Additionally, we conducted downhole susceptibility measurements along a transect in the northern area to examine the cross-section of elongated pits located outside of and parallel to the side walls of houses (Fig. 2.2.1, dashed box) (known in German as *hausbegleitende Längsgruben* and in English as house-accompanying pits). To define the spatial context of the excavation area, we also include the magnetic prospection data measured from the surface, which is described and discussed in more detail in chapter 2.1.

This introduction is followed by a brief description of the applied field measurements and data processing. Then, the results of each geophysical method are given and compared with each other and with the archaeological excavation documentation. This comparison forms the basis for the final discussion.

Methods

Magnetic prospection

In magnetic prospection, the strength of Earth's internal magnetic field is measured with an accuracy of up to 1 ppm at Earth's surface. The results are typically presented in the form of maps, in which archaeological features, such as pits, house remains or kilns, can become visible as spatial variation of Earth's magnetic field if they are less or more strongly magnetised than the surrounding soil. Magnetic maps are commonly used directly to identify and categorise archaeological features, examine features' spatial relations, and plan excavations. Chapter 2.1 discusses the measurement setup for the magnetic mapping.

The magnetisation magnitude of buried material depends mainly on the type and concentration of the contained iron oxides, but also on the grain size distribution of the magnetic minerals. An archaeological structure is detectable by magnetic measurements if its magnetisation differs from that of the surrounding soil matrix. However, the magnetisation can not be mapped directly. So-called inversion computations are required to determine the three-dimensional shape of distinct magnetised bodies or the continuous magnetisation distribution of soils (*e.g.* Pickartz *et al.* 2019; Neubauer and Eder-Hinterleitner 1997). Measured magnetic field anomalies are principally ambiguous with respect to the magnetisation strength and shape of the causative magnetic bodies. Therefore, inversion computations require additional information constraining the mathematically possible solutions. Such constraints may consist of independent measurements of the magnetic soil properties, such as the magnetic susceptibility (see below), or information on the depth and thickness of magnetised layers from excavations or corings.

Ground-penetrating radar

GPR images the interfaces of subsurface structures in terms of radar reflection amplitudes. A transmitter antenna emits pulses of a few nanoseconds (ns) duration into the ground. These pulses propagate through the subsurface until they are reflected at the interfaces between subsurface layers and objects that differ from each other in terms of electromagnetic soil properties. The reflected signals are measured by a receiver at the surface. GPR is sensitive to the ground's electrical conductivity as well as its dielectric permittivity and contrast therein. Electrical conductivity is responsible for the energy absorption and thus the sounding depth, whereas permittivity and its contrasts affect the propagation velocity of the signal and the strength of the reflection from subsurface interfaces, respectively (*e.g.* Davis and Annan 1989). The electrical conductivity and the dielectric permittivity themselves depend mainly on the water content, as well as the clay and silt fractions of the soil. The porosity of the soil, and thereby its water content, depends on the compaction and cementation of the soil. Therefore, compacted or cemented soil volumes may be detected by GPR measurements (*e.g.* Wunderlich 2012).

We conducted the GPR survey of the present study with a 200 MHz antenna by GSSI Inc. The underlying loess limits the depth of investigation to approximately 1 m to 2 m. Assuming a velocity of 6 cm/ns, the expected spatial resolution is approximately 0.075 m according to the quarter-wavelength criterion. We measured the excavation area in two different setups: an area of 2 m × 17 m (northern strip) as well as a larger area of 9 m × 35 m (western half) (cf. Fig. 2.2.2). We measured the smaller area with 30 cm cross line spacing and the larger area with 60 cm cross line spacing.

We applied the following processing steps to our data: (a) trace repositioning to correct the position of the GPR traces in a profile; (b) time zero correction; (c) a background subtraction filter, which reduces the direct waves and ringing noise; (d) a bandpass filter with cut-off frequencies 10, 50, 350, and 390 MHz; (e) migration with a constant velocity of 6 cm/ns; and (f) an automatic gain control (AGC) amplification with a time window length of 10 ns. To produce time slices, all parallel profiles were combined and cut into 2 ns thick slices in which the squared sum of absolute amplitudes was calculated.

Electromagnetic induction

EMI instruments consist of a transmitter and a receiver. The transmitter coil emits a 'primary' oscillating magnetic field at a frequency in kHz or 10 kHz range. Dependent on the electrical conductivity distribution of the subsurface, electric eddy currents are induced in the soil, generating a 'secondary' magnetic field recorded at the receiver coil together with the primary field. From these, a direct output is generated consisting of values of the 'apparent electrical conductivity' of the soil and the so called 'in-phase' (IP) component, which is proportional to the magnetic susceptibility. Both these values represent average values of the soil volume encircled by the diameter of a 'footprint', Earth's surface and the sounding depth (Everett and Weiss 2002). Footprint and sounding depth depend on signal frequency and transmitter to receiver distance. As described above, the electrical conductivity depends on the sediment composition and water content. Like the magnetisation, the magnetic susceptibility depends on the sort and concentration of iron oxides, as described above for the magnetisation.

If the applied EMI instrument enables measurements with different sounding depths, inversion computations can be conducted that convert the corresponding average apparent electrical conductivity values into depth functions of 'true' in-situ electrical conductivity. These depth functions can then be spatially compiled into an approximate 3D distribution of electrical conductivity, from which depth maps of soil layers and interfaces can be derived. The EMI procedure is technically very efficient, but the results need depth calibration by coring or spot excavation because of an inherent physical uncertainty relationship between electric conductivity and layer thickness.

We used a CMD Mini-Explorer by GF Instruments. The device consists of one transmitter and three receiver coils, the axes of which can be oriented horizontally or vertically (HCP or VCP modes). The distance between the transmitter and receivers are 0.32 m, 0.71 m, and 1.18 m, leading to effective sounding depths of 0.25 m, 0.5 m, and 0.9 m in VCP mode and 0.5 m, 1.0 m, and 1.8 m in HCP mode. Further details on the method and the device can be found in *e.g.* Bonsall *et al.* (2013).

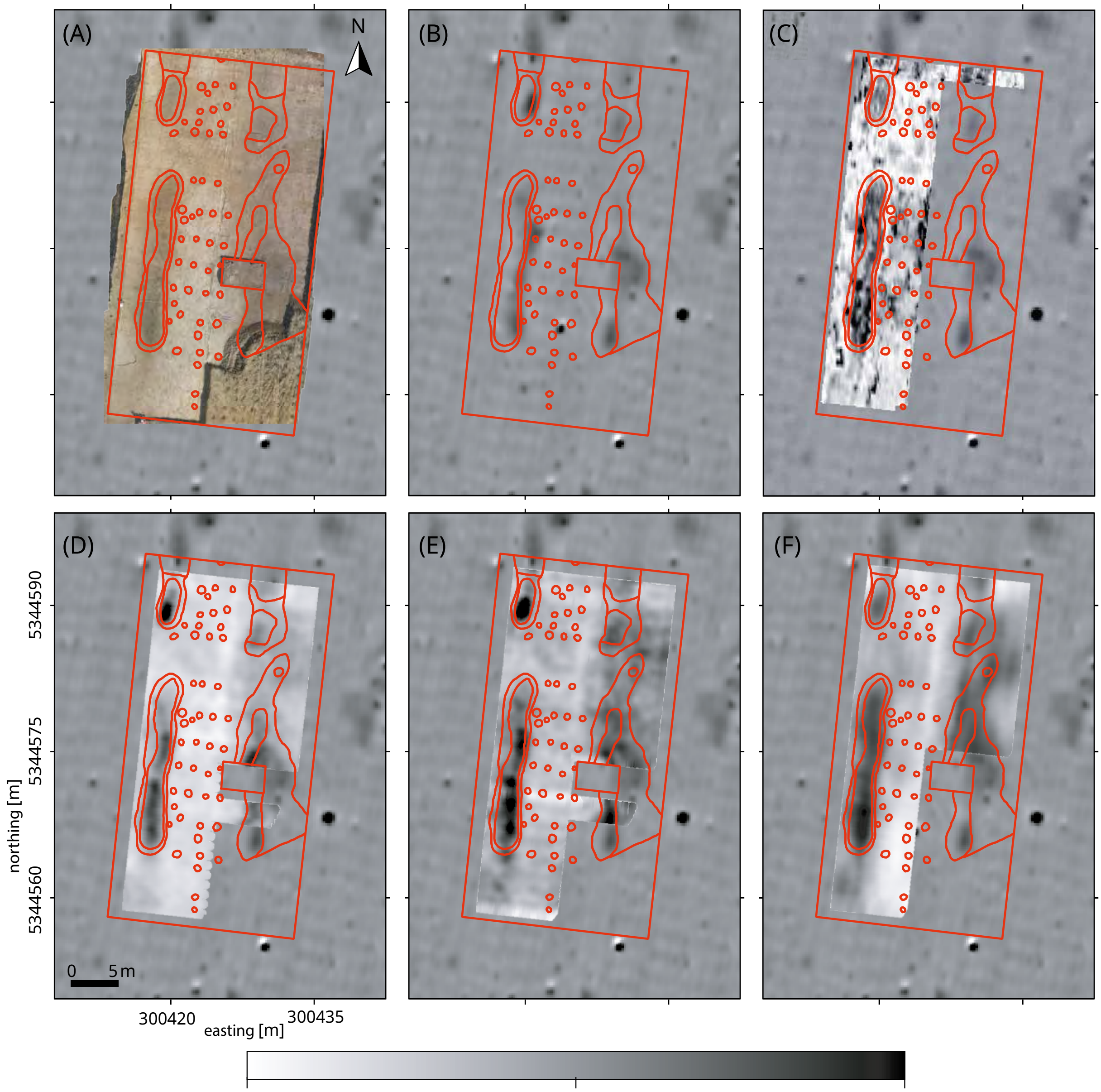
The area was covered with measurements at 10 Hz sampling frequency along parallel profiles with a cross-line spacing of 50 cm using both coil orientations. The data were then interpolated to a 0.5 m × 0.1 m grid. Noise resulting from the motion of walking was removed with a low pass filter (third-order Butterworth filter with cut-off wavenumber at 0.7 m^{-1}). The in-phase components that were notably affected by a temporal drift were corrected with the method of Delefortrie *et al.* (2014).

The filtered conductivity measurements of HCP and VCP coil orientations were used for determining electric conductivity to depth function for each point of the gridded area. These inversion computations were performed with the software IX1D by Interpex. HCP and VCP measurements were jointly inverted using the 'smooth model' mode (Constable *et al.* 1987). In this mode, the sounded depth range is subdivided into a set of layers with predefined thicknesses, which are kept fixed during the computation, while the conductivity values are altered subjected to smoothness constraints. We defined 10 layers between 0.05 m to 1.5 m depth, with logarithmically equidistant thicknesses. The resulting one-dimensional models were stitched together to form a 'cube' of electric conductivity values. From this 3D model, we cut out a number of 2D vertical sections or horizontal depth slices, which are presented in Figures 2.2.4 and 2.2.5.

The measurements were conducted when the earth moving of the excavations was still in progress. The time interval between the unearthing of the western half of the excavation area and the measurements was longer than for the eastern part. One expected effect of a greater interval is that the subsurface could dry out, and this is, in fact, visible in the measurements and in the inversion result.

Magnetic susceptibility

The magnetic susceptibility is a specific property of soils and sediments that describes how strongly a material becomes magnetised in the presence of an external magnetic field, in the case of archaeological studies, Earth's magnetic field. Anomalies detected by magnetic prospection originate from variations in the magnetisation of the subsurface. As indicated above, magnetic maps show the location and a 'distorted' contour of the subsurface bodies. To resolve their geometry and magnetic properties, additional information is needed. The magnetic susceptibility is one of these properties. The susceptibility can be seen as a proxy for the iron oxide content and anthropogenic activities – such as fire, deposition of organic materials in pits, and construction of buildings – that enhance the iron oxide content. Therefore,



(B)	-10	ΔB_Z [nT]	10
(C)	neg.	amplitude	pos.
(D)	0.8	IP [ppt]	1.35
(E)	4	σ [mS/m]	50
(F)	0.5	depth [m]	1

Figure 2.2.2. The excavation area as mapped by the different imaging methods, detailed in the table below the maps. A photogrammetry during the opening phase of the excavation; B magnetic mapping; C GPR time slice from 6-8 ns showing contrasts of permittivity through GPR reflection strength; D in-phase component of VCP configuration for the smallest coil separation, visualising the horizontal variation of magnetic susceptibility in a qualitative way; E electric conductivity distribution from the inversion of EMI measurements for the first layer (0.05-0.07 m depth); F depth of the 18 mS/m iso-surface of the conductivity model beneath planum 1, whereby the iso-surface is interpreted as the bottom of the pits (see below). Each sub-figure shows the magnetic map in the background and the archaeological interpretation (red lines) superimposed.

the MS can be used to document archaeological structures. Furthermore, high-resolution measurements with point distances of a few centimetres enable the documentation of gradual variations. This is an important advantage over traditional archaeological documentation, as transitional boundaries are often simplified to discrete boundaries. For the discussion of the measurement technique of induction coil devices, such as the ones we applied, we refer to Evans and Heller (2009).

We measured the susceptibility on planum 1 using the SM-30 by ZH instruments on a 0.2 m × 0.2 m grid covering an area of 2 × 9 m. The inline point distance was reduced to 0.1 m in the border area of the pit and at the locations of the postholes. With this device, only point measurements are conducted so that the possible measurement area is limited in size. The values are displayed as greyscale images.

In addition to mapping, we performed downhole measurements to determine cross-sections of the house-accompanying pits in terms of magnetic susceptibility. Based on the magnetic anomaly, 22 mm diameter auger holes where cored, with a minimum distance of 0.25 m and a maximum depth of 2 m. We measured the susceptibility with the MS3 device and the MS2H sensor by Bartington Instruments Limited for depths deeper than 0.1 m with 0.05 m vertical point distance. Prior to the corings, the susceptibility of the topsoil was measured with the MS2K sensor. For a smooth image, the data is horizontally interpolated to 0.125 m point distance.

Results

In Figure 2.2.2, an overview of the results of the different survey methods is given. The red contours mark the pits and possible postholes as they have been identified by visual inspection of the excavated soils and sediments. In the following, we present the results for each method in detail. We close this section with a comparison to the archaeological excavation.

Magnetic prospection

The magnetic map (Fig. 2.2.1 and Fig. 2.2.2B) was used to plan the excavation. It shows the long pits of the southern house as elongated anomalies. Their shape is irregular, and the eastern long pit is wider in its central part. The amplitude of the anomalies rises up to 6.4 nT and varies throughout the long pits. Apart from the northern pair of long pits, there are no more anomalies visible in the excavation area that can securely be interpreted as archaeologically relevant based on the magnetic prospection data.

Ground-penetrating radar

The results from the GPR survey show the location of the western long pits of the houses, visible as two elongated features, one in the north and one in the south (Fig. 2.2.2C). The black colour indicates a higher reflection amplitude compared to the surrounding area, which is depicted in white. Between the southern two house-accompanying pits, there is an area of smaller amplitudes compared to those of the long pits, but higher than the surroundings. The archaeologically documented postholes are not visible in the GPR time slice. In addition to the pits, some spot-like or small, elongated anomalies with a higher reflection amplitude are visible in the time slice from 6 to 8 ns. However, these could not be related to any documented archaeological structures.

Figure 2.2.3 shows a GPR profile crossing the western house-accompanying long pit of the southern building. From this profile (Fig. 2.2.3B), the depth of the pit can be estimated to be 1.1 m beneath planum 1. The other profiles of the area show depths between 0.6 and 1.2 m of the pits beneath planum 1. The radargrams also do not reveal any signs of postholes.

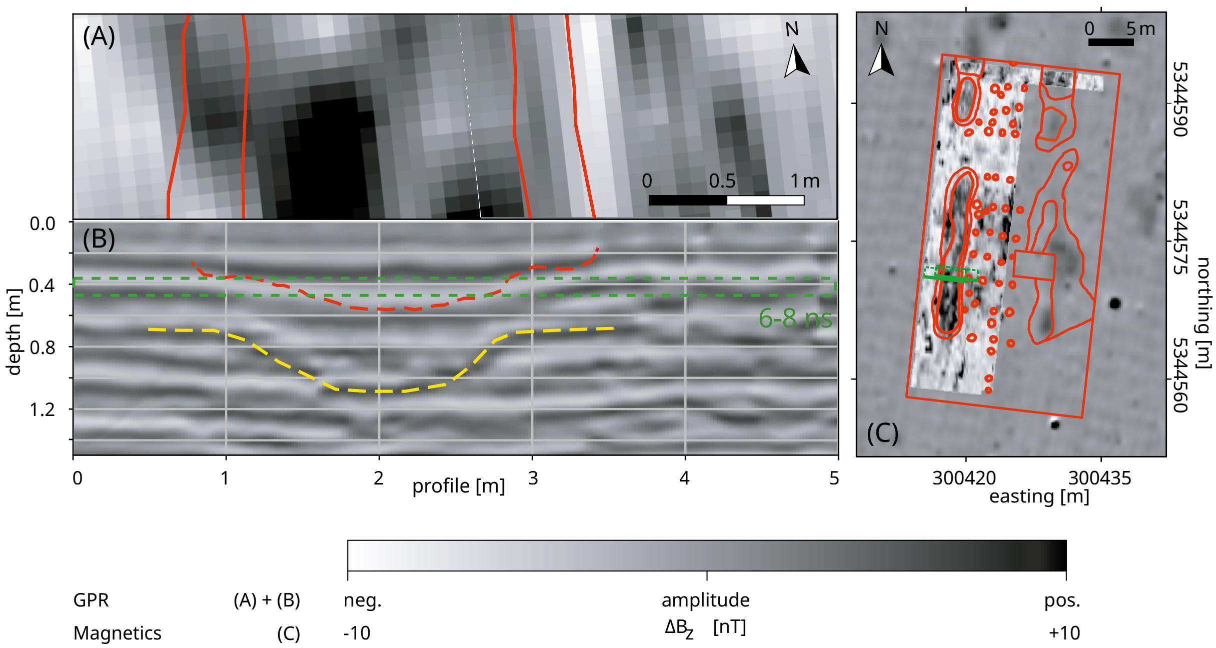


Figure 2.2.3. A Time slice at 6-8 ns (corresponding to a depth of about 0.36 m to 0.48 m) of the GPR measurements directly on the planum, with archaeological interpretation (red lines) superimposed; B GPR depth profile 38, with the location of the archaeological documentation (red dashed line), the depth determined from the GPR reflection image of the bottom of the pit (yellow line), and the depth of the time slice (green dashed box) superimposed; C magnetic map and time slice from 6-8 ns, with the location of profile 38 (solid green line) and the archaeological interpretation (red lines) superimposed.

Electromagnetic induction

Magnetic susceptibility mapping through EMI in-phase measurements

The in-phase component of the VCP measurements with the smallest coil separation (Fig. 2.2.2D) shows the western long pits as distinct anomalies, with values lower than the 'background' level, down to 0.57 ppt. The in-phase component seems to be affected by the different time spans between earthworks and measurements. The background level varies between around 1.25 ppt (±0.03 ppt) in the western part and around 1.18 ppt (±0.05 ppt) in the eastern part. The northern quarter of the south-western pit shows values about 1.16 ppt (±0.05 ppt) and such values would be barely visible in the eastern part. There are no further anomalies that can be related to an archaeological context.

3D electric conductivity distribution from EMI out-of-phase measurements

The top layer of the determined 3D electric conductivity distribution extends from 0.05 m to 0.07 m depth. It shows the location of the long pits as zones of increased conductivity values up to 79.1 mS/m (Fig. 2.2.2E), whereas the conductivity outside the long pits is only around 19.2 mS/m (±4 mS/m) in the western part of the excavation and around 26.1 mS/m (±5.5 mS/m) in the eastern part. Most probably this difference is caused by the different time spans between the earthworks and the measurements in both parts of the area, during which the soil dried to different extents. Due to the different levels of background conductivities, the western long pits are easier to recognise in the greyscale images than the eastern ones. The north-western long pit is characterised by a distinct region of increased conductivity. The south-western long pit shows variations between 22.9 mS/m and 59.2 mS/m throughout the pit. None of the depth slices show any anomalies that could be interpreted as postholes.

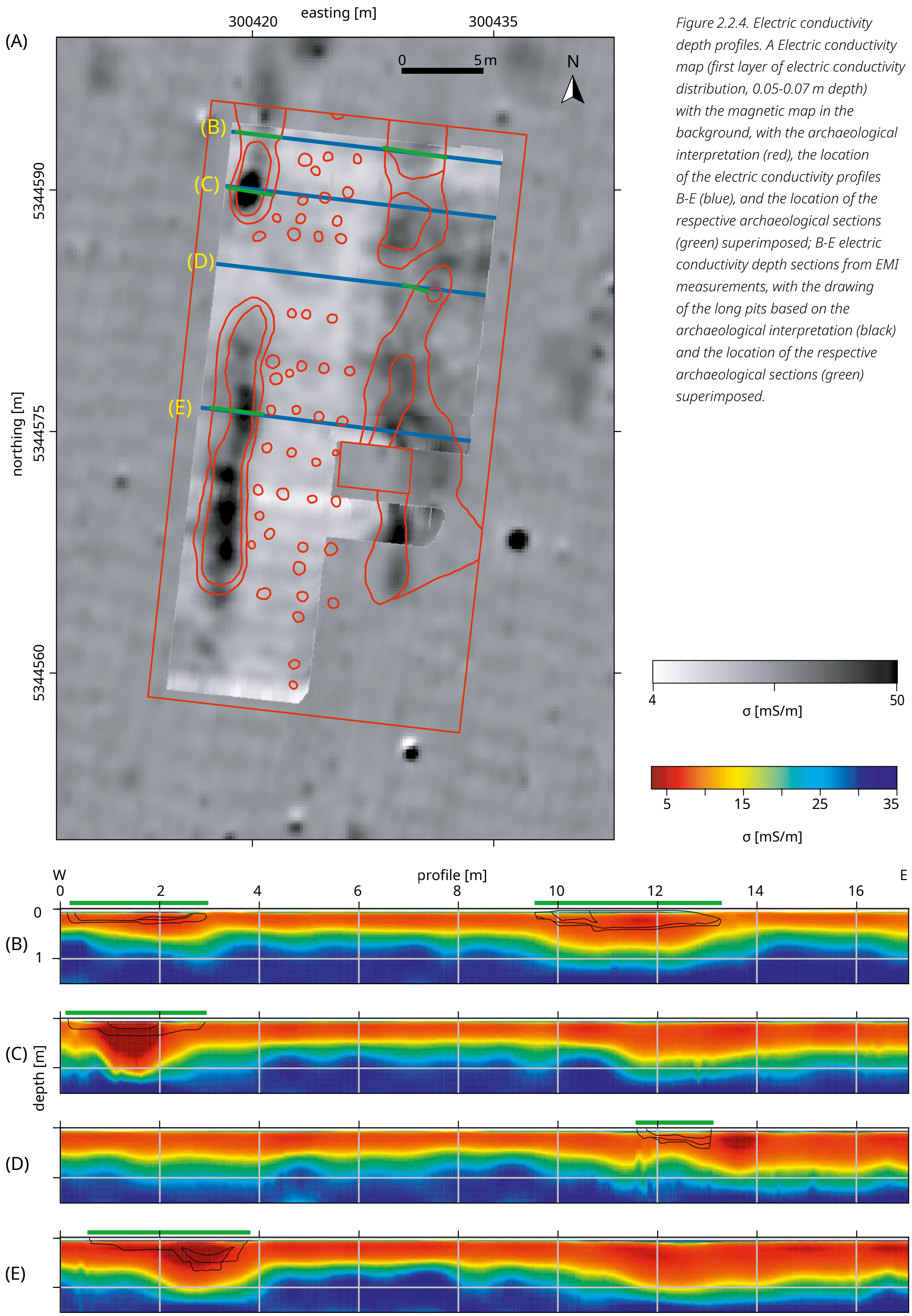
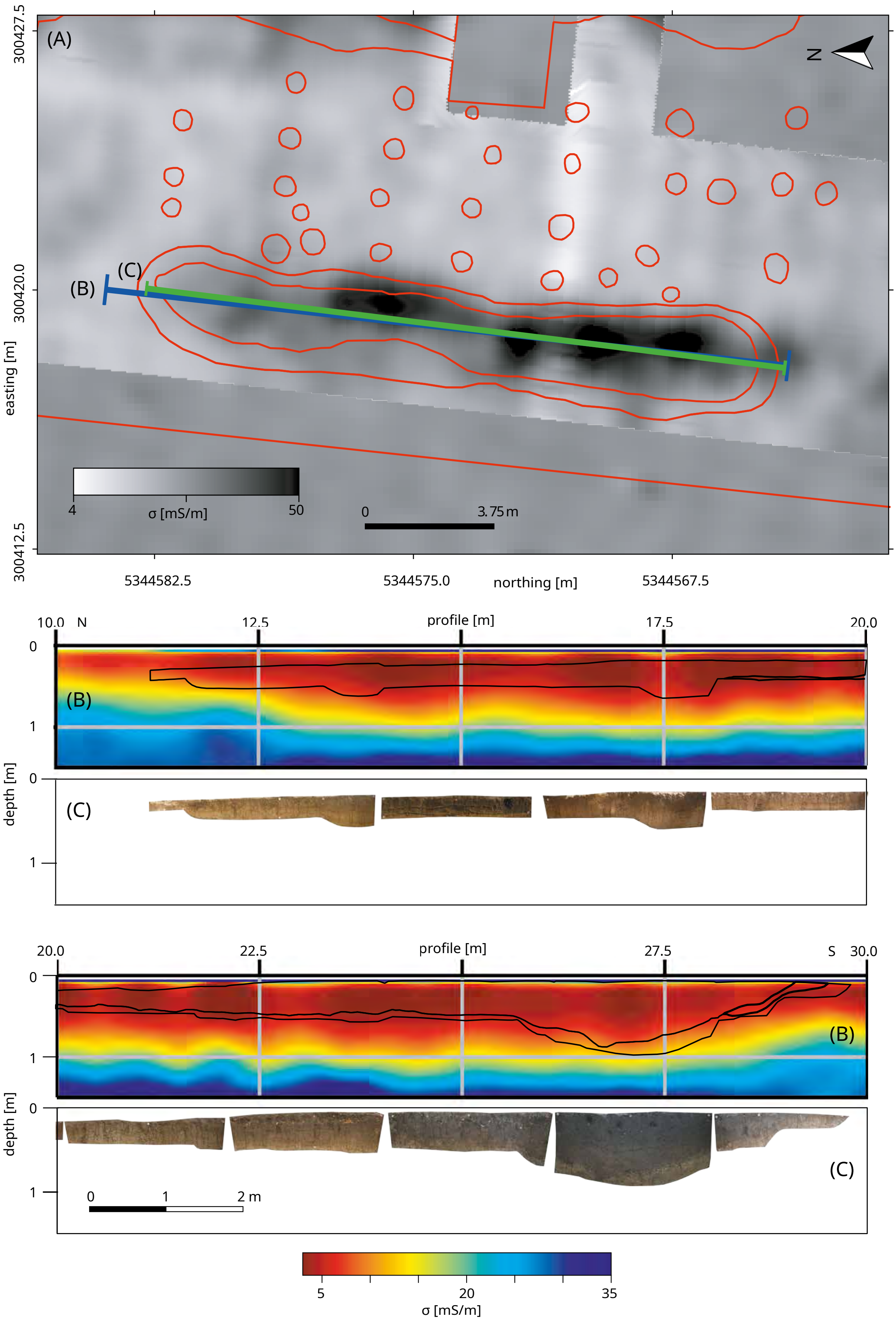


Figure 2.2.4. Electric conductivity depth profiles. A Electric conductivity map (first layer of electric conductivity distribution, 0.05-0.07 m depth) with the magnetic map in the background, with the archaeological interpretation (red), the location of the electric conductivity profiles B-E (blue), and the location of the respective archaeological sections (green) superimposed; B-E electric conductivity depth sections from EMI measurements, with the drawing of the long pits based on the archaeological interpretation (black) and the location of the respective archaeological sections (green) superimposed.


(A)
N
(B)
(C)
300427.5
300420.0
300412.5
easting [m]
4
σ [mS/m]
50
0
3.75 m
5344582.5
5344575.0
northing [m]
5344567.5
10.0 N
12.5
profile [m]
17.5
20.0
depth [m]
20.0
22.5
27.5
S 30.0
0
1
2 m
5
20
35
σ [mS/m]

To evaluate the stratigraphic structure suggested by the electric conductivity distribution, we use the depth profiles derived from the 3D distribution in Figures 2.2.4 and 2.2.5. As can be seen in Figure 2.2.4, profiles A and B cut the northern pair of long pits, profile C cuts the northern tip of the south-eastern long pit, and profile D cuts both southern long pits. The cross-sections of the long pits are visible as areas with decreased conductivity down to 1 mS/m. Based on these profiles, different shapes of cross-sections and varying depth extensions can be derived. In profile A, the region of very low conductivity is comparatively small and shallow. Profile B is located 3.5 m southwards and shows a different cross-section for the western long pit. The long pit is wider and deeper. In the western part, profile C is not cutting any pit; however, in the eastern part, a pit of small dimension is distinctly visible. As is also visible in the depth slices, regions of decreased conductivity extend over several metres of the profile. Both long pits seem to be 'smeared out' in the direction outside the house. No anomalies are visible that can be related to postholes.

In the GPR depth section, we could identify a reflection from the bottom of the long pit. Using this information, we could define the corresponding conductivity iso-surface as an indicator for the bottom of the linear pit. This enabled us to contour the pit bottom in 3D, as further discussed below.

Figure 2.2.5 shows a profile that cuts the south-western long pit lengthwise. The conductivity model (Fig. 2.2.5B) is stitched from several crossline profiles. The photogrammetry (Fig. 2.2.5C) shows that the fill varies throughout the long pit, which is also reflected in the variation of the conductivity within the long pit. However, there is no obvious correlation between soil colour and conductivity values inside this long pit.

Magnetic susceptibility

Planum 1

Figure 2.2.6A shows the areal distribution of magnetic susceptibility as derived from point measurements superimposed on the magnetic map (surface measurements) and the excavation results. Figure 2.2.6B is a cut-out of this map. The area of the long pit coincides with increased susceptibility values of up to $214 \cdot 10^{-5}$ SI, with a mean of $(111\pm30) \cdot 10^{-5}$ SI. Hereby, some of the higher values correlate with the location of burned clay and some of the lower values correlate with uneven surfaces, leading to bad ground coupling of the susceptibility sensor. The area outside the house (west of the long pit) has a mean susceptibility of $(50\pm9) \cdot 10^{-5}$ SI, and the area inside the house (east of the long pit), $(27\pm11) \cdot 10^{-5}$ SI.

Cross-section of house-accompanying long pits

In Figure 2.2.7, the downhole susceptibility measurements and the respective magnetic measurements are shown (in the northern area, Fig. 1 dashed box). Generally, the susceptibility increases with depth until a maximum of $192 \cdot 10^{-5}$ SI is reached at approximately 0.4 m to 0.7 m depth. With further depth, the susceptibility decreases again, to values around $30 \cdot 10^{-5}$ SI. This general form of the susceptibility depth curve can be observed in all corings at the site. Consequently, solely the maximum and its location characterise the shape of the cross-section of the long pits. Considering the $150 \cdot 10^{-5}$ SI isoline as boundary of the central part of the long pit, it starts at a depth of 0.4 m and is 1.5 m wide.

The comparison with the magnetic measurements shows that areas of increased susceptibility correlates with the local maximum of the magnetic anomaly.

Figure 2.2.5 (left). Electric conductivity longitudinal profile through the south-western long pit. A Electric conductivity map (top layer), with the location of the profile and section (blue and green lines, respectively) and the archaeological interpretation (red lines) superimposed; B conductivity model through the pit, with the archaeological interpretation of the sections (black lines) superimposed; C photogrammetry of the archaeological sections. B and C have been split in two in order to fit the page.

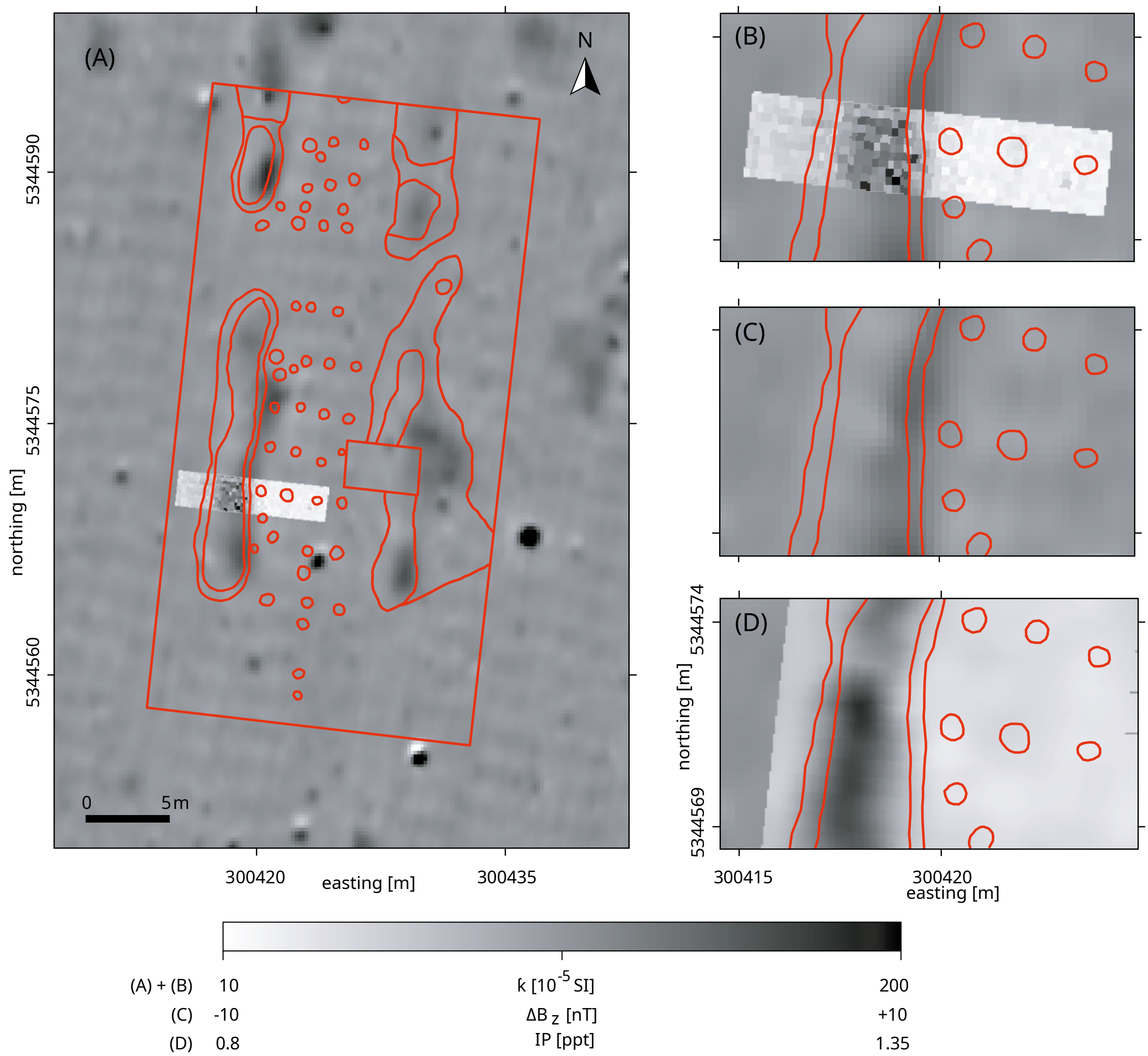


Figure 2.2.6. A Areal susceptibility measurements, with the archaeological interpretation (red lines) superimposed and the magnetic map in the background; B detail of A; C detail of A showing magnetic map only; D detail of A, showing EMI In-phase component of VCP configuration for the smallest coil separation, showing the magnetic susceptibility distribution of the uppermost layer in a spatially smoothed, qualitative way.

Comparison of geophysical results and archaeological documentation

Figure 2.2.2A shows the photogrammetry of the planum at the state of the measurements. The pits are recognisable by the darkest soil colours. The colour contrast to the surrounding material is higher in the western half (light soil colour) than in the eastern half (intermediate soil colour). This difference in contrast may originate from the different air exposure time and the resulting degree of drying or from an actual difference in the composition. Despite this difference in contrast, we observe a correlation between soil colours and geophysical measurement or the respective deduced specific physical parameter: darker soil colours correlate with higher IP and the respective susceptibility values, higher electric conductivity values, and increased reflection amplitudes in the near-surface time slice from 6-8 ns. For the IP (Fig. 2.2.2D) and conductivity values (Fig. 2.2.2E), this correlation especially applies also the surrounding matrix: dark, intermediate and light soil colours correspond to high, intermediate and low IP or conductivity values. For GPR and MS, no assertion can be made, since measurements were performed only in the western half of the

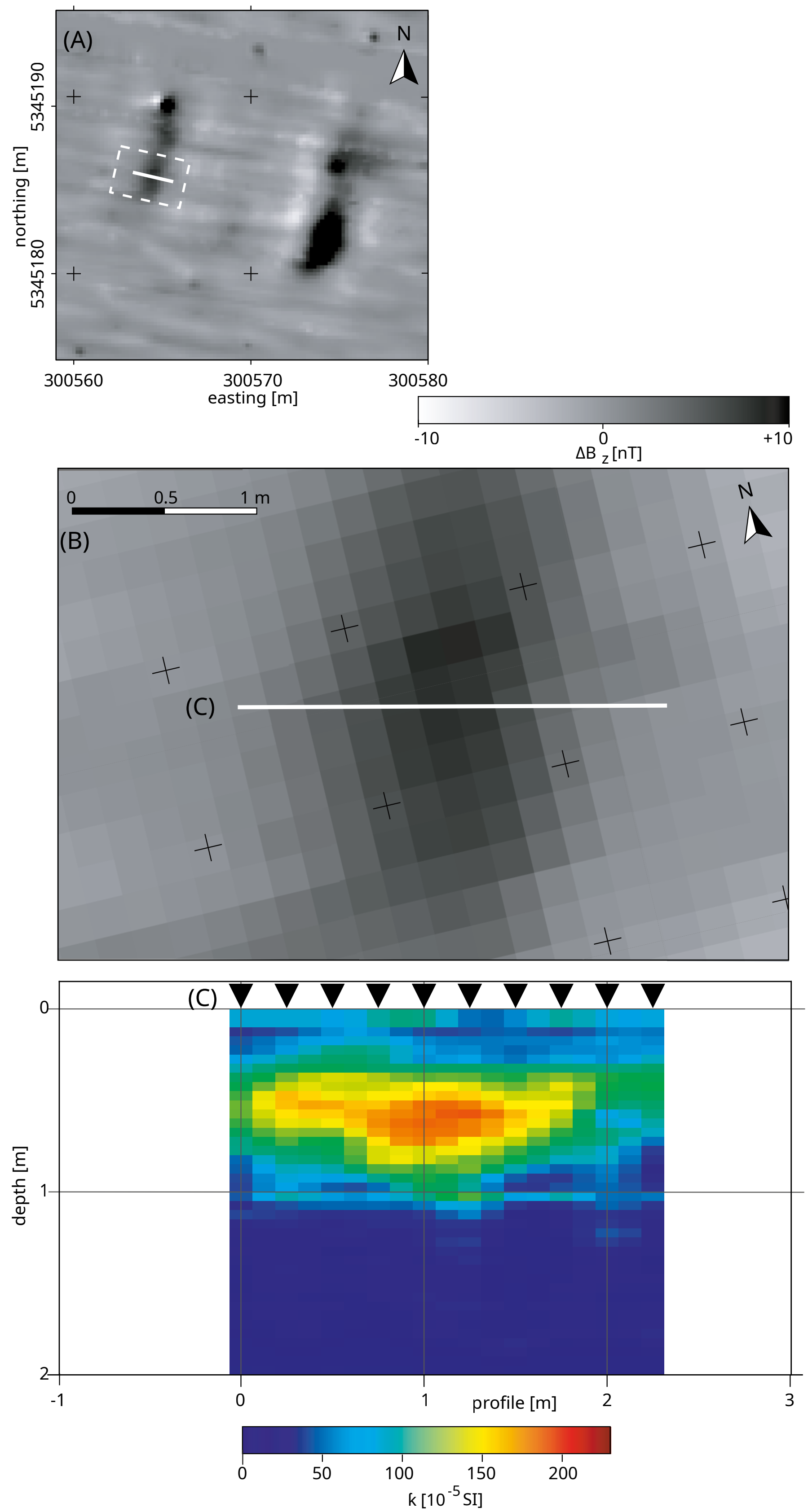
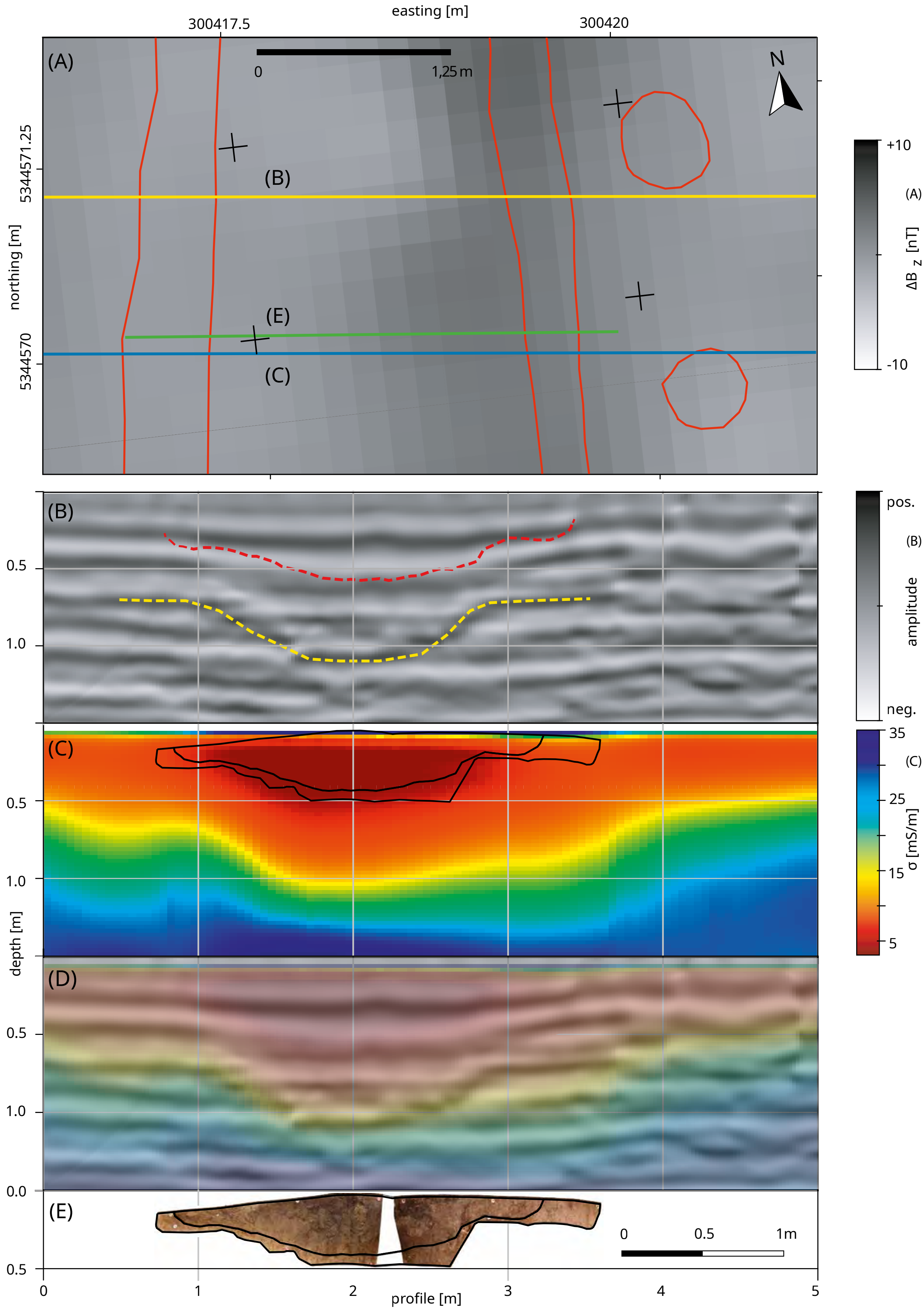


Figure 2.2.7. Susceptibility distribution based on downhole measurements. A Magnetic map, with the profile location (white line) and area depicted in B (white dashed box) superimposed; B magnetic map of the cored long pit, with the profile location (white line) superimposed; C susceptibility distribution, with location of corings (black triangles) indicated.


easting [m]
300417.5
300420
(A)
0
1,25 m
N
(B)
(E)
(C)
5344571.25
northing [m]
5344570
+10
(A)
ΔB z [nT]
-10
(B)
0.5
1.0
pos.
(B)
amplitude
neg.
(C)
0.5
1.0
depth [m]
35
(C)
25
σ [mS/m]
15
5
(D)
0.5
1.0
0.0
(E)
0
0.5
1m
0.5
0
1
2
3
4
5
profile [m]

trench. However, the correlation between soil colour and conductivity does not hold for small conductivity variations inside the south-western pit (cf. Fig. 2.2.5).

Having discussed the observed contrast, we can briefly turn to the resultant geometry of the subsurface structures. From Figure 2.2.2, we can see that all methods mapped the long pits horizontally in a similar shape and spatial extent. However, none of the geophysical methods were able to map the documented postholes. This can be seen as an indication that the volume of the remaining soil fill of the posthole must be vanishingly small. According to the excavation report, the contours of the postholes were visible only for a short time after the removal of the topsoil and 'disappeared' after the planum had dried out.

For the comparison of the depth extension of the pits, we focus on the south-western long pit, as shown in Figure 2.2.8. Figure 2.2.8A shows the magnetic map around the respective profile that is shown in B as a radargram, in C as an EMI inversion result, in D as an overlay of the latter two, and in E as photogrammetry. This comparison shows that the reflections of the GPR as well as the conductivity distribution suggest a deeper bottom of the pit than the archaeological interpretation did. The same interpretation results also from the profiles in Figure 4.

The comparison of the radargram and the conductivity model (Fig. 2.2.8 D) suggests that the 18 mS/m iso-surface can be regarded as an estimate for the bottom of the long pits. Figure 2.2.9 shows the depth of this iso-surface under planum 1. This iso-surface has a minimum depth of 0.4 m under planum 1. The south-western long pit is the deepest one, with a depth up to 1.1 m at its southern end. Notably, the bottom of the house-accompanying long pits shows a distinct microtopography, with the deepest part at their southern end. The magnetic map suggests this continuous, elongated pit character of the house-accompanying long pits, whereas the EMI conductivity distribution shows that this applies only to the upper ~50 cm of the construction. The microtopography of the bottom revealed by EMI indicates that the long pit structure is composed of a sequence of more or less circular pits.

As shown in Figure 2.2.8, the bottom of the long pit appears to be deeper in the geophysical images than it was supposed to be according to the visual inspection during excavation. In contrast, the deepest part of the south-western long pit (see Figure 2.2.5B and C at approx. 27 m) is documented at approximately the same depth, as indicated by the 18 mS/m iso-surface, in comparison to the archaeological documentation. However, considering also the other parts of this long pit along the profile, the differences in the depths of the pit supposed by the geophysical and archaeological interpretation remain, and they need to be discussed (see next section).

Discussion

We begin the discussion with a focus on the investigated targets, outlining the perspectives of geophysical documentation. Then we give an overview of the in-situ measurement approach in general terms. This is followed by a discussion of the details concerning the applied methods.

Figure 2.2.8 (left). Profiles of the south-western long pit. A Magnetic map, with archaeological interpretation (red lines), the location of the GPR profile (yellow line), the EMI profile (blue line), and the archaeological section (green line) superimposed; B GPR depth section of the pit bottom of the long pit, showing the depth as derived from the GPR reflections (yellow), and as determined by visual inspection of soil colour (red); C electric conductivity depth section from EMI overlain with the pit bottom (innermost black line) of the archaeological section (outermost black line; same as shown in red in B); D combined plot of the electric conductivity depth section and the radargram; E photogrammetry of the archaeological section from which the pit depth was derived.

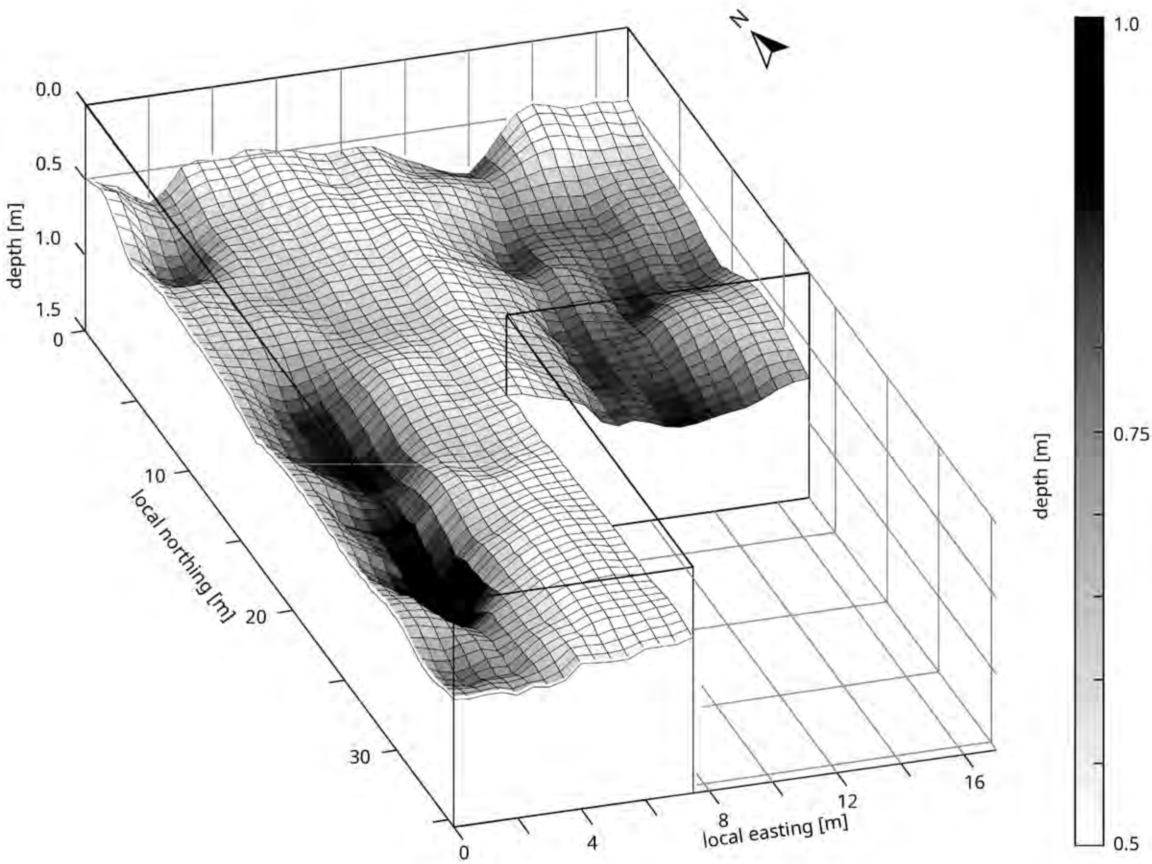


Figure 2.2.9. Map showing the depth of the 18 mS/m iso-surface of the electric conductivity model beneath planum 1 (aspect of depth to horizontal axes 1:5).

Investigated targets: Results and perspectives of geophysical documentation

The presented results show that the archaeological features and the surrounding matrix can be documented in an objective manner based on physical properties. This enables the deduction of conclusions relevant for the archaeological interpretation.

House-accompanying long pits

We derived a map of the bottom of the house-accompanying long pits by combining EMI measurements with depth information from GPR (Fig. 2.2.9). However, we avoided suggesting distinct values of the dimensions of the long pits based on geophysical measurements alone because this necessitates the definition of thresholds between different observed entities (pits and surrounding matrix). In order to obtain the most reliable depth calibration of the geophysical images, we recommend complementing the geophysical sounding by shallow corings and geophysical downhole measurements in future. Although the actual depths of the long pits may be somewhat different from the depths of the selected iso-conductivity contour, the lateral depth variations still holds. This means that the segments of the long pits were originally dug to different depths or are preserved only to different degrees. The geometrical shape, *i.e.* the microtopography, shown in Figure 2.2.9, is irregular and therefore indicates that the long pits were not dug in a single event but, rather, are comprised of an apposition of smaller pits. This was also verified in the excavations.

Still, the depth of the pits and the microtopography have to be considered with some care because in many cases conductivity models represent the distribution of soil moisture and clay content rather than stratigraphic interfaces (*e.g.* Verdonck *et al.* 2019). Therefore, a change in the composition of the pit fill can, in principal, result in the same geophysical results. To resolve the ambiguity between soil moisture and clay content, coring and geophysical downhole measurements need to be added to the methodology. They would allow us to directly determine soil moisture and clay content at the coring site and to determine geophysical pedo-transfer functions that improve the calibration apart from the coring points.

Pursuing the interpretation with the determined depths of the long pits, we can see that Figures 2.2.4, 2.2.5 and 2.2.8 clearly show that the bottom is indicated as being deeper by the geophysical measurements than by the excavation. A change in the physical properties is not necessarily connected with a change in the soil colour, which is examined with the bare eye in the course of excavation to determine the bottom of the pits. Thus, on the one hand, the observed physical change can be independent from the change in the soil colour and, on the other hand, the definition of a distinct boundary based on soil colour with the bare eye can be challenging because of the change of water content over time, varying light conditions or gradual changes in the soil matrix.

House interior vs. surrounding soil

The GPR measurements showed increased reflection amplitudes in the area between the long pits. These might indicate an increased compaction of the sediments resulting from the usage of the building. However, a difference in soil composition of the sediments inside and outside the house can result also in differences in reflection amplitude. To test for variation in the clay content by methods other than soil sampling, gamma-ray measurements could be conducted in future investigations.

Also, the horizontal susceptibility distribution shows a distinct image of the long pits. The long pits show up with a significant contrast, of up to 400 per cent, compared with the surrounding soils. The areas of undisturbed soil outside the house, west of the long pit, and inside the house, east of the long pit, also show different average values, of $(56\pm12)\cdot10^{-5}$ SI and $(27\pm11)\cdot10^{-5}$ SI (Fig. 2.2.6). A comparison with results of the extensive coring campaigns shows that the susceptibility values found inside the house are in the same range as those of the underlying loess (cf. Fig. 2.2.7 and Pickartz *et al.* 2020). This indicates that the area between the two house-accompanying long pits at planum level has not been altered over time in terms of the susceptibility, in contrast to the surrounding, where anthropogenic or pedogenic processes have led to an increase in susceptibility compared to the subsoil loess. A slight soil compaction of typically 10 per cent, as may be indicated by GPR, would imply an increase in magnetic susceptibility of the same order, which is not observed. However, we do not see this as a contradiction because the lateral variation of the susceptibility of loess outside the long pits is of the same order of magnitude. Therefore, compacted soil patches are difficult, if at all, to detect by susceptibility measurements. With this approach, other characteristic areas, *e.g.* workshops, that are not visible to the bare eye could also be detectable (cf. Hulin *et al.* 2014).

Postholes

None of the applied geophysical methods were able to detect the remains of the archaeologically identified postholes. There are three possible reasons for this: lack of contrast in the physical soil parameters, too small volume of the remaining posthole fill, lack of spatial sampling or horizontal resolution of the sounding methods.

Lack of physical contrast would imply that the posts have been removed and the hole has been filled with the unaltered soil of the surrounding matrix. This is because rotten remains of organic material, such as tree trunks, can be expected to develop anomalies at least in magnetic susceptibility due to the activity of magnetic bacteria (*e.g.* Fassbinder *et al.* 1990; *ibid.* 2015).

To produce a geophysical signal measurable with field instruments, the anomalous soil structure needs to have a certain minimum volume. For GPR, the posthole fill would need to have a thickness of the order of a quarter of the dominant wavelength, that is, ca. 8 cm in the present case. The diameter of the soil volume sounded by in-situ measurements of magnetic susceptibility is of the order of 5 cm. Therefore, it would be unlikely to detect a posthole geophysically if the thickness of the remaining posthole fill were less than these values, even if it were exposed at the planum.

Finally, spatial sampling and horizontal resolution need to be considered as a possible cause. The 13 excavated postholes have widths between 0.35 m and 0.63 m. The horizontal resolution for GPR is determined by the size of the Fresnel zone, and this depends on the wavelength and the depth. Here, the wavelength is of the order of 0.3 m, resulting in a horizontal resolution of ~8 cm at the earth surface and ~40 cm at 1 m depth. Therefore, the postholes would have been detected with GPR if the contrasts were large enough. Also, for the horizontal susceptibility measurements with a point distance of 0.1 m, the spatial sampling was high enough because the area sounded by each scan is of 5 cm diameter only. The situation is different for EMI, where the smallest coil distance of the applied instrument was 0.32 m, leading to a sounding volume of about 60 cm diameter. This volume may have been a critical prerequisite to detect the postholes even if a measurable contrast had been present. However, in summary, we can conclude that the lack of visibility of the postholes in the geophysical records is, in this case, not caused by a lack of resolution or coarse sampling, but indeed by a lack of contrast in the respective physical parameters or by a lack of mass of the remaining posthole fill. Comparably, most postholes were hard to locate during the excavation, as the colour of their fill was often almost identical to that of the surrounding soil, due to bleaching or washing out of minerals over time. The postholes are best visible in situations of overall humidity, *i.e.* directly after excavation, or after a longer period of rain. However, due to the conditions of a summer excavation, such conditions are too seldom encountered.

For the archaeological interpretation, this might indicate that the posts were removed when the house was abandoned and that only anthropogenically undisturbed sediments filled the remaining postholes. Another explanation would be that the remains of the posts eroded completely or were destroyed through ploughing.

To detect putative postholes, it is important to conduct all measurements, including photography, quickly after removing the topsoil. Slight variations in the soil colour indicated the location of the putative postholes; however, the colours faded while exposed to air. This suggests that the contrast in the physical properties can also change due to air exposure. On the one hand, the water content changes and, on the other hand, oxidation processes might take place.

In conclusion, the detection of postholes seems to be possible only with very sensitive devices with high spatial resolution and sampling and with prompt measurement after air exposure.

Methodical discussion: Specific problems and perspectives

General aspects of in-situ measurements

Many authors have stated that integrated surveys using a combination of different geophysical methods (*e.g.* Linford 2006; Verdonck *et al.* 2019; Kvamme *et al.* 2019) and a high feedback level between geophysicists and archaeologists (*e.g.* Boucher 1996; Horsley *et al.* 2014) are profitable. However, in-situ measurements to aid documentation and characterisation of excavated features still seem to be limited to a few examples compared to the overall number of archaeogeophysical case studies (*e.g.* von der Osten-Woldenburg *et al.* 2002; Simon *et al.* 2012; Hulin *et al.* 2014; Ard *et al.* 2015; Kainz 2016). A technical report (Bevan 2005) discusses the advantages and disadvantages. As advantages, it lists, inter alia, the accurate imaging of gradual boundaries (vs. the simplification to a discrete boundary), the detection of contrasts that are not visible to the human eye, no influence from surface rubble – or, in this case, the plough zone – and performing the measurements directly on the archaeological features. The latter also enables a better spatial resolution, since the distance between probe and features is smaller. The disadvantages are possible effects of the excavation boundaries (similar to topographical effects) and stronger effects of soil moisture changes, since former deeper layers are now exposed. We also observed most of these advantages and disadvantages, as discussed above and below. Disadvantageous financial and practical aspects are obviously the time and cost of additional survey campaigns. Depending on the method, additional time for processing and interpretation is needed, so that not all measurement results can immediately be incorporated in the ongoing excavation.

In general, the choice of geophysical methods depends on the subsurface and the targets. For the subsurface and targets at the site of Vráble, the combination of GPR and EMI yielded satisfactory results. The application of both methods is also feasible during the course of an excavation, since the instruments are mobile during the measurements. This is in contrast to electrical resistivity measurements, for example, which require the deployment of electrodes to the ground that might hinder the excavation work for a certain amount of time. Both EMI and GPR are electromagnetic methods and accordingly they are both sensitive to the electric conductivity and magnetic soil properties (GPR: magnetic permeability; EMI magnetic susceptibility). This overlapping sensitivity makes the results comparable, as a change of the respective signal is expected at the same depth. Yet, they also complement each other, since the methods work in different frequency ranges. The favourable complementing characteristics are: The lack of spatial resolution of the EMI is complemented with the high resolution of GPR and vice versa, in that the reduced depth of investigation of GPR is complimented by a higher depth of investigation of EMI. Despite the challenging survey conditions (loess as conductive, and therefore damping subsurface and targets as well as surrounding matrix consist of very similar material), the combination of the two methods yields results that clearly show the subsurface structures. The comparison with the excavation documentation shows that these results are plausible.

We have shown that the combination of GPR and EMI measurements after stripping the topsoil allows for the documenting of the archaeological features before being destroyed through excavation. The time for measurements, processing and interpretation obviously depends on the size and complexity of the excavation area. On a prepared area (positioning already done) and with enough labour to partly conduct measurements and processing at the same time, an area like discussed here can be examined to preliminary results within an extended working day. Although the excavation has to stop during the measurements, the advantage is that the gathered data document a piece of cultural heritage which is afterwards destroyed. Moreover, the interpretation of the geophysical measurements can reveal targets as focus for the excavation and, as shown above, can determine the depths of features. This allows the team to adjust the excavation speed and therefore, perform the excavation more efficiently.

EMI measurements

The presented electric conductivity model explains the measured data with a root mean square error predominately between 5 % and 15 %. However, due to the principal of equivalence of EMI sounding, many models exist that explain the measured data equally well. These equivalent models differ in layer thicknesses and electrical conductivity values, but agree in the product of layer thickness and conductivity. The model output by the selected EMI software usually depends on the incorporated inversion algorithm, as well as on the starting parameters of the computation used (*i.e.* number of layers, minimum and maximum depth, and starting conductivity). Therefore, EMI measurements principally need calibration, for example, with corings, geophysical downhole measurements, excavations or even seismic or GPR surface profiling. Nevertheless, for regular, non-chaotic sedimentation conditions, it can be assumed that the prevailing sediment bedding form and compositional layering of the soil show up in the electric conductivity depth sections with geometrical similarity, even though the absolute layer depths may be different. This may also constitute a geometric similarity between conductivity structures and soil colour contours deduced from photography of trench walls.

Finally, it has to be considered that 3D models of electric conductivity stitched together from 1D conductivity-depth function are only an approximation of the true subsurface conductivity distribution. They need to be considered with care in cases where the archaeological targets show complicated 3D forms at spatial scales that are of the same or smaller size than the diameter of the EMI footprint. However, this is not problematic in the present case because the dimensions of the investigated pits seem to have been accurately mapped by EMI, as shown by comparison with the other methods.

GPR measurements

The GPR measurements directly on the archaeological features introduce difficulties in the interpretation. The direct wave of the 200 MHz antenna has an approximate period of 20 ns, with a respective wavelength of 60 cm. Hence, the reflections of the archaeological features are superimposed by the direct wave. Moreover, the direct wave is also influenced by absorption and coupling effects of the antenna and/or the subsoil's moisture and porosity. The area of the house between the two pits appears as intermediate reflective (Fig. 2.2.2C). The part of the GPR signal causing this anomaly is also part of the direct wave. This change in amplitude may have resulted from a reflection from a denser sediment layer in the area of the house compacted through its usage. This hypothesis could be tested in further excavations with direct analyses of the density and punctual measurements of GPR velocity. To resolve this sort of very shallow structure, an antenna with a much higher frequency than 200 MHz would be needed.

Susceptibility measurements

Our investigations have shown that vertical sections of susceptibility can be generated very efficiently by coring and downhole measurements and that the pit fill can be identified very reliably through its susceptibility value (Fig. 2.2.7). Therefore, we see the susceptibility measurements as a direct method for extending the documentation of pits and similar archaeological features in an objective way to the areas outside excavation trenches and plana (cf. Pickartz *et al.* 2020).

Hand-held susceptibility devices, which are available on the market for mapping excavation plana and trench walls, differ strongly in data acquisition speed. We chose to perform point-mode measurements (single, hand-triggered measurements) instead of continuous-mode measurements (measurements triggered by a fixed sample frequency) to ensure the highest possible measuring accuracy for susceptibility values and positioning. Taking point mode measurements this is a time-consuming procedure. The continuous mode would be faster, but – to our knowledge – none of the available devices was equipment with a suitable positioning system or interface, which complicates mapping areas continuously with centimetre spacing even if they are only a few square metres in area. Hence, an improvement of the practical procedure is necessary to enable fast and accurate measurements in future.

Conclusions

We applied ground penetrating radar, electromagnetic induction, and magnetic susceptibility measurements during an ongoing excavation of the Neolithic site of Vráble. The measurements were performed on a planum 60 cm beneath the modern surface to characterise the archaeological structures beyond visual inspection by physical soil parameters and to extend the 2D archaeological documentation of the planum into a 3D model. Incorporating geophysical measurements in the ongoing excavation documents the subsurface structures before being destroyed through excavation. Then the deduced sub-surface models can be used to adjust the excavation process, *e.g.* in terms of speed of soil removal and small-scale target focussing. Essential for the geophysical documentation is a sound depth calibration of the measurements through coring, geophysical downhole measurements, test excavation and/or comparative measurements with different depth-sensitive geophysical methods at Earth's surface.

Our conclusions relating specifically to the Vráble site are the following:

The shape of house-accompanying long pits could be determined in 3D by EMI measurements after local calibration through GPR, excavation trenches and downhole susceptibility measurements. It turned out that the long pits have an irregular bottom, indicating a discontinuous construction over time. In some cases, the comparison between archaeological documentation and EMI and GPR measurements showed that the bottom of the long pits was obviously deeper than excavated.

The uppermost soil layer of the planum shows distinct differences in MS and GPR amplitude strength inside and outside the investigated house. This difference could be explained by a compaction of the sediments originating from the usage of the house floor. To confirm this hypothesis, more houses need to be investigated, including also soil density analyses.

At the locations of postholes suggested on the base of visual evidence, no distinct anomalies of geophysical parameters could be detected, even though the spatial resolution of the measurements was sufficient. We therefore conclude that the posthole fill had been basically eroded and dispersed in the removed topsoil, such that only a faint remnant of their very bottom remained by chance on the planum – too little material to be detected by the sensors applied.

To further improve the significance of excavation-accompanying geophysical measurements, we suggest conducting further research to integrate archaeological, geophysical and pedological observations for a thorough understanding of the features and the surrounding subsurface. This can be, inter alia, soil density measurements to test soil compaction and gamma-ray measurements for mapping variations of the clay content of the topsoil. Analyses of the frequency dependence of the magnetic susceptibility, as well as in-situ determination of the content of iron oxides, could be used to examine soil formation processes at the archaeological site. A more detailed characterisation of the magnetic properties could also help to design the site-specific inversion approach for up-scaling interpretations from an excavation area to a complete site established on the basis of areal prospection data.

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2.3. Geomorphological and geoarchaeological investigations at the LBK and Želiezovce settlement site of Vráble

Stefan Dreibrodt, Hans-Rudolf Bork

Abstract

This chapter describes the study of the Holocene erosion history of the slopes adjacent to the Linearbandkeramik (LBK) site of Vráble (Nitriansky kraj, Slovakia). The analysis of sediments deposited at the outlet of a small valley about 1.5 km east of the settlement site resulted in a detailed chronostratigraphy of Holocene phases of slope instability and slope stability. No erosion was found for the phase of LBK settlement. Instead, Neolithic soil erosion occurred during the Lengyel (4700-4400 cal BCE) and Baden (3300-2900 cal BCE) periods in the catchment. The most intensive soil erosion at the site occurred during medieval and modern times, in particular during the past 60 years. Screening for colluvial layers in another valley that is located within the Neolithic settlement contained very little accumulation of eroded soil in a colluvial layer package less than 1 m in thickness. Relating the deposited colluvial layers to the respective catchment areas results in very little Holocene losses of soil per square metre. Thus, post-depositional erosion is an improbable explanation for differences in preservation depths of postholes of the LBK houses.

The fills of different types of pits were analysed with the same set of laboratory methods (magnetic susceptibility, portable energy dispersive X-ray fluorescence (ped-xrf), colour-spectrometry, loss on ignition). The application of statistical analysis on the results revealed very little difference among the pit fills. Thus, either all the pits must have been filled initially with a similar substrate of local origin or the initial properties of all the pit fills must been strongly altered by subsequent soil formation. The magnetic properties of the pit fills are explainable by a contribution of magnetotactic bacteria to the decomposition of the organic-rich fills of the pits. Since waterlogging is improbable considering the topographical situation of the site and the parent material (loess), oxygen-depleted conditions may have been induced by the decomposition process of the pit fills, which were presumably rich in organic

matter. The resulting contrast in the magnetic properties between pit fills and the surrounding surface soil is the reason for the visibility of pit fills in magnetic maps and thus the basis for magnetic prospection.

Keywords: Soil erosion, geochemical and geophysical analysis of pit fills, magnetics of unburnt archaeological findings, soil magnetism

Introduction

The Neolithic LBK settlement of Vráble is situated at 48°13`033 N, 18°18`050 E, at an altitude of 140 to 150 m a.s.l. Tertiary sediments covered with Pleistocene and Holocene deposits characterise the geology of the study site. During last glaciation, river sediments, solifluction debris layers and loess were deposited. Holocene sediments cover the lower parts of the slopes (colluvial layers) and the valley of the Žitava river (alluvial sediments). Chernozems and cambisols formed within the loess during the Holocene (Miklòs and Hrnĉarová 2012). The climate at Vráble is classified as cold-temperate (Köppen-Geiger Dfb), having a mean annual temperature of 9.9°C and a mean annual precipitation of 593 mm for the period 1982-2012 (Climate-Data.org). According to Walter and Straka (1970), the potential natural vegetation forms of the region are mixed woodland with a dominance of beech and oak. In the recent past and today, the site has been covered by large agricultural fields.

The Neolithic LBK site is located on a fluvial terrace underlain by a thin loess cover (*c.* 2.5 m), with gentle slopes that incline towards a small, adjacent creek (Kovacovský potok) and towards the Žitava river, with a low slope gradient (Fig. 2.3.1a).

Based on dating of sediments recovered from more than 20 percussion corings, Nowaczinski *et al.* (2015) reconstructed the Holocene fluvial history of the nearby Žitava river. Sediments of the Weichselian glaciation form the base of the sediment sequences. During the early Holocene, as was the case in most central European river valleys (*e.g.* Dreibrodt *et al.* 2010; Macklin *et al.* 2006), there was rather limited fluvial activity; the river Žitava could be characterised as a large creek during that period. The first mid-Holocene river activity was detected in small channel fills dating to *c.* 4300 cal BCE. Above, a thick stack of overbank fines indicates that the fluvial regime changed during the mid- to late Holocene. Flooding of the Žitava river became more frequent than before. Stratigraphically, the lateral erosion of the Early Bronze Age settlement ‚Fidvar' marks the probable starting time of the observed increase in fluvial activity, that is, no earlier than the Bronze Age and perhaps even as late as medieval times (Nowaczinski *et al.* 2013).

The diachronous settlement history is known from intensive archaeological surveys in the surroundings of the investigated site (*e.g.* Gauss *et al.* 2013; Müller-Scheeßel *et al.* 2013). This enables an estimation of the duration of the post-LBK set-

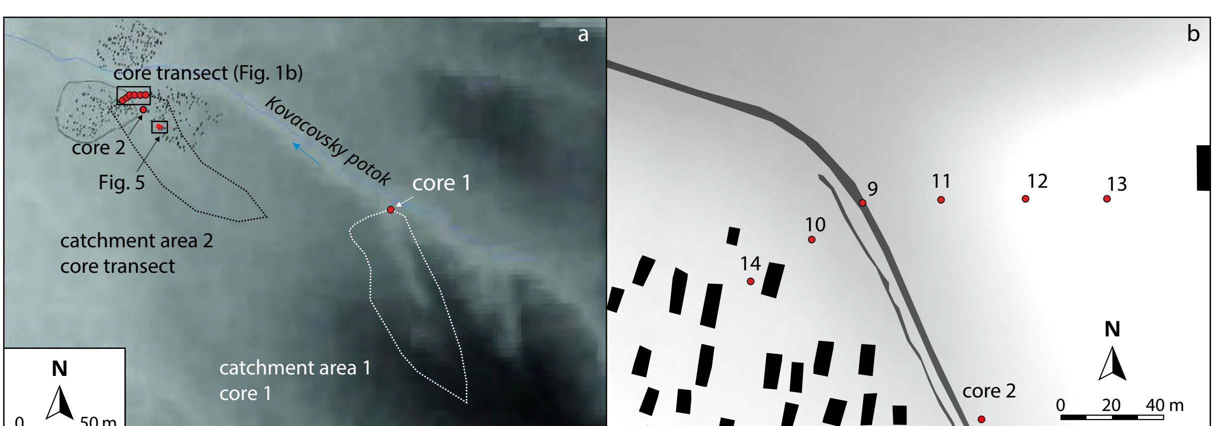

Figure 2.3.1. Location of the investigated profiles and corings in relation to the LBK site of Vráble.

tlement phases, which were probably characterised by agricultural field use and therefore could have enabled soil erosion at the site. Features and finds post-dating the LBK settlement at the site relate to the Lengyel period, the Baden period, the Kosihy-Čaka period, the Bronze Age, the Roman Iron Age, Roman times, and the period from the Middle Ages to the present. Thus, the post-LBK phases of assumed agricultural field use total *c.* 2150 years (Dreibrodt *et al.* 2017). In turn, based on the assumption that woodland encroached over the territory during non-agricultural phases, the wooded post-LBK phases sum to *c.* 4165 years.

In the following contribution, we present results of analyses on slope deposits that allow the estimation of pre-, syn- and post-Neolithic erosion at the site. Figure 2.3.1 displays the location of the percussion drilling coring points and the catchment areas of the studied deposits, both covering ***c.*** 36 ha. Results of the onsite analysis of pit fills, which contain information about the formation processes and the post-depositional alteration of the archaeological record, are given in the second part of the chapter.

Methods

Field methods

For the reconstruction of the Holocene soil erosion history of the site, sequences of sediments and soils in percussion drilling cores were studied. The cores were opened, documented in drawings and digital photos, and described according to usual methods (AG Boden 2005). Samples were taken for dating and laboratory analysis.

Pit fills identified in percussion drill cores and in the walls of the archaeological excavations were analysed using geoarchaeological methods. All sequences were documented in drawings and digital photographs. Samples were taken for laboratory analysis.

Laboratory methods

Dating

Pieces of charcoal embedded in sediment sequences were dated using the radiocarbon method. The ages give maximum ages for the sediment layers. Since the investigated slopes are relatively short and morphologically not very complex, as it is often the case in the Central European lowlands, these ages could be considered to provide data approximating the erosion process (*e.g.* Dreibrodt and Wiethold 2015). The results were calibrated using OxCal v4.2.3 (Bronk Ramsey and Lee 2013) with the IntCal13 atmospheric calibration curve (Reimer *et al.* 2004) and are presented in cal years CE/BCE (2 sigma).

Geophysical and geochemical methods

The bulk density was determined gravimetrically using steel cylinders of 100 cm^3 (n=3) for samples of two profiles.

Prior to additional laboratory analysis, the samples were dried for 3 weeks at 35°C, carefully disintegrated with mortar and pestle and divided into two fractions, smaller than and larger than 2 mm. Subsequent analysis was carried out on the fraction < 2mm. During this sieving procedure, embedded particles of charcoal and daub were removed from the < 2 mm fraction and their weight was documented.

Grain size distribution analysis was carried out on fills of pits at the Neolithic site using a Malvern Laser particle sizer, after removal of soil organic matter (H_2O_2, 70°C) and carbonates (acetic acid buffer, 70°C, pH 4.8). Each sample was measured for at least 45 seconds, and the measurement was repeated at least 10 times. Finally, the measurements were averaged. For the sediment of a colluvial fan, a combination of wet sieving and sedimentation of the fine fraction (< 63µm) in Atterberg cylinders was applied to determine the grain size distribution after removal of soil organic matter and carbonates. The magnetic susceptibility was measured on 10 ml samples (< 2 mm fraction) using a Bartington MS2B susceptibility meter (resolution $2*10^{-6}$ SI, measuring range $1\text{-}9999*10^{-5}$ SI, systematic error 10%). Measurements were carried out at low (0.465 kHz) and high (4.65 kHz) frequency. A 1% Fe_3O_4 (magnetite) was measured regularly to check for drift and to calibrate the results. Mass-specific susceptibilities and frequency-dependent magnetic susceptibility (χfd) were calculated (Dearing 1999). The colour of the samples was measured using a Voltcraft Plus RGB-2000 Color Analyzer set to display in a 10-bit RGB colour space within a spectral range of 400 to 700 nm (Rabenhorst *et al.* 2014; Sanmartin *et al.* 2014). Although some scholars have noted correlations between soil characteristics and RGB data (*e.g.* Moritsuka *et al.* 2014), RGB data are internally highly correlated. All RGB data were therefore de-correlated before statistical tests were performed, using the equations of Viscarra Rossel *et al.* (2006), resulting in values for hue, light intensity and chromatic information.

Total elemental contents of the samples (%, ppm) were measured on a ped-xrf (Nixon XL3t900-ed-XRF device) and converted into elemental contents (%/ppm) by weight. For pXRF measurements, ground samples (Agate mill) were placed in a plastic tube covered by a 4 µm film. These were then measured in a lead-mantled measurement chamber with He-flotation using the 'mining, Cu/Zn' settings, for 300s. Since this device not only records quantitative elemental concentrations, but also can report measurement errors, all elements with > 10% errors were omitted from further analysis. The results for the elements Cd, Y, Sr, Rb, Zn, Fe, Mn, Ti, Ca, K, Al, P, Si, Mg, and Pb meet these requirements. The data were transformed into percent by weight values according to calibration factors reported in Dreibrodt *et al.* (2017). Loss on ignition (LOI) values were measured as estimates of the organic matter and carbonate content of the sediments (Dean 1974). After drying the samples at 105°C overnight, the weight loss of the samples was determined after heating times of 2 h at 550°C and 940°C each. For selected profiles, some additional analysis was carried out.

Results

Holocene erosion history

Catchment 1

Soils and sediments from a colluvial fan close to the outlet of a small, secondary valley to the Kovacovský potok were extracted within a long percussion drilling core (Fig. 2.3.1). During the Holocene, *c.* 3.5 m of soils and slope deposits accumulated at the drilling site due to soil erosion in the catchment area (Fig. 2.3.2).

At the base of the sequence, a calcareous, yellowish brown silt layer was found. This is probably a fluvially redeposited loess from the adjacent slopes of the valley catchment. In the upper part of this layer, a soil has formed. This is reflected by the dissolution of the carbonates, the accumulation of soil organic matter and clay, and a dark brown colour in a buried humus horizon. The brownish colour of the underlying

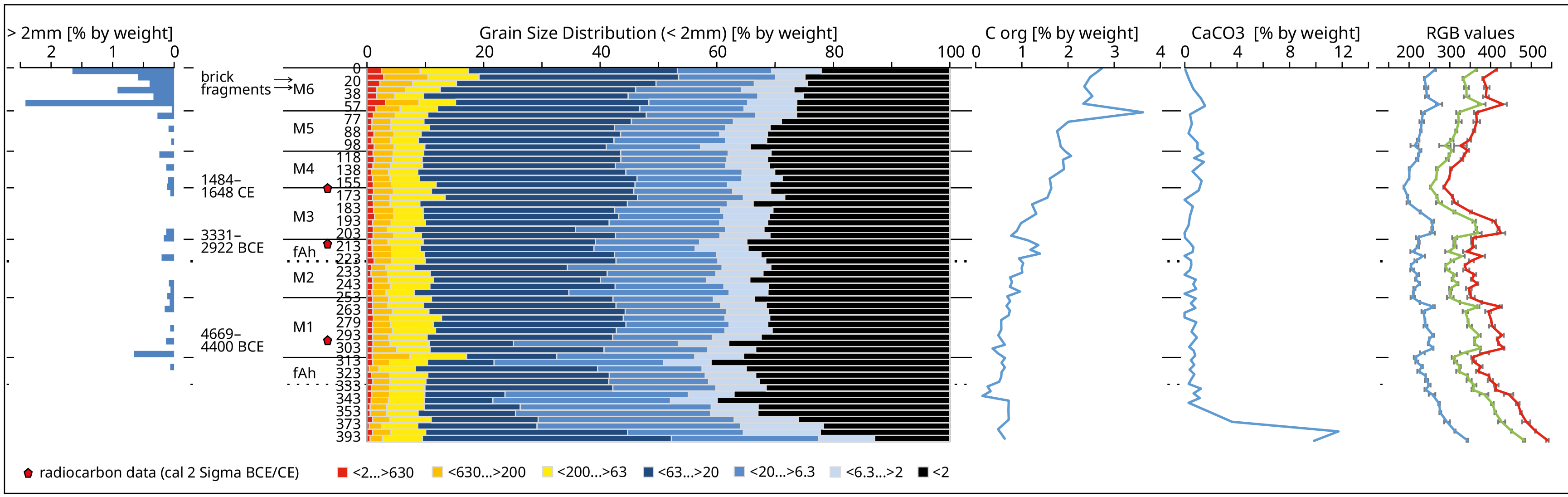

Figure 2.3.2. Dates and selected laboratory data from core 1 at a colluvial fan close to the LBK settlements of Vráble.

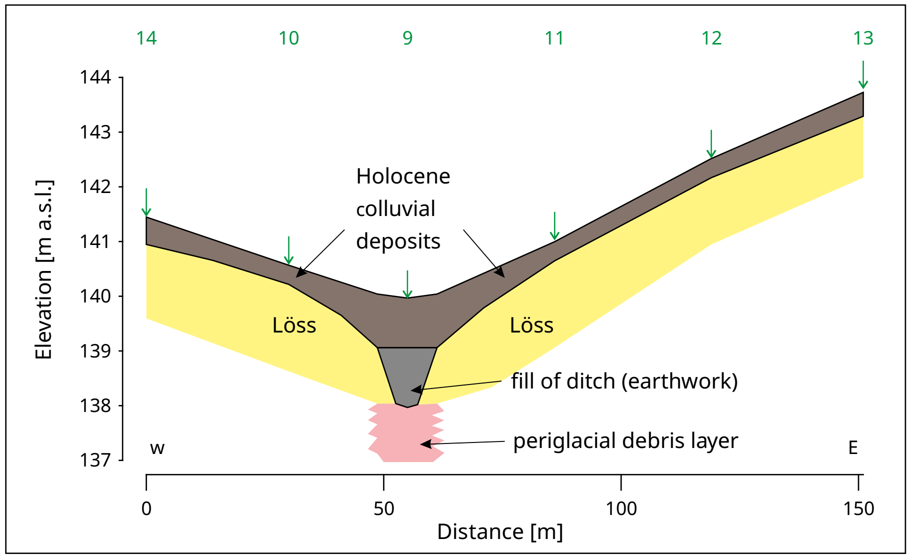

Figure 2.3.3. Scheme of the distribution of younger Quaternary sediments at the percussion drilling coring transect between the southern neighbourhoods of the LBK settlement of Vráble.

loess could indicate the formation of a cambisol Bw-horizon under woodland during the early Holocene. A first Holocene colluvial layer, M1, was deposited at the site *c.* 4700-4400 cal BCE. Some coarser particles and sand, as well as paler colours, characterise the sediment. Its deposition could be related to a woodland clearance and an agricultural land use phase of the Lengyel cultural period, subsequent to the LBK phase present in the archaeological record of the surrounding landscape. A second colluvial layer, M2, was deposited *c.* 3300-2900 cal BCE. This points to a renewed phase of woodland clearance and agricultural land use during the Baden cultural phase. It is reflected in the archaeological record within the surrounding landscape. Afterwards, a longer period of slope stability could be deduced from the pedogenetic alteration of M2. A humus horizon formed on the surface of M2, with a higher content of organic carbon and darker colours than in the lower part of the layer. Above, a sequence of medieval and modern era colluvial layers was deposited (M3, M4, M5, M6). Whereas we have no numerical age information for M3, it seems likely that it was deposited during medieval times, which is known as the phase of most intensive soil erosion during the Holocene in many landscapes of central Europe (*e.g.* Bork *et al.* 1998; Dreibrodt *et al.* 2010). The upper 150 cm (M4, M5, M6) were deposited during modern times according to a radiocarbon date of *c.* 1450-1650 CE from M4. The recent intensive agricultural land use phase with heavy machinery working on large fields (*c.* past 60 years) resulted in very intensive soil erosion on the slopes above the site (M6, upper 60 cm). This is illustrated by increasing amounts of coarse particles and sand, paler colours and some carbonates in M6, which additionally contains pieces of brick. The occurrence of carbonates in the colluvial layer indicates the beginning erosion of the loess cover that underlies the soil on the surrounding slopes.

Catchment 2

In a transect of percussion drilling cores through a valley inclining with a small angle towards the Kovacovský potok, the thickness of accumulated Holocene colluvial layers close to the LBK settlement was studied (Fig. 2.3.1; 2.3.3). In the middle of the transect, the 3 m long core 9 allows an insight into the current stratigraphy of the younger quaternary sediments. At the base (*c.* 2-3 m), a periglacial solifluction debris layer composed of a mixture of large, unrounded stones and fine material is present.

Above this layer (*c.* 1-2 m), the organic-rich fill of the large ditch of the enclosure that encircles the western settlement core of the Neolithic settlement is present. These layers are buried in core 9 by a stack of Holocene colluvial layers of a cu-

Figure 2.3.4. Photograph of core 2, drilled at a lower slope position in a small depression beneath the LBK settlement of Vráble. Upper 1.2 m contain the Holocene colluvial layers.

mulative thickness of *c.* 1 m. The transect illustrates the decrease in thickness of the Holocene slope deposits towards the western and eastern slopes of the valley form. At the slopes, less than 0.5 m of colluvial material accumulated throughout the Holocene. In the additional percussion drilling core 2, within the deepest part of the valley, a more complete Younger Quaternary stratigraphy was recovered (Fig. 2.3.1; 2.3.4). At the base (3.7-4.0 m), a periglacial solifluction layer that resembles the one in core 9 was detected. Above (3.7-2.0 m) sandy layers, probably of fluvial origin, is interlayering. Between 2.0 and 2.5 m, these sediments have been altered by soil formation (Bw-horizon). This Bw-horizon could reflect remains of an Allerød soil. At *c.* 1.9 m, an erosional hiatus is indicated by the accumulation of a stone-rich layer. This probably reflects slope instability that occurred during the Younger Dryas. Above (*c.* 1.9-1.2 m), loess has been deposited. The brownish colour in the upper part of the loess (*c.* 1.2-1.4 m) indicates early Holocene formation of a cambisol under woodland. The described sequences are buried by a stack of Holocene colluvial layers of a cumulative thickness of *c.* 1.2 m.

According to numerous investigations of colluvial layers in central Europe, the soil eroded in lowland landscapes is deposited almost completely (>> 90 percentage) at the lower slope positions, and only very little material is transferred to river floodplains (Bork *et al.* 1998). Thus, the colluvium stored at the lower slopes represents an almost complete record of Holocene erosion. Assuming that the same amount was eroded throughout the catchment area during the Holocene and deposited as colluvial material at the outlets of the studied valleys, much less than 1 mm would have been eroded on average from the slopes of the catchment. Thus, a destruction of the LBK record at Vráble by post-depositional intensive erosion phases can be excluded.

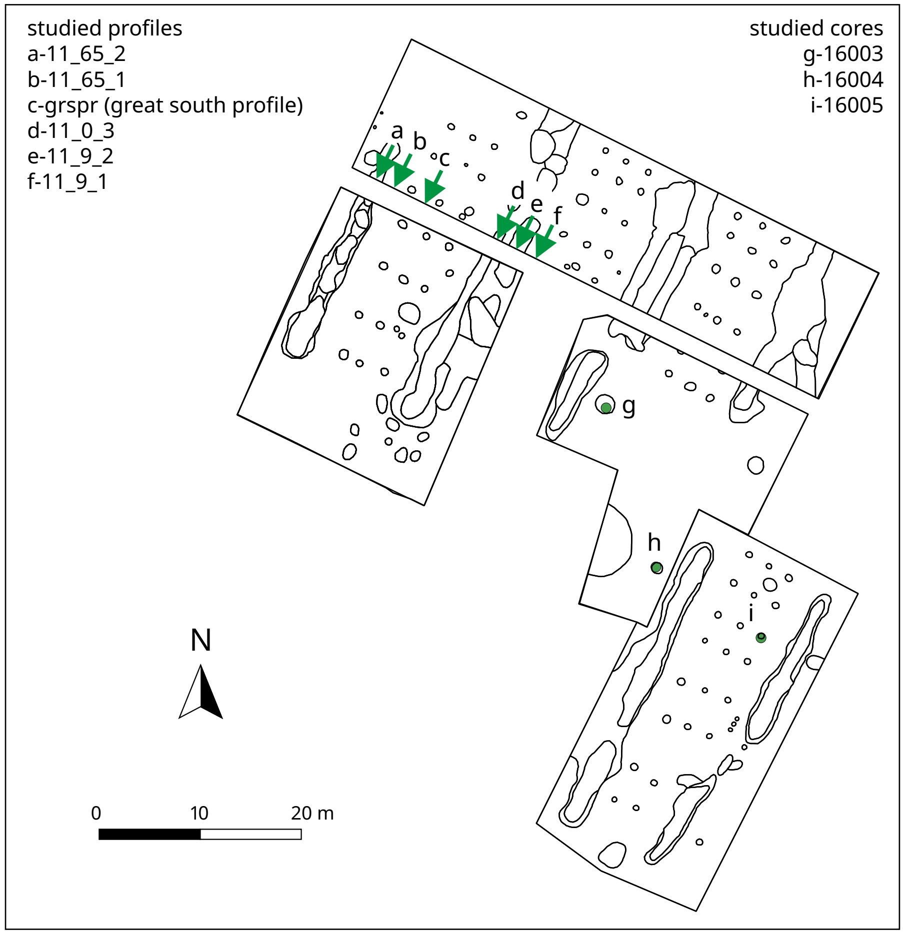

Figure 2.3.5. Location of the studied profiles and percussion drillings within the excavation area. Profiles a, d, and f are fills of house-accompanying long pits. Profiles b, c, and f are profiles through the soil outside the house-accompanying long pits. Drilling point g penetrates a truncated cone pit, drilling point h a small pit of unknown function, and drilling point i a posthole.

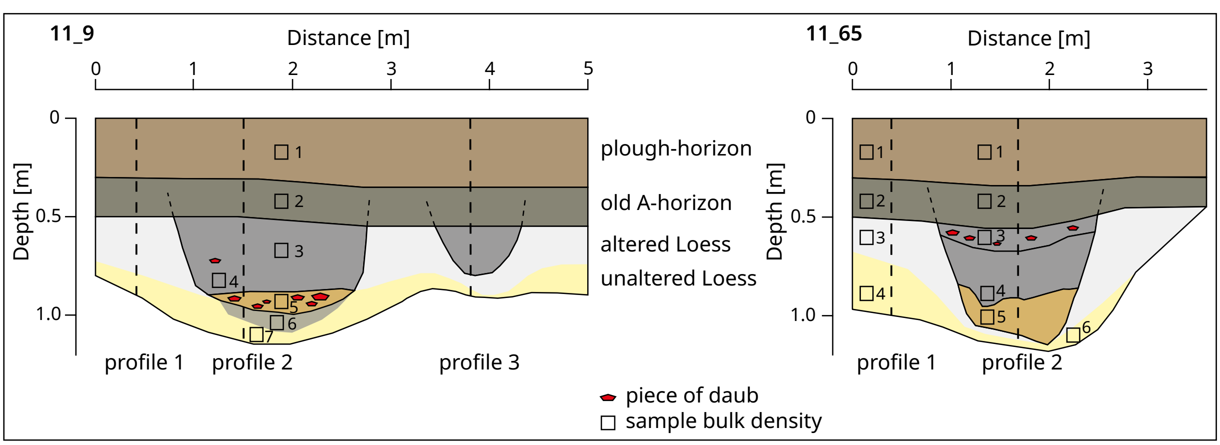

Figure 2.3.6. Profiles from three house-accompanying long pits. Location of samples for bulk density and geochemical analysis indicated.

Properties of the studied pit fills

Continuous sequences of samples were taken from the fills of different contexts in the 2016 archaeological excavation area, in depth increments of 5 to 10 cm (Fig. 2.3.5). Samples were also taken in the walls of the excavation trench, including the recent surface soil (Fig. 2.3.6). Three of them provide complete fills of house-accompanying long pits (11_65_2, 11_9_2, 11_9_1), whereas three others give a comparison with the soil outside the filled long pits (11_65_1, 11_9_1, grspr). Additionally, percussion drillings were conducted at a truncated cone pit (16003), a small pit of unknown function (16004), and a posthole (16005) (Fig. 2.3.5).

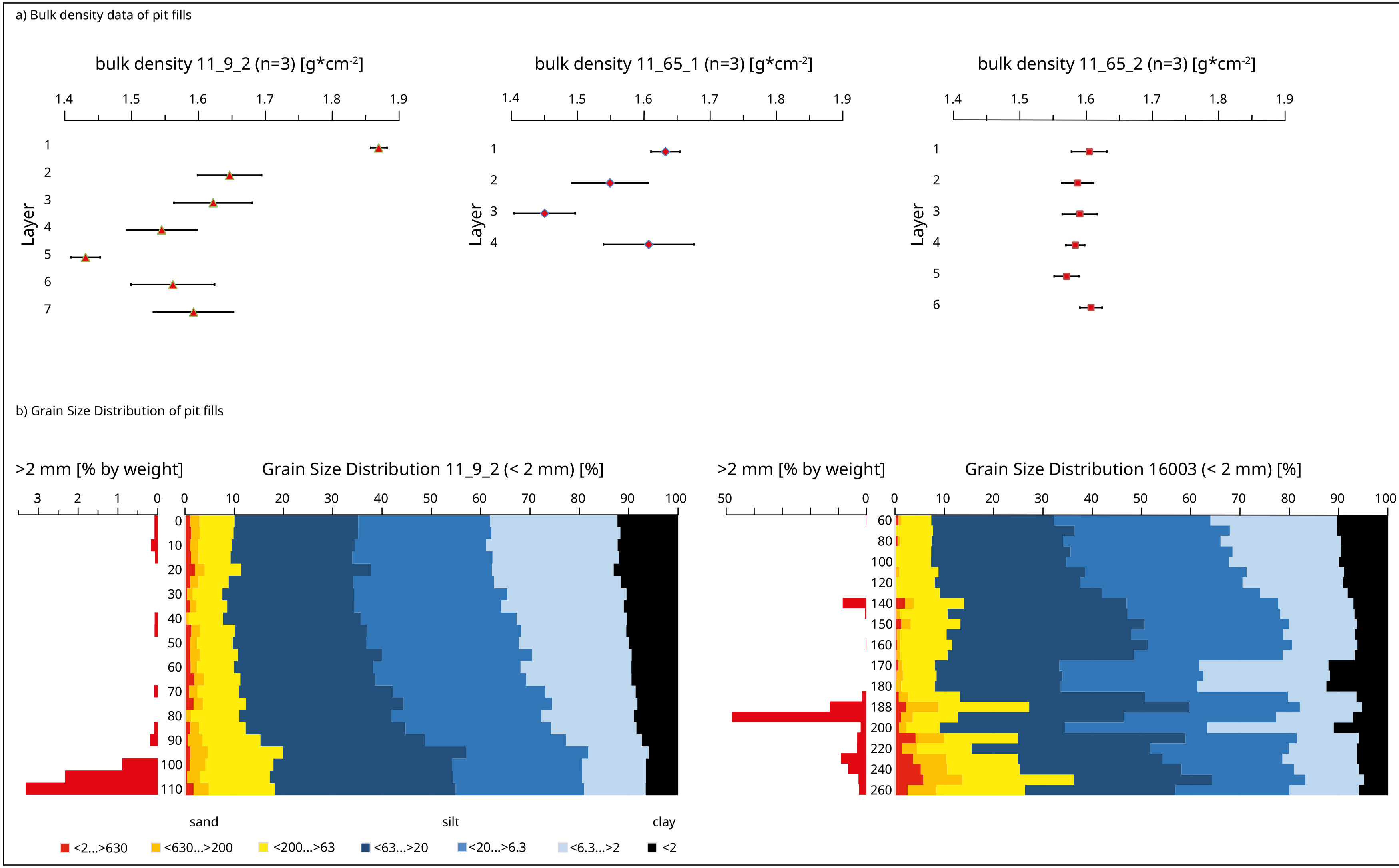

Figure 2.3.7. Bulk density data and grain size distribution data from selected pit fills.

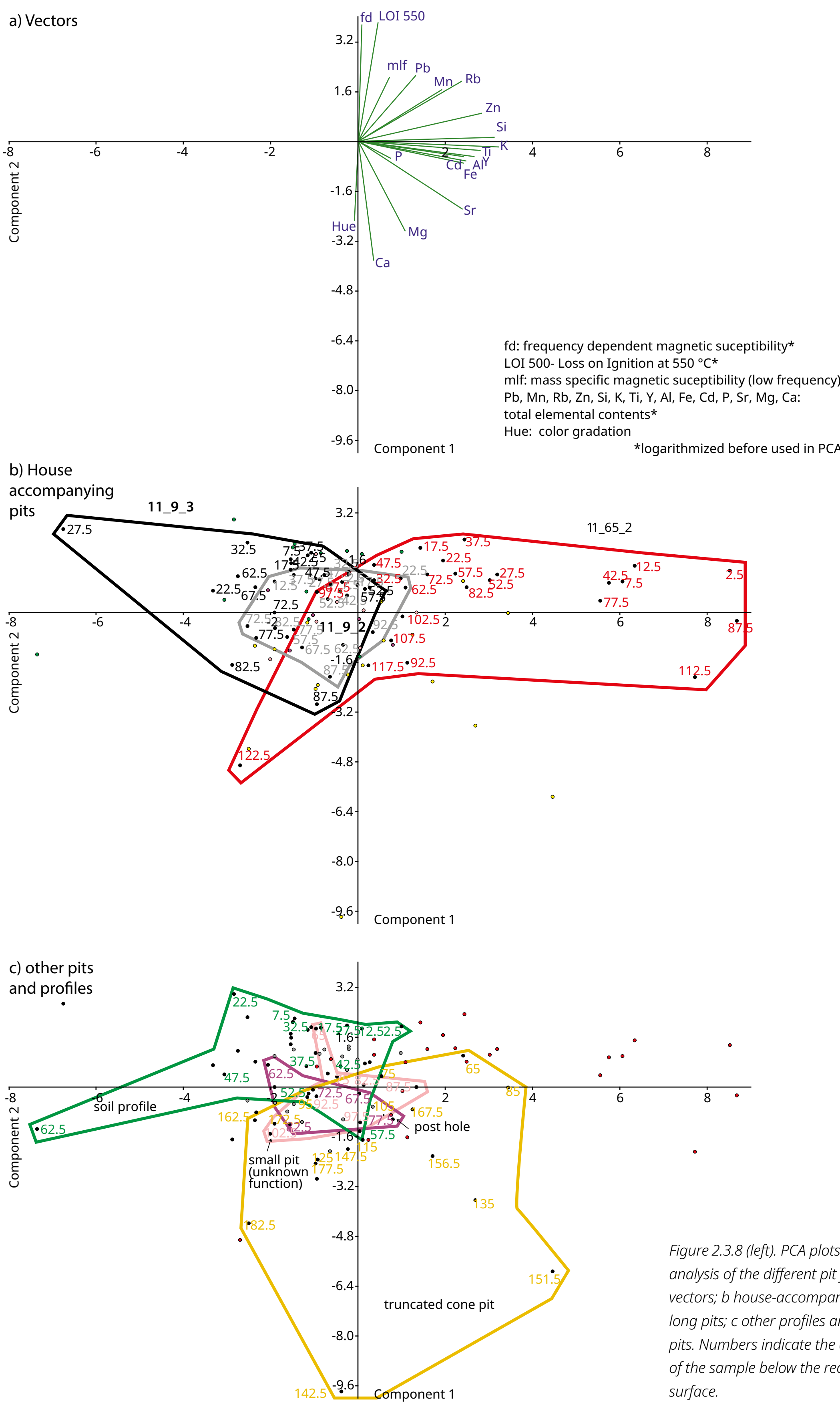

Figure 2.3.8 (left). PCA plots of the analysis of the different pit fills. a vectors; b house-accompanying long pits; c other profiles and pits. Numbers indicate the depth of the sample below the recent surface.

A noticeable macroscopic property of the studied pit fills is their almost homogenous appearance. The fill shows a dark brownish colour, indicating an initial source of the infill that was a mixture of mineral and organic matter, enriched in the latter. Occasionally, pieces of daub are present in the house-accompanying long pits. These pieces of daub make up less than 1% by volume in most of the fills in the archaeological excavation area of 2016.

Selected results of the laboratory analyses are given in Fig. 2.3.7 and Table 2.3.1[1]. The bulk density of profiles 11_9 and 11_65 shows values between 1.4 and 1.6 g*cm^{-3}, with one exceptional high value of approx. 1.85 g*cm^{-3} (Fig 2.3.7a). The unaltered loess returns values of approx. 1.6 g*cm^{-3}. The loess returns lesser densities when it has been altered by soil formation (1.45 and 1.55 g*cm-3). The fill of the pits is characterised by similar to slightly lower densities than the unaltered loess. In the uppermost sample of profile 11_9, the plough-pan of the recent Ap-horizon was measured, revealing a very high density.

The grain size distribution of different pit fills shows a very similar composition in general, one that is dominated by silt (*c.* 90%) and also contains some sand and clay (both *c.* 10%) (Fig. 2.3.7b). This indicates its inheritance of the mineral part of the pit fill from the local loess. A shift to somewhat finer particles is visible in the pit fill compared with the loess as their base. Deeper layers of the parent material contain more sand.

A Principal components analysis (PCA) was conducted with the data measured by the four different methods comparably on all fills of the different pits or filled features. The first three components explain 68% of the observed variability. Included were the mass-specific magnetic susceptibility (low frequency), the frequency-dependent susceptibility, the LOI 500, and the total content of Cd, Y, Sr, Rb, Zn, Fe, Mn, Ti, Ca, K, Al, P, Si, Mg and Pb (Fig. 2.3.8).

The scatter plot indicates, in general, a certain similarity of the material that fills the studied findings. All pit fills overlap in the central region of the PCA plot. The separate plotting of the deeper fill material of the house-accompanying long pit 11_65_2 (depth 87.5-117.5 cm) could reflect a different composition compared with the house-accompanying long pits 11_9_2 and 11_9_3. It is the base fill of 11_65_2, buried below a layer rich in daub and therefore probably representing a preserved remnant of the original fill. In contrast, the fill of long pit 11_9_2 exhibits a daub-rich layer at its base. The fill above this daub layer could represent the initial fill as well as a fill generated by natural sedimentation processes after abandonment of the site. Parts of the fill of the truncated cone pit differ from the other pit fills, too. Another conspicuousness of the scatter plot is a certain ordering of the samples against their depth below the recent surface. This reflects the influence of post-depositional soil formation on the properties of the samples. The overall general overlapping of even the findings at 50 to 100 cm below the present surface may reflect a strong pedogenetic alteration of the archaeological record, as previously noted by Dreibrodt *et al.* (2017). Thus, the recognised similarity of the different pit fills could reflect a) a similar initial infill and b) additionally, stronger post-depositional alteration by soil formation during the past approx. 7000 years.

The magnetic properties of the studied pit fills are displayed in Figure 2.3.9. The natural background level of magnetic susceptibility scatters around 20 *10^{-5} SI m^{3}*kg^{-1} (low frequency). All findings as well as the soil that has formed at the site show enhanced susceptibilities. The general pedogenetic increase is displayed by the profiles grspr, 11_61_1, and 11_9_1. From the parent material towards the soil surface, there is a trend of augmenting susceptibility values, starting at *c.* 20-30 *10^{-5} SI m3*kg-1(low frequency), up to a maximum of c. 80-90 *10^{-5} SI m^{3}*kg^{-1} (low frequency) attained *c.* 40 cm below the present surface. The layer with enhanced susceptibility

1 Online available at https://www.jma.uni-kiel.de/en/research-projects/data-exchange-platform.

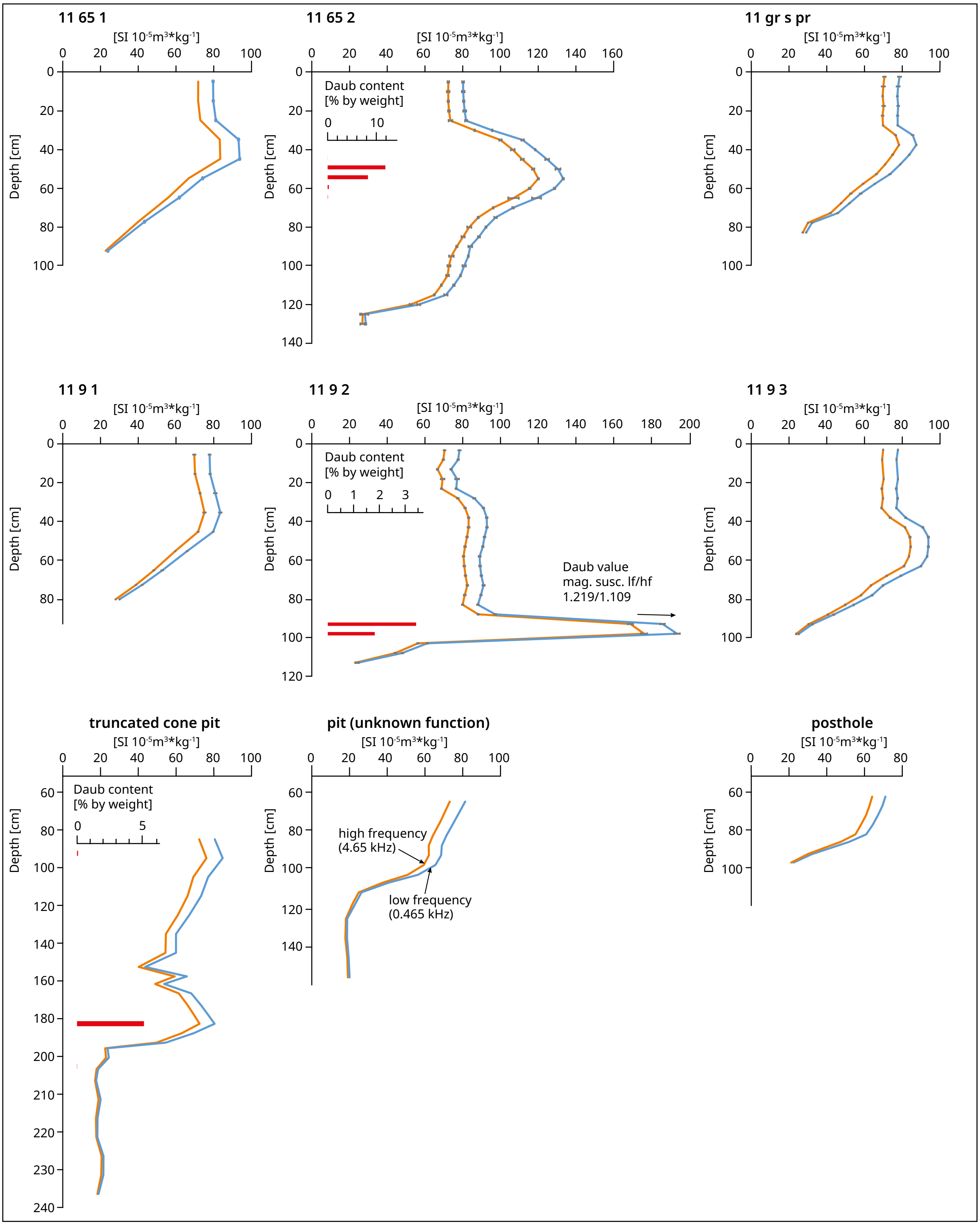

Figure 2.3.9. Magnetic properties of the investigated profiles of pit fills and soils in the excavation area. Daub content of the samples indicated as insets.

has a thickness of *c.* 10-15 cm. Above this layer, towards the surface, a decrease to values of about 80 $*10^{-5}$ SI m^3*kg^{-1}(low frequency) or less is visible in the profiles.

The fills of the archaeological features show different patterns of magnetic susceptibility. All features show an enhancement compared to the parent material. The origin of this magnetic enhancement may be related to anthropogenic activity directly, to the use of ancient surface soil as a fill material, or to the post-depositional pedogenetic enhancement of the ancient fill. Burned material (daub) explains the highest peaks in the profiles 11_9_2, 11_65_2, and partly in the truncated cone pit. Whether the Neolithic people filled in the pits with old surface soil remains unclear. The profiles that are situated deeper below the recent surface show enhanced susceptibility values compared to the parent material (about 80 SI $*10^{-5}$ SI m^3*kg^{-1}), but lower values than parts of the pit fills that are buried closer to the recent surface. This is visible in the dark, humus-rich fills of the house-accompanying long pits, even in layers free of burned material (11_65_2, 11_9_2, 11_9_3). There, values similar to the observed maxima of pedogenetic enhancement (about 90 $*10^{-5}$ SI m^3*kg^{-1}) are seen down to greater depths.

Since there is no indication for a higher content of burned material within the fills of the pits, neither in the content of burned artefacts, nor in the geochemical signature of the fills (*e.g.* K content), there must be another explanation for the enhanced magnetic susceptibility.

Our results indicate that the fill of the LBK contexts was dominated by local soil material (geochemical properties) that was enriched by organic matter, probably everyday waste (dark colour, LOI 500). Thus, processes of decomposition of the organic part of the fill very probably resulted in the observed enhanced magnetisation.

The formation of ultrafine superparamagnetic magnetite has been reported not only from burning, but also from soils and sediments in waterlogged sites. Whereas some researchers favour a non-biogenetic genesis of magnetite in soils (*e.g.* Maher and Taylor 1988), others argue that the magnetite could be of biogenic origin (*e.g.* Fassbinder *et al.* 1990). The latter authors detected magnetotactic bacteria in samples of waterlogged soils. In freshwater (*e.g.* Blakemore *et al.* 1979; Spring *et al.* 1993) or marine environments (Petermann and Bleil 1993; Stolz *et al.* 1986), where magnetotactic bacteria have been studied for longer, they were found to thrive close to or below the oxic-anoxic interface (Bazylinski *et al.* 2013). Considering the site conditions at Vráble, waterlogging is not a probable explanation for the complete observed record. On one hand, it could have occurred episodically at the base of the house-accompanying long pits. These pits do not have an outlet, nor are they sheltered from an addition of water by precipitation (*e.g.* Dreibrodt *et al.* 2017), required for aerobic decomposition of organic matter according to technical instructions of pit composting (FAO 2003). Contrariwise, the orientation of the pits along the eaves of the LBK houses probably even increased the number and duration of watering phases during the lifetime of the prehistoric house. In addition, after the abandonment of the houses, what remained of the long pits, whether completely filled or not, were enduring anomalies of higher water content compared to the surrounding, unbuilt areas. The organic fill of everyday waste that ended up in the house-accompanying long pits of the LBK could have been exposed to decomposition under anoxic conditions partly triggered by waterlogging. On the other hand, the topographic situation (on a plateau) and the parent material (loess) are improbable as conditions that would have supported the development of waterlogging.

Thus, additional explanations might be considered for the implementation of anoxic conditions during the decomposition process. Soil scientists report a remarkable microscale variability of water and oxygen access (*e.g.* Hartmann and Simmeth 1990; Hattori 1973; Sexstone *et al.* 1985). Thus, on the micro-level (*e.g.* within soil aggregates), anoxic conditions probably prevailed during phases of organic matter decomposition. Moreover, the availability of large amounts of palatable organic matter, poor in slowly decomposable, recalcitrant components (probable for everyday waste), could have resulted in rapid growth of decomposing microbial biomass and thus may have lead to a 'hot spot' of biological activity in the soil (Kuzyakov and Blagodatska 2015). This could induce an oxygen depletion within the deeper layers of the pit fills, whereas the upper layers are less likely to have become oxygen depleted because of the faster exchange with the atmosphere due to diffusion. That could be a reason for the decrease of magnetic susceptibility values in the topsoil in all of our profiles.

Since a remanent component of the magnetisation in the pit fills at Vráble has been detected additionally to the induced magnetisation as described here (Pickartz *et al.*, submitted), the scenario of organic matter decomposition with a contribution of magnetotactic bacteria under limited oxygen access below a critical subsurface depth (here *c.* 30 cm) provides the best explanation for the observed magnetic properties of the archaeological findings.

Since this scenario implies a co-occurrence of the archaeological features with organic-rich fills and soil magnetism in general, it may be tested in further investigations at additional sites.

Conclusions

Holocene soil erosion was found to have started after the phases of LBK land use (Lengyel, Baden). An increased intensity of erosion occurred at the studied site during medieval and, in particular, modern times. The intensity of the detected soil erosion is unlikely to have changed the LBK record significantly. The investigated pit fills show similar geochemical properties, implying a local origin of the infilled material. The pit fills were rich in organic waste (probably everyday waste). The magnetic properties of the organic-rich fills were probably controlled by the decomposition of organic matter with a contribution of magnetotactic bacteria. This finding has implications for magnetic prospection of buried organic-rich archaeological remains and soil magnetism in general, beyond the site of Vráble.

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Section 3: Settlement features and Human burials

3.1. The archaeological features from the LBK and Želiezovce settlement site of Vráble

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Abstract

We document and describe the archaeological features excavated at the sites of Vráble 'Veľké Lehemby'/'Farské' (Nitriansky kraj, Slovakia) during the years 2012-2017. The data are organised around the houses, which are represented by a table recording their architectural elements, the accompanying lateral long pits and other structures. The main descriptive category is the 'object', which represents an interpretational unit of features (which can be, for example, cuts or different fill layers). We also account for the find quantities, relative chronological dating based on pottery ornamentation, and ^{14}C dating based on Bayesian modelling. We also describe the features associated with the enclosure around the southwestern neighbourhood.

Keywords: Archaeological objects in Neolithic Vráble; Neolithic houses; Neolithic enclosure, LBK; Želiezovce

Introduction

The settlement complex of Vráble 'Veľké Lehemby'/'Farské' is located in an area where the subsoil is formed on clayish loess (see Chapter 1). This means that after the removal of the humus layer with an excavator to the boundary level of soil and subsoil, different shades of light brown were recognised. The absence of well-defined colour differences is a result of very fine soil particles leaking downwards through loess cracks and/or any free voids in the upper part of the topsoil. Recognition of this phenomenon was essential for deciding to what depth the humus layer had to be removed, which depended on the contrast between the archaeological features and the light brown background. In many cases, the delimitation of the feature outlines proved the most challenging part of the excavation. In some instances, discolorations, *i.e.* darker colours attributed to features, turned out to be naturally occurring phenomena (so-called ‘pseudo-features’). For this reason, the original outline documented on Planum 1 does not always correspond to the outline documented on Planum 2, where the targeted area, usually located between the two long pits, was excavated to a deeper level. A similar situation occurred when postholes were not immediately visible at the surface due to the insufficient organic material content, leading to a non-differentiated colour of the archaeological feature. This phenomenon is well known from other places in the Upper Žitava Valley.

When documenting house features here, we refrained from applying any of the types developed for the western Linearbandkeramik (LBK) areas, as they cannot be replicated in Slovakia. Nor was it possible to differentiate between house segments or to identify traces of wall ditches. In most cases, excavations allowed verification of the rows of postholes running perpendicular to the long walls (termed cross rows). In a few cases, traces of wall posts were identified.

Below, we present a systematic description of the house features excavated from 2012 to 2017. This catalogue is sorted by excavation campaign. The reported probability distribution of radiocarbon dating represents 2σ (Meadows *et al.* 2019). This chapter focuses on the features not directly related to the human burials.

Excavation campaign 2012

The spring campaign of 2012 was intended as exploratory research aimed at the verification of archaeological features and finds visible in the magnetometric plan as well as at the assessment of their state of preservation (Fig. 3.1.1).

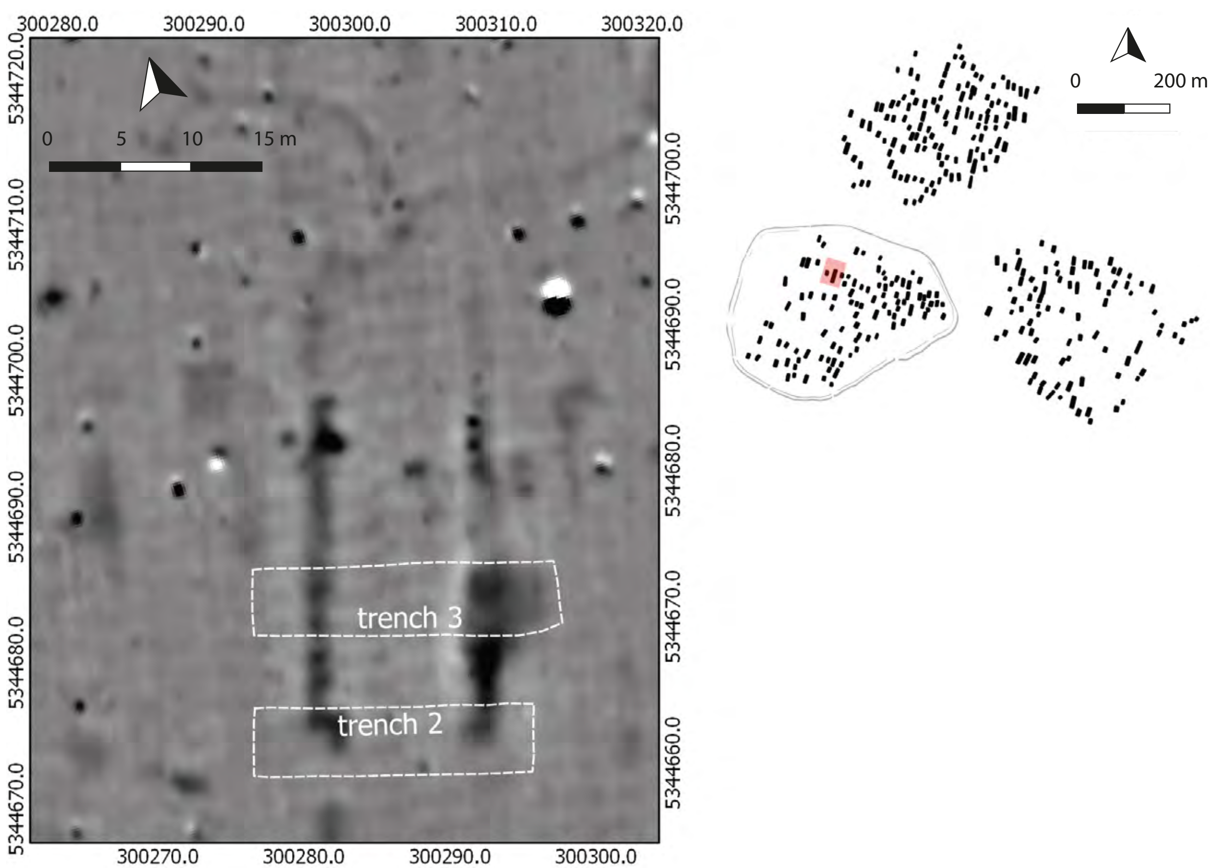

Figure 3.3.1. Overview of the excavation area in 2012.

The excavation area encompassed one house structure that was clearly visible on the magnetometric plan of the southwestern settlement area (area I). The results of this first excavation season have already been published in the form of a preliminary report (Furholt *et al.* 2014). Field surveys which served to examine the natural landscape showed that a low number of ceramic finds/artefacts were to be found on the surface, indicating that later agricultural activities had not destroyed the uppermost layer of the pits. From a field archaeological perspective, the research supported the thesis that the majority of finds would be found in their depositional contexts. The overall scarcity of surface finds is illustrated by the fact that only a single adze fragment was found on the surface of the Vráble 'Veľké Lehemby'/'Farské' settlement.

Trenches 2 and 3

The two excavation trenches were labelled Trench 2 and Trench 3; Trench 1 is a database classification term applied to all finds recovered outside of excavation trenches. Each of these two trenches measured 5×20 m and were located perpendicular to the southern part of house 39 (cf. Fig. 3.1.1). The trenches were separated by a 5 m long baulk to provide a profile. Trench 3 was later extended 2 m eastwards in order to document the outline of the long pit S3/30.

House no.	39
Dating	relative chronology: Želiezovce group absolute chronology: 5150-5050 BCE
Orientation	14.7°
Length in m	25.12
Number of cross rows documented	6
Width between house walls in m	6.71
Average width of cross rows in m	5.98
Distance between cross rows (from south to north) in m	0.84
Long pits	western: H39/01; eastern: H39/02
Postholes	roof-bearing: H39/09, H39/10, H39/14, H39/17, H39/18, H39/20, H39/21, H39/22, H39/26, H39/27, H39/28 wall-bearing: H39/03, H39/04, H39/05, H39/06, H39/07, H39/08, H39/11, H39/12, H39/13, H39/15, H39/16, H39/23, H39/24, H39/25, H39/29
Other features	pit: H39/30 (stratigraphically older)
Maximum depth of features from Planum 1 in cm	long pit: H39/01: 40.01, H39/02: 124.01 posthole: H39/04: 21.00, H39/05: 28.39, H39/06: 19.12, H39/09: 9.00, H39/10: 13.61, H39/12: 16.06, H39/16: 11.25, H39/17: 63.84, H39/18: 19.98, H39/20: 18.89, H39/22: 13.93, H39/23: 8.46, H39/24: 13.36, H39/25: 11.24, H39/26: 28.44, H39/27: 12.28, H39/28: 15.06, H39/ 29: 35.58
Excavated volume in m^3	long pit: H39/1: 6.9, H39/2: 2.7

Table 3.1.1. House 39 – contextual, chronological and architectural information.

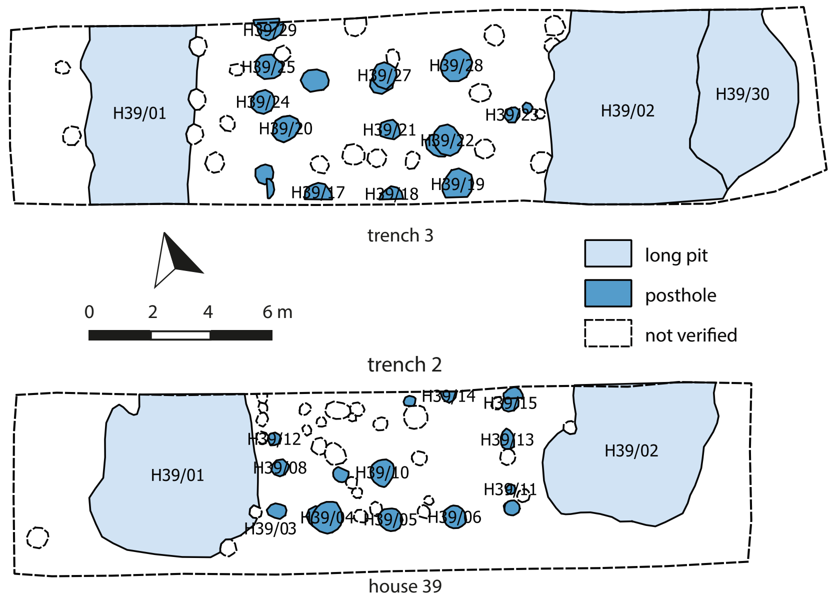

Figure 3.1.2. Planum of house 39.

House 39 was recognised on the basis of two clearly visible long pits (H39/1, H39/2) and a series of postholes (Fig. 3.1.2).

The outlines documented in Planum 1 were generally uncertain and required removal of a second spit (15 cm) in order to verify the initial identification. This allowed removal of uncertain features, since the profile cuts verified the presence of archaeological deposits. The clearly visible features were three rows of roof-bearing postholes, characterised by substantial size, and the smaller postholes that formed the walls (cf. Furholt *et al.* 2014, Table 2). The field crew remarked that the three potential wall-bearing postholes in the north-eastern part of the excavated area (H39/24, H39/25 and H39/29) resemble roof-bearing posts. Postholes H39/9, H39/14, H39/20 and H39/22 were likely not linked to house 39. The radiocarbon date of one of the long pits (Poz-60638) was significantly older than the other dates connected to the house, suggesting that activities had taken place at the site prior to the house's construction. Postholes H39/9, H39/14, H39/20 and H39/22 may therefore also represent an older construction.

Long pits

Long pit H39/01 (western) was c. 3 m wide and c. 26 m long (Fig. 3.1.3). The excavated length measured almost 10 m. The cross section was characterised by a flat base and an overall regular outline.

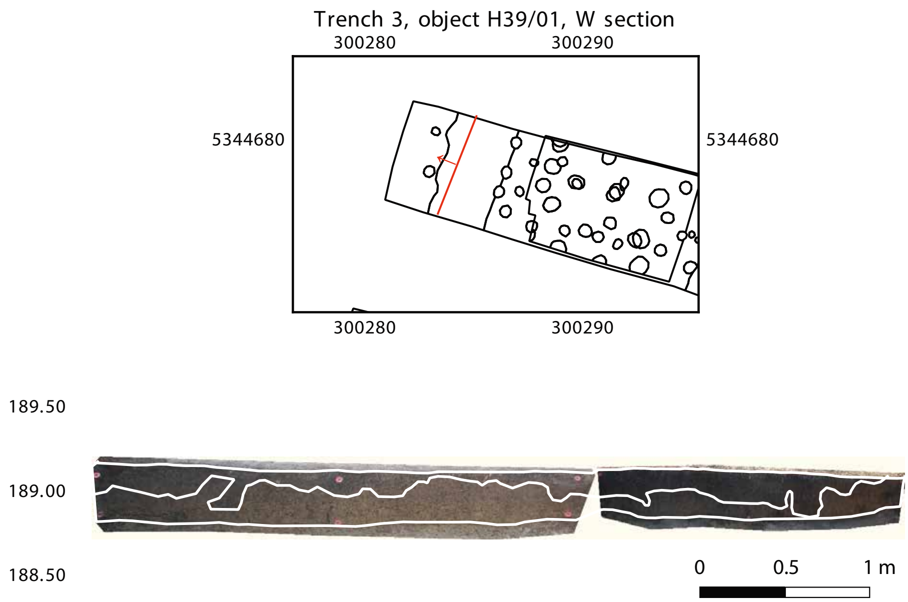

Figure 3.1.3. Plan and section of long pit H39/01.

Long pit H39/02 (eastern) was c. 5 m wide and c. 24 m long (Fig. 3.1.4). The excavated length measured almost 10 m. The cross-section was characterised by a flat base and an overall regular outline, similar to H39/01.

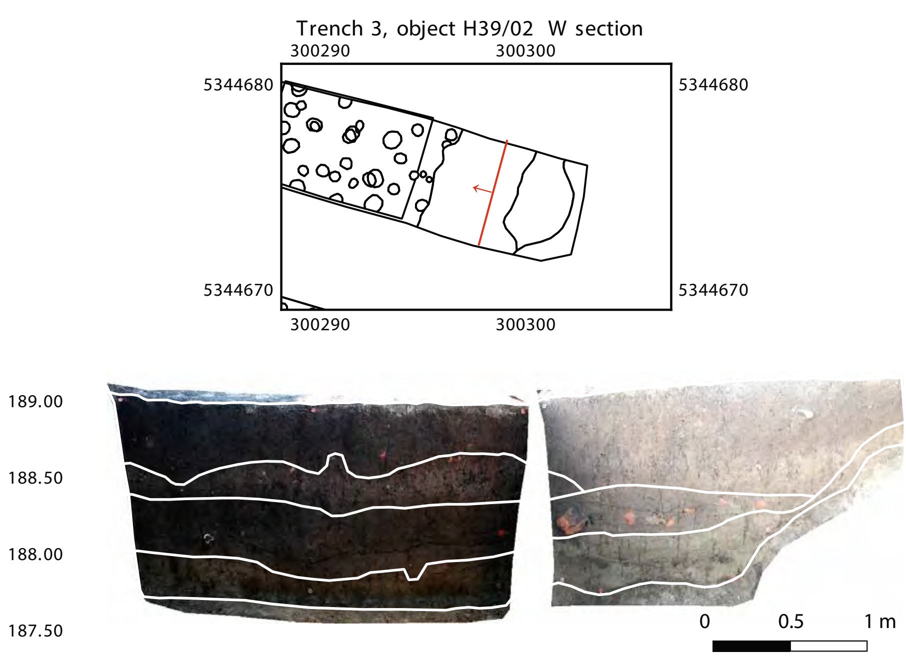

Figure 3.1.4 (top). Plan and section of long pit H39/02.

Both long pits H39/1 and H39/2 were characterised by an extrusion in the south. The central fills of the pits were characterised by a high burnt daub content. In the southern part of Trench 2, object H39/1a was superimposed over object H39/1.

Other pits

Pit H39/30 is a stratigraphically older, beehive-shaped pit cut by long pit H39/02 (Fig. 3.1.5). In the preliminary report (Furholt *et al*. 2014), it was reported as the first phase of the long pit, with a consecutive recutting.

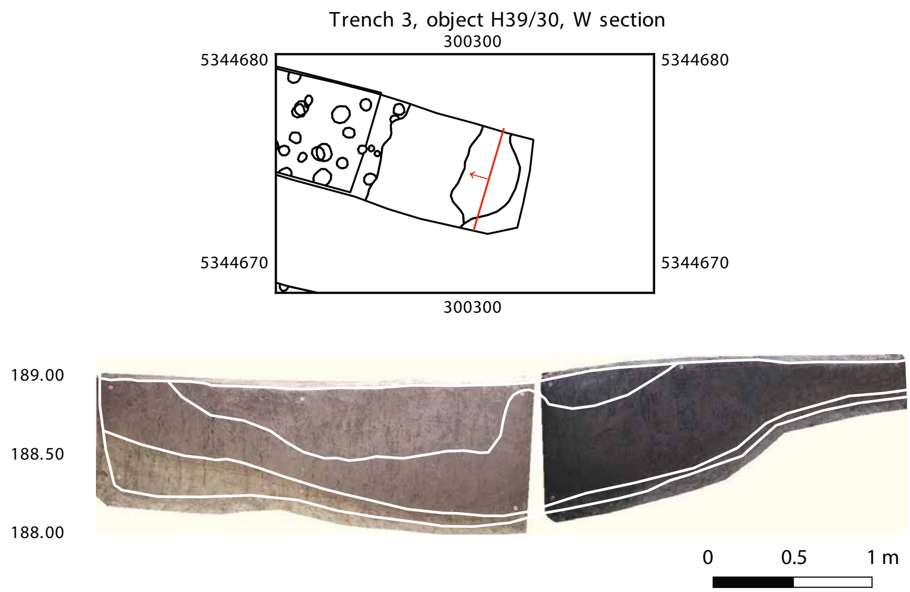

Figure 3.1.5 (below). Plan and section of beehive-shaped pit H39/30.

Finds

A total of 6024 g of ceramic material was recovered from house 39. In season 2012, the finds analysis focused on the study of overall patterns. It did not involve collection of data on the presence of decoration and the weight of the respective samples. The other find categories were weighed. In the summary tables, we provide the rounded weight, except for the chipped stone, where we provide the weight to one decimal.
Chipped stone artefacts: 3 limnosilicit flakes and 1 blade (Furholt *et al.* 2014, Table III; 18).
Other artefacts: 1 triangular clay bead, from QC1 (Furholt *et al*. 2014, Table IV; 29).

Table 3.1.2. House 39 – summarised find information.

Category	Number	Weight (g)
ornamented ceramics	302	-
unornamented ceramics	176	-
chipped stone	-	-
ground stone	-	-
bone	420	776
daub	-	19 122

Excavation campaign 2013

The aim of the 2013 excavation campaign was to document an entire house and to sample a different part of the settlement (Fig. 3.1.6).

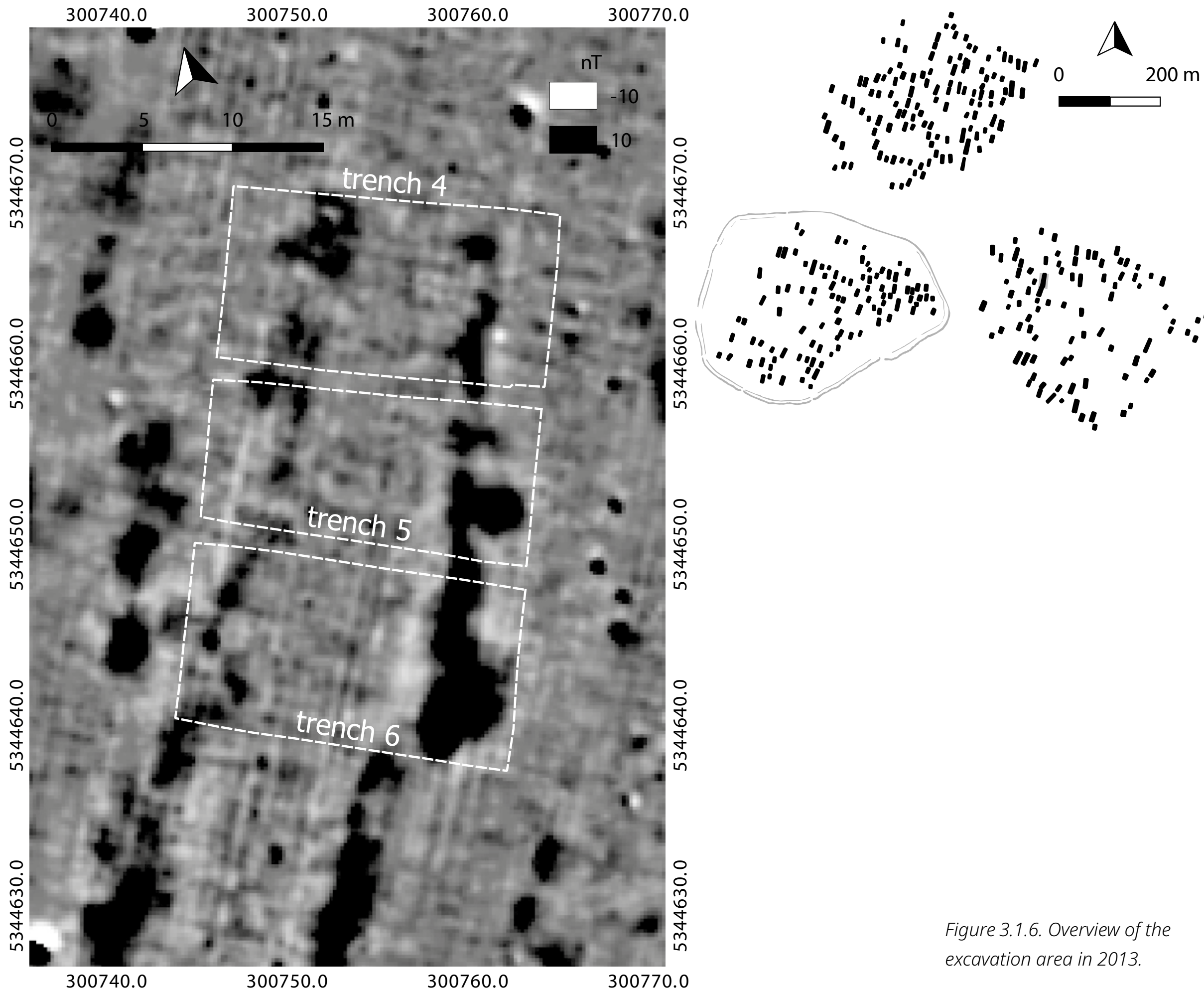

Figure 3.1.6. Overview of the excavation area in 2013.

Two houses – 102 and 103 – were selected for excavation in order to extend the scope of the investigation.

Trenches 4, 5 and 6

Trenches 4, 5 and 6 measured c. 9,5x18 m, 8,5x18 m and 10x18m and were separated by a 1 m wide baulk (cf. Fig. 3.1.6). House 102 was documented in all three trenches, while the overlap of house 102 and 103 was most clearly visible in the southernmost trench (Trench 6). The northern corners of long pits H102/1 and H102/2 were located outside the northernmost trench (Trench 4).

House no.	102
Dating	relative chronology: Želiezovce group absolute chronology: 5050-4795 BCE
Orientation	12.5°
Length in m	15.91
Number of cross rows documented	8
Width between house walls in m	6.75
Average width of cross rows in m	4.47
Distance between cross rows (from south to north) in m	2.50
Long pits	western: H102/1; eastern: H102/2
Postholes	roof-bearing: H102/5, H102/6, H102/7, H102/8, H102/9, H102/10, H102/11, H102/12, H102/14, H102/15, H102/16, H102/17, H102/18, H102/20, H102/25, H102/26, S5/21
Other features	-
Maximum depth of features from Planum 1 in cm	long pit: H102/1: 57.10, H102/2: 49.00 posthole: H102/5: 45.29, H102/6: 8.17, H102/8: 7.00, H102/12: 45.02, H102/14: 27.22, H102/15: 23.36, H102/16: 19.93, H102/17: 15.17, H102/18: 26.14, H102/25: 35.00, H102/26: 51.33
Excavated volume in m^3	long pit: H102/1: 4.6; H102/2: 4.5

Table 3.1.3. House 102 – contextual, chronological and architectural information.

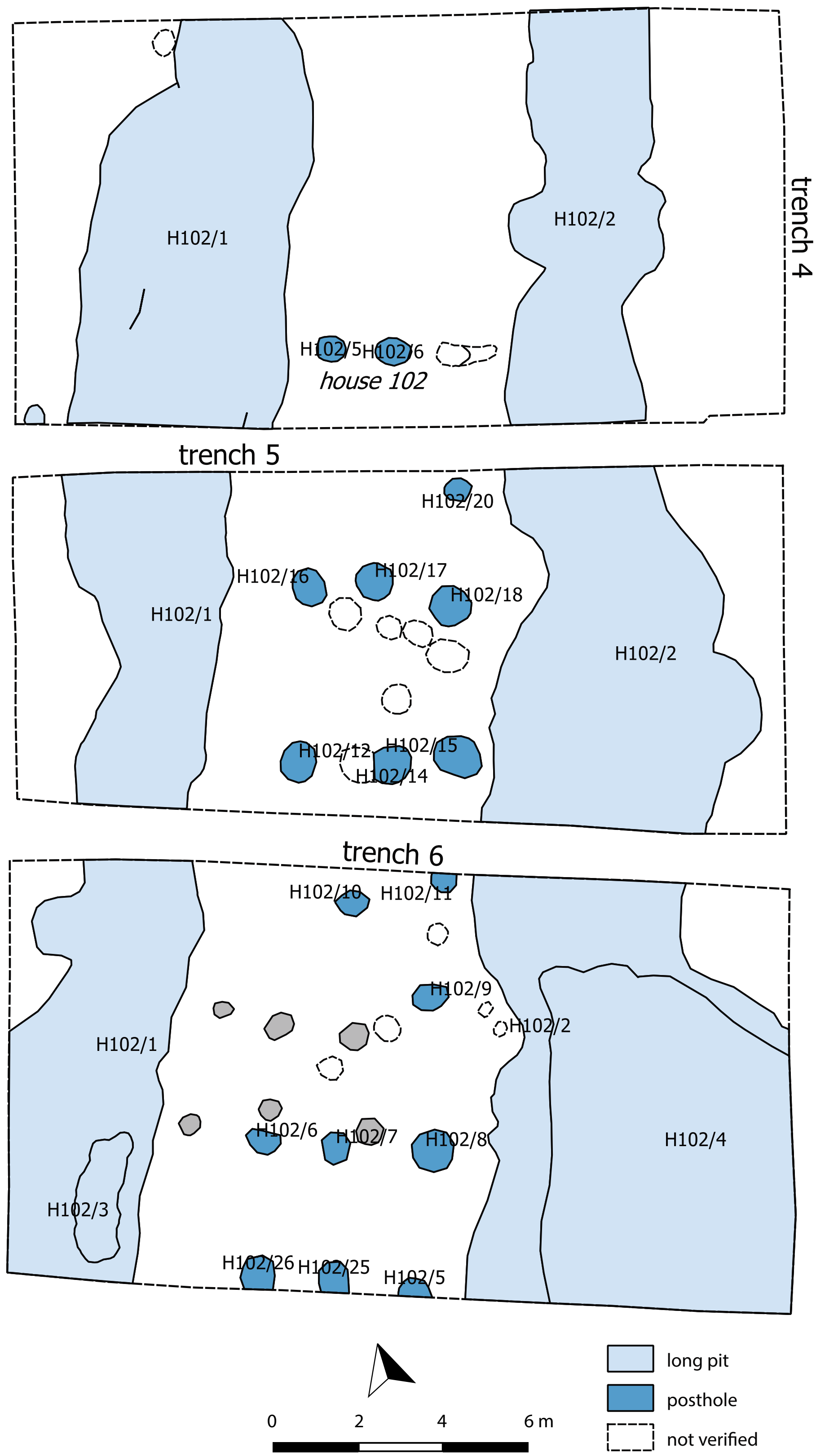

Figure 3.1.7. Planum of house 102.

House 102 was identified on the basis of eight roof-bearing rows of posts (Fig. 3.1.7). Based on the magnetometric imagery, three additional rows in the northern portion of the excavated area can be assumed, but these were not preserved below the topsoil. Two additional rows most likely belonging to house 103 were documented farther south, in Trench 6. The consecutiveness of the two houses was further documented in the long pits, because the southern parts of objects H102/1 and H102/2 comprised large deposits of burnt daub and the remains of walls. The depth of the long pits suggests a cut into an older pit related to house 103, which is further supported by the presence of older pottery and by the radiocarbon dating (Poz-60641-3).

Long pits

Long pit H102/1 (western) was more than 5 m wide at its widest point and was c. 35 m long. The trenches covered almost the entirety of the object (Fig. 3.1.8). The planum documented the changing width of the outline, with the wider part located in Trench 4. The shape of the long pit was trough-like and generally regular.

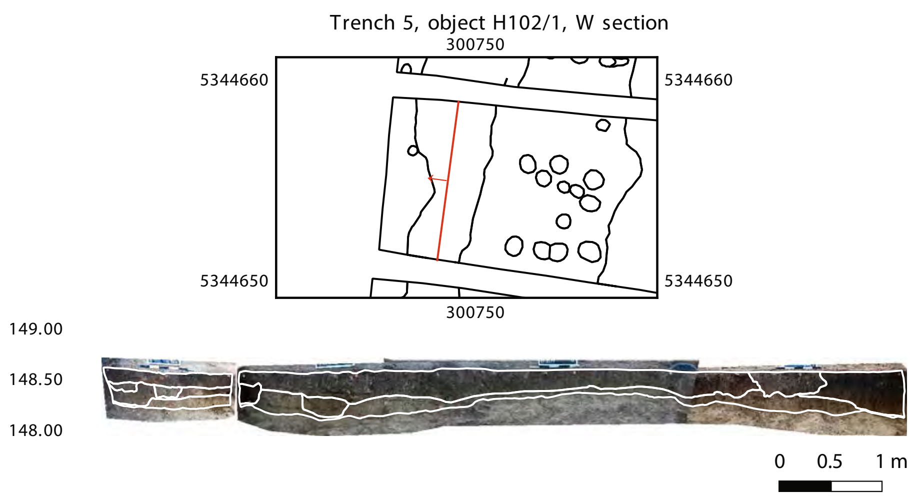

Figure 3.1.8. Plan and section of long pit H102/1.

Long pit H102/2 (eastern) was more than 6 m wide at its widest point and was c. 31 m long. The trenches covered almost the entirety of the object (Fig. 3.1.9). The planum documented the changing width of the outline, with the wider part located in Trench 6. The shape was overall trough-like, with a regular outline. In the southern part of the long pit, an extensive widening of the object was documented as H102/4.

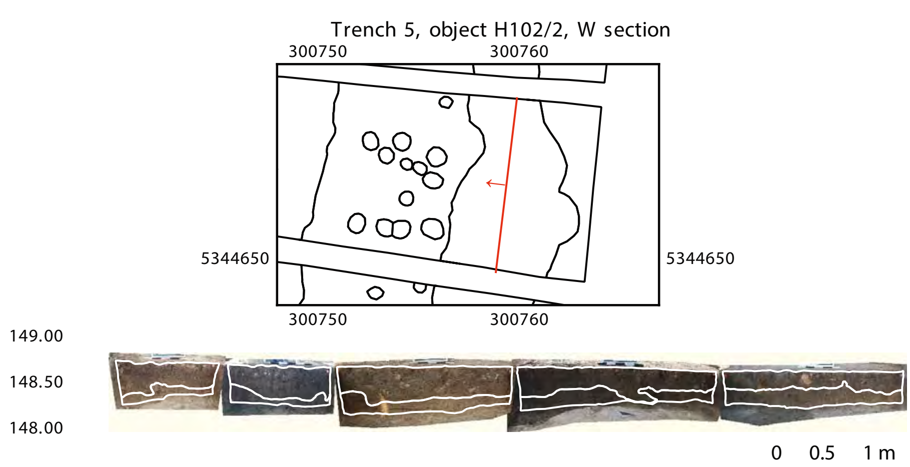

Figure 3.1.9. Plan and section of long pit H102/2.

Both long pits were visible in Planum 1. Their horizontal structure, the recognition of which is highly dependent on the state of preservation, was generally characterised by mixed deposits with individual spots of burnt daub. The southern part of long pit H102/2 was characterised by a substantial burnt daub content.

Finds

House 102 yielded an extraordinarily large number of pottery sherds and a high ratio of decorated: undecorated sherds. The finds from house 103 are also listed here. Because of the stratigraphic situation – resulting in finds from house 103 being mixed into the long pits of house 102 – these finds cannot be consistently separated. Other: 1 clay bead.

Category	Number	Weight (g)
ornamented ceramics	1153	17 871
unornamented ceramics	3062	52 991
chipped stone	-	-
ground stone	3	857
bone	326	592
daub	-	114 521

Table 3.1.4. House 102 – summarised find information.

House no.	103
Dating	relative chronology: younger LBK absolute chronology: 5250-5050 BCE
Orientation	7°
Length in m	14.38
Number of cross rows documented	2
Width between house walls in m	4.89
Average width of cross rows in m	4.26
Distance between cross rows (from south to north) in m	1.42
Long pits	none preserved, but materials belonging to house 103 were found in long pits H102/1 and H102/2
Postholes	roof-bearing: H103/4, H103/5, H103/6
Other features	-
Maximum depth of features from Planum 1 in cm	posthole: H103/4: 54.10, H103/5: 51.30, H103/6: 67.00
Excavated volume in m^3	-

Table 3.1.5. House 103 – contextual, chronological and architectural information.

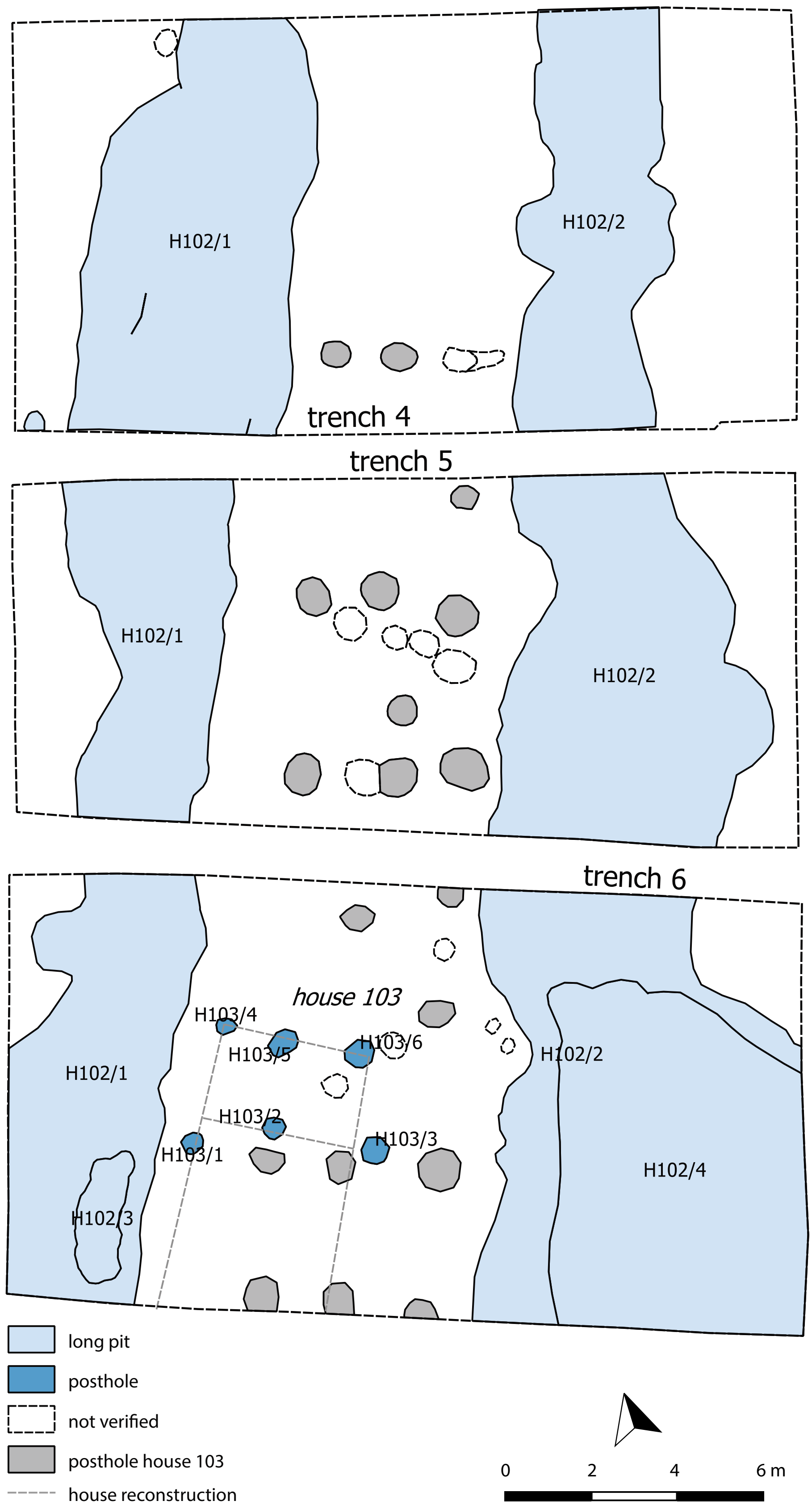

Figure 3.1.10: Planum of house 103.

Long pits

No long pits were preserved in the archaeological record, as they were most likely destroyed by the later long pits belonging to house 102 (Fig. 3.1.10). Perhaps the lowermost fills found below the massive deposits of burnt daub in long pit H102/2 should be considered as the primary deposits linked to house 103, as indicates by the older radiocarbon dating (Poz-60639).

Excavation campaign 2014

In excavation season 2014, a total of four trenches were opened in order to investigate six individual houses (Fig. 3.1.11-12). These were labelled Trenches 7 (*c.* 5×5 m), 8 (*c.* 5×57 m), 9 (*c.* 5×5 m) and 10 (*c.* 5×7,5 m).

Despite the removal of the top 50 cm of the soil with an excavator, the W-O oriented plough marks were still visible below the humus, indicating that archaeological finds would have been redeposited from their original find locations by plough activity. While finds recovered from the lower spits could be unambiguously linked to specific objects, this was not always possible for the finds from the upper parts of the excavated areas.

In Trench 8, the areas between the pits were manually deepened by 15 cm, and the find distributions were associated to artificial squares of varying dimensions rather than particular features. The spatial distribution of finds indicates an increased presence of ceramic material in squares 1, 4 and 5.

The small trenches 7, 9 and 10 (5x5 m; 5x7,5 m) were designed specifically to acquire high-resolution information on animal husbandry from the long pits (cf. Fig. 3.1.11-12). The selected objects were excavated in 1×1 m research squares, in 10-20 cm thick spits, in a chequerboard pattern, and the entire fill was systematically sieved with a 5 mm mesh size sieve. This was done in order to acquire a representative sample of all bone and tooth sizes related to the faunal materials. However, the amount of recovered materials proved to be insubstantial, indicating that the time-consuming sieving did not yield samples that were statistically significant for analytical purposes.

Trench 7

The excavation targeted the southern end of the eastern long pit of house 244, which was very well visible in the magnetic image (Fig. 3.1.13).

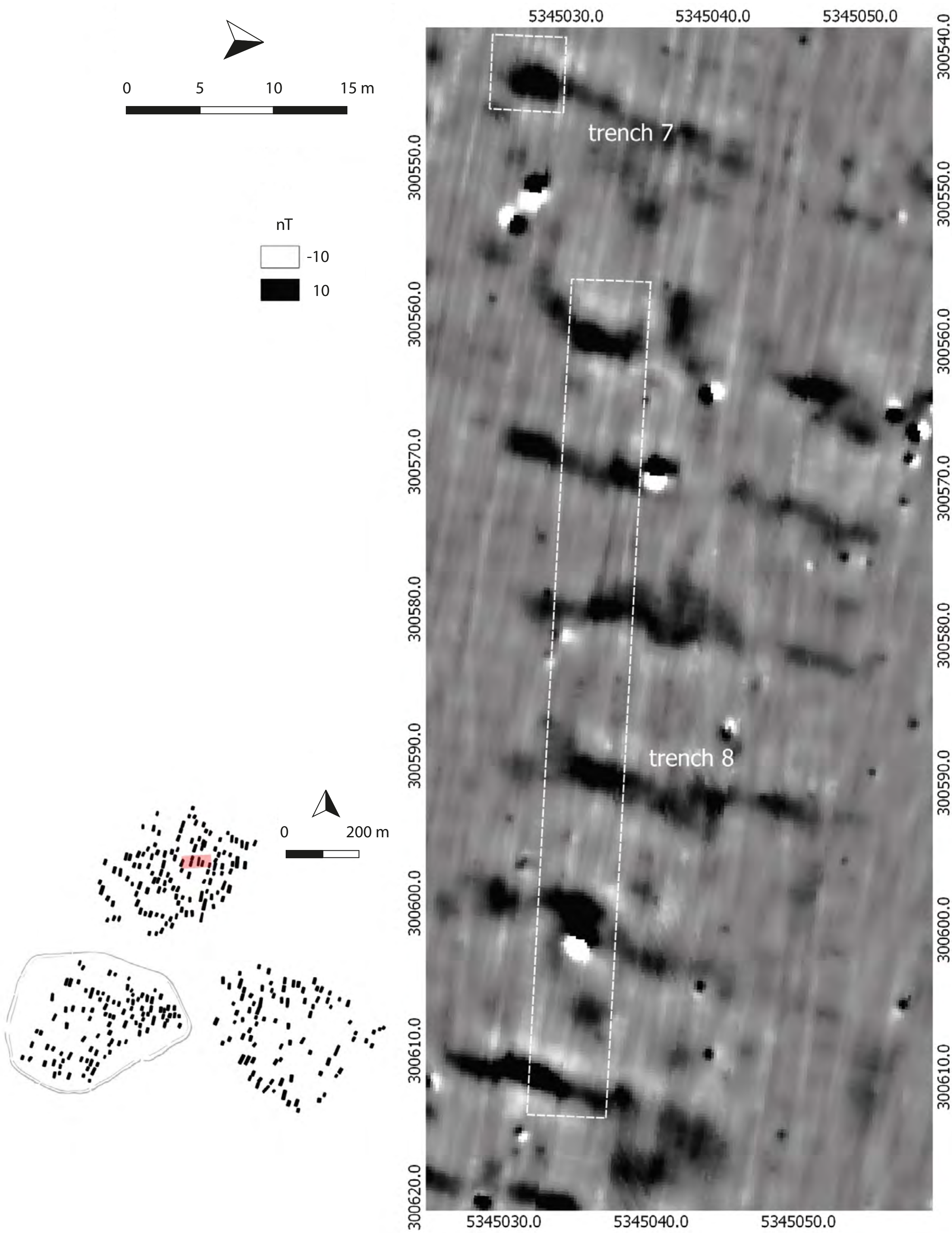

Figure 3.1.11. Excavation area of trenches 7 and 8 in 2014.

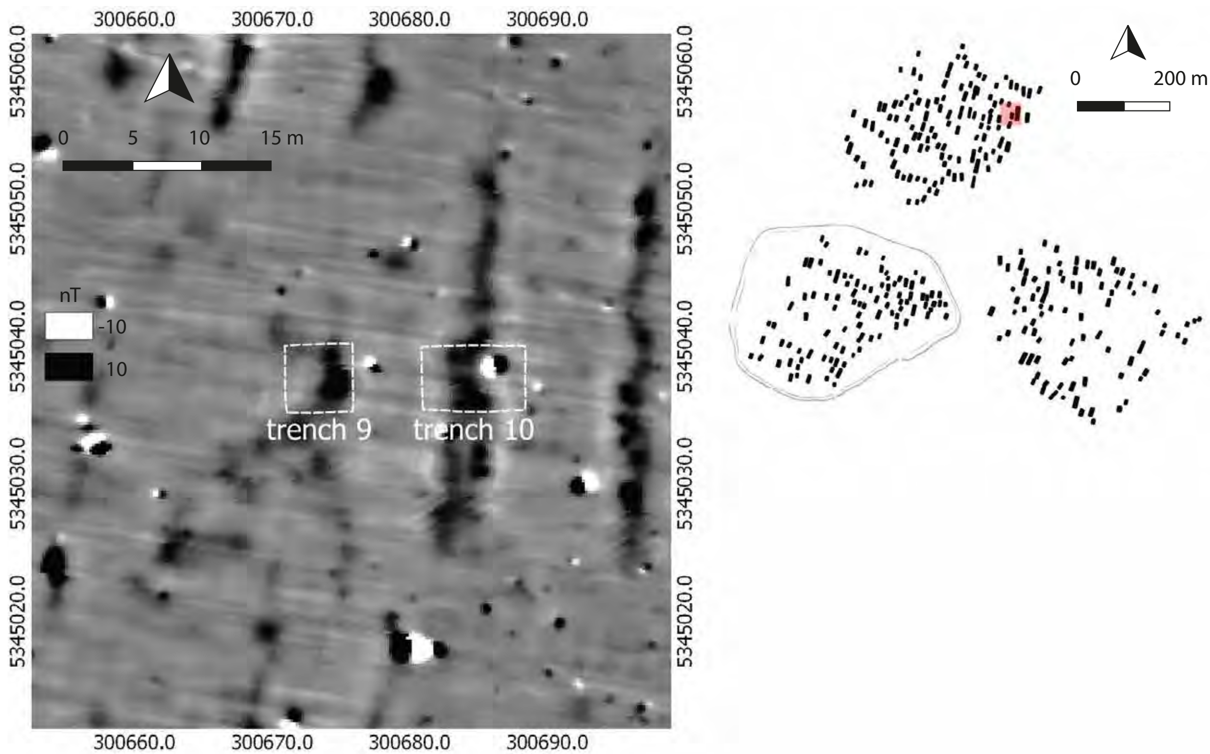

Figure 3.1.12. Excavation area of trenches 9 and 10 in 2014.

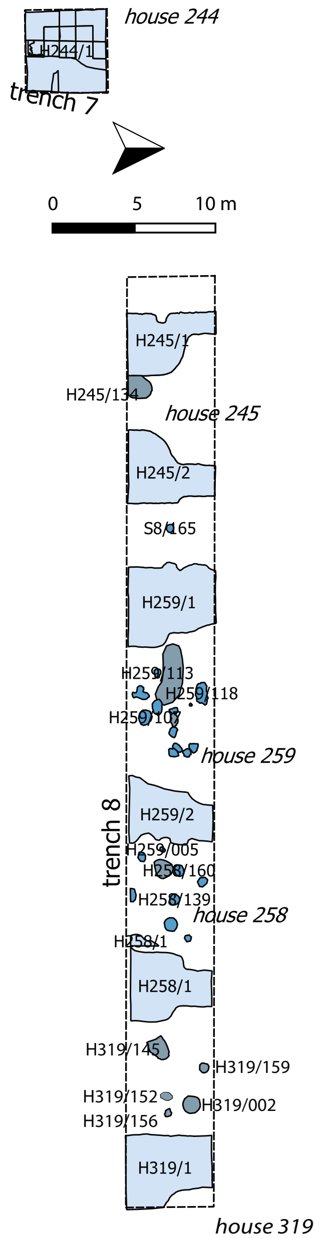

Figure 3.1.13. Planum of trenches 7 and 8 in 2014.

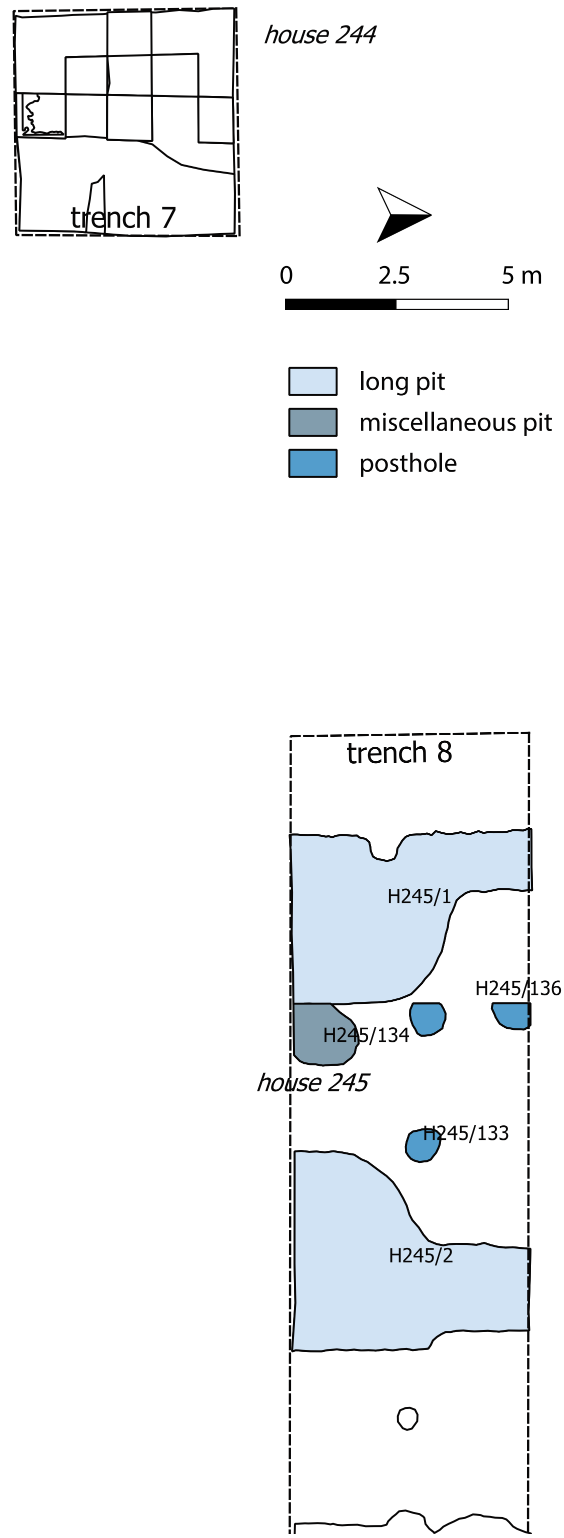

Figure 3.1.14. Planum of house 244.

The trench was divided into 1×1 m squares and excavated in a chequerboard pattern in 15-20 cm thick spits.

House no.	244
Dating	relative chronology: younger LBK absolute chronology: 5250-5050 BCE
Orientation	16.7°
Length in m	21.65
Number of cross rows documented	0, as only one long pit was excavated
Width between house walls in m	-
Average width of cross rows in m	-
Distance between cross rows (from south to north) in m	-
Long pits	eastern: H244/1
Postholes	-
Other features	-
Maximum depth of features from Planum 1 in cm	long pit: H244/1: 91.60
Excavated volume in m³	long pit: H244/1: 2.1

Table 3.1.6. House 244 – contextual, chronological and architectural information.

Due to the restricted size of Trench 7 (5×5 m), the observations regarding house 244 are limited to the eastern long pit found in this trench (Fig. 3.1.14).

Long pit

The long pit was c. 3 m wide and was relatively deep (Fig. 3.1.15). The high visibility of the object on the magnetometric plan was a result of a thick deposit of burnt daub found in the long pit. The deposit comprised of a 3 m wide layer documented already 50 cm below the Planum 1 in the northern part of the trench. Below the daub-rich deposit, a clear anthropogenic fill was documented in all directions available for archaeological observation. While it is improbable that the layer formed uniformly across all the different parts of the long pit, the homogeneity of the fill could be related to a cutting of an older long pit.

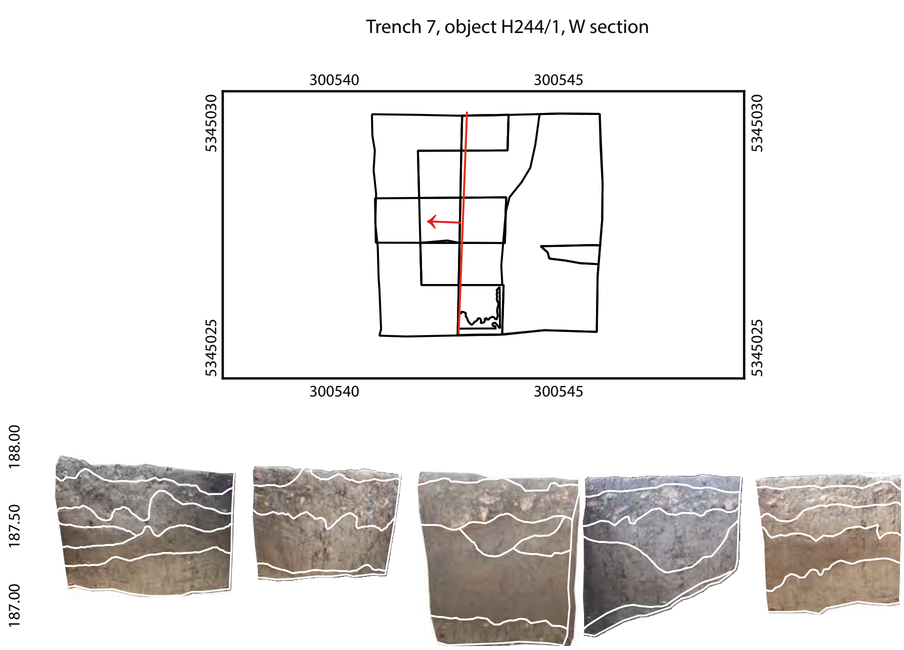

Figure 3.1.15. Plan and section of long pit H244/1.

Finds

The finds related to house 244 were characterized by a large amount of daub and a rich inventory of ground stone tools.

Category	Number	Weight (g)
ornamented ceramics	141	243
unornamented ceramics	-	1582
chipped stone	-	-
ground stone	1	352
bone	41	-
daub	-	47718

Table 3.1.7. House 244 – summarised find information.

Trench 8

Trench 8 was 5 m wide and 57 m long and was placed to cut through 6 pair-wise long pits (cf. Fig. 3.1.13). The long pits belong to houses 245, 258, 259 and 319, all oriented W-O and documented on the magnetometric imagery. The state of preservation of the postholes was unsatisfactory and therefore only a small number of objects related to houses 258 and 259 could be documented.

House no.	245
Dating	relative chronology: younger LBK absolute chronology: 5250-5150 BCE
Orientation	18°
Length in m	11.77
Number of cross rows documented	2
Width between house walls in m	8.15
Average width of cross rows in m	2.14
Distance between cross rows (from south to north) in m	1.02
Long pits	western: H245/1; eastern: H245/2
Postholes	-
Other features	pit: H245/134
Maximum depth of features from Planum 1 in cm	long pit: H245/1:62.00, H245/2: 86.00 pit: H245/134: 43.67
Excavated volume in m³	long pit: H245/1: 2.5, H245/2: 1.9

Table 3.1.8. House 245 – contextual, chronological and architectural information.

Long pits

Long pit H245/1 was a 2 m wide, trough-like object (Fig. 3.1.17). The outline of the pit was generally irregular. Below a dark fill layer of c. 20-30 cm thickness was a 60 cm thick concentration of burnt daub.

Long pit H245/2 was a 2 m wide pit with a flat base (Fig. 3.1.18). Under the homogenous dark fill layer of c. 10-20 cm thickness was a 40 cm thick concentration of daub.

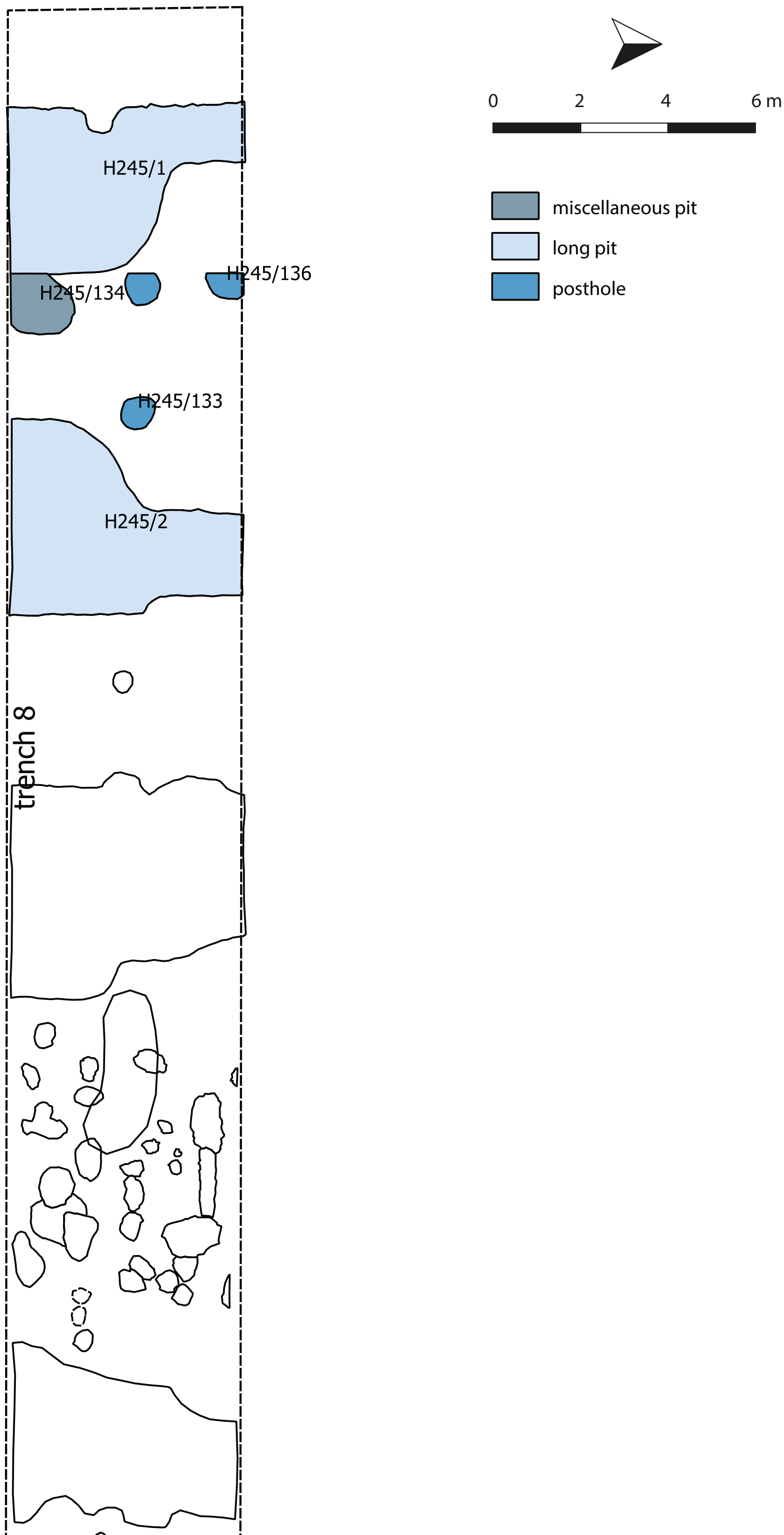

Figure 3.1.16. Planum of house 245.

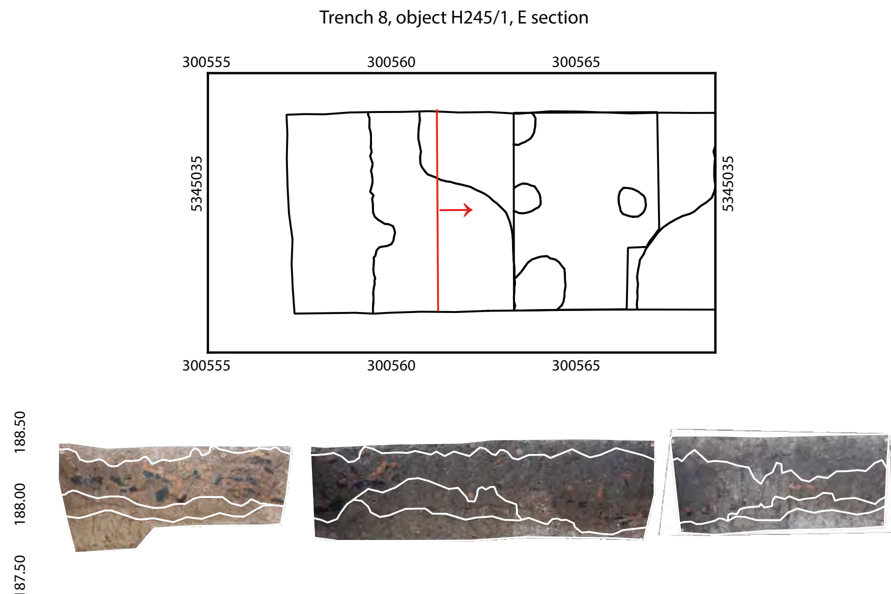

Figure 3.1.17. Plan and section of long pit H245/1.

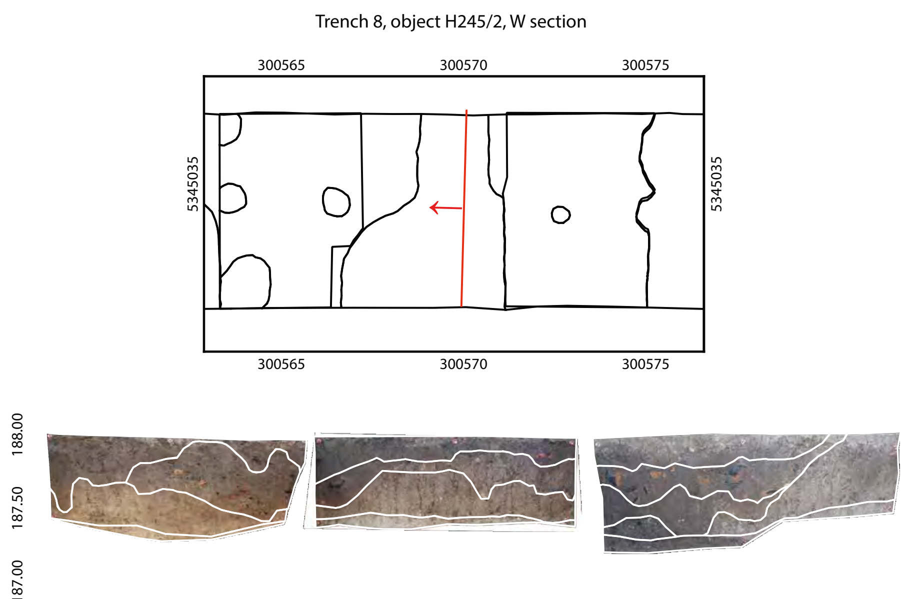

Figure 3.1.18. Plan and section of long pit H245/2.

Other pits

Pit H245/134 was characterised by a round plan, partially cut by long pit H245/1. The outline of the pit was generally rounded, and it had a relatively homogenous fill with discernible finds. Based on the size and the fill, the pit was interpreted as a waste disposal structure.

Finds

Category	Number	Weight (g)
ornamented ceramics	34	163
unornamented ceramics	-	392
chipped stone	-	-
ground stone	-	-
bone	26	-
daub	-	3589

Table 3.1.9. House 245 – summarised find information.

House no.	258
Dating	relative chronology: younger LBK-Želiezovce group absolute chronology: 5200-5000 BCE
Orientation	14.5°
Length in m	22.16
Number of cross rows documented	3
Width between house walls in m	6.90
Average width of cross rows in m	3.01
Distance between cross rows (from south to north) in m	1.46
Long pits	eastern: H258/1
Postholes	roof-bearing: H258/130, H258/139, H258/160, H258/161, H258/162, H258/163
Other features	pit: H258/141
Maximum depth of features from Planum 1 in cm	long pit: H258/1: 69.70 posthole: H258/139: 23.03, H258/160: 32.88, H258/161: 34.16, H258/162: 26.95, H258/163: 35.97
Excavated volume in m^3	long pit: H258/1: 2.4

Table 3.1.10. House 258 – contextual, chronological and architectural information.

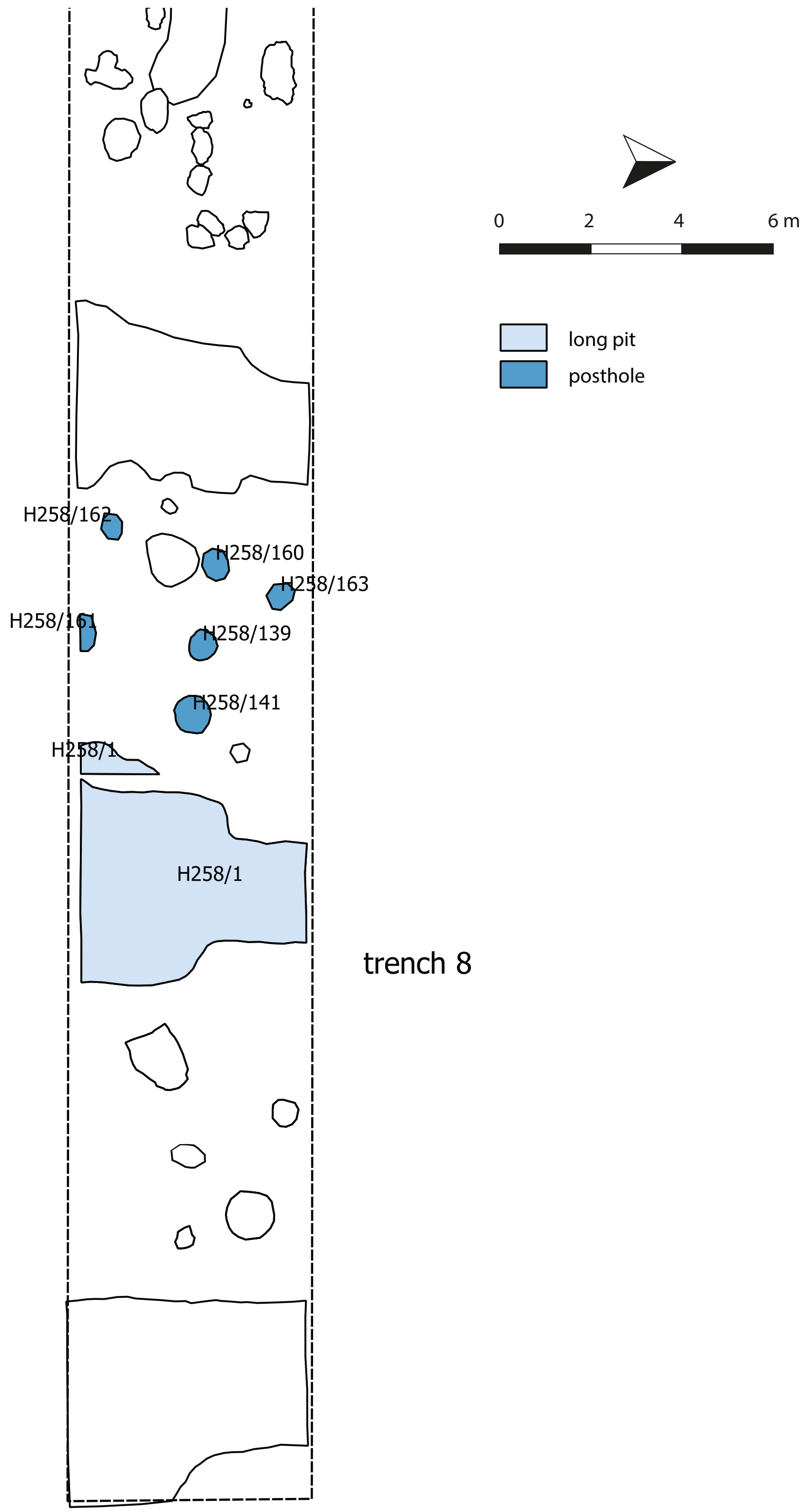

Figure 3.1.19. Planum of house 258.

House 258 was accompanied by an eastern long pit H258/1 (Fig. 3.1.19). The western long pit is discernible in the magnetometric imagery but was completely destroyed in Trench 8 by a younger object, H259/2.

Long pit

H258/1 was a 4 m wide, slightly trough-shaped pit with an irregular pit base (Fig. 3.1.20). Under a dark fill layer of 20-40 cm thickness a thick concentration of daub was documented.

Finds

The eastern long pit, H259/2, completely destroyed the western long pit, H258, and, as a result, older material was recovered from the fill of long pit H258 (Fig. 3.1.21).

Category	Number	Weight (g)
ornamented ceramics	143	128
unornamented ceramics	-	320
chipped stone	-	-
ground stone	-	-
bone	-	-
daub	-	1165

Table 3.1.11. House 258 – summarised find information.

Figure 3.1.20. Plan and section of long pit H258/1.

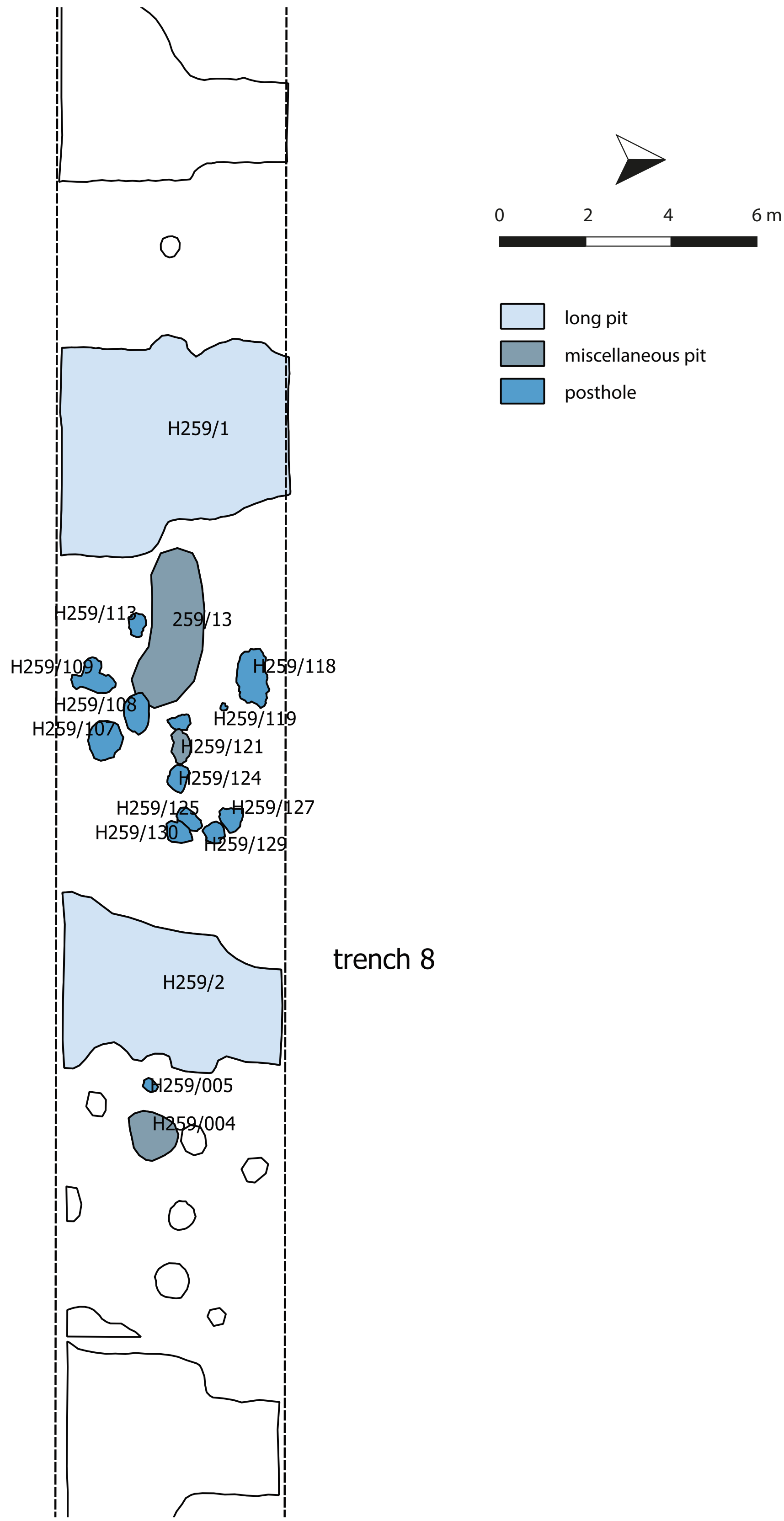

Figure 3.1.21. Planum of house 259.

House no.	259
Dating	relative chronology: younger LBK-Želiezovce group absolute chronology: 5200-5000 BCE
Orientation	4.4°
Length in m	25.42
Number of cross rows documented	3
Width between house walls in m	6.62
Average width of cross rows in m	4.09
Distance between cross rows (from south to north) in m	1.46
Long pits	western: H259/1; eastern: H259/2
Postholes	roof-bearing: H259/107, H259/108, H259/109, H259/113, H259/118, H259/119, H259/120, H259/125, H259/130 wall-bearing: H259/005
Other features	pit: 259/13
Maximum depth of features from Planum 1 in cm	long pit: H259/1: 90.3, H259/2: 85.40 posthole: H259/107: 52.16, H259/108: 42.31, H259/109: 46.15, H259/113: 25.99, H259/118: 52.79, H259/119: 45.58, H259/120: 21.05, H259/125: 21.67, H259/130: 19.87 pit: 259/13: 27.00
Excavated volume in m^3	long pit: H259/1: 2.2, H259/2: 2.1

Table 3.1.12. House 259 – contextual, chronological and architectural information.

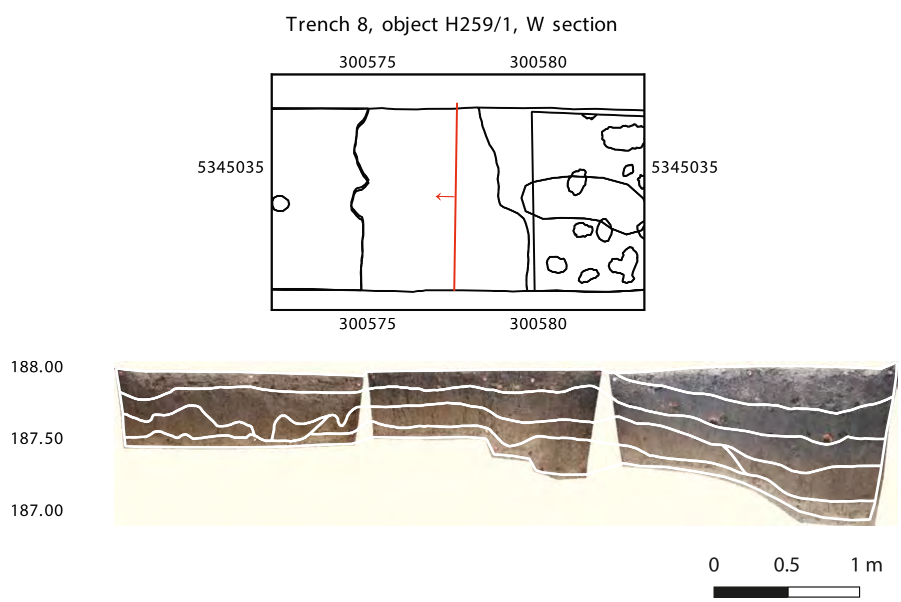

Figure 3.1.22. Plan and section of long pit H259/1.

Long pits

Long pit H259/1 (western) was 4 m wide and c. 25 m long, and a 5 m long section of it was excavated (Fig. 3.1.22). The long pit was characterised by a slightly trough shape with a generally flat base. Under a homogeneous and dark fill layer of c. 20-40 cm thickness was a thick concentration of daub.

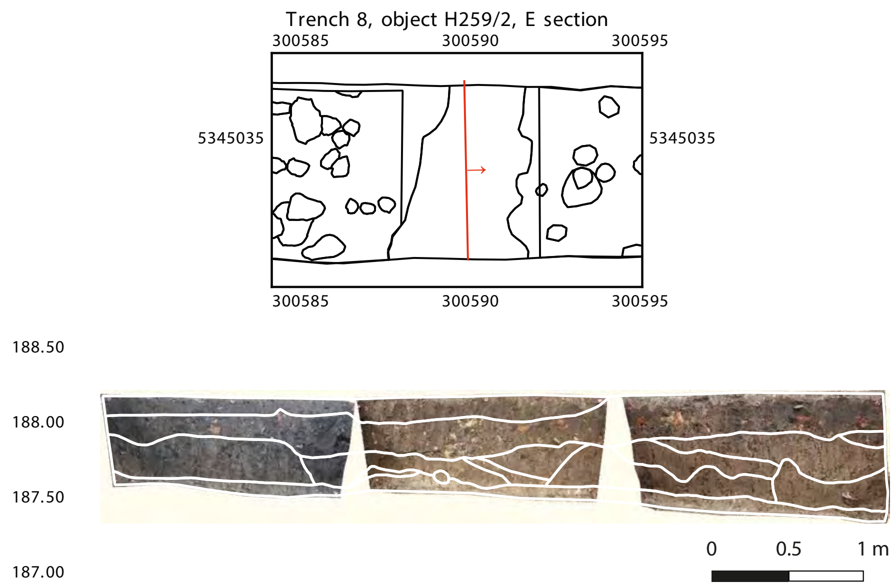

Figure 3.1.23. Plan and section of long pit H259/2.

Long pit H259/2 (eastern) was 4 m wide and 22.32 m long, and a c. 5 m long section of it was excavated (Fig. 3.1.23). The outline was slightly trough-shaped, and it had an irregular base. A deepening of the long pit was observed towards the southern part of the long pit. In the middle part of the section, an increased presence of daub fragments was observed, but it was not characterised by a large concentration.

Other pits

Object 259/13 was relatively small, with an elongated plan and a rectangular-shaped cross-section. The fill was homogeneous and difficult to discern from the surroundings, initially suggesting a possible posthole function. Due to the extensive size of the outline and the multiplicity of neighbouring postholes, it was re-classified as a pit.

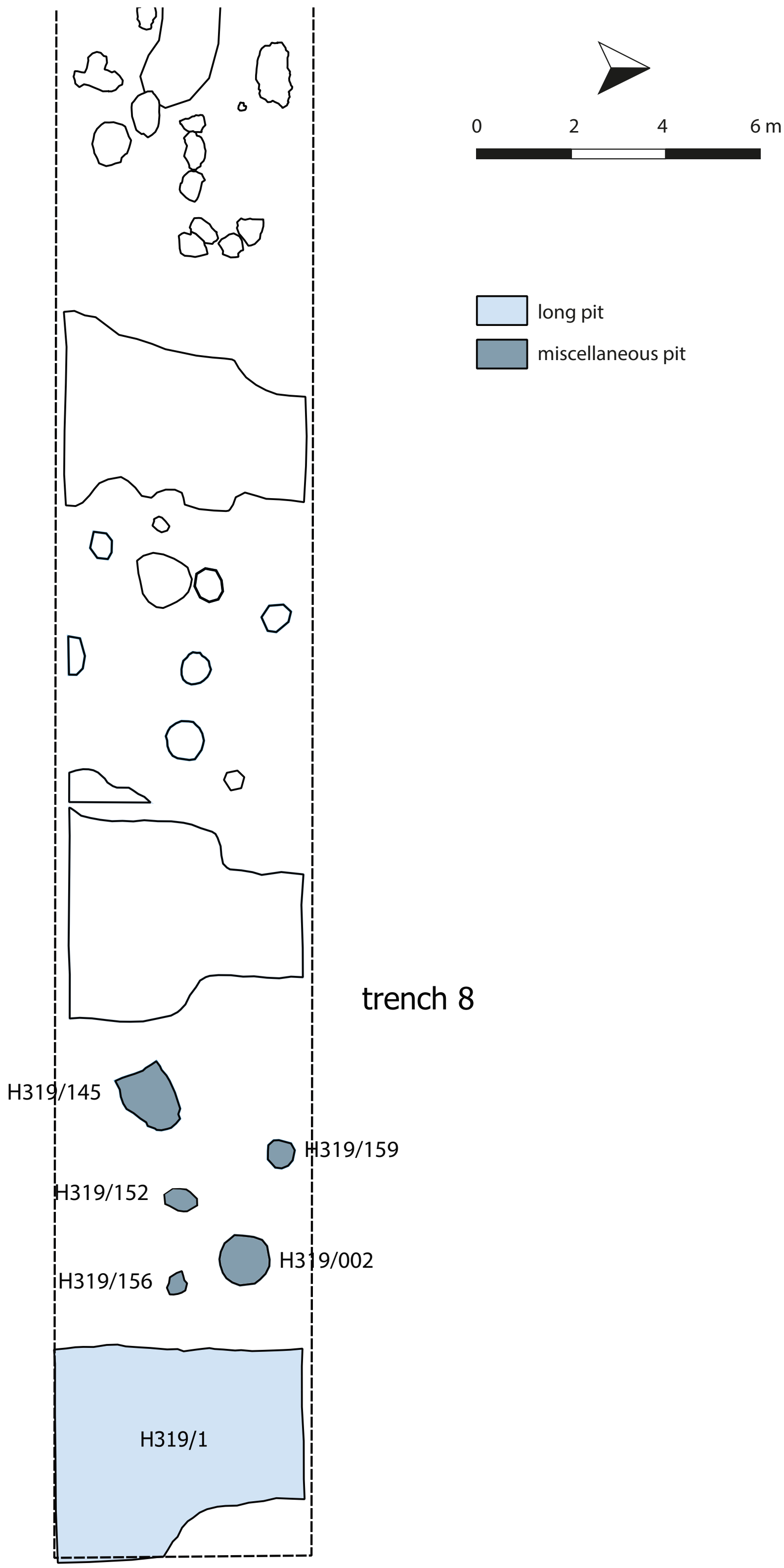

Figure 3.1.24. Planum of house 319.

Finds

Table 3.1.13. House 259 – summarised find information.

Category	Number	Weight (g)
ornamented ceramics	177	1109
unornamented ceramics	355	6559
chipped stone	-	-
ground stone	10	7066
Bone	211	-
Daub	-	32 064

Table 3.1.14. House 319 – contextual, chronological and architectural information.

House no.	319
Dating	relative chronology: younger LBK absolute chronology: -
Orientation	17.8°
Length in m	21.19
Number of cross rows documented	0
Width between house walls in m	-
Average width of cross rows in m	-
Distance between cross rows (from south to north) in m	-
Long pits	western: H319/1
Postholes	-
Other features	pits: H319/002, H319/145, H319/152, H319/156, H319/159
Maximum depth of features from Planum 1 in cm	long pit: H319/1: 77.1 pit: H319/002: 53.70, H319/145: 27.95, H319/152: 56.00, H319/156: 34.00
Excavated volume in m³	long pit: H319/1: 2.5

House 319 was located outside Trench 8, but its presence was documented as pit H319/1 (Fig. 3.1.24). The object was previously reported as H258/1 (Cheben and Furholt 2019).

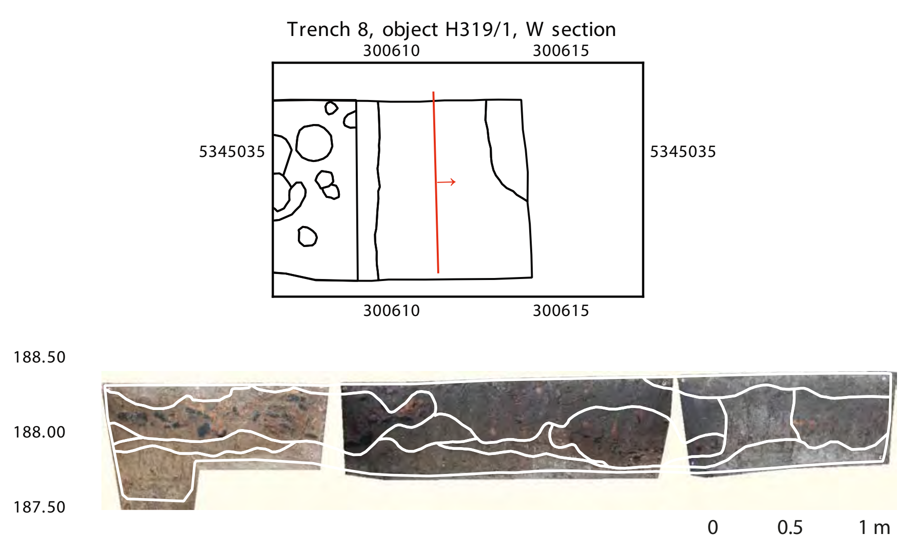

Figure 3.1.25. Plan and section of long pit 319/1.

Long pits

Long pit H319/1 was 4 m wide, with a slightly trough-shaped outline and a slightly irregular shape along the N-S profile (Fig. 3.1.25). Under a dark and homogeneous fill of up to 20 cm thickness was a 60 cm thick daub-rich layer, with the remains indicating different degrees of burning.

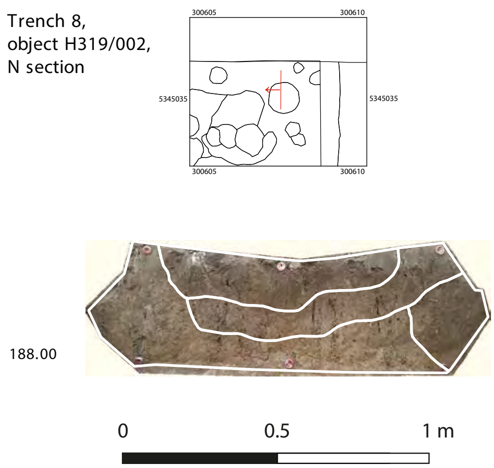

Figure 3.1.26. Plan and section of hearth H258/141.

Other pits

Pit H319/002 was an oval, flat and slightly trough-shaped pit (Fig. 3.1.26). The pit was initially documented as a concentration of relatively large pebbles found on Planum 1. Despite the absence of vitrification, the concentration of stones was later classified as a hearth.

Pit H319/145 was an elongated, partially disturbed pit with a homogeneous, brown fill. The disturbance is related to the construction of long pit H258/1. The pit measured 138 cm in length and 101 cm in width and was 28 cm deep suggesting a waste disposal function.

Pit H319/152 represents the remains of small, circular pit measuring 47cm in diameter and 56cm in depth. Although initially classified as a posthole, the size of the feature and dark brown fill with tiny remains of daub suggests that it was used for waste disposal.

Pit H319/156 was a small, circular pit measuring 47cm in diameter and 34cm in depth. Initially considered a posthole, the pit was re-classified as a waste disposal pit due to the large fragment of burnt daub found inside.

Pit H319/159 was a circular pit measuring 59cm in diameter. Due to the size of the structure it was considered as a waste disposal pit, although the fill analysis did not provide substantial evidence for this classification.

Finds

Category	Number	Weight (g)
ornamented ceramics	24	-
unornamented ceramics	-	251
chipped stone	-	-
ground stone	-	-
Bone	-	-
Daub	-	2029

Table 3.1.15. House 319 – summarised find information.

Trench 10

The trench measured 5×7.5 m and cut the western long pit of house 262, as well as the western and central posthole rows – features H262/6 and H262/6 (Fig. 3.1.27). To the west, in Trench 9, was a pit complex excavated in 1×1 m squares within this 5×5 m trench.

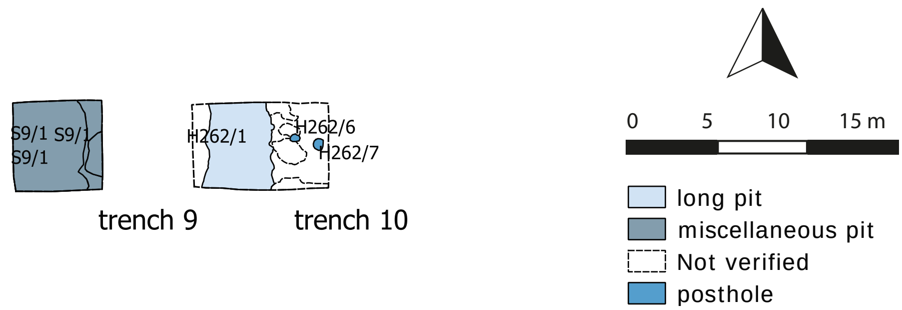

Figure 3.1.27. Overview of trenches 9 and 10 in 2014.

House no.	262
Dating	relative chronology: younger LBK-Želiezovce group absolute chronology: 5050-5000 BCE
Orientation	3.1°
Length in m	30.98
Number of cross rows documented	0
Width between house walls in m	-
Average width of cross rows in m	-
Distance between cross rows (from south to north) in m	-
Long pits	western: H262/1
Postholes	roof-bearing: H262/6, H262/7
Other features	pit: H262/4
Maximum depth of features from Planum 1 in cm	long pit: H262/1: 108.9 posthole: H262/6: 24.69, H262/7: 39.46 pit: H262/4: 48.00
Excavated volume in m³	long pit: H262/1: 2.2

Table 3.1.16. House 262 – contextual, chronological and architectural information.

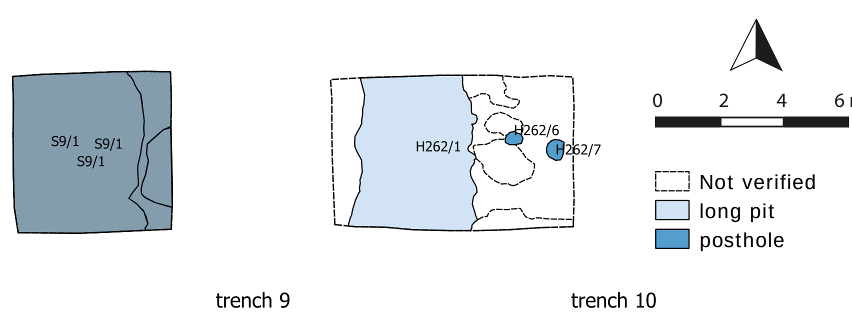

Figure 3.1.28. Planum of house 262.

The good visibility of house 262 in the magnetometry was replicated on Planum 1, where the majority of postholes were well visible (Fig. 3.1.28).

Long pits

Long pit H262/1 (western) was c. 3 m wide and was characterised by a trough-like shape with a flat base (Fig. 3.1.29). Two separate fills were distinguished: a 30 cm thick and well-preserved burnt daub deposit on top of a homogenous feature devoid of finds.

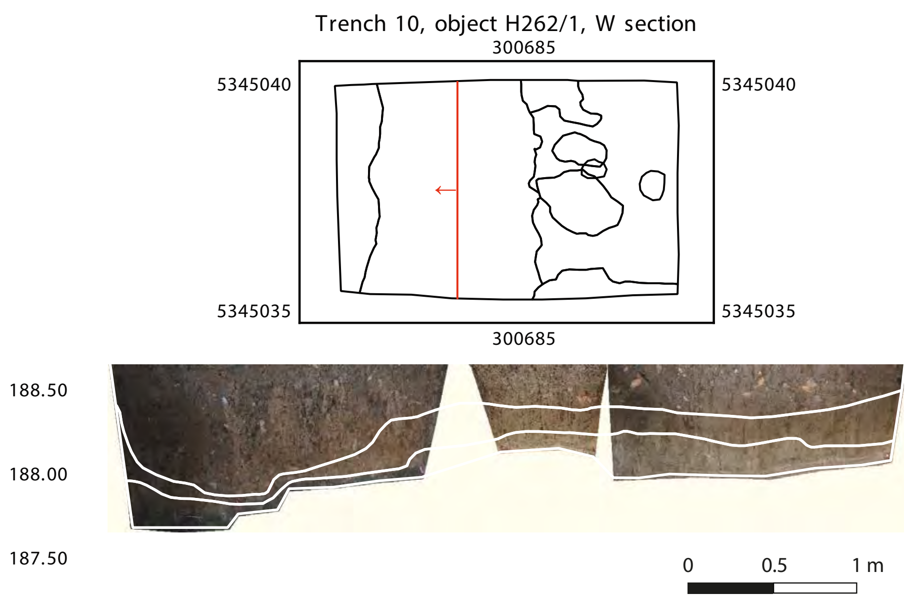

Figure 3.1.29. Plan and section of long pit 262/1.

Other pits

A larger pit complex (object S9/1) was documented west of the house in Trench 9 (Fig. 3.1.30). The complex had an irregular shape and comprised of two to three fill layers, one of which was rich in daub.

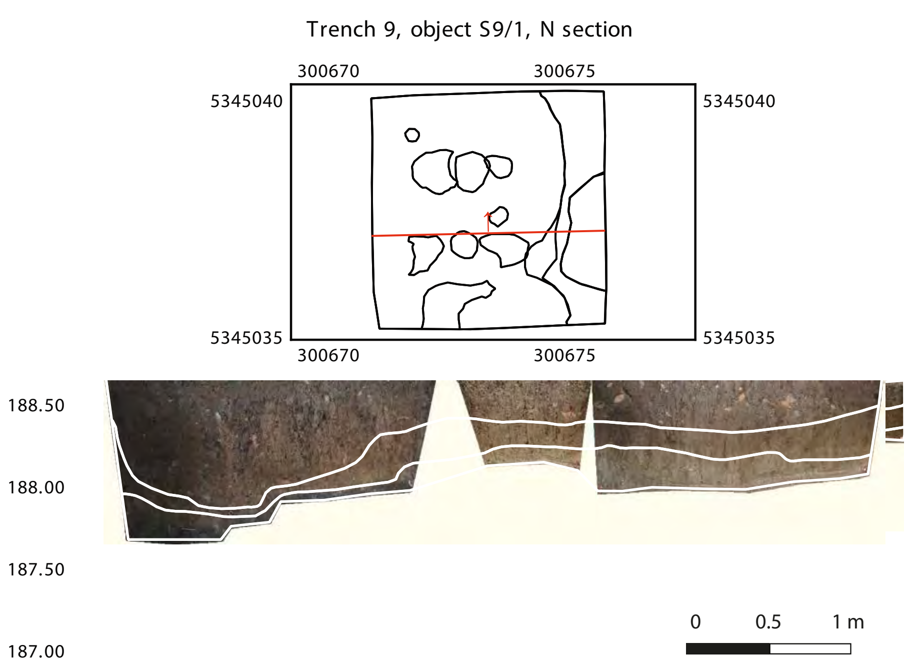

Figure 3.1.30. Plan and section of pit complex S9/1.

Finds

Category	Number	Weight (g)
ornamented ceramics	19	228
unornamented ceramics	214	1345
chipped stone	-	-
ground stone	-	-
bone	91	-
daub	-	3576

Table 3.1.17. House 262 – summarised find information.

Excavation campaign 2016

During the excavation campaign of 2016, a group of four to five closely spaced houses were excavated in the southern part of the settlement N neighbourhood (Fig. 3.1.31).

A total area of 2283 m² was divided into Trenches 11-14. The initial expectation was that the excavation of the area would provide evidence of contemporary occupation. However, over the course of the excavations it became clear that the houses represented a chronological sequence. The findings have already been partially published as a preliminary report (Müller-Scheeßel et al. 2016).

Trenches 11 and 12

Trench 11 measured 52×14 m and included the majority of the features of house 131, as well as the western long pit of house 132. Trench 12 measured 20×25 m and covered the northern parts of houses 131, 132 and 133.

The remains of wall-posts were only documented in objects H131/60 and H131/70 (Fig. 3.1.32). In both instances the posts measured c. 35 cm in diameter. A unique case was provided by object H131/70 where a diagonally-oriented posthole was observed. We interpret it as evidence that the post was tilted and pulled out after the house was abandoned.

House no.	131
Dating	relative chronology: Želiezovce group absolute chronology: 5050-5000 BCE
Orientation	30.2°
Length in m	28.48
Number of cross rows documented	7
Width between house walls in m	9.53
Average width of cross rows in m	4.11
Distance between cross rows (from south to north) in m	3.52
Long pits	western: H131/1, H131/2; eastern H131/7, H131/8, H131/57
Postholes	roof-bearing: H131/3, H131/4, H131/5, H131/6, H131/38, H131/39, H131/40, H131/58, H131/59, H131/60, H131/61, H131/62, H131/63, H131/69, H131/70, H131/103, H131/105, H131/106, S12/64
Other features	S12/101
Maximum depth of features from Planum 1 in cm	long pit: H131/1: 93.06, H131/2: 63.00, H131/7: 23.01, H131/8: 125.00, H131/57: 98.00 posthole: H131/3: 65.41, H131/4: 59.76, H131/5: 40.82, H131/6: 48.48, H131/38: 48.15, H131/39: 48.53, H131/40: 52.58, H131/58: 62.51, H131/59: 56.65, H131/60: 53.17, H131/61: 55.97, H131/62: 51.90, H131/63: 37.76, H131/69: 51.39, H131/70: 69.48, H131/103: 75.21, H131/105: 65.63, H131/106: 37.07, S12/64: 46.62 pit: S12/101: 87.02
Excavated volume in m³	long pit H131/1: 0.91, H131/2: 3.36, H131/7: 1.22, H131/57: 24.91

Table 3.1.18. House 131 – contextual, chronological and architectural information.

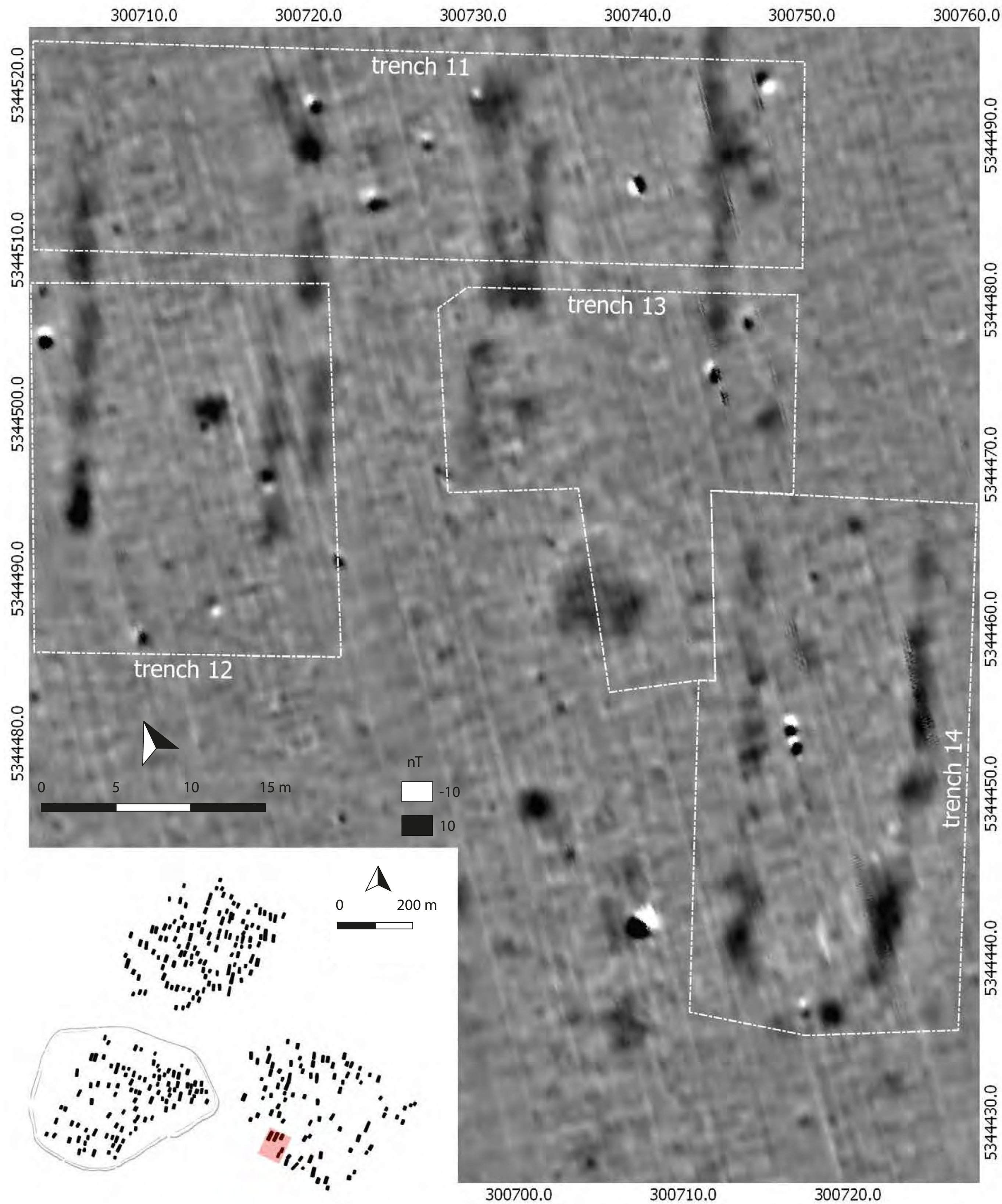

Figure 3.1.31. Overview of the excavation area in 2016.

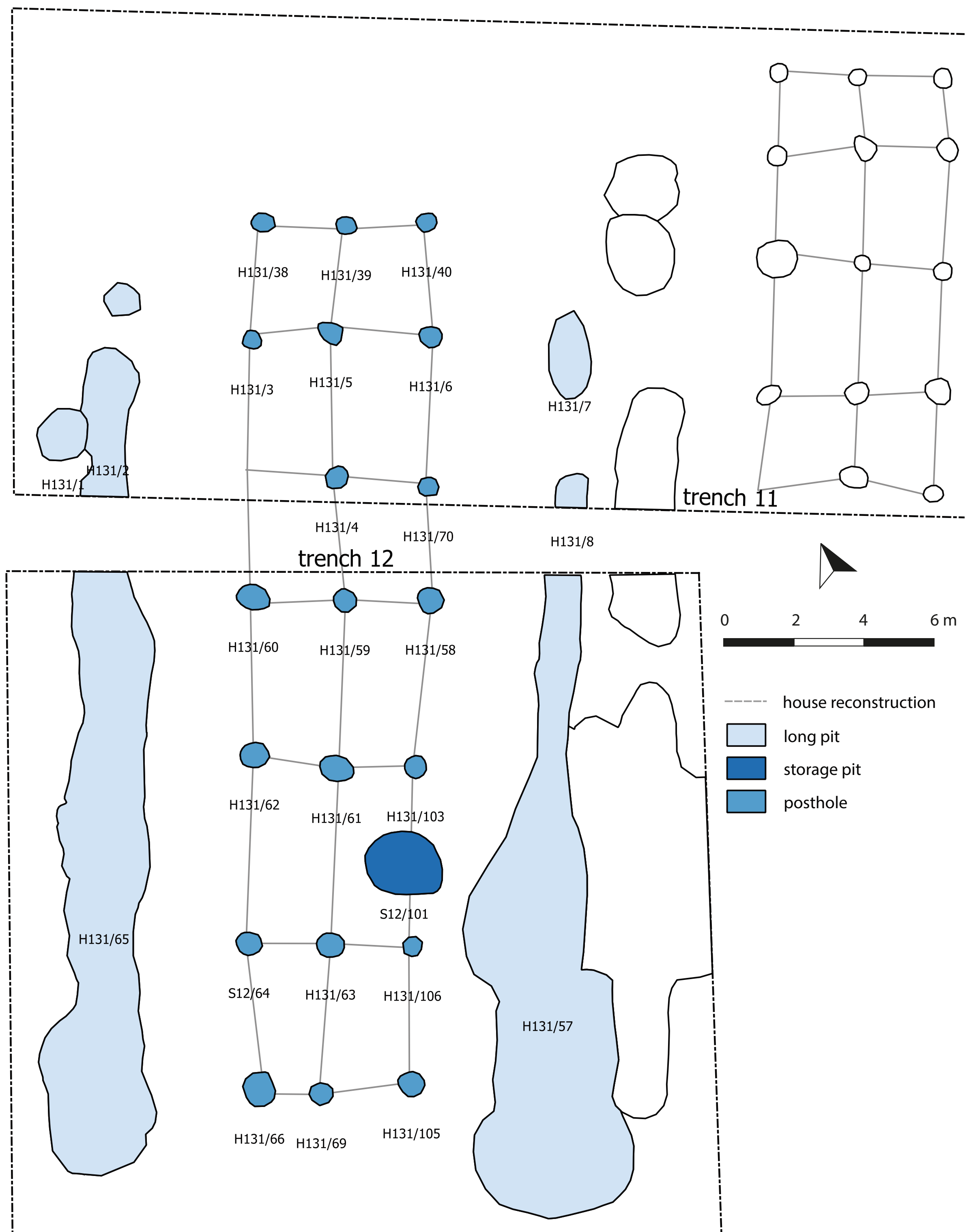

Figure 3.1.32. Planum of house H131.

Long pits

Long pit H131/65 (western) measured c. 26.5 m, was relatively narrow with the northernmost part separate from the rest of the object (Fig. 3.1.33). The southern part comprised of a distinct bulge and a depression. Two phases were distinguished: a flat-based deep cut (H131/65a) followed by a later cut by a younger pit.

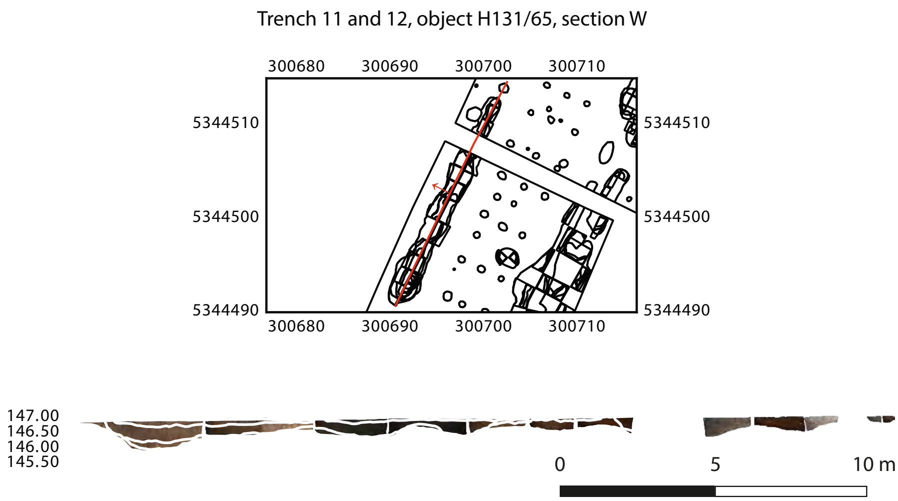

Figure 3.1.33. Plan and section of long pit H131/65.

The other long pit (eastern) has a similar length and was also located between trenches 11 and 12 (Fig. 3.1.34). The northern part had a narrow, straight shape, while the southern comprised of two bulges: in the centre of Trench 12 (H131/57b) and at the southern end (H131/57a).

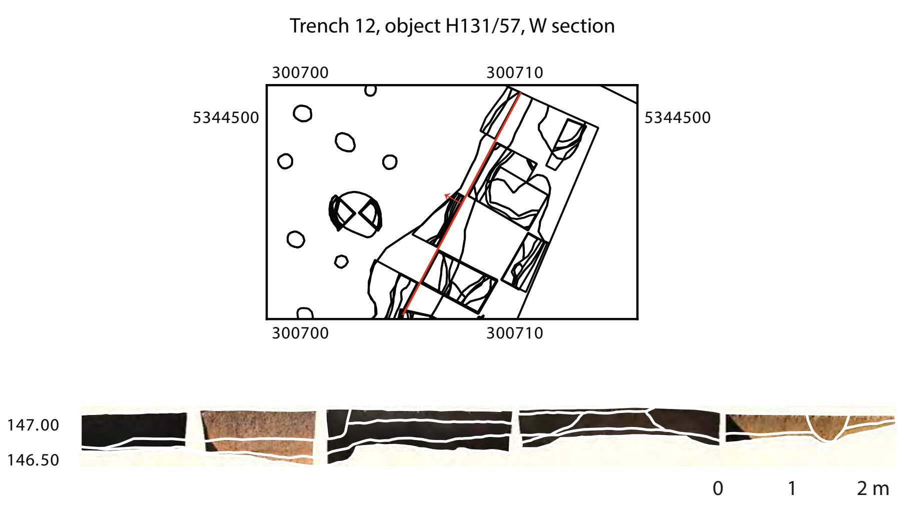

Figure 3.1.34. Plan and section of long pit H131/56.

Other pits

Pit 102/12 was originally a beehive-shaped pit. It was later repurposed into a waste disposal pit (Fig. 3.1.35). It measured c. 2.3 m in diameter and was c. 87 cm deep. The fill was relatively homogeneous, with discernible daub concentrations.

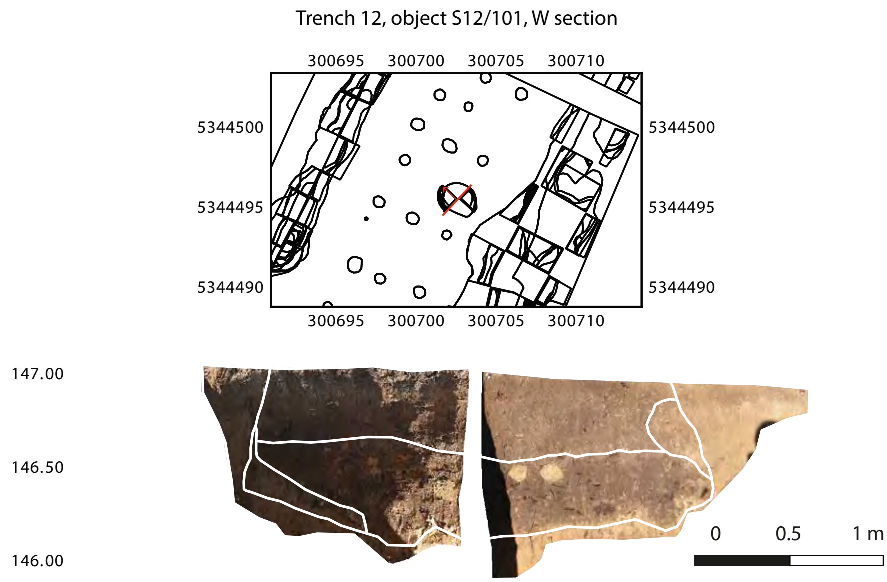

Figure 3.1.35. Plan and section of beehive-shaped pit S12/101.

Finds

Ceramics: 1 piece of painted pottery was found in object 131/65.
Chipped stone artefacts: Multiple obsidian artefacts were found in features related to house 131: 2 cores, 5 flakes, 26 blades, 11 pieces of debris, 2 rejuvenation core flakes and 11 splinters. The finds represent the largest concentration of obsidian artefacts found in all excavated houses.
Ground stone artefacts: 7 grinding stones and 1 adze were found in features related to house 131.

Table 3.1.19. House 131 – summarised find information.

Category	Number	Weight (g)
ornamented ceramics	144	1823
unornamented ceramics	1737	11 144
chipped stone	112	196.7
ground stone	14	2206
Bone	1068	1938
Daub	-	50 006

Trenches 11, 12, and 13

Trench 11 measured 52×14 m. Trench 12 measured 20×25 m. Trench 13 was divided into two parts: a northern part, measuring 24×13 m, and a narrower, southern part, measuring 8×13 m (cf. Fig. 3.1.31).

House no.	132
Dating	relative chronology: Želiezovce group; a second Prelengyel activity phase absolute chronology: 5225-5050 BCE
Orientation	26°
Length in m	27.31
Number of cross rows documented	5
Width between house walls in m	11.11
Average width of cross rows in m	4.24
Distance between cross rows (from south to north) in m	2.31
Long pits	western: H132/9a, H132/9, H132/13, H132/14; East: H132/24, H132/113; eastern: H132/113, H132/24, H132/25
Postholes	roof-bearing: H132/15, H132/16, H132/17, H132/18, H132/19, H132/20, H132/22, H132/23, H132/45, H132/46, H132/47, H132/49, H132/50
Other features	beehive-shaped pit: S11/21 pit: H132/10, H132/12
Maximum depth of features from Planum 1 in cm	long pit: H132/9: 76.00, H132/14: 35.1, H132/24: 61.00 H132/113: 71.9 posthole: H132/15: 44.60, H132/16: 55.5, H132/17: 55.32, H132/18: 38.06, H132/19: 38.66, H132/20: 43.74, H132/22: 25.98, H132/23: 20.14, H132/45: 33.89, H132/46: 21.07, H132/47: 30.95, H132/49: 19.37, H132/50: 20.00 beehive-shaped pit: S11/11: 44.40 pit: H132/10: 34.8, H132/12: 42.4
Excavated volume in m^3	long pit H132/9: 22.97, H132/10: 1,89, H132/12: 1.05, H132/14: 0.71, H132/113: 12.19

Table 3.1.20. House 132 – contextual, chronological and architectural information.

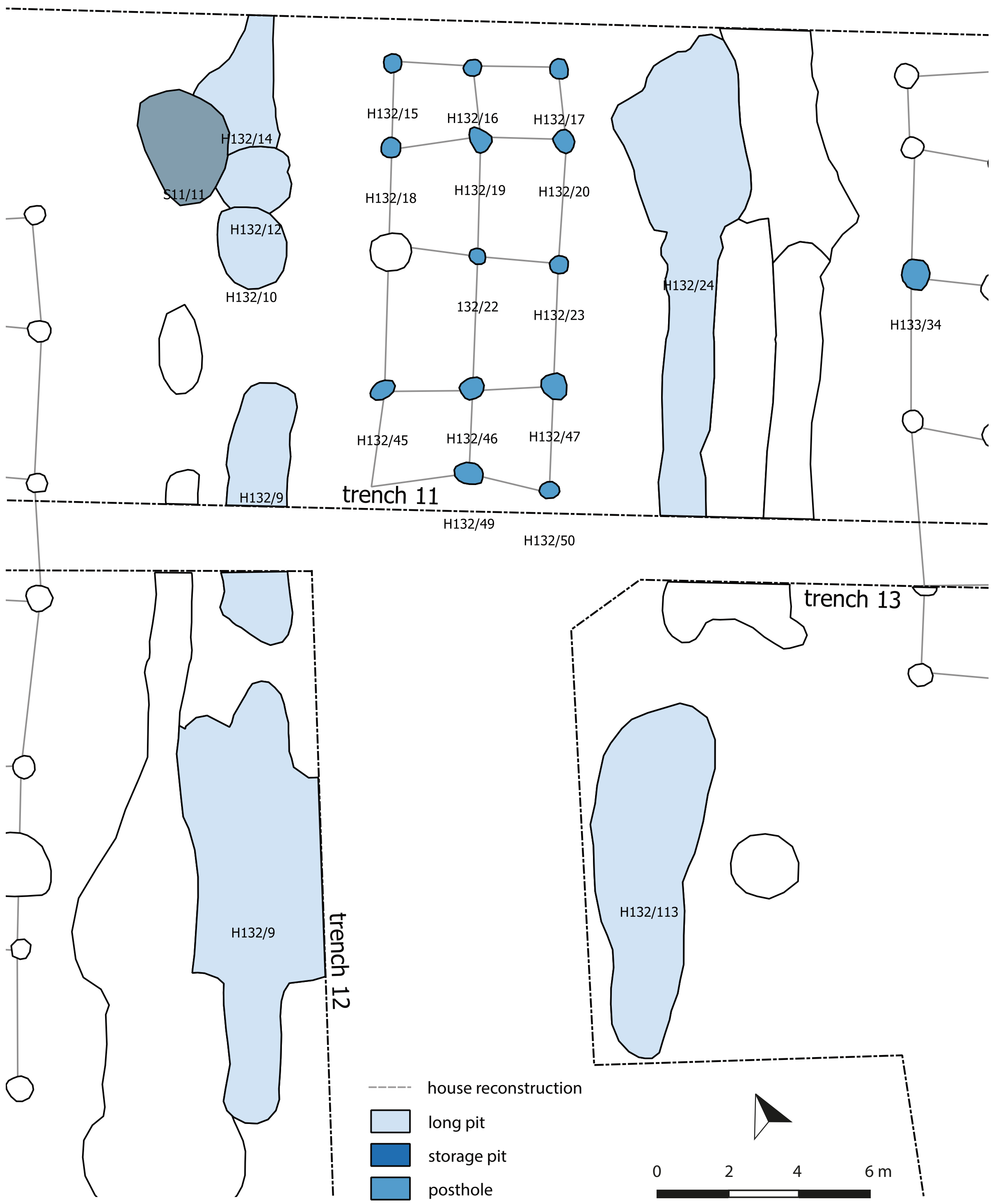

Figure 3.1.36. Planum of house 132.

The northern, central and southern (line of objects H132/2 and H132/9) parts of house 132 were documented (Fig. 3.1.36). The length of the structure was established on the basis of excavating long pits H132/9 in trench 12 and the excavation of the southern part of the eastern long pit H132/113. In comparison to other constituents of the long pits found in Vráble, several objects found in the vicinity of house 132 contained Prelengyel pottery.

Long pits

The western long pit comprised of a discontinued sequence of pits (H132/9, H132/13 and H132/14) with clear breaks between particular constituents (Fig. 3.1.37). The adjacency of long pit H131/57 did not allow establishing of a clear stratigraphic relationship, and the chronological distinction between the two was determined based on radiocarbon dating. Object H132/113 had a trough-shaped form with a flat and regular form. The two recuttings were observed in the long profile. The long pit was cut by three pits H132/10, H132/12 and S11/11, which based on the ceramic analysis were dated to the Prelengyel phase of the settlement.

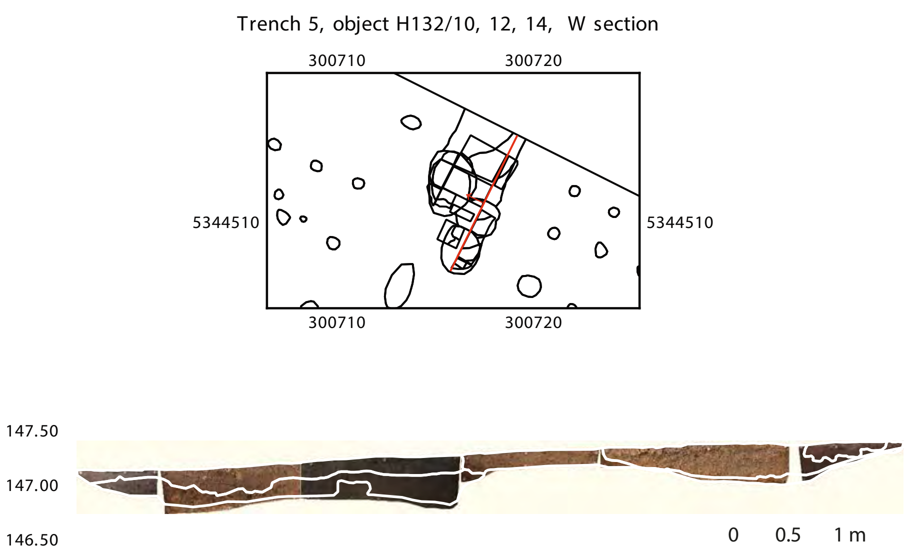

Figure 3.1.37. Plan and section of long pit H132/10, 12, 14.

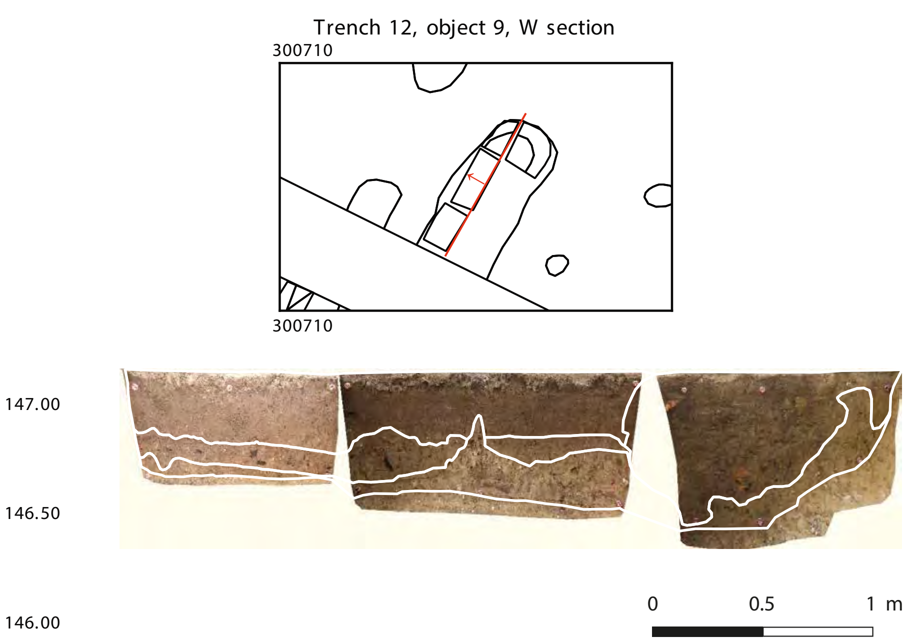

Figure 3.1.38. Plan and section of long pit H132/9 in trench 11.

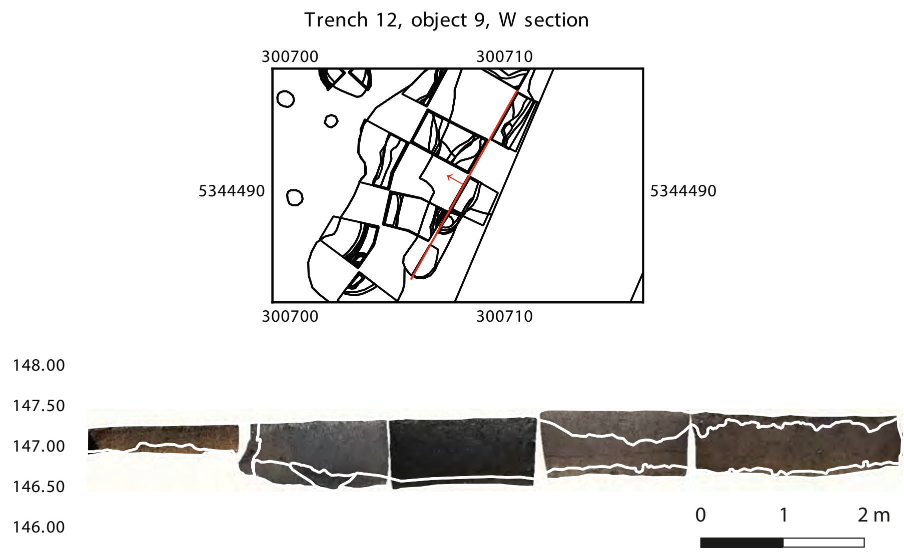

Figure 3.1.39. Plan and section of long pit H132/9 in trench 12.

Long pit H132/24 and H132/113 (eastern) was of varying width, *i.e.* the northern part measured 3,65 m in its widest point, while the southern part 3,24m (Fig. 3.1.40). The central parts of the pit were much narrower, measuring ca. 1,4m. The cross-section of the long pit showed a trough-shaped base of the long pit in the central and southern part of the object, while the northern part was characterised by an extensive depth. The width differentiation identified after the removal of planum 1 was a reason to believe that the long pit comprises of two distinct features of stratigraphic consecutiveness, namely the wide northern part of the long pit (now renamed H132/24a) and the narrow part in the middle. A longitudinal cross-section did not provide clear evidence of such a stratigraphic overlap. Based on the typochronological dating of the object it was proposed that it probably represents a later recutting, which belongs to the Prelengyel phase of the settlement. However, the radiocarbon sample extracted from the fill produced an old dating, positioning the feature within the 5225-5050 BCE time-span. Based on this discrepancy, the following scenario was developed: the old date represents a bone that stems from the earlier stage of the long pit and can be linked to the original house chronology during the Želiezovce phase, it was redeposited as the Prelengyel recut was carried out. The presence of the Prelengyel pottery in the long pit is representative of the later disturbance of the structure, which could not be clearly determined based on the stratigraphic evidence.

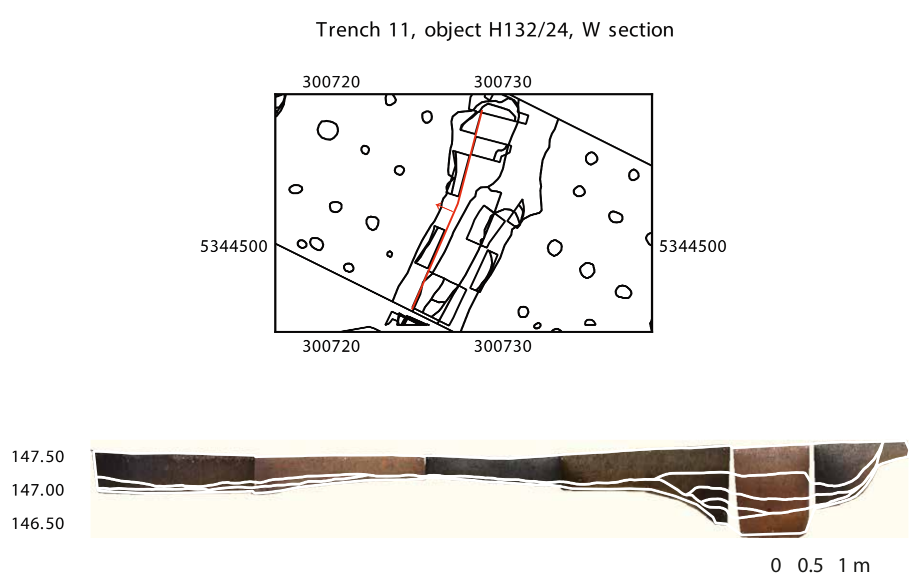

Figure 3.1.40. Plan and section of long pit H132/24.

Other pits

S11/11 was a shallow pit cutting in object H132/12 from the east (Fig. 3.1.41). The base of the pit was irregular but clearly distinguishable from the surrounding loess in its western part. The fill in the eastern part was rather homogeneous, which suggests that the pit had a short-term use and was most likely filled in with the initially removed fill of object H132/12. However, the analysis of the ceramic material showed the presence of Prelengyel pottery inside the fill, which suggests possible settlement activities in the final stage of the Vráble settlement.

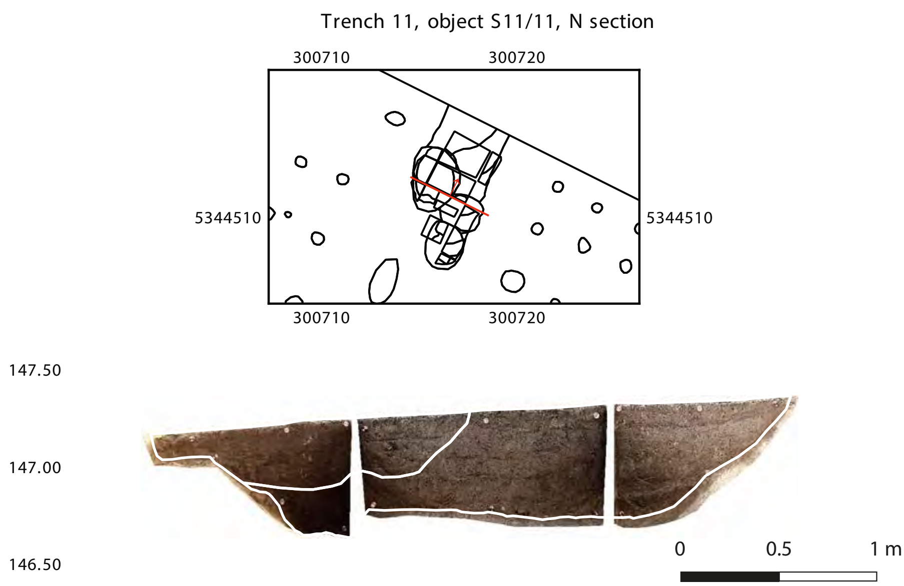

Figure 3.1.41. Plan and section of pit S11/11.

S11/21 was a beehive-shaped pit with a flat base and a relatively homogeneous, dark fill (Fig. 3.1.42). Only small patches of daub could be distinguished.

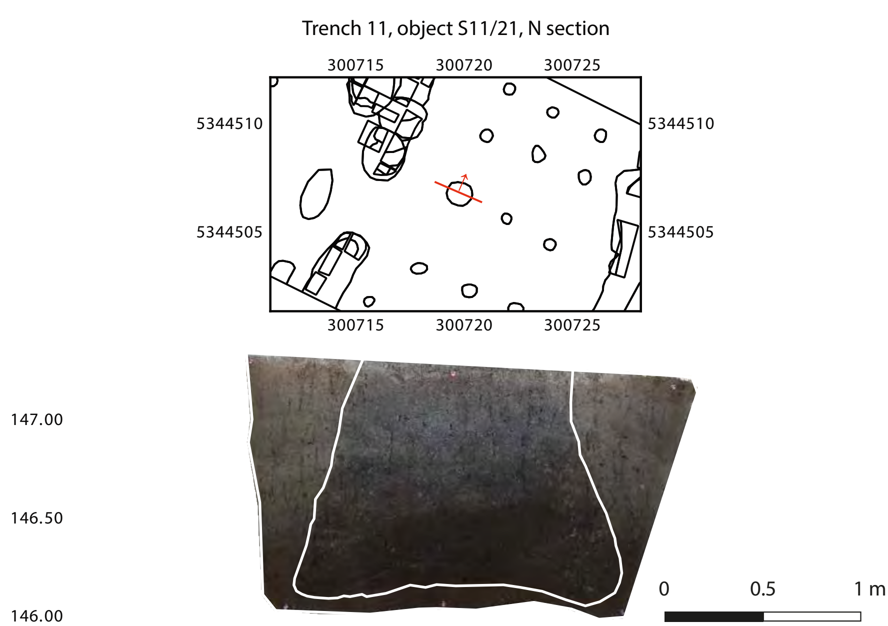

Figure 3.1.42. Plan and section of beehive-shaped pit S11/21.

H132/10 was a circular pit cutting through the circular pit H132/10 (cf. Fig. 3.1.37). The base of the pit was irregular with a shallow southern part and increasing depth towards pit H132/12. In the southern part of the pit burnt daub fragment were documented, possibly marking the initial occupation of house 132, while the upper fill represents a younger disturbance. Based on the typological analysis the material found inside the pit was dated to the Prelengyel phase.

H132/12 was was a circular pit cutting through the long pit H132/14 (cf. Fig. 3.1.37). The rather wide pit, ca. 2,1m wide, was characterised by a mixed, homogeneous fill and an irregular base. The possible reason behind the extensive width is the destruction of the stratigraphically younger pit H132/14. Such an event had to result in the mixing of the underlying archaeological material. Based on the typological analysis of the ceramic material the pit was dated to the Prelengyel phase.

Finds

Ceramics: 1 round bowl with a painted interior was found in object H132/9.
Chipped stone artefacts: A few obsidian artefacts were found in features related to house 132: 5 blades, 2 pieces of debris, 1 rejuvenation core flake and 2 splinters.
Ground stone artefacts: 1 muller, 1 grinding stone, 1 rubbing stone, 1 whetstone and 1 adze were found in features related to house 132.
Other artefacts: 1 conical, perforated stone bead with a slight ridge inside the perforation, weighing 0.3 g.

Table 3.1.21. House 132 – summarised find information.

Category	Number	Weight (g)
ornamented ceramics	57	1677
unornamented ceramics	1077	10 548
chipped stone	29	166.4
ground stone	5	1013
Bone	461	2834
Daub	-	53 155

Table 3.1.22. House 133 – contextual, chronological and architectural information.

House no.	133
Dating	relative chronology: Želiezovce group absolute chronology: 5200-5000 BCE
Orientation	22°
Length in m	20.77
Number of cross rows documented	6
Width between house walls in m	9.33
Average width of cross rows in m	4.14
Distance between cross rows (from south to north) in m	2.75
Long pits	western: H133/25, H133/26; eastern: H133/37
Postholes	roof-bearing: H133/28, H133/29, H133/30, H133/31, H133/32, H133/33, H133/34, H133/35, H133/52, H133/54, H133/55, H133/115, H133/116, H133/117, H133/118, H133/119, S13/115, S13/116
Other features	beehive-shaped pit: S13/114, S13/120 pit: S11/71
Maximum depth of features from Planum 1 in cm	long pit: H133/26: 59.02, H133/37: 83.08 posthole: H133/28: 14.30, H133/29: 31.65, H133/30: 27.60, H133/31: 21.07, H133/32: 24.92, H133/33: 26.14, H133/34: 36.41, H133/35: 37.06, H133/52: 42.18, 133/54: 35.56, 133/55: 35.27, 133/115: 40.75, H133/117: 3.00, H133/118: 33.39, H133/119: 20.40, S13/116: 18.53 beehive-shaped pit: S13/114: 129.00, S13/120: 140.30 pit: S11/71: 47.01
Excavated volume in m^3	long pit H133/26: 5.66, H133/37: 29.88

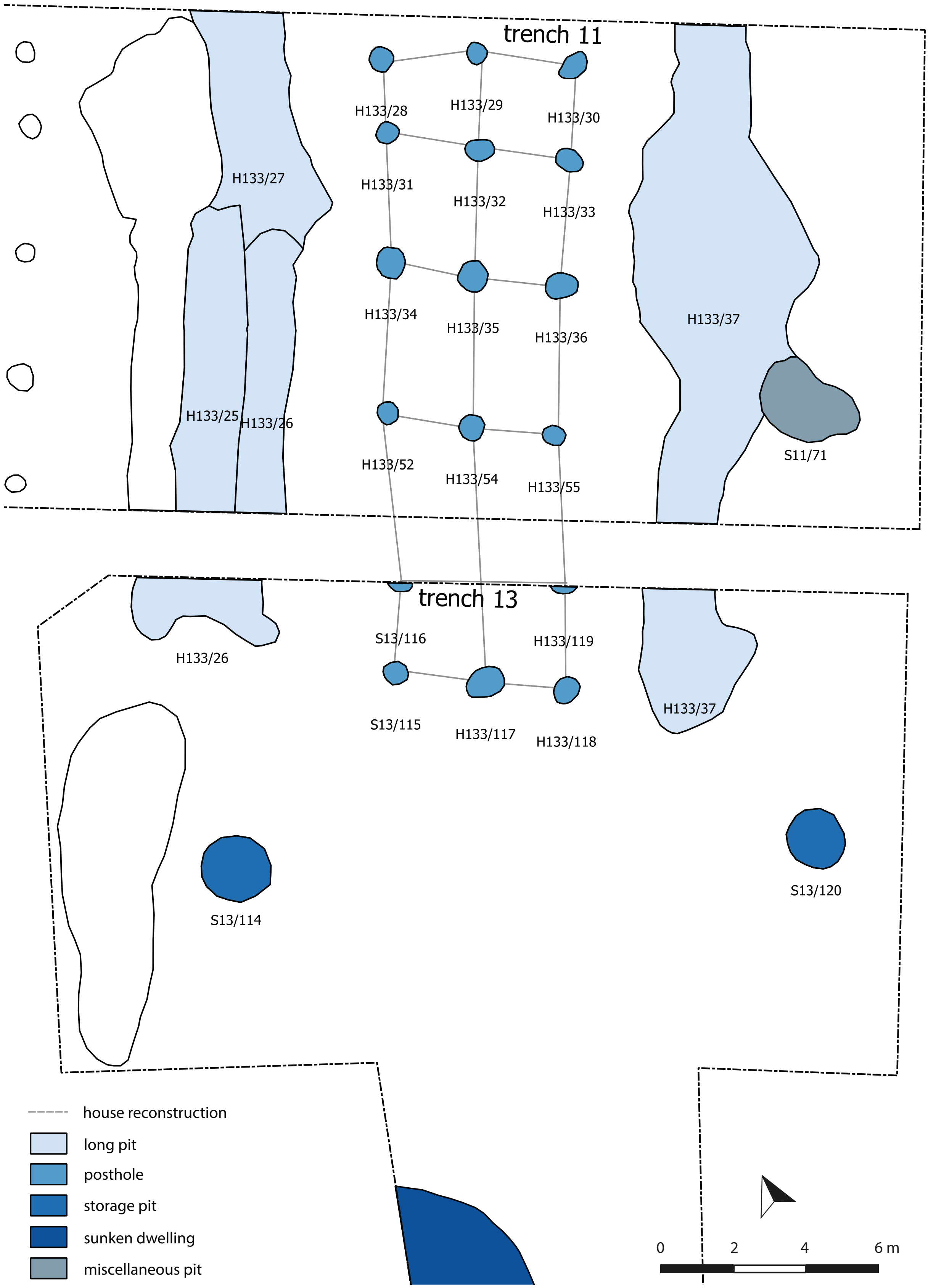

Figure 3.1.43. Planum of house 133.

Feature H133/26 cuts through H132/25, indicating the later chronological position of the house, an observation further supported by radiocarbon dating (Fig. 3.1.43).

Long pits

The western long pit comprised of objects H132/25 and H133/26 was 2 m wide and had a rounded, trough-like shape (Fig. 3.1.44). Object H133/27 was located to the north of H133/26, where an extension of the pit was found.

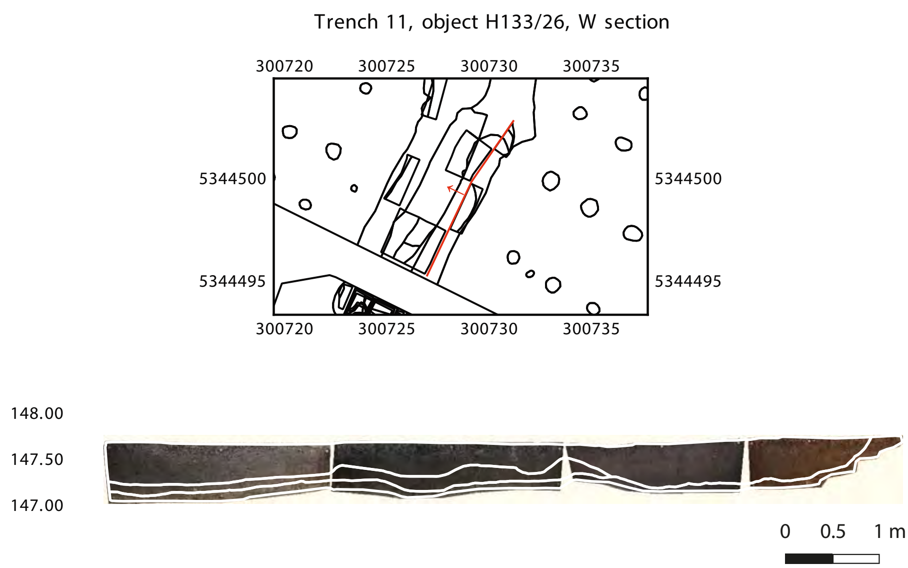

Figure 3.1.44. Plan and section of long pit H133/26.

Long pit H133/37 (eastern) was 5 m wide at its widest point, although narrower parts were documented as well (Fig. 3.1.45). The long pit was generally trough-shaped.

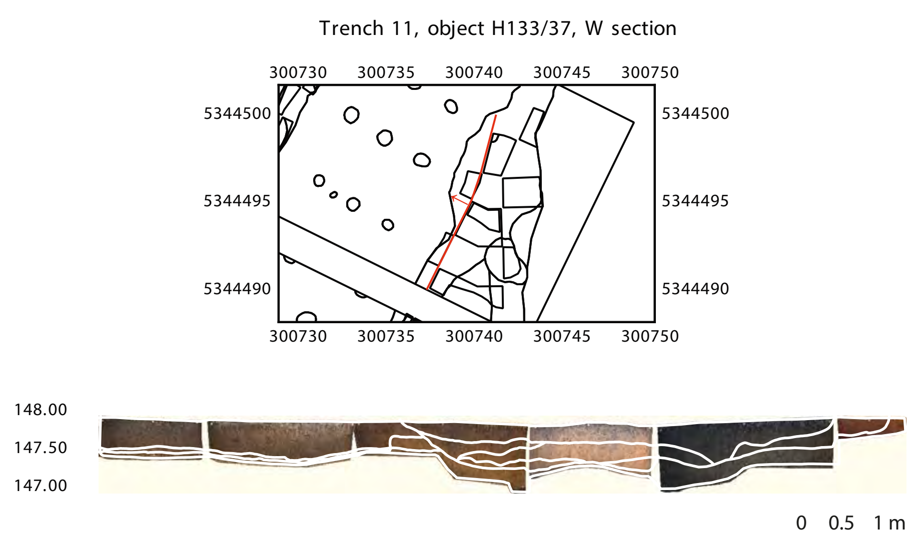

Figure 3.1.45. Plan and section of long pit H133/37.

Other pits

S13/114 was a beehive-shaped pit with a flat base and partially collapsed walls (Fig. 3.1.46). No finds were documented from it.

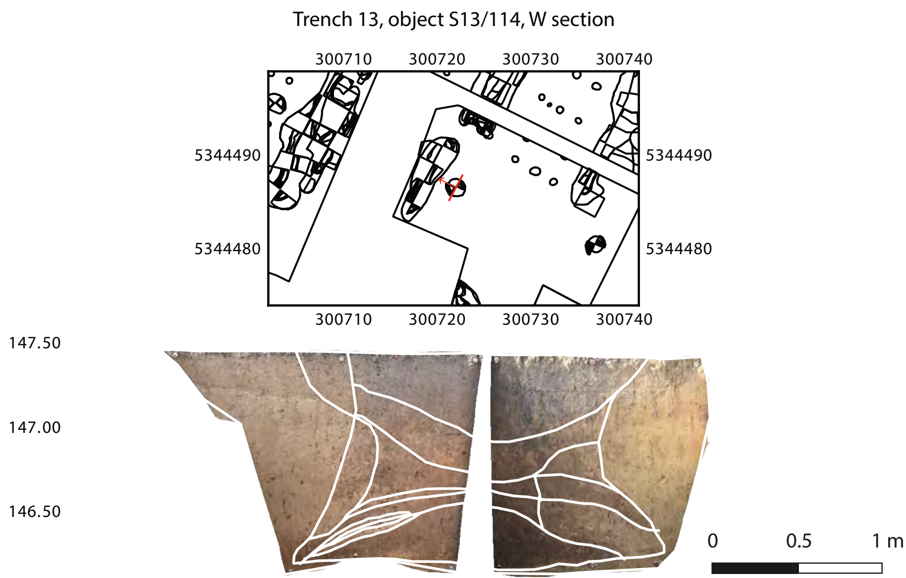

Figure 3.1.46. Plan and section of beehive-shaped pit S13/114.

S13/120 was a beehive-shaped pit with a flat base and partially collapsed walls (Fig. 3.1.47). No finds were documented from it.

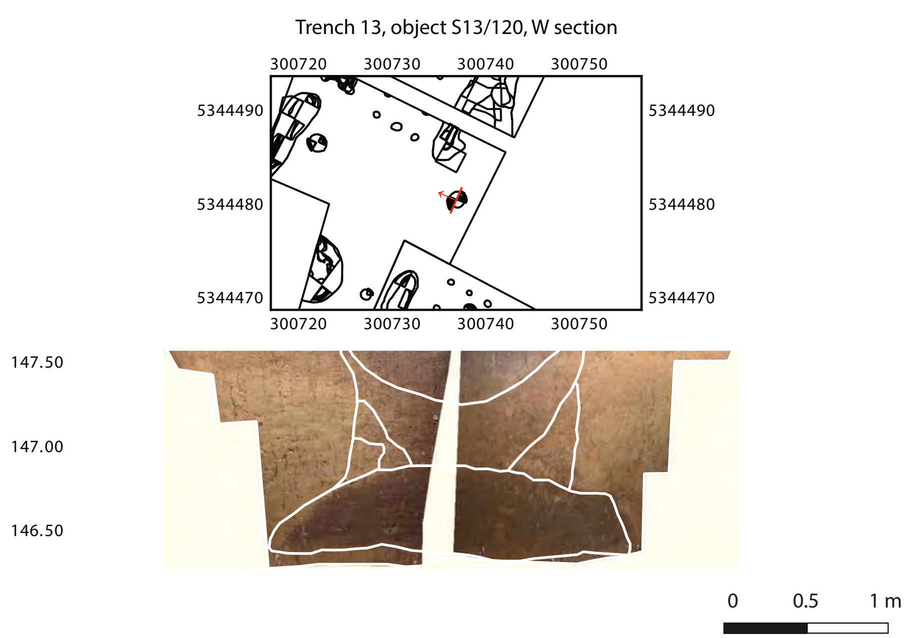

Figure 3.1.47. Plan and section of beehive-shaped pit S13/120.

Finds

Ceramics: 1 fragment of a Bükker-style ceramic was found in object H133/25. Fragments of miniature vessels were found inside object 133/37.
Chipped stone artefacts: a handful of obsidian artefacts were found in features related to house 133: 4 flakes, 11 blades, 1 piece of debris and 1 rejuvenation core flake.
Ground stone artefacts: 4 grinding stones were found in features related to house 133.

Category	Number	Weight (g)
ornamented ceramics	99	2286
unornamented ceramics	1504	11 702
chipped stone	91	226.75
ground stone	4	1655
Bone	393	746
Daub	-	9356

Table 3.1.23. House 133 – summarised find information.

Trench 14

Trench 14 measured 35×18 m, which covered the entire surface area of house 126 (cf. Fig. 3.1.31).

House no.	126
Dating	relative chronology: Želiezovce group absolute chronology: 5050-5000 BCE
Orientation	26.7°
Length in m	17.67
Number of cross rows documented	6
Width between house walls in m	10.79
Average width of cross rows in m	5.34
Distance between cross rows (from south to north) in m	3.03
Long pits	western: H126/123, eastern: H126/124
Postholes	roof-bearing: H126/125, H126/126, H126/127, H126/128, H126/129, H126/131. H126/132, H126/133, H126/134, H126/135, H126/136, H126/137, H126/141, H126/142, H126/144, H126/147, H126/148, H126/149, H126/151 wall-bearing: S14/138, S14/140
Other features	pit: S14/130
Maximum depth of features from Planum 1 in cm	long pit: H126/123: 25.4, H126/157: 37.00, H126/124: 74.00 posthole: H126/125: 31.01, H126/126: 38.43, H126/127: 38.43, H126/128: 46.88, H126/129: 29.59, H126/131: 22.12, H126/132: 41.14, H126/133: 26.27, H126/134: 27.68, H126/135: 40.12, H126/136: 40.72, H126/137: 42.77, H126/141: 31.57, H126/142: 14.19, H126/144: 59.4, H126/147: 32.71, H126/148: 35.83, H126/149: 34.86, H126/151: 35.92, S14/138: 21.01, S14/140: 27.08 pit: S14/130: 36.01
Excavated volume in m^3	long pit H126/123: 28.15, H126/124: 16.82

Table 3.1.24. House 126 – contextual, chronological and architectural information.

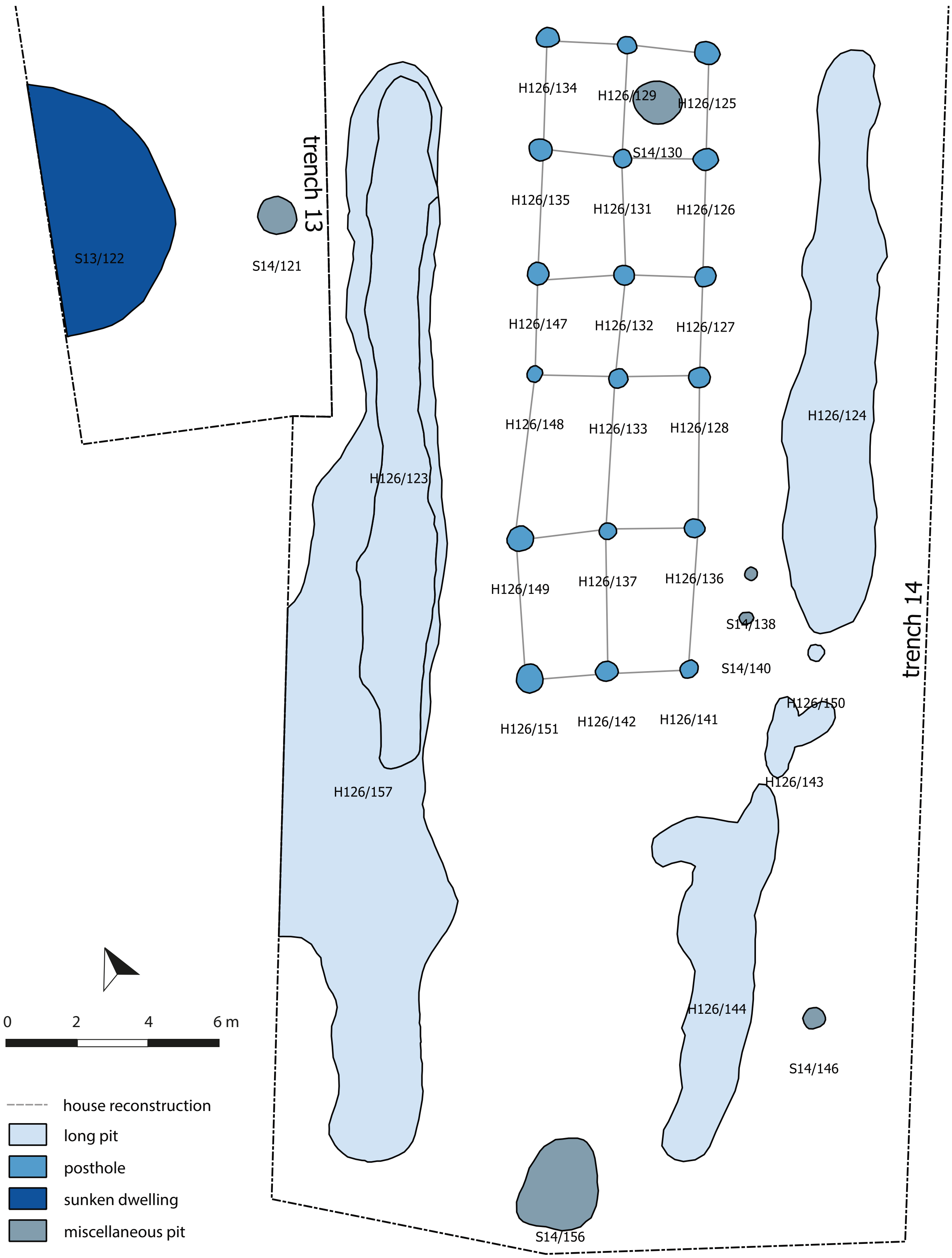

Figure 3.1.48. Planum of houses 126 and 127.

Based on the excavated length of the long pits, it can be stated that the entire surface of the house was documented (Fig. 3.1.48).

Long pits

H126/123 (western) was c. 1.5 m wide and was slightly trough-shaped, with a flat base (Fig. 3.1.49). The fill was homogeneous except for that of the northern part, where, directly under Planum 1, the remains of a daub construction were documented.

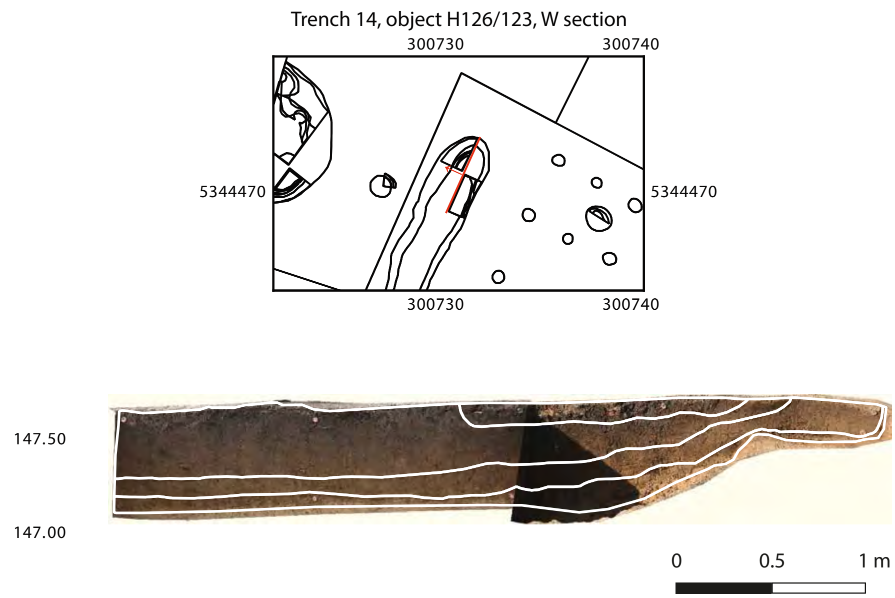

Figure 3.1.49. Plan and section of long pit H126/123.

H126/124 (eastern) was c. 2.5 m wide and was irregular in shape, with a flat base in the northern and central parts, and with deepenings in-between these parts and in the southern part (Fig. 3.1.50). Based on the examination of the fill, it was possible to interpret the deeper parts as comprising the original fill. The cross-section indicates the presence of both trough-shaped and V-shaped outlines.

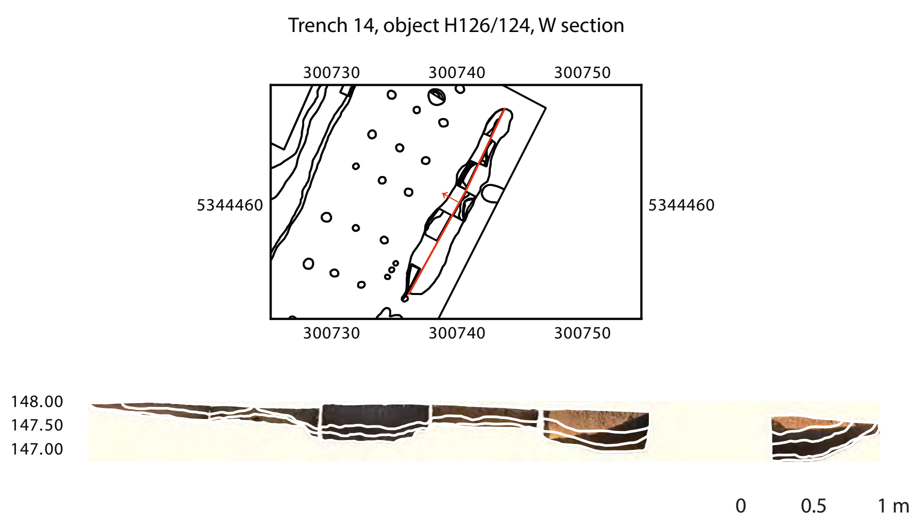

Figure 3.1.50. Plan and section of long pit H126/124.

Other pits

S14/130 was a shallow, slightly trough-shaped pit located to the north of the house. The fill was relatively homogeneous, suggesting a waste disposal function.

Finds

Chipped stone artefacts: 5 obsidian blades and 1 rejuvenation core flake were found in features related to house 126.
Ground stone artefacts: 1 rubbing stone was found in features related to house 126.

Category	Number	Weight (g)
ornamented ceramics	31	523
unornamented ceramics	349	2876
chipped stone	11	37.6
ground stone	1	49
Bone	127	592
Daub	-	12 173

Table 3.1.25. House 126 – summarised find information.

House no.	127
Dating	relative chronology: Želiezovce group absolute chronology: 5050-5000 BCE
Orientation	24.3°
Length in m	13.63
Number of cross rows documented	-
Width between house walls in m	-
Average width of cross rows in m	-
Distance between cross rows (from south to north) in m	-
Long pits	western: H127/157; eastern: H127/144
Postholes	
Other features	beehive-shaped pit: S3/30 (stratigraphically older)
Maximum depth of features from Planum 1 in cm	long pit: H127/157: 87.40, H127/144: 72.00 beehive-shaped pit: S3/30: 97.06
Excavated volume in m³	long pit H127/157: 8.38, H127/144: 10.23

Table 3.1.26. House 127 -contextual, chronological and architectural information.

No postholes were documented, and the long pits were relatively short in comparison to other objects (cf. Fig. 3.1.31). Therefore, H127 was classified as a potential house.

Long pits

Object H127/144 resembled a long pit, but due to the absence of an adjacent house, it was classified as a pit (Fig. 3.1.51). The object was c. 2.5 m wide. The base was trough-like, with an irregular outline along the N-S axis and two deepenings in the southern part.

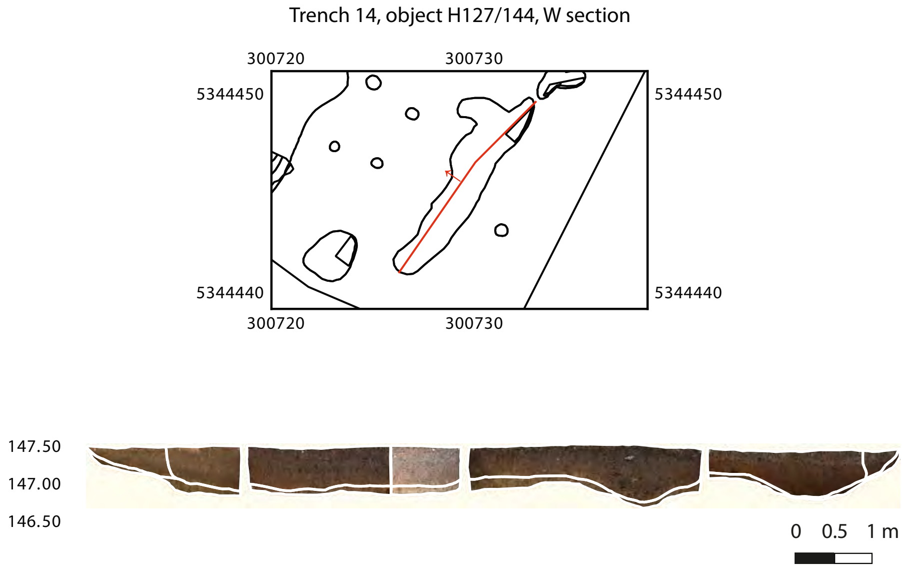

Figure 3.1.51. Plan and section of long pit H127/144.

Object H127/157 was a long pit (western) with a flat base and a stratigraphically later cut in the southern part (Fig. 3.1.52). The object was c. 4 m wide. The cut may indicate a later construction of a beehive-shaped pit.

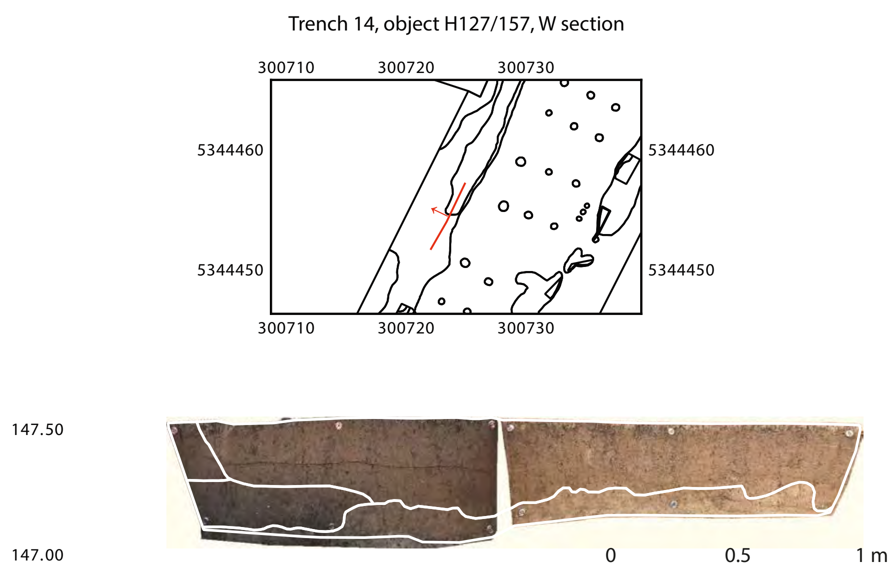

Figure 3.1.52: Plan and section of long pit H127/157.

Other pits

S14/143 was a two-phase, trough-shaped pit located directly to the north of the possible long pit H127/144. The proximity of the two objects suggests they may have had a functional relationship.

Object 127/145 was re-classified as G1/S14: a burial without a clearly discernible grave construction. The absence of the outline is likely linked to the infilling of the grave with the loess extracted during the grave digging. Object H127/144 cut through the grave, removing the lower part of the individual's legs. The footbones of the individual were found in the fill of H127/144.

Finds

Ceramics: 1 ceramic fragment with decorated interior and exterior was found in object H127/144.
Chipped stone artefacts: 1 obsidian blade was found in features related to house 127.
Ground stone artefacts: 2 grinding stones were found in features related to house 127.

Category	Number	Weight (g)
ornamented ceramics	51	1354
unornamented ceramics	777	6232
chipped stone	12	62.9
ground stone	2	1021
Bone	140	532
Daub	-	24 298

Table 3.1.27. House 127 – summarised find information.

Excavation campaign 2017

In 2017, two trenches, one each in two of the entrances to the enclosure, were excavated, as well as two houses located to the north of the main entrance (Fig. 3.1.53).

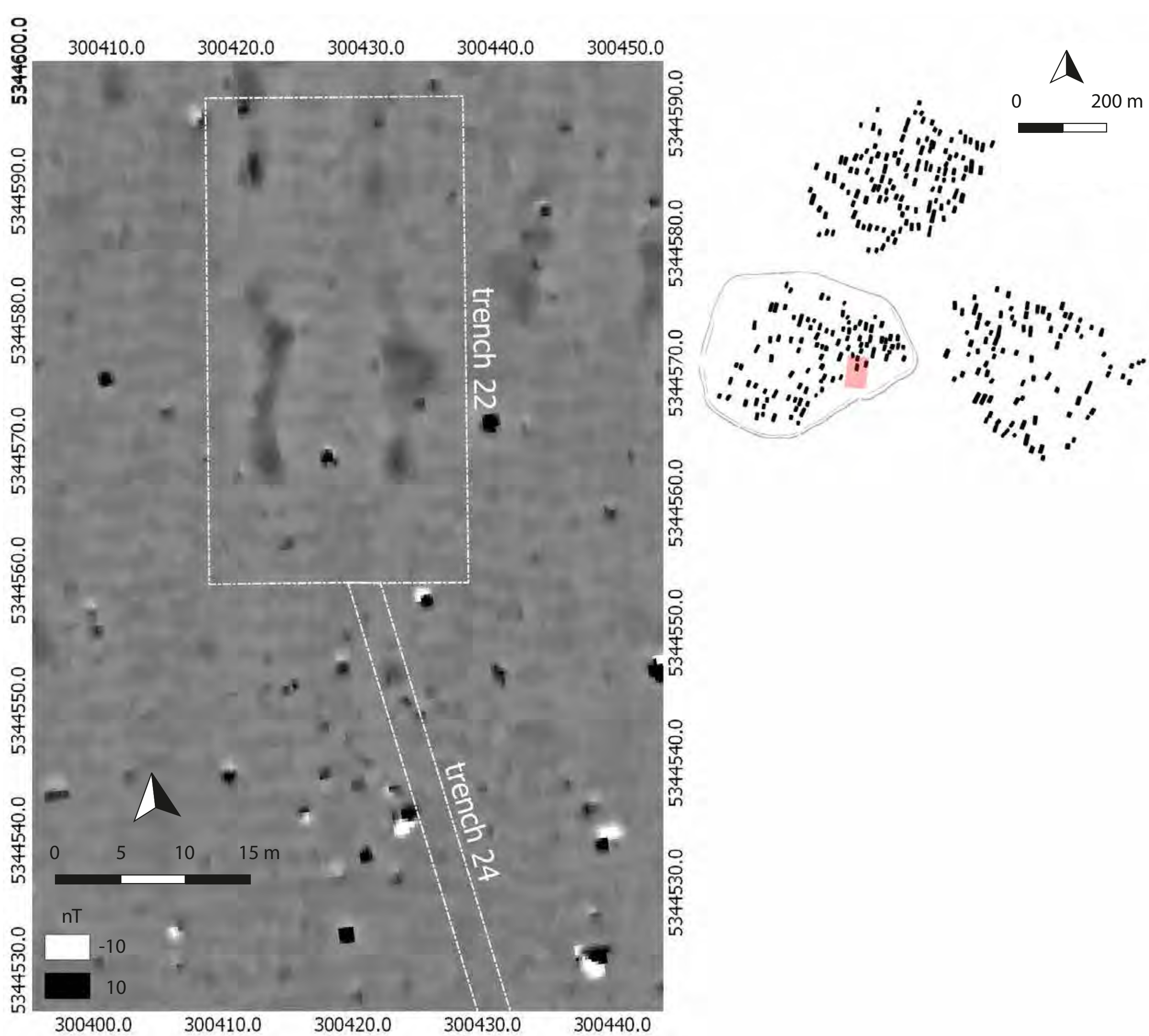

Figure 3.1.53. Overview of the excavation area in 2017.

Trench 22

Trench 22 measured approximately 38×20 m and covered the entire surface of house 23 and the southern part of house 317.

House no.	23
Dating	relative chronology: Želiezovce group absolute chronology: 5050-5000 BCE
Orientation	11.8°
Length in m	17.22
Number of cross rows documented	4
Width between house walls in m	6.64
Average width of cross rows in m	3.17
Distance between cross rows (from south to north) in m	2.76
Long pits	western: H23/102; eastern: H23/103
Postholes	roof-bearing: H23/114, H23/117, H23/118, H23/120, H23/121, H23/128, H23/141
Other features	-
Maximum depth of features from Planum 1 in cm	long pit: H23/102: 75.08, H23/103: 135.70 posthole: H23/114: 30.62, H23/117: 24.04, H23/118: 5.00, H23/120: 29.4, H23/121: 19.05, H23/128: 10.00, H23/141: 34.92
Excavated volume in m^3	long pit H23/102: 1.26, H23/103: 5.57

Table 3.1.28. House 23 -contextual, chronological and architectural information.

All posthole fills were black, with unclear outlines (Fig. 3.1.54). Only 7 were positively verified after profile cuts. Long pits H23/102 and H23/103 were well preserved.

Long pits

Long pit H23/102 had a flat and regular outline, with two cuts in the central and southern parts (Fig. 3.1.55). The southern part was not a younger disturbance but, rather, a deepening related to the formation of the pit. The cross-section showed an irregular and partly flat, trough-shaped structure. The fill was homogeneous, with daub concentrations found only on Planum 1. In the northern part, a burial was found (G11/S22).

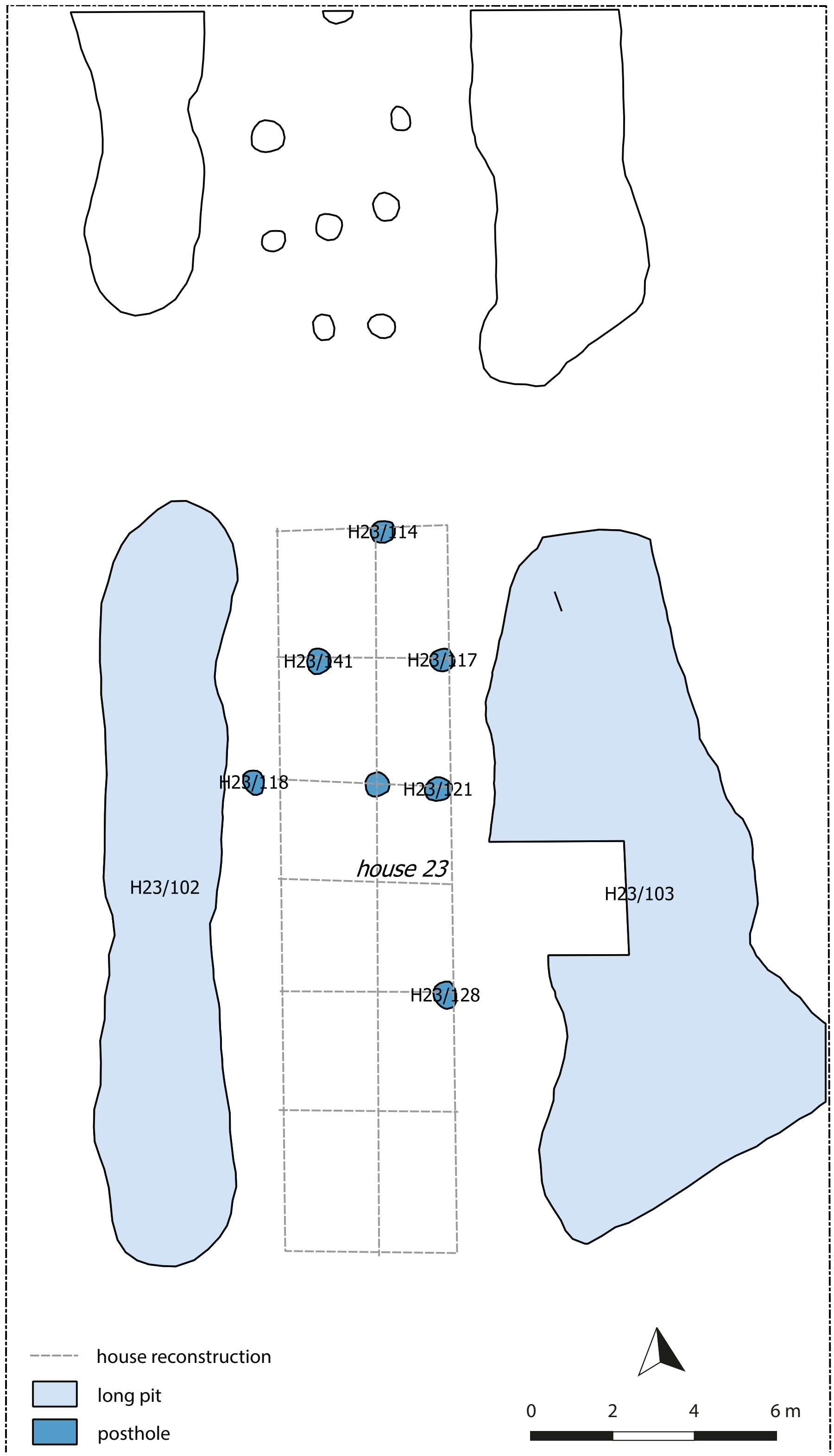

Figure 3.1.54. Planum of house 23.

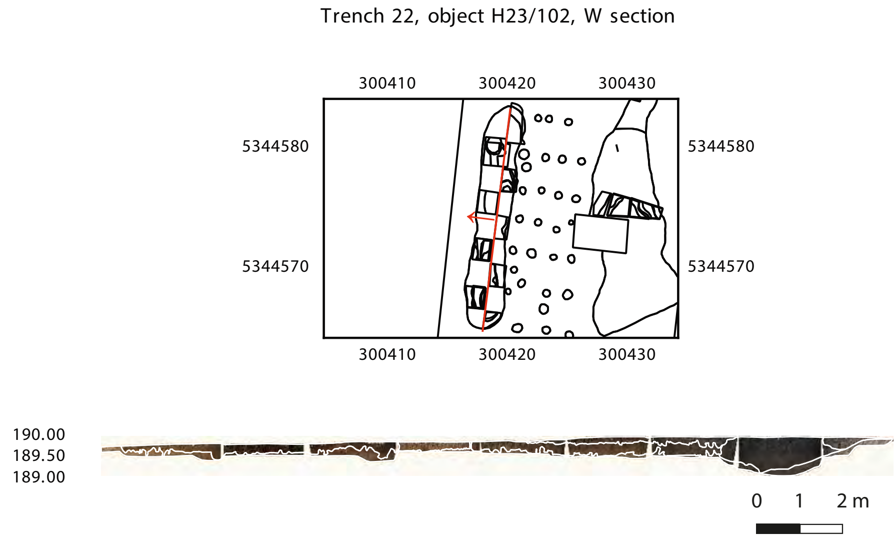

Figure 3.1.55. Plan and section of long pit H23/102.

Long pit H23/103 was slightly curved eastwards (Fig. 3.1.56). The profile was characterised by an irregular shape and a central depression.

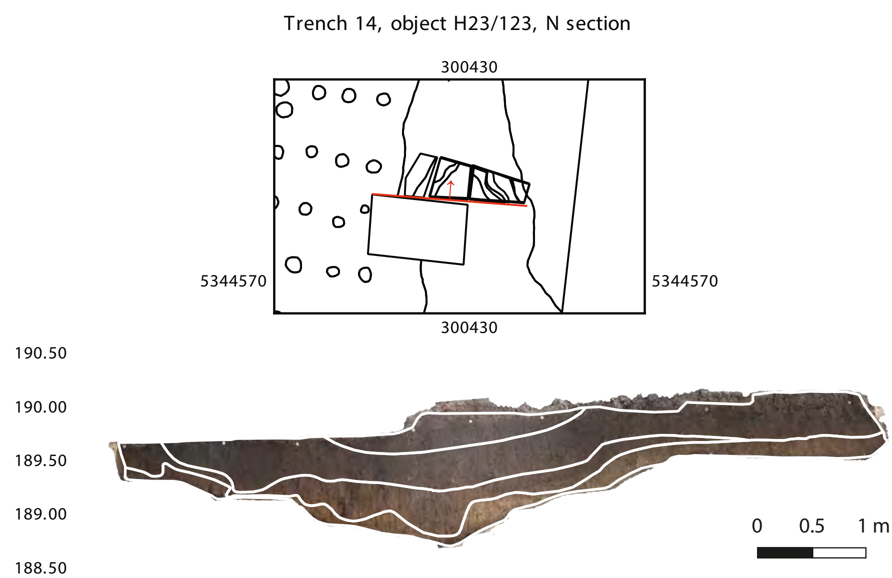

Figure 3.1.56. Plan and section of long pit H23/103.

Finds

Chipped stone artefacts: 1 flake and 1 piece of limnoquarcite were found in features related to house 102.

Category	Number	Weight (g)
ornamented ceramics	271	3514
unornamented ceramics	871	6881
chipped stone	10	29.9
ground stone	5	733
Bone	326	-
Daub	-	30 158

Table 3.1.29. House 123 – summarised find information.

House no.	317
Dating	relative chronology: Želiezovce group absolute chronology: 5050-5000 BCE
Orientation	15.3°
Length in m	19.33
Number of cross rows documented	4
Width between house walls in m	6.67
Average width of cross rows in m	3.69
Distance between cross rows (from south to north) in m	2.04
Long pits	western: H317/100; eastern: H317/101
Postholes	roof-bearing: H317/104, H317/105, H317/106, H317/108, H317/145, H317/146, H317/147, H317/148
Other features	-
Maximum depth of features from Planum 1 in cm	long pit: H317/100: 33.70, H317/101: 33.00 posthole: H317/104: H16.90, 317/105: 5.00, H317/106: 18.87, H317/108: 20.72, H317/145: 15.85, H317/146: 17.68, H317/147: 21.52, H317/148: 5.34
Excavated volume in m³	long pit H317/100: 13.5, H317/101: 8.23

Table 3.1.30. House 317 -contextual, chronological and architectural information.

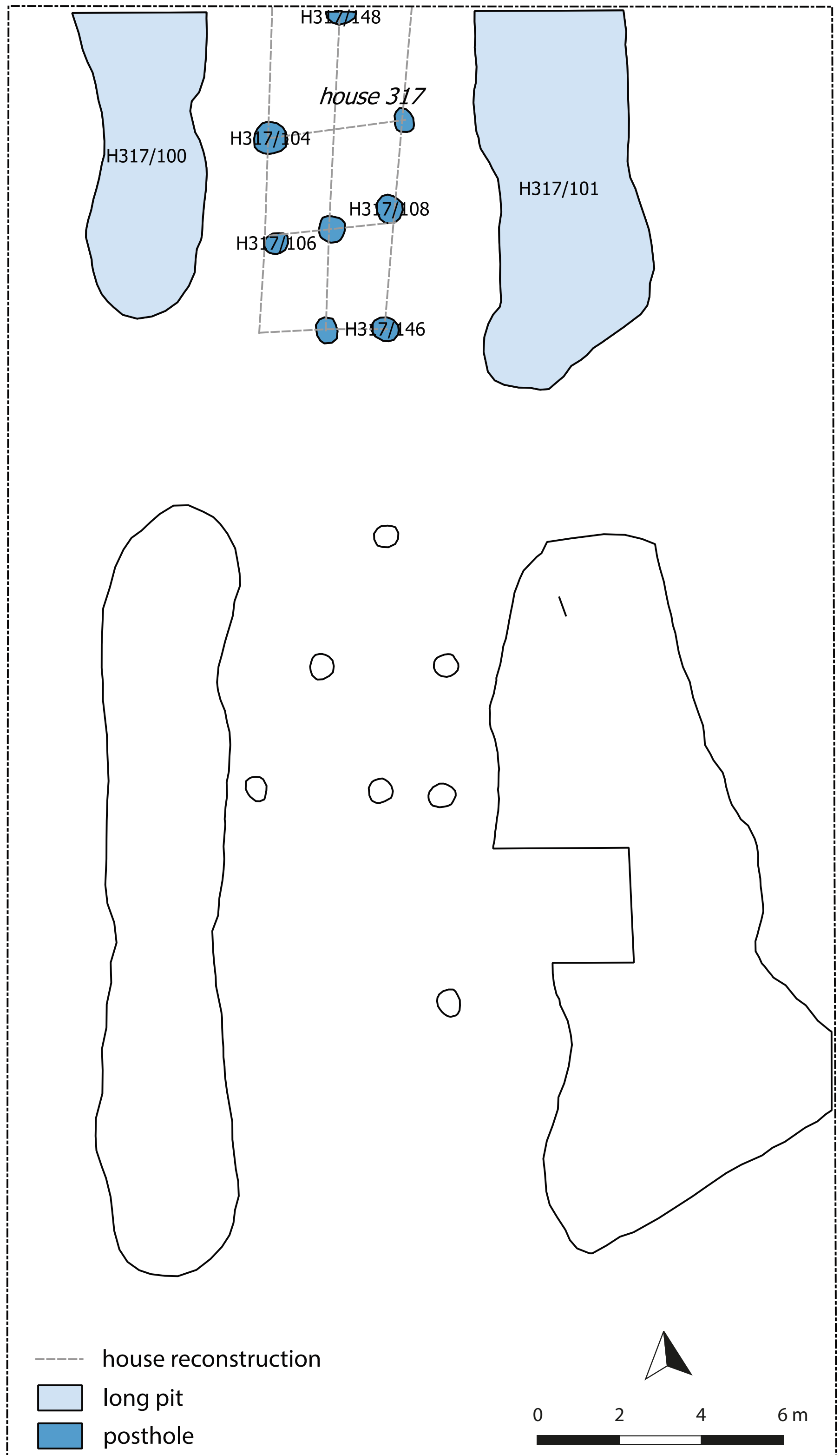

Figure 3.1.57. Planum of house 317.

Only the southern part of the house was documented in Trench 22 (Fig. 3.1.57).

Long pits

Long pit H317/100 (western) had a flat base and had no distinguishable deepening in the profile (Fig. 3.1.58). The cross-sections indicated a flat and slightly trough-shaped base. The fill was homogeneous, and some daub remains were documented in Planum 1.

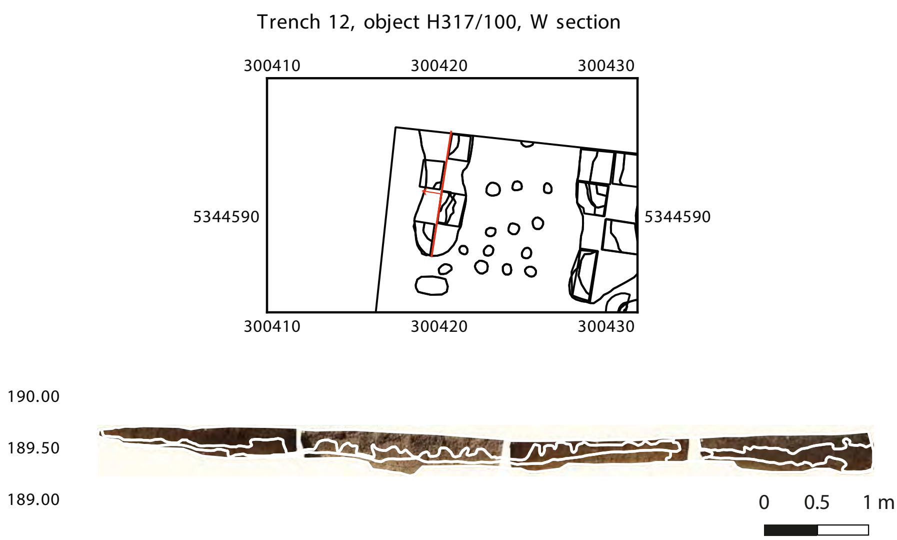

Figure 3.1.58. Plan and section of long pit H317/100.

Long pit H317/101 (eastern) had a flat, slightly irregular outline and no distinguishable deepening (Fig. 3.1.59). The cross-section showed an irregular formation with flat sections and a homogeneous fill.

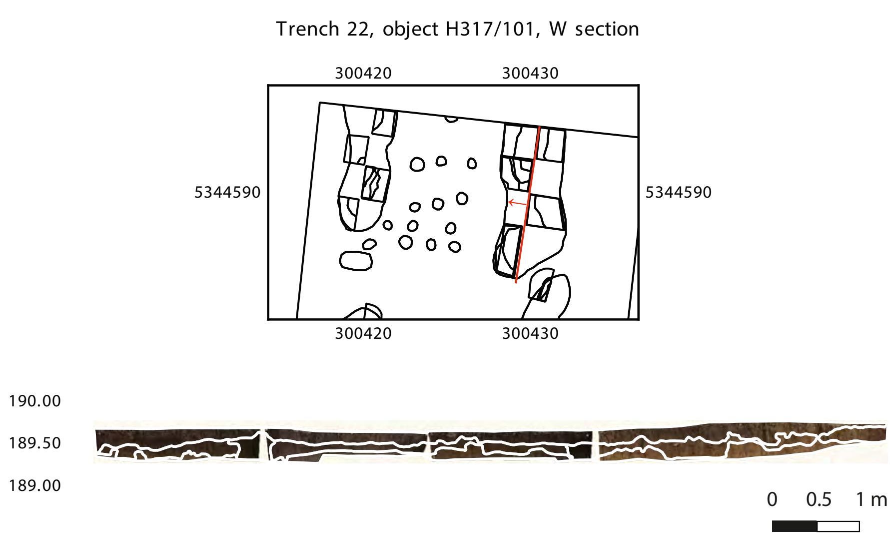

Figure 3.1.59. Plan and section of long pit H317/101.

Finds

Chipped stone artefacts: 1 core, 2 flakes, 2, blades, 2 pieces of limnoquarcite, 2 pieces of white, matt flints, and 1 piece of greenish grey flint were found in features related to house 317.
Ground stone artefacts: 4 grinding stones were found in the long pits of house 317.

Category	Number	Weight (g)
ornamented ceramics	39	824
unornamented ceramics	306	2664
chipped stone	11	159.9
ground stone	4	2087
bone	-	-
daub	-	3702

Table 3.1.31. House 317 – summarised find information.

The enclosure

Already on the magnetic plan, the enclosure encircling the southwestern neighbourhood is a very distinctive feature. From the interpretation of the magnetic anomalies, it seems that there were seven openings, of which three are very visible (see Chapter 2.1).

While the ditches had already been cross-sectioned by a small trench in 2010 (Furholt *et al.* 2014), two of the three clear entrances were partly excavated in 2017 to clarify their structure and their chronological relationship (Fig. 3.1.60). Unexpectedly, within the ditch and around the ditch entrances, a large number of human remains were found. For these, the reader is referred to Chapter 3.2.

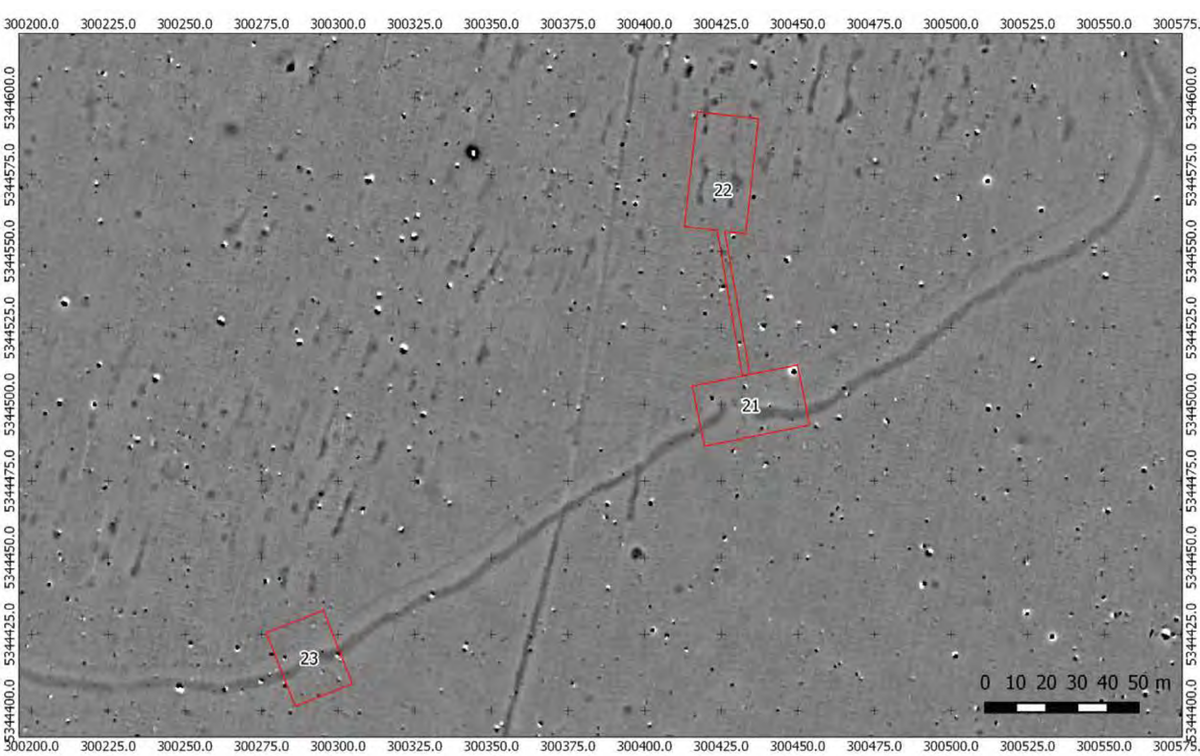

Figure 3.1.60. Overview of the excavated areas of the 2017 campaign. Trench 21 focussed on the supposed main entrance, Trench 23 on the next entrance to the west.

The main entrance

The largest entrance according to the magnetic plan was the one located in the south-eastern part of the enclosure. It stands out because both ends of the outer ditch clearly curve inwards. The ditch segment at the eastern side of the entrance curves in so much that the entrance itself is oriented in a south-westerly direction (going out), instead of a south-easterly direction, as it would have without the irregular curve. This is significant, as is supports the argument that all entrances detected actually lead away from the other two neighbourhoods, instead of facilitating contacts between the inhabitants of the Vráble 'Veľké Lehemby'/'Farské' settlement. While constructing the enclosures, the people involved probably made the conscious decision to re-orient this entrance away from the south-eastern neighbourhood. The magnetic plan also clearly shows a smaller, inner ditch that largely runs parallel to the large ditch, and, as shown in Chapter 2.1, there are also indications of an even smaller third linear anomaly, which is only visible in some sections of the enclosure and only when the resolution of the plan is increased. Also, in the entrance area, a number of smaller anomalies were detected in the magnetic plan.

Excavation area 21 covered this main entrance and a few metres of the ditches on both sides. In addition, the area to the north, inside the enclosure, was uncovered in order to explore the structure of the inner ditches. The excavation of area 21 confirmed all anomalies visible in the magnetic plan and added some others.

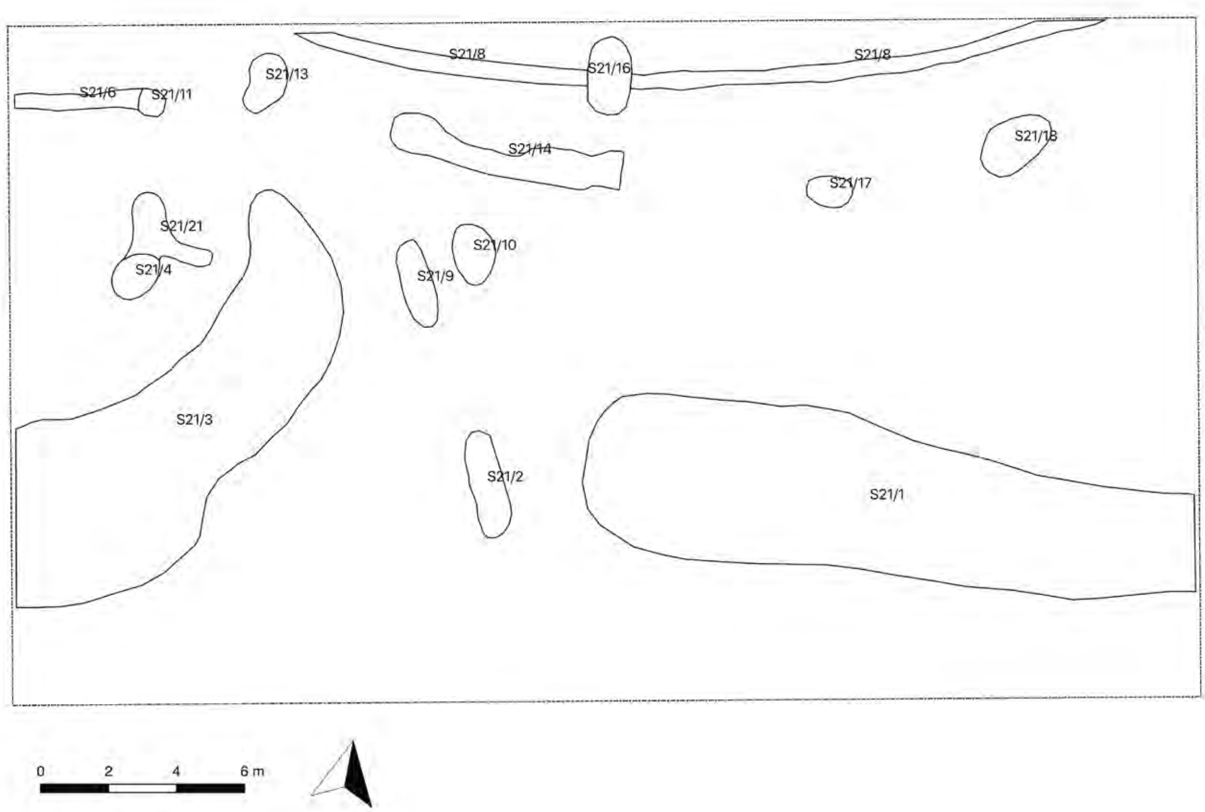

Figure 3.1.61. Planum of area 21 with the relevant archaeological objects.

The outer ditch (objects S21/1, S21/3) is 2.6-4 m and 1.0-1.5 m deep when measured from the modern surface (Fig. 3.1.62). It is filled with a dark brown fill, which makes it easily detectable against the background of the natural loess. Most of the profile section of both branches of the ditch clearly showed that there are at least two ditch phases, as had already been proven by the 2010 campaign (Furholt *et al.* 2014, 234). The older one is more U-shaped, and the fill is not homogenous. This fill was recut with a V-shaped one, which was later in-filled with a more homogeneous sediment, which resulted in the destruction of the older ditch phase. As the older period is only preserved in the edges of the upper part of the ditch, we could not collect any datable materials from this first phase. There are, however, no indications of a long period between the two enclosure phases.

The second (inner) ditch was not as well preserved. In the wall of the trench, it was faintly visible as a brownish feature measuring 1.5 m wide and only 0.7 m deep below the modern surface, with the bottom at 189.95 m a.s.l. (Fig. 3.1.63). In the supposed course of the ditch, several objects were recorded that did not form a continuous structure (objects S21/6, S21/11, S21/13, S21/14, S21/17, S21/18). We interpret these as remnants of an originally continuous ditch with uneven depths, the lowest parts of which we found in Planum 1. This is indicated by the magnetic plan, which shows a continuous ditch also in the eastern part, which was only preserved in the brunification layer, so that it was not visible in the profile of excavation area 21. It is possible that the three distinct, pit-like structures in this eastern part of the inner ditch indicate a different construction technique, namely, a pit alignment instead of a continuously dug ditch. But if that is indeed the case, it would differ from the evidence recorded on the western side, where a continuous ditch was recorded. However, it may also be that especially objects S21/17 and S21/18 represent spatially constrained recuttings, as their fill was very distinct, having inclusions of many stones and animal bones.

The two ditches described so far were also detected in the small, 2 m wide cut through the ditch excavated in 2010 (Furholt *et al.* 2014, 234 figs. 6-8). In the publication of the 2010 campaign, the authors discuss the possibility that the inner ditch may have represented a palisade, a possibility which can now be discarded because, following the 2017 work at the site, we can, with some probability, identify a palisade running parallel to and north of these two ditches. This was detected 2 m to the north of the second, inner ditch, where it was visible as a 40 cm wide continuous feature, preserved to a depth of just 5 cm deep into Planum 1, if at all. In the trench wall, its bottom was at 190.05 m a.s.l., about 55 cm below the modern surface (Fig. 3.1.64). We cut this ditch at several places, but due to the shallow depth to which it was preserved, a palisade structure could not be clearly confirmed. This was only achieved in excavation area 23 (see below). All in all, the interpretation of the third, inner-most ditch as a palisade ditch is one of high probability, without being ultimately confirmed.

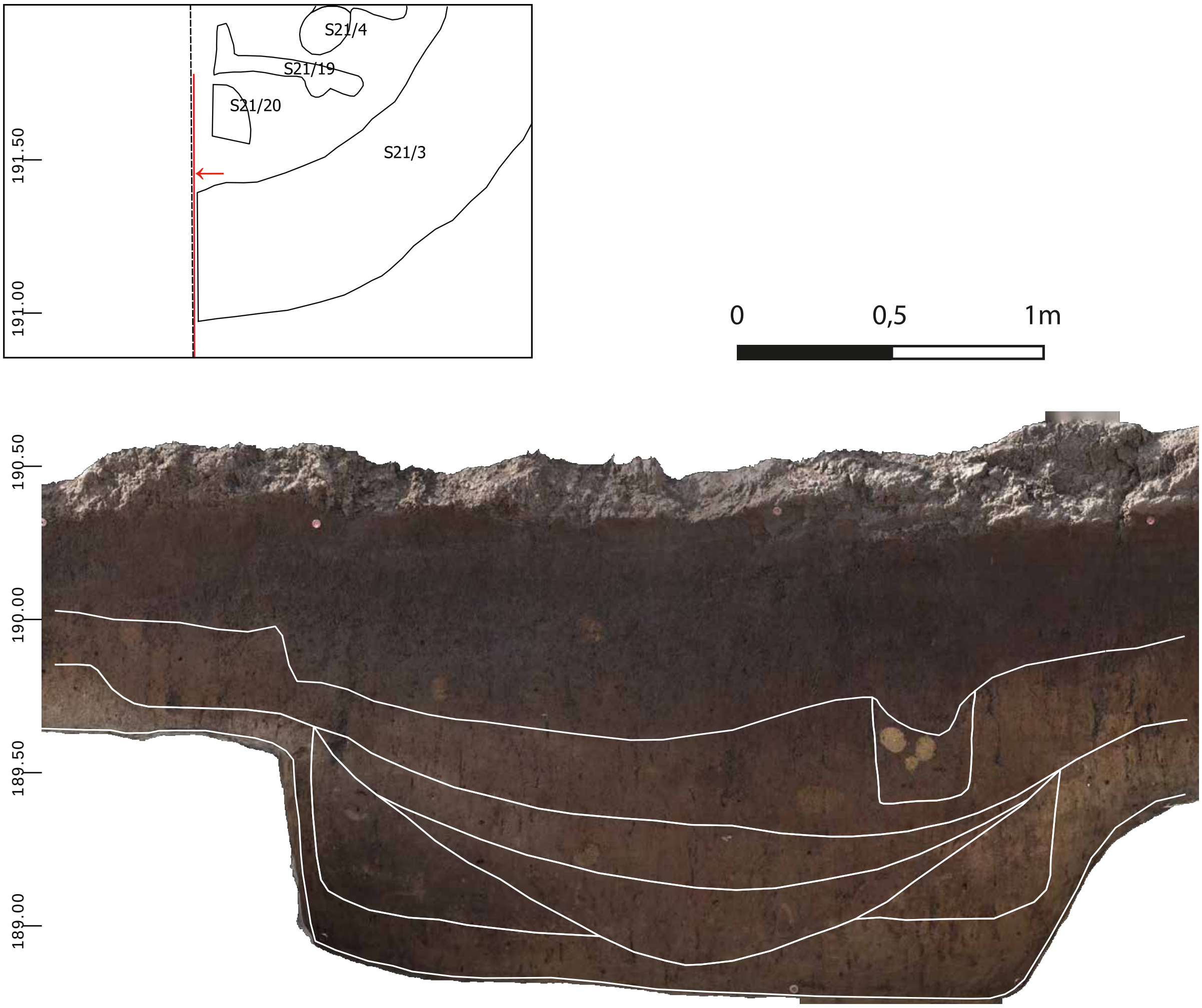

Figure 3.1.62. Profile section of the outer ditch (object S21/3). The red line marks the location of the profile; the arrow marks the viewing angle.

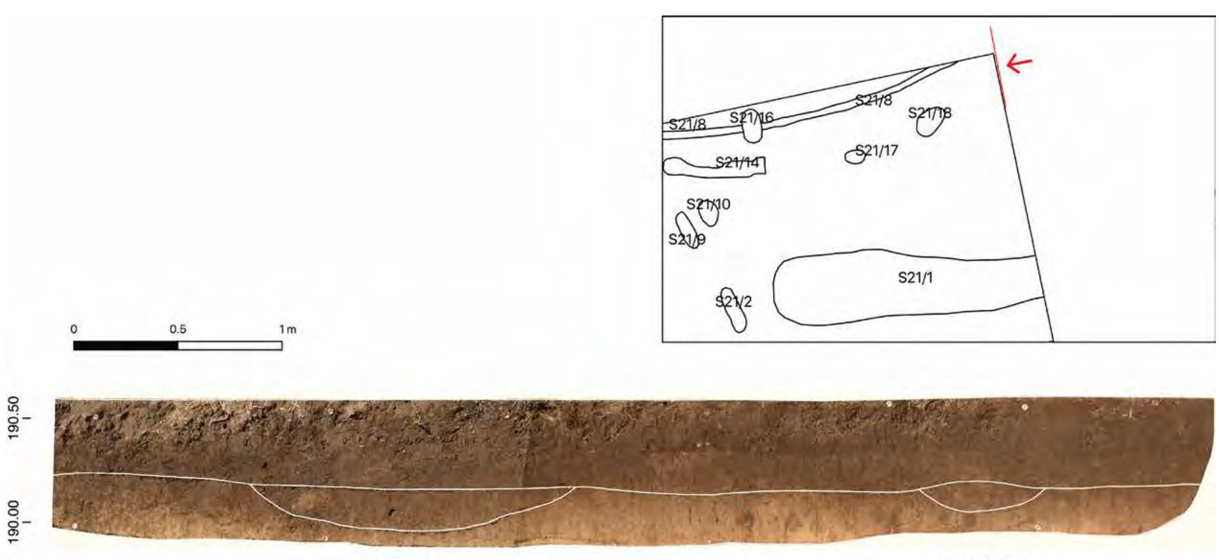

Figure 3.1.63. Profile section of the inner ditch and the palisade ditch. The red line marks the location of the profile; the arrow marks the viewing angle.

In the centre of the entrance, two narrow, elongated pits were found, closely aligned south-south-east-north-north-west, at a distance of about 3.3 m. They measured 3.0×1.0 m (object S21/2) and 2.6×0.9 m (object S21/9) on Planum 1, respectively. However, they narrowed considerably only 20 cm below, to a width of only 30-40 cm and stayed this wide to the bottom. For S21/2, the end was reached at 189.0 m a.s.l., 0.9 m below Planum 1 and 1.5 m below the modern surface. For S21/9, the bottom was even found only at 188.5 m a.s.l., that is, 1.4 m below Planum 1 and 2.1 m below the modern surface. They were virtually devoid of finds, and showed a brown fill with loessy inclusions, as if they had filled quickly and deliberately, by means of human intervention. These kinds of pits, termed *Schlitzgruben* (literally slotted pits, also referred to as V-shaped pits) are often encountered in LBK settlements (Lenneis 2013), and they have been interpreted in different ways. However, in the case of Vráble 'Veľké Lehemby'/'Farské', their position and alignment in the centre of the entrance make it very likely that they represent architectural features immediately connected with the entrance situation (Fig. 3.1.60). Our interpretation is one of two narrow lines of posts, or small walls, connected to some kind of gate construction. This is reinforced by the finding of a similar arrangement in the second entrance area excavated (in excavation area 23; see below). It seems that they channelled traffic through the entrance, with the main gap allowing access from the south-west and thus reinforcing the impression that the main focus of this entrance was away from the south-eastern neighbourhood.

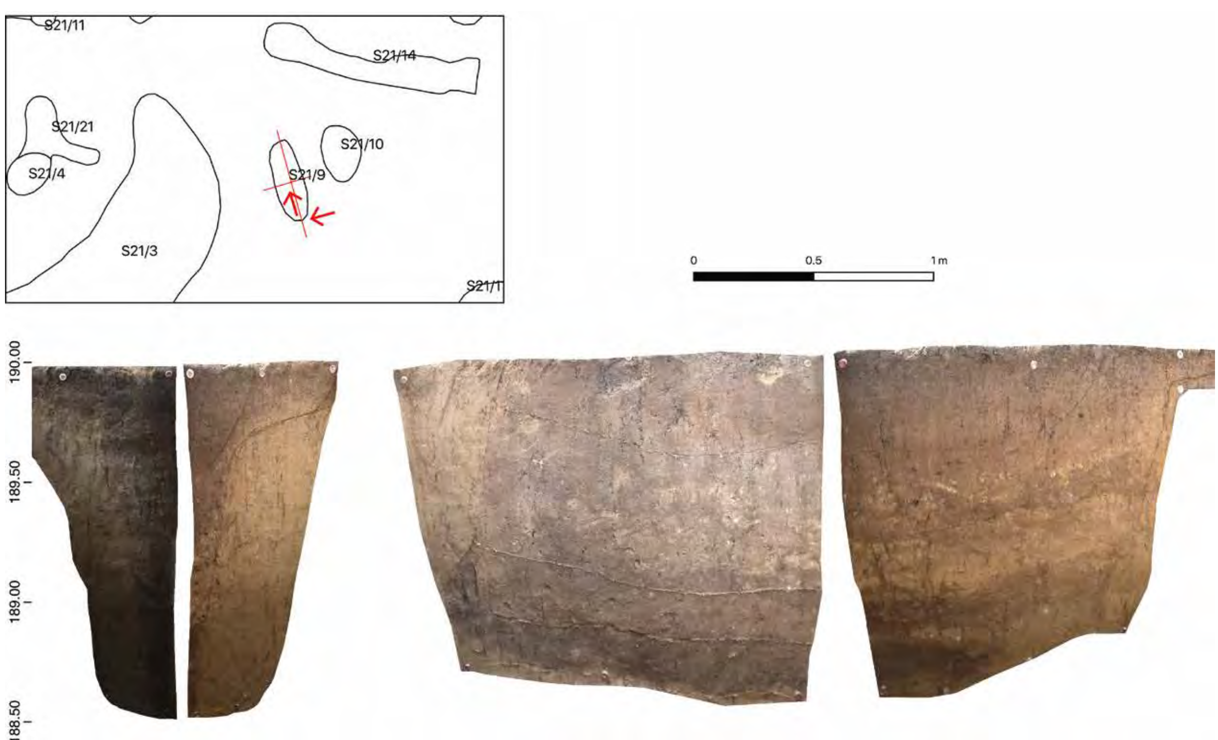

Figure 3.1.64. Profile sections of the Schlitzgruben object S21/9. The red line marks the location of the profile; the arrow marks the viewing angle.

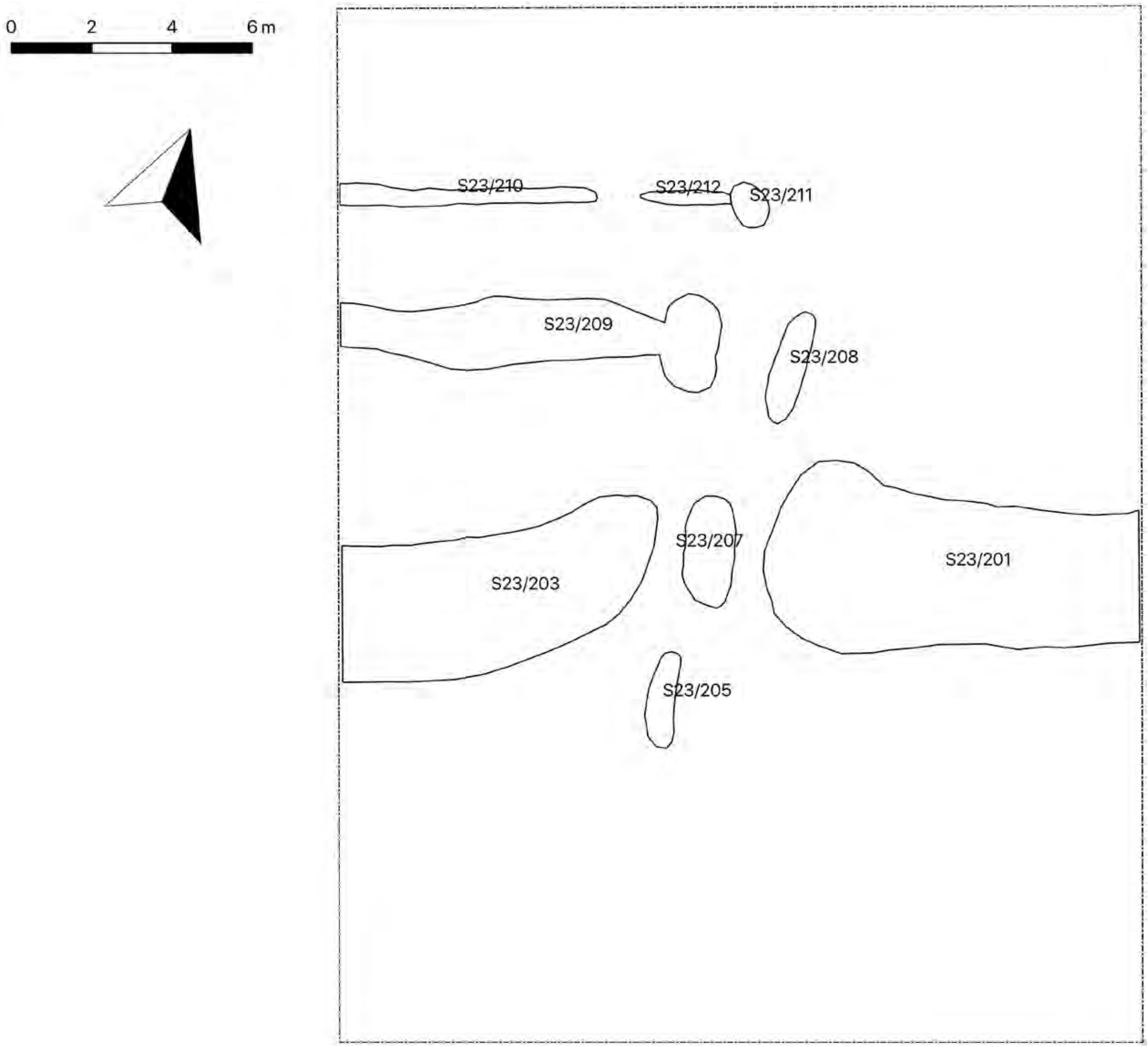

Figure 3.1.65. Planum of area 23 with the main archaeological objects. Object S23/201, a section of the outer ditch, was not excavated.

Within the western ditch segment (Object S21/3) and along both of its sides, a number of human burials and depositions of human bones were found (see Chapter 3.2). One burial (G10/S21) cut through the inner palisade ditch, making the case for a chronological succession of these features. Indeed, as several of the burials are clearly oriented along the outer ditch, four were found in the fill of the outer ditch, and one was found in the fill of the inner ditch (G9/S21), and they all produced more or less the same ^{14}C ages (see Chapter 4.2), there is the possibility that the palisade actually represents a different phase than the two outer ditches. This would be supported by the lack of parallelism between the palisade, on the one hand, and the two ditches, on the other. In the ditch section to the east of this main entrance, there were no regular burials, but there were a number of human bones possibly belonging to one individual (I15/S21).

The second entrance

At 160 metres to the west-south-west of the main entrance, a second entrance to the enclosed area of the south-western neighbourhood was excavated in 2017, labelled excavation area 23 (Fig. 3.1.65). The features encounter here very much mirror the

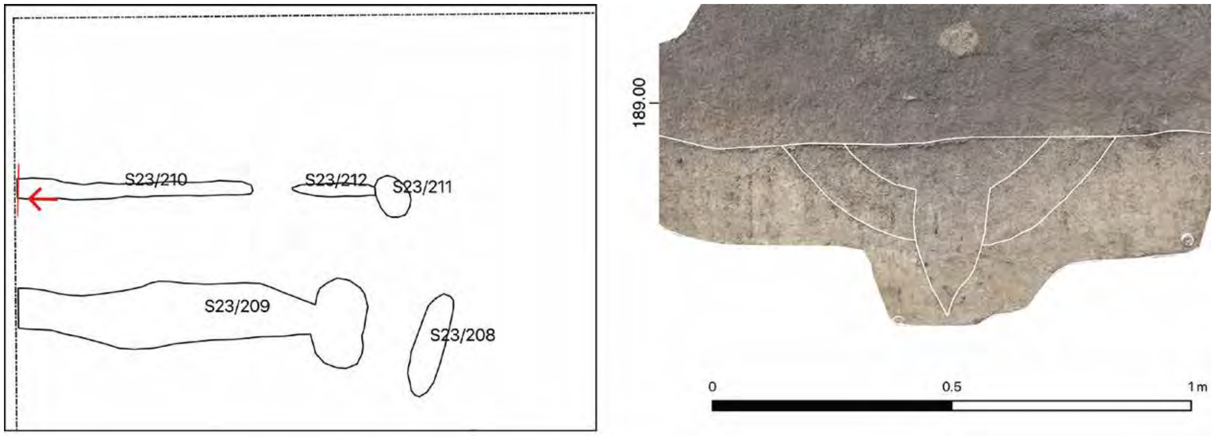

Figure 3.1.66. Profile section of the palisade ditch object S23/210. The red line marks the location of the profile; the arrow marks the viewing angle.

situation encountered in area 21. Because of time constraints, only the objects in the western half of the trench were excavated.

In the outer ditch (object S23/203), we can again see two ditch phases, an older one, with steeper wall, which is then later cut by the younger one, with less steep walls. The outer ditch has the same dimensions, with a width of about 3 m and a depth of 1.7 m below the modern surface. Like in area 21, the ditch segment contained the depositions of two headless individuals (G11/S23, G12/S23) on the bottom of the fill of the second phase and above additional human bones (I16/S23).

In the centre of the entrance, three *Schlitzgruben* (objects S23/205, S23/207, S23/208) were encountered, again being devoid of any finds. They were not as closely aligned as those in Trench 21, but they had similar dimensions (length×width×depth below modern surface: S23/205: 2.4×0.4×1.6 m; S23/207: 2.7×0.4×2.0 m; S23/208: 2.4×0.4(?)×1.5 m).

At 4 m north of the main, outer ditch, we again encountered the second, smaller ditch (object S23/209). This time, it was only preserved in the western part of area 23. It contained a number of human bones, but no complete burials (I17/S23).

The third, innermost ditch (objects S23/210-212) was again only 0.3 m wide and also only preserved in the western part of the excavation area (Fig. 3.1.66). In the western profile of the trench wall, we documented the discolouration left by a now-decayed pointed post, largely confirming the palisade interpretation of this inner structure.

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3.2. The burials and human remains from the LBK and Želiezovce settlement site of Vráble

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Abstract

All three neighbourhoods at the Neolithic site of Vráble 'Veľké Lehemby'/'Farské' (Nitriansky kraj, Slovakia) yielded human remains. The largest number was discovered in the 2017 campaign, which centred on two of the entrances through the enclosure around the south-western area. The assemblage comprises the remains of at least 19 individuals. While some of the skeletons lay on their side, either right or left, with hands in front of the face or in the lap, a large variety of other modes of treatment were present as well. Two individuals were found in long pits of houses, and ten individuals were deposited in ditch sections. Perimortem damage detected on the skeletal remains was most probably a result of post-mortem manipulation of the bodies shortly after death, either by small animals or by humans. This suggests that the bodies were probably left uncovered for a short period of time or placed in a shallow pit and buried under a thin covering layer (earth, shrouds, etc.). From at least three individuals, the head had been removed some time after deposition. Except for elderly individuals, all adult age categories are represented in the sample, with the prevalence of prime-aged individuals (25-35 years). Interpersonal violence is indicated by one case of healed cranial trauma. Other traumas are associable with either accidents or interpersonal violence. Palaeopathological and stable isotope analyses suggest that the special treatment of the individuals found in irregular positions may be connected with their social status.

Keywords: LBK, burial rites, osteoarchaeology, height estimates, palaeopathology, stable isotope analysis

Introduction

In the course of the 2017 excavation campaign, which targeted two of the entrances of the enclosure encircling the south-western neighbourhood of the Vráble 'Veľké Lehemby'/'Farské' settlement, single human bones and complete human skeletons were encountered. This was true for Trench 21, aiming at the most prominent entrance in the south, and also for Trench 23, targeting the next entrance c. 150 m to the west. In these two areas, the remains of at least 16 individuals were found. One further individual was excavated in that same year in the western long pit of one house in the south-western neighbourhood. In 2016, one individual had already been encountered in the long pit of a house in the south-eastern neighbourhood, and in 2014, a human skull fragment had been found in the northern neighbourhood. Thus, so far, we have found the remains of at least 19 human individuals. Without extensive aDNA evidence, this number can only be approximate because we cannot exclude that bones found at a considerable distance from each other belong to the same individual or that disarticulated bones found close together stem from different individuals.

Because most of the supposed burial pits of the regular burials – with the notable exception of G8/S21 – were not visible on Planum 1, search trenches running parallel to the ditch were dug with the aid of a small digging machine, one in Trench 21 and two in Trench 23. Because they yielded no further human remains, it is almost certain that no other burials were present in those two trenches.

In this chapter, we first describe the archaeological context of the human remains and accompanying finds catalogue-wise, and we then give an overview of the anthropological findings. For the general context of the enclosure and its entrances, the reader is referred to Chapter 3.1 and for more detailed discussions of the ceramic and stone finds to Chapters 5.1 and 5.2, respectively. For each individual, a table below the text pertaining to that individual lists basic information. This includes, among others, the ^{14}C dates. For an evaluation of their significance, the reader is referred to Chapter 4.2. For the dates processed in the laboratory in Poznan, $\delta^{15}N$ and $\delta^{13}C$ stable isotope data are available, which are also listed in the individual tables. The chapter closes with considerations on the nature of the burial practices at Vráble, putting them in the wider Linearbandkeramik (LBK) context. Preliminary results on the human burials are also about to be published elsewhere (Müller-Scheeßel et al. 2016; Müller-Scheeßel et al. accepted).

Catalogue of burials and human remains

G1/S14 (Fig. 3.2.1)

In Trench 14, at the border of object H127/144, the eastern long pit of house 127, a human skeleton was discovered. Parts of the skull were visible already in Planum 1, at 147.5 m a.s.l. The lowest bones lying in situ where found at 147.2 m a.s.l., thus 30 cm lower. Dislocated human bones were even found 30 cm deeper down in the pit fill. It was not possible to detect any traces of a burial pit fill. Thus, either the long pit extended further and enclosed the body, or the pit for the burial was dug into it. Either way, the fill must have been composed of loess, which could not be distinguished from the loess of the surroundings.

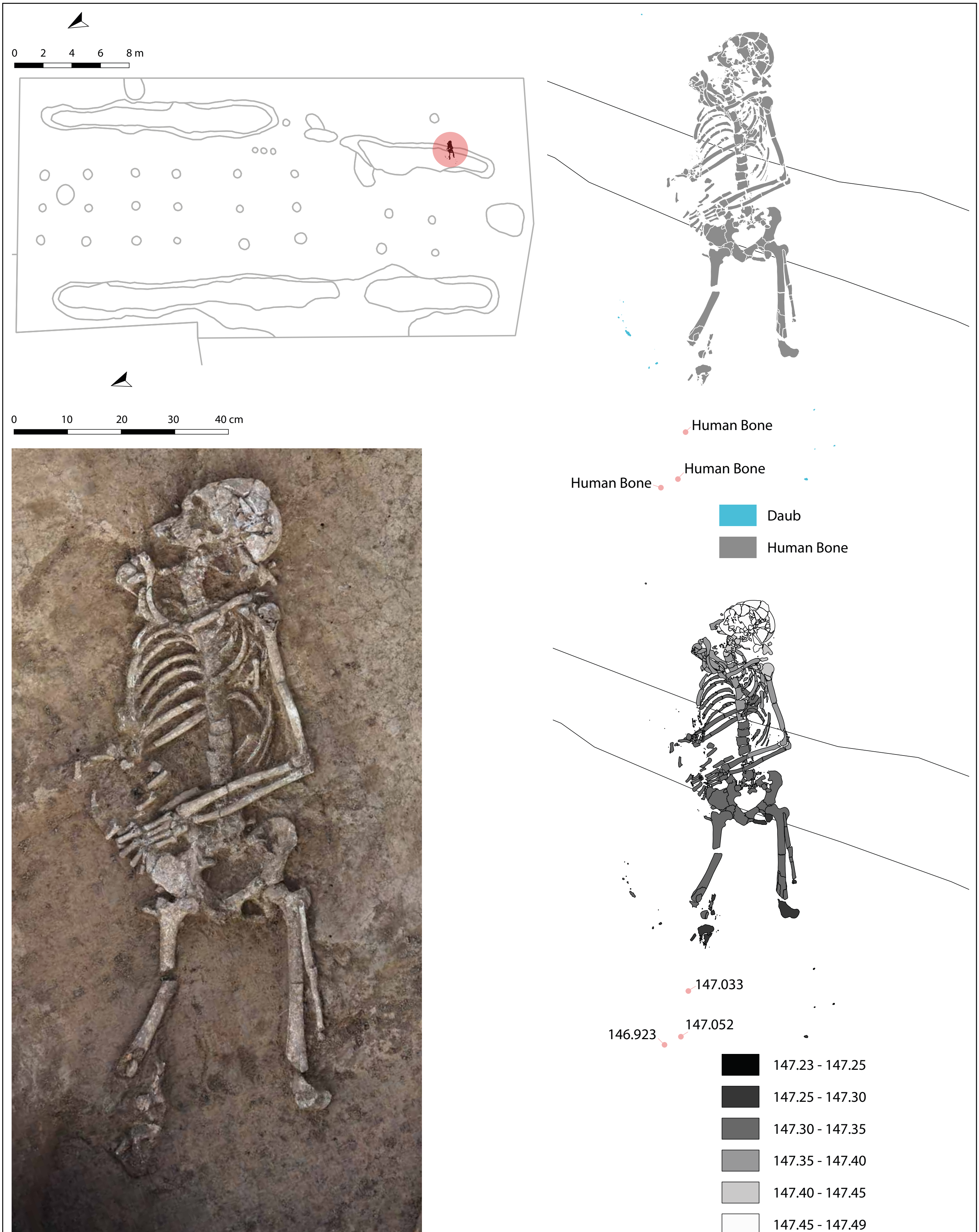
Both legs were destroyed from the knee downwards. The condyle of the left femur was broken and turned upside down; the tibia and the patella had been displaced and were lying on the right side of the skeleton; the right tibia was incomplete. The fact that the left fibula was found immediately to the left of the left femur, lying parallel to it, is intriguing. The absence of foot bones implies that the fibula was placed there after the destruction of the lower legs. This would have been possible only when the soft tissue on the lower leg had already largely decomposed. When the rest of the pit fill was excavated, more human bones were found that probably belong to the feet of this individual.

The skeleton lay on its back, with the axis of the spine oriented east-south-east-west-north-west and with the head pointing to the east. The head was strongly arched back, while the right arm lay beneath the upper body, with the right hand placed close to the right pelvic bone. The position of the right arm likely would only have been possible after the ligaments had at least partly decomposed. The left hand was well preserved. The phalanges pointed inwards, which gave the impression that the hand was formed into a fist, but this could also be due to the decomposition process. The right hand was heavily disturbed. Phalanges belonging to it were also found in the chest and even inside the skull. This suggests that an animal burrowed through the part of the burial where the upper body lay. Some of the bones also exhibited traces of animal gnawing.

Small pieces of daub belong to the fill of the pit; they are not burial goods.

Burial goods	-
Sex	male?
Age	20-34
Pathologies	healed cranial trauma posteriorly on the parietals; Schmorl's node on C2 + C3; perimortem fractures to bones; signs of animal gnawing
^{14}C	Poz-87474 (cranial bone): 6060 ± 35 Poz-87473 (rib): 5960 ± 40
$\delta^{15}N$	-
$\delta^{13}C$	-

Figure 3.2.1 (right). G1/S14. Top left: location in Trench 14; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.


0 2 4 6 8 m
0 10 20 30 40 cm
Human Bone
Human Bone
Human Bone
Daub
Human Bone
147.033
147.052
146.923
147.23 - 147.25
147.25 - 147.30
147.30 - 147.35
147.35 - 147.40
147.40 - 147.45
147.45 - 147.49

G2/S21 (Fig. 3.2.2)

On the border of the eastern branch of the outer ditch (object 3), immediately beneath Planum 1, at about 189.9 m a.s.l., human bones were encountered, partly still in anatomical position, partly disturbed. A burial pit was not discernible, as the skeleton was lying in the brownish leaching of the topsoil. However, by projecting the bones and finds in the adjacent profile, it became clear that the individual was not buried in the ditch fill (Fig. 3.2.3), but, rather, on the bank of the ditch. The maximum difference in depth between the uppermost and lowermost remains is about 25 cm.

The skeleton is fairly complete; the skull is represented only by the lower jaw and a few fragments. It seems possible that the missing parts still remain in the trench wall. Some of the bones, especially those from the upper part of the skeleton, show signs of animal gnawing.

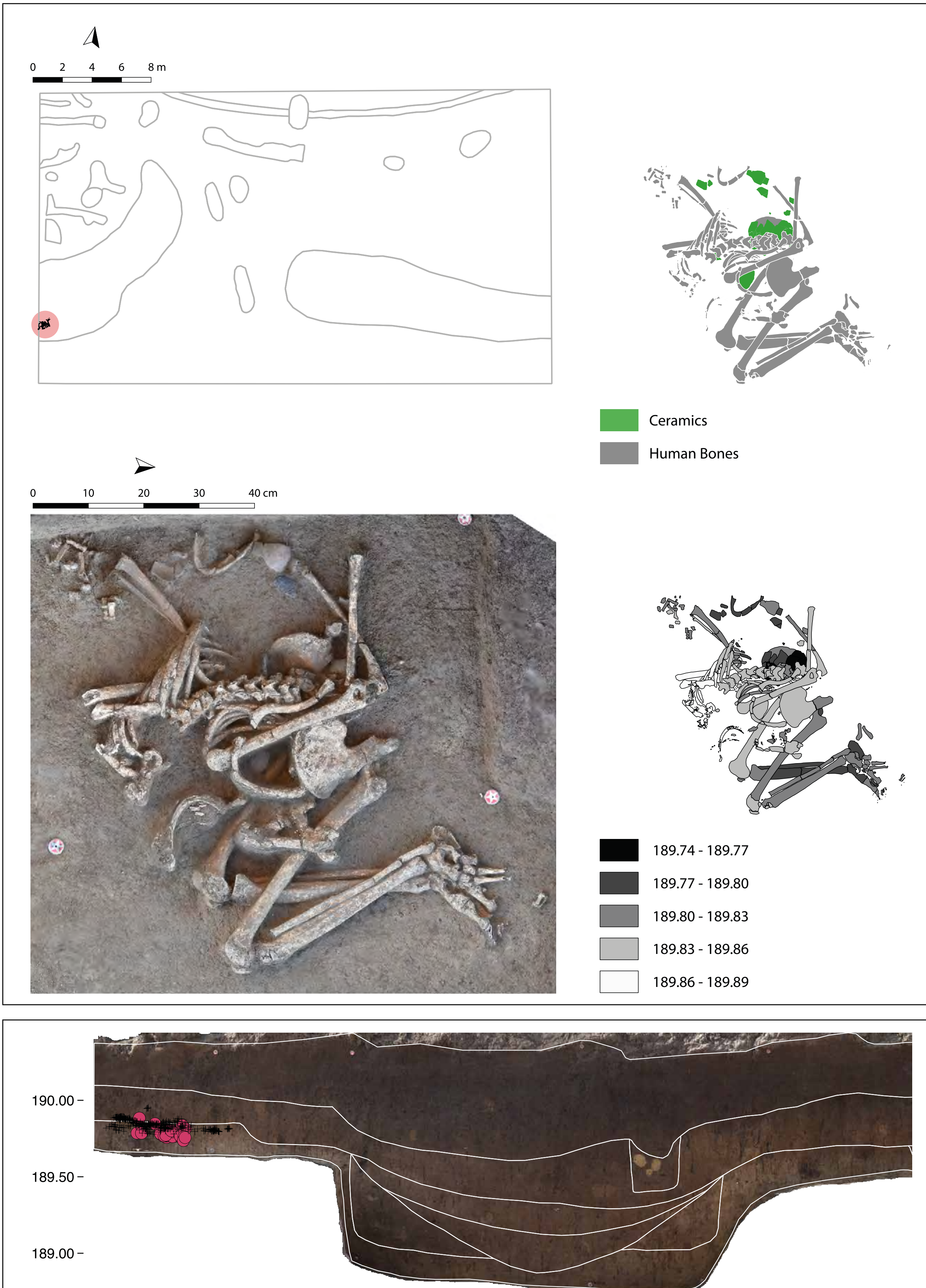
Most of the bones were still in articulation; however, it was obvious that only the lower limbs, including the hips and the right forearm, were still in the position where they once had been buried. From that, it seems that the individual was deposited on its right side, in a crouched position, with the head pointing to the south-west. Compared with this position, and taking into account the location of the lower arms with the finger bones still in situ, it follows that the entire upper body must have been moved to the east, e.g., the shoulder girdles by about 50 cm. The left scapula, lying on the femora, was displaced even farther. Because most of vertebrae and long bones are still in anatomical position, this dislocation of the upper body must have taken place not too long after deposition. However, the physiologically impossible arrangement of the left arm and the fact that the lower jaw is still at the approximate original position of the skull point to a time window when the ligaments holding the bones together were already partly severed or weakened.

Partly on the same level as the human bones, but partly also clearly beneath them (on Fig. 3.2.2 this is also true for the sherds shown for visibility reasons above the pelvis), a lot of ceramic sherds were found. The reconstruction showed that they belong to two vessels.

Burial goods	2 small, undecorated, biconical pots, only one of them more or less complete (Pl. 3.2.1,1-2)
Sex	male
Age	25-34
Pathologies	cranial porosity (esp. occipital bone) ilium with signs of reduced bone density; perimortem fractures to bones; signs of animal gnawing, especially on upper part of the skeleton
^{14}C	KIA-52446 (cranial bone): 6060 ± 24 Poz-98358 (rib): 6090 ± 40
$\delta^{15}N$	11.0
$\delta^{13}C$	−19.7

Figure 3.2.2 (top right). G2/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.

Figure 3.2.3 (below right). G2/S21. Human bones (crosses) and ceramic sherds (circles) projected in the adjacent west profile of the ditch (quadrants 23 and 24).


0 2 4 6 8 m
Ceramics
Human Bones
0 10 20 30 40 cm
189.74 - 189.77
189.77 - 189.80
189.80 - 189.83
189.83 - 189.86
189.86 - 189.89
190.00 –
189.50 –
189.00 –

G3/S21 (Fig. 3.2.4)

On the border of the eastern branch of the outer ditch (object 3), but 5 m north-west of G2/S21, immediately beneath Planum 1, at about 190.0 m a.s.l., a human skeleton in anatomical position was encountered. A burial pit was not discernible, as the skeleton was lying in the brownish leaching of the topsoil. However, by projecting the bones and finds in the adjacent profile, it becomes clear that the individual, similarly to G2/S21, was not buried in the ditch fill (Fig. 3.2.5), but on the bank of the ditch. The maximum difference in depth is little more than 10 cm.

Apart from the damage done by the excavation machine to the skull and legs, the skeleton is fairly complete, although many bones are fragmentary and poorly preserved. Some of them show signs of animal gnawing. The individual was buried in a crouched position, on its right side, with the head pointing to the south-west. The arms were bent, and the hands were lying together in front of the face. Probably due to post-depositional processes, the skull was more or less upright, and in modern times the cranium and the mandible had been crunched together, so that the lower jaw was found inside the skull.

In a position that was clearly below the human bones were two concentrations of ceramic sherds. Cross-mends show that all of these sherds stem from the same vessel. Judging from the main concentration, the vessel had been placed below the middle part of the spine.

Burial goods	1 small, complete bowl with small lugs (Pl. 3.2.1,3)
Sex	male?
Age	25-34
Pathologies	cribra orbitalia; dental calculus; perimortem fractures to the bones; signs of animal gnawing
^{14}C	Poz-98348 (cranial bone): 6000 ± 40 KIA-52449 (rib): 6119 ± 25
$\delta^{15}N$	10.4
$\delta^{13}C$	−20.0

Figure 3.2.4 (right). G3/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.

Figure 3.2.5 (below). G3/S21. Human bones (crosses) and ceramic sherds (circles) projected in the adjacent west profile of the ditch (quadrants 25 and 28).


0 2 4 6 8 m
0 10 20 30 40 cm
Ceramics
Human bones
189.93 - 189.95
189.95 - 189.98
189.98 - 190.01
190.01 - 190.04
190.04 - 190.06

G4/S21 (Fig. 3.2.6)

In the centre of the eastern branch of the outer ditch (object 3), about 5 m from its end and 2 m farther south than G5/S21, close to the bottom, at about 189.2 m a.s.l., a human skeleton in anatomical position was encountered. A burial pit was not discernible. The skeleton was obviously lying at the upper border of the deepest layer (Fig. 3.2.23), following its slight slope, as the lower body was a little bit higher than the upper body.

The skeleton is fairly complete, although many bones are fragmentary and poorly preserved. Most prominently, the skull is missing. No signs of violent detachment were found on the adjacent vertebrae; however, given the poor state of preservation, such signs are also not necessarily to be expected. Parts of the lower limbs are missing, but it cannot be excluded that this an artefact of excavation. While the same is true for the right hand, the left hand seems to be truly missing. Furthermore, parts of the left hip were found dislocated to the right of the body, about 30 cm from its original location. The fragments of a skull found about 50 cm to the north-north-east, but also 50 cm higher, probably do not belong to this individual but to I18/S21.

The individual was deposited in a prone position, with the (now missing) head pointing south-south-west, following the course of the ditch. Both arms were stretched, the left more braced. Judging from the position of the bones of the forearms, both palms were facing upwards. The lower left leg is not preserved, but the right was slightly bent.

Some scattered artefacts found nearby (stone, ceramic sherd) are probably part of the fill of the ditch rather than burial goods.

Burial goods	-
Sex	indeterminate
Age	3-6
Pathologies	-
^{14}C	Poz-98359 (tibia): 6170 ± 40
$\delta^{15}N$	10.9
$\delta^{13}C$	−20.4

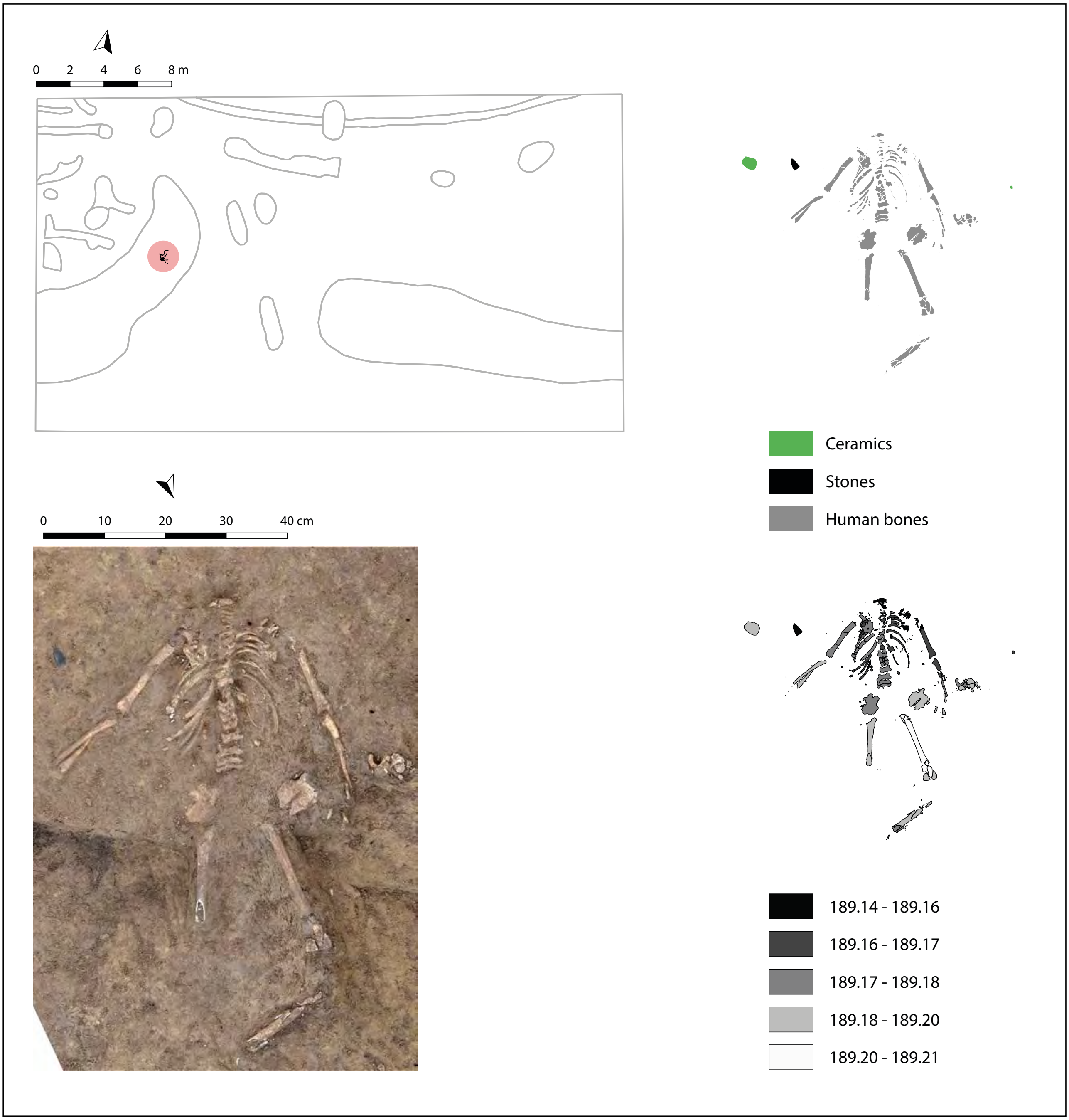


Figure 3.2.6. G4/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.

G5/S21 (Fig. 3.2.7)

In the centre of the eastern branch of the outer ditch (object 3), about 3 m from its end and 2 m north of G4/S21, close to the bottom, at about 189.2-189.5 m a.s.l., a human skeleton, only partly in anatomical position, was encountered. A burial pit was not discernible, the skeleton was obviously lying at the upper border of the deepest layer (Fig. 3.2.23), following its slope, as the main parts of the upper body were about 0.3 m higher than the lowest of the lower body.

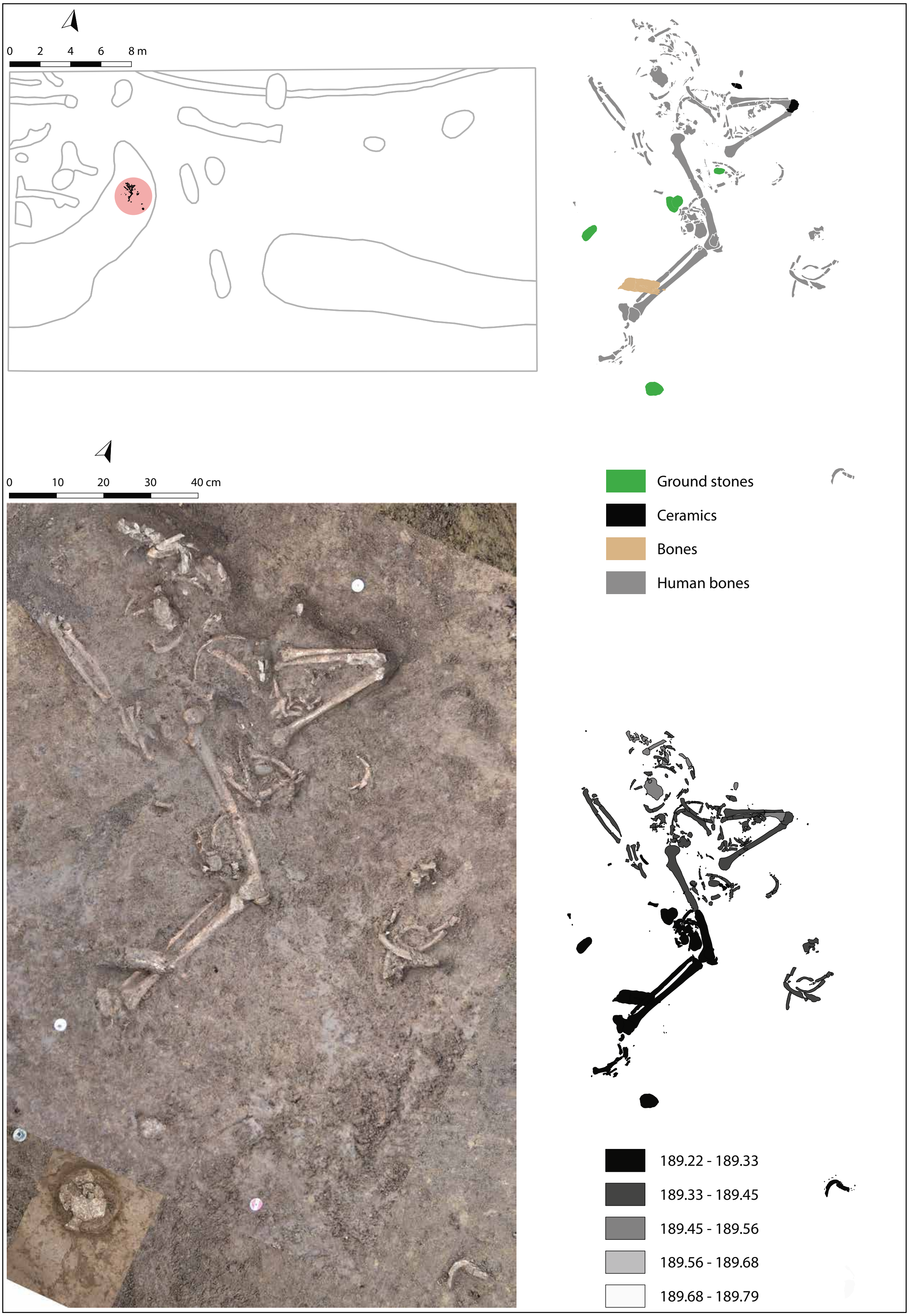
Only selected parts of the skeleton were still in anatomical position. This is true, *e.g.* for the complete right arm, including some of the hand bones; for the lower left arm, including the hand bones; and for the complete left leg. However, it is physiologically impossible that all these bones are all still in situ, in particular the left leg and the lower left arm. It thus appears that the individual originally was deposited on its belly on the slope of the ditch, with the head orientated to the north-west. It then follows that the complete right arm has moved by about 50 cm downslope. This would also apply to large parts of the chest, as ribs were found where the hip once was, close to the left knee and even farther down the slope.

Given the state of dislocation, it is very difficult to make statements on the completeness of the individual. It cannot be excluded that the scattered long bones found in upper layers of the ditch and fragments of a skull found about 30 cm to the south, but also 50 cm higher, belong in part to this individual (there is at least one surplus ulna, though). However, because of the horizontal separation of up to 10 m and the vertical separation of up to 50 cm, it was decided to group the scattered bones together (see below I18/S21). In any case, the body underwent heavy post-depositional disturbance, at a point in time when part of the ligaments were still holding together (right arm), but other parts were already weakened or dissolved (chest, right shoulder). A longer exposure is also attested by signs of animal gnawing on some of the bones. Finally, it is worth mentioning that among the cervical vertebrae, C2 (axis) is present, but C1 (atlas) is missing. Thus, it seems that G5/S21 mirrors the treatment of G4/S21, G12/S23 and G13/S23 in terms of the removal of the entire cranium, together with the lower jaw and the atlas. While the skullcap may be represented by the fragments mentioned above, no lower jaw was found.

While the scattered artefacts found nearby (stone, ceramic sherds, animal bones) are probably not to be considered as burial goods, their close association with the human bones is still remarkable, especially as almost no animal remains were found in the rest of the ditch fill (objects S21/1, S21/3, S23/203). In this vain, it is worth mentioning that scattered among the human bones, larger chunks of charcoal were found (unfortunately, indeterminate; see Chapter 5.6).

Burial goods	-
Sex	male?
Age	15-24
Pathologies	antemortem trauma or a cyst on the 1st proximal hand phalanx; fused cervical vertebrae (C2 + C3), indicating possible case of Klippel-Feil syndrome; perimortem fractures to the bones; signs of animal gnawing
^{14}C	Poz-98350 (rib): 6240 ± 40
$\delta^{15}N$	10.9
$\delta^{13}C$	−19.8

Figure 3.2.7 (right). G5/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.


0 2 4 6 8 m
0 10 20 30 40 cm
Ground stones
Ceramics
Bones
Human bones
189.22 - 189.33
189.33 - 189.45
189.45 - 189.56
189.56 - 189.68
189.68 - 189.79

G6/S21 (Fig. 3.2.8)

North of the eastern branch of the outer ditch (object S21/3), only 1 m south of G7/S21, on and immediately beneath Planum 1, at about 190.0 m a.s.l., a human skeleton in anatomical position was encountered. A burial pit was only barely discernible, as the skeleton was lying in the brownish leaching of the topsoil. The maximum difference in depth is less than 10 cm.

Apart from damage done by the machine to the skull and legs, most of the bones are fragmentary and very poorly preserved, and some are missing entirely. It is impossible to say if these are truly missing or have just turned into unrecognisable pieces. Some of the bones show signs of animal gnawing.

The individual was buried in a crouched position, half on its left side, half on its back, with the head pointing south-west. The lower legs were strongly flexed. The arms were bent, and the right and left hands must have been lying close to the right and left shoulders, respectively.

Two concentrations of ceramic sherds were found which could be reconstructed to stem from two vessels. One concentration was found in front of the skull and the other between the left shoulder and the left hand. Close to the left upper arm, a tiny obsidian flake was found.

Burial goods	1 obsidian flake; 2 small, complete pots, one of which with handles (Pl. 3.2.1,4-5)
Sex	indeterminate
Age	18-22
Pathologies	perimortem fractures to the bones; signs of animal gnawing
^{14}C	Poz-98342 (cranial bone): 5920 ± 40 KIA-52448 (fibula): 6119 ± 25
$\delta^{15}N$	10.2
$\delta^{13}C$	−20.3

Figure 3.2.8 (right). G6/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.


0 2 4 6 8 m
obsidian blade
0 10 20 30 40 cm
Ceramics
Human bones
189.93 - 189.94
189.94 - 189.95
189.95 - 189.96
189.96 - 189.97
189.97 - 189.99

G7/S21 (Fig. 3.2.9)

North of the eastern branch of the outer ditch (object S21/3), and only 1 m north of G6/S21, below Planum 1, at about 189.90 m a.s.l., a human skeleton in anatomical position was encountered. A burial pit was only barely discernible on Planum 1, but on the level of the skeleton, the soil around it was of slightly darker colour. The maximum difference in depth is about 20 cm.

The individual was well preserved and complete. It was buried in a crouched position, on its left side, with the head pointing north-north-west. The legs were flexed. The arms were strongly bent, and the hands were lying close to the mouth.

One chert blade was discovered on the right shoulder (Pl. 2.3.1,8; Fig. 3.2.10) and another one beside the left upper arm (Pl. 2.3.1,9; Fig. 3.2.11). Behind the skull, one complete ceramic vessel (Pl. 2.3.1,6), one flat adze (Pl. 2.3.1,7), one stone of uncertain purpose (rubbing stone?) and many animal bones had been deposited (Fig. 3.2.12). According to archaeozoological experts (see Chapter 5.4), the bones stem from the more or less complete left half of a sheep (*Ovis aries*; identification by Ulrich Schmölcke; including scapula, ulna, radius, pelvis, femur, tibia, calcaneus, as shown in Figure 3.2.12).

While the skeleton at first glance seems complete and untouched, several observations merit attention. First, the lumbar vertebrae of the individual are somewhat dislocated in relation to the thoracic ones. Second, the head of the right femur is clearly no longer in anatomically correct position. Third, in relation to the burial goods behind the skull, it seems that the probable rubbing stone once was placed on top of the vessel. This vessel did not simply crash under the weight of the stone, but was tilted sideways. Fourth, the adze is in a somewhat awkward position, because it overlaps with one of the sheep bones and is also superimposed by the left tibia. Fifth, while the ends of tibia and femur of the sheep are lying so close together that we can probably assume they were put into the grave as one, they are no longer in a physiologically possible position in relation to each other.

Together, these observations lead to the conclusion that the items and the body must have had room to move after deposition, which presupposes some kind of hollow space inside the grave. Further, the position of the animal bones above and below the adze indicates that they had been arranged in the grave in a different manner than they were found, perhaps originally aligned along the walls (of the hollow space). And, finally, the body of the human seems to have moved slightly as well after deposition.

Burial goods	2 chert blades (1 of which thoroughly patinated); 1 flat adze; 1 small, undecorated pot (Pl. 3.2.1,6-9); 1 rubbing stone (?); left half carcass of a sheep
Sex	male
Age	30-44
Pathologies	calculus, esp. on the rear teeth; perimortem fractures to the bones
^{14}C	Poz-98364 (cranial bone): 6080 ± 40 KIA-52445 (rib): 6044 ± 25 Poz-98362 (animal bone): 6030 ± 40
$\delta^{15}N$	10.5
$\delta^{13}C$	−20.2

Figure 3.2.9 (right). G7/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.

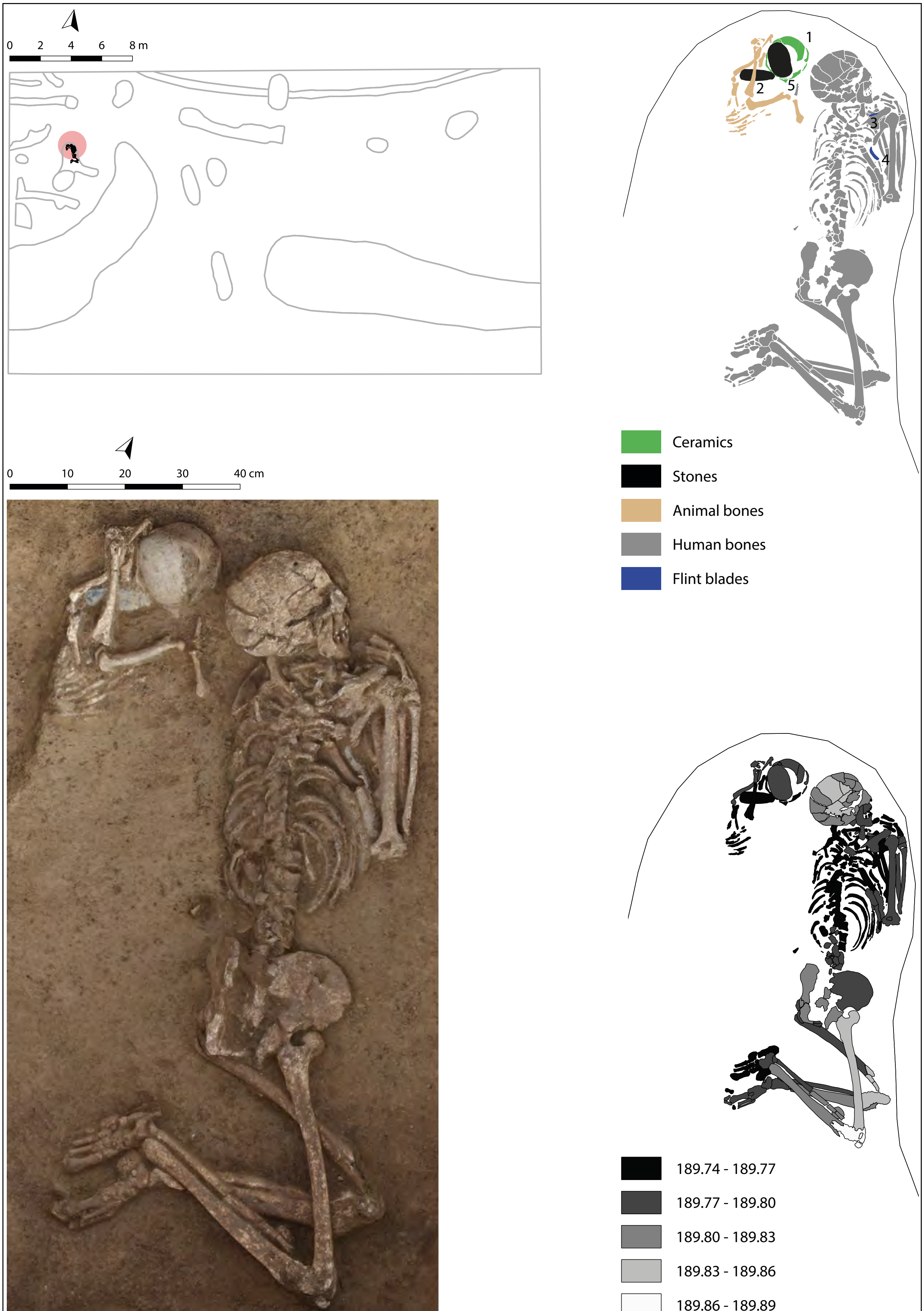

0 2 4 6 8 m
1
2
5
3
4
Ceramics
Stones
Animal bones
Human bones
Flint blades
0 10 20 30 40 cm
189.74 - 189.77
189.77 - 189.80
189.80 - 189.83
189.83 - 189.86
189.86 - 189.89

Figure 3.2.10. G7/S21. One of two chert blades in situ (Pl. 3.2.1,8).

Figure 3.2.11. G7/S21. One of two chert blades in situ (Pl. 3.2.1,9).

Figure 3.2.12. G7/S21. Burial goods behind the skull.

G8/S21 (Fig. 3.2.13)

More or less in the middle of the eastern and the western branch of the outer ditch (objects S21/1 and S21/3) and only 1 m to the north-east of Schlitzgrube (literally slotted pit, also referred to as V-shaped pit) object S21/9, object S21/10, the oval burial pit of G8/21, measuring about 1.8 to 1.2 m, was clearly discernible. At about 189.90 m a.s.l., a human skeleton in anatomical position was encountered. The maximum difference in depth is about 30 cm.

The individual was well preserved and complete. It was buried in a crouched position on its left side, with the head pointing south-south-east. The legs were flexed. The arms were strongly bent, and the hands were lying in front of the face.

Behind his back, near his lowest ribs, a long flint blade had been positioned in such a way that it lay parallel to the spine, with the point pointing towards the individual's head. Additionally, three larger ceramic vessels had been put behind its back at a little distance, and three additional, but smaller, vessels were lying close to the head. A possible additional vessel was reconstructed on drawing, but it seems likely that the sherds shown in Plates 3.2.2,1 and 3.2.2,2 belong to the same vessel.

The lumbar vertebrae of the individual are somewhat dislocated in relation to the thoracic ones (Fig. 3.2.14). Furthermore, the position of the vessels is peculiar. All of them are lying on their sides, and one of them is even superimposing the skull. Thus, is seems that they have moved and tumbled in the direction of the skeleton after deposition.

The position of the vessels suggest some kind of supporting construction below the vessels (and probably also the body) which at some point gave way and so led to the chaotic impression. Excavation revealed no remains of any organic matter, however, so we do not know whether this construction was some kind of bier or perhaps only a padding of leaves and twigs.

Burial goods	1 flint blade; 6-7 ceramic vessels (Pl. 3.2.2,1-8)
Sex	male
Age	20-29
Pathologies	poorly healed fracture of the left clavicle, lateral side; calculus, esp. on the rear teeth; slight signs of hypoplasia on the front teeth (at the age of 0.5-3 years); cribra orbitalia; perimortem fractures to the bones; use of front teeth as tools; squatting facets
^{14}C	Poz-98360 (cranial bone): 6150 ± 40 KIA-52444 (rib): 6155 ± 20
$\delta^{15}N$	6.4
$\delta^{13}C$	−20.4

Figure 3.2.13 (right). G8/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.

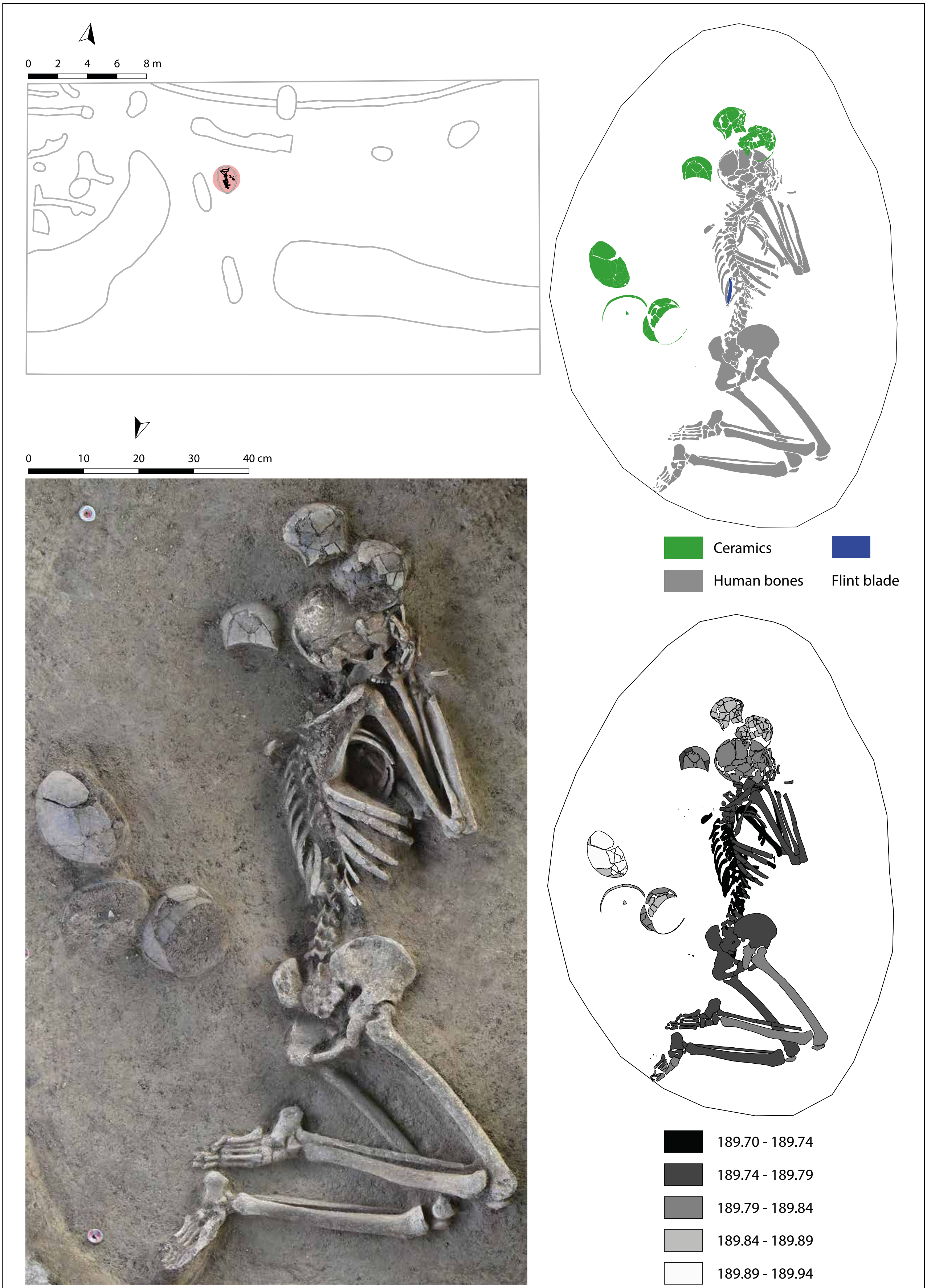

0 2 4 6 8 m
0 10 20 30 40 cm
Ceramics
Human bones
Flint blade
189.70 - 189.74
189.74 - 189.79
189.79 - 189.84
189.84 - 189.89
189.89 - 189.94

Figure 3.2.14. G8/S21. Close-up of the spine after removal of the rib cage.

G9/S21 (Fig. 3.2.15)

In the course of the faintly visible smaller ditch (object S21/14), at about 189.80 m a.s.l., a human skeleton in anatomical position was encountered. The maximum difference in depth is little more than 10 cm. While a dedicated burial pit was not discernible, the good state of preservation of the skeleton presupposes that the ditch predates the individual. Either the individual was laid in the still open ditch and then covered by earth or it was put into a pit recut into the already filled ditch. As the depth of the lowest bones of the individual coincides with the depth of the ditch as visible in the profiles, the first option seems the more probable.

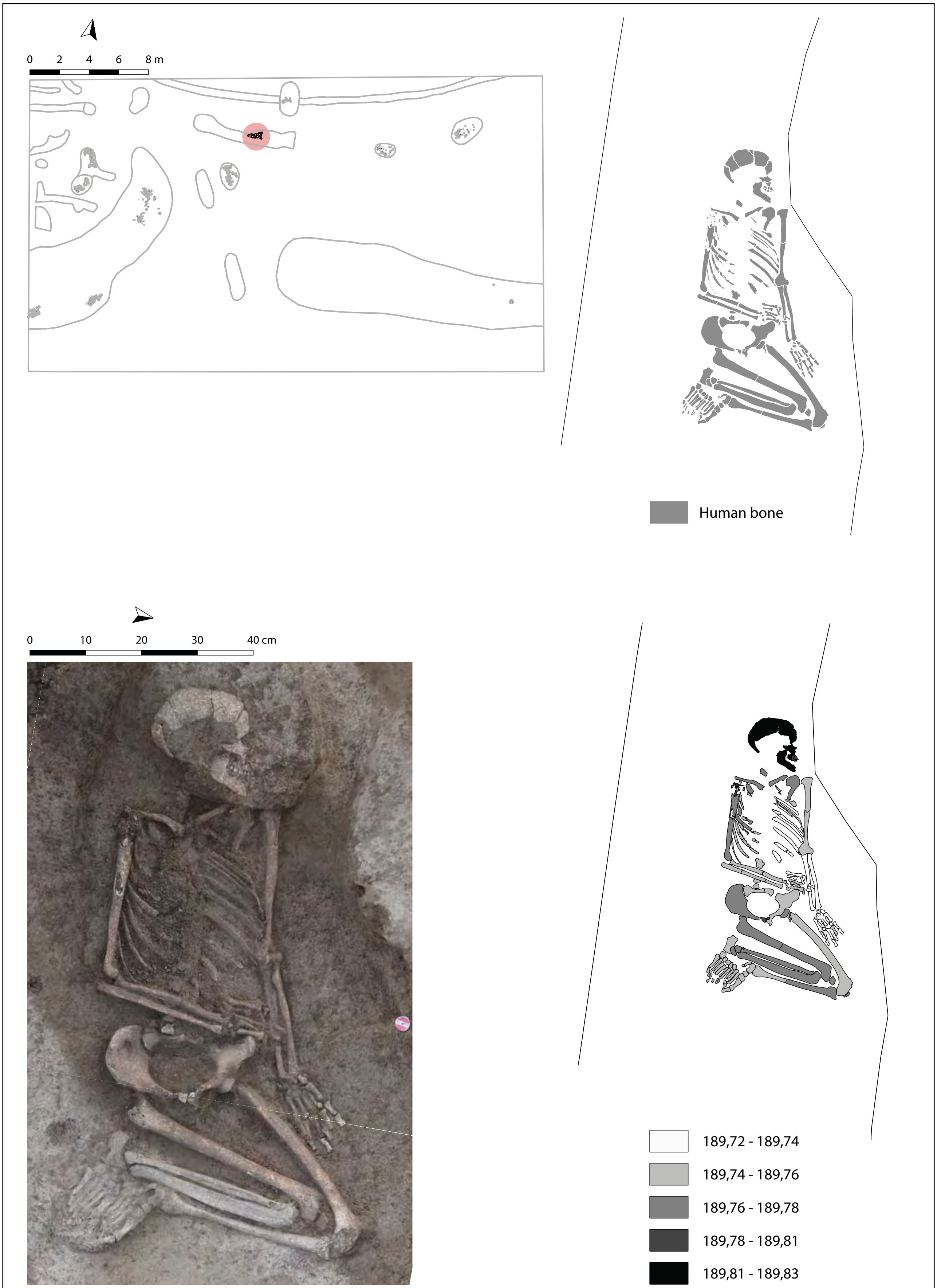
The individual was well preserved and complete. It was buried in a crouched position, on its left side, with the head pointing west. The legs were strongly flexed. The left arm was lying straight beside the body, with the palm facing upwards; the right forearm was laid across the stomach so that the right hand was resting on the left hip.

There were no burial goods.

In contrast to other individuals, no signs for post-depositional disturbances are present. The only peculiar observation concerns the left arm and the left shoulder. The left shoulder seems raised to the chin, and the left arm rests clumsily beside the body.

Burial goods	-
Sex	female
Age	40-49
Pathologies	calculus, esp. on the front teeth; signs of osteopenia/osteoporosis; perimortem fractures to the bones
^{14}C	KIA-52447 (cranial bone): 6081 ± 25 Poz-98352 (rib): 6100 ± 40
$\delta^{15}N$	10.4
$\delta^{13}C$	−20.1

Figure 3.2.15 (right). G9/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.


0
2
4
6
8 m
Human bone
0
10
20
30
40 cm
189,72 - 189,74
189,74 - 189,76
189,76 - 189,78
189,78 - 189,81
189,81 - 189,83

G10/S21 (Fig. 3.2.16)

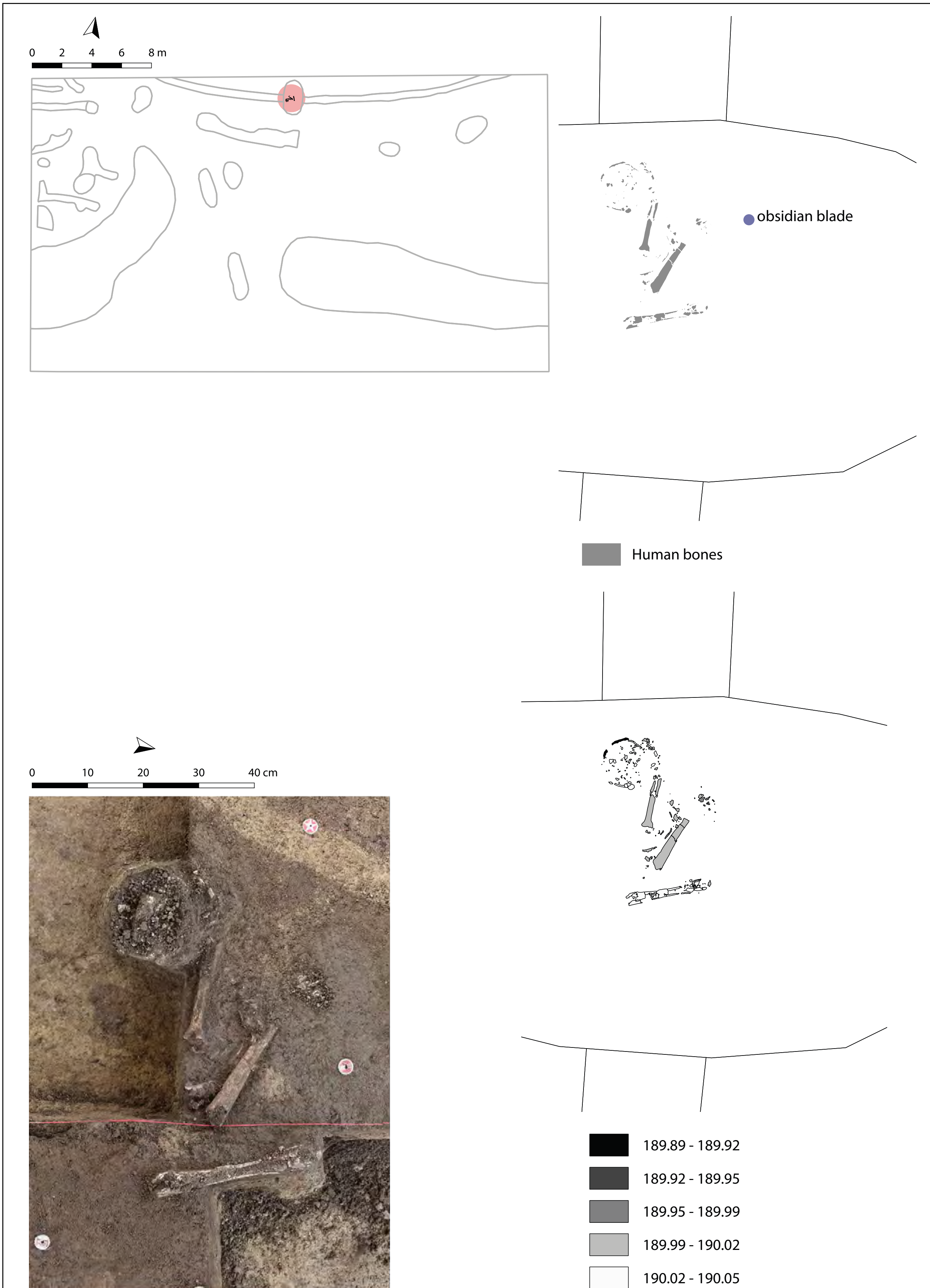
In the course of the faintly visible palisade ditch, at about 190.05 m a.s.l., on Planum 1, poorly preserved human bones were encountered. The maximum difference in depth is little more than 5 cm. It is certain that their deposition postdates the palisade ditch.

The individual – recognisable were the skull and some long bones – was so poorly preserved and damaged by the excavator that it is impossible to say if it had been buried in a crouched position or not.

One obsidian blade found 30 cm north of the skull can probably regarded as a burial good.

Burial goods	1 obsidian blade (Pl. 3.2.2)
Sex	indeterminate
Age	15
Pathologies	perimortem fractures to the bones
^{14}C	KIA-52450 (cranial bone): 6002 ± 25 Poz-98357 (humerus): 6050 ± 40
$\delta^{15}N$	10.9
$\delta^{13}C$	–19.8

Figure 3.2.16 (right). G10/S21. Top left: location in Trench 21; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.


0 2 4 6 8 m
obsidian blade
Human bones
0 10 20 30 40 cm
189.89 - 189.92
189.92 - 189.95
189.95 - 189.99
189.99 - 190.02
190.02 - 190.05

G11/S22 (Fig. 3.2.17)

Close to the northern end of the western long pit of house 23 (object S22/102), at about 189.70 m a.s.l., human bones were encountered intermingled with animal bones, stones and daub. It seems that the bones were deposited in a pit recut into the long pit.

The bones were poorly preserved and displaced, but from their position, the original deposition of the individual can safely be reconstructed. It seems that it was laid down on its back with the upper body bent leftwards, so that the torso was pointing to the south-west while the upper legs were pointing to the north-north-west. Interestingly, the femur heads both faced in the same direction, implying that after partial decomposition, the left leg, including the hip, must have been turned. From this, it follows that the body was probably left uncovered for some time.

The finds associated with the individual probably do not represent burial goods, as they resemble refuse normally found in the long pits.

Burial goods	-
Sex	indeterminate
Age	20-29
Pathologies	perimortem fractures to the bones
^{14}C	Poz-98366 (long bone): 5840 ± 40
$\delta^{15}N$	10.0
$\delta^{13}C$	−19.9

Figure 3.2.17 (right). G11/S21. Top left: location in Trench 22; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.


0 2 4 6 8 m
0 10 20 30 40 cm
Daub
Stone
Bones
Human Bones
189.49 - 189.54
189.54 - 189.60
189.60 - 189.65
189.65 - 189.70
189.70 - 189.75

G12/S23 (Fig. 3.2.18)

Close to the eastern end of the western branch of the outer ditch in Trench 23 (object S23/203), at about 188.4 m a.s.l., human bones were encountered. The individual was deposited close to the bottom of the ditch, in the same layer as G13/S23, whose feet were at less than 80 cm distance to the south (Fig. 3.2.22).

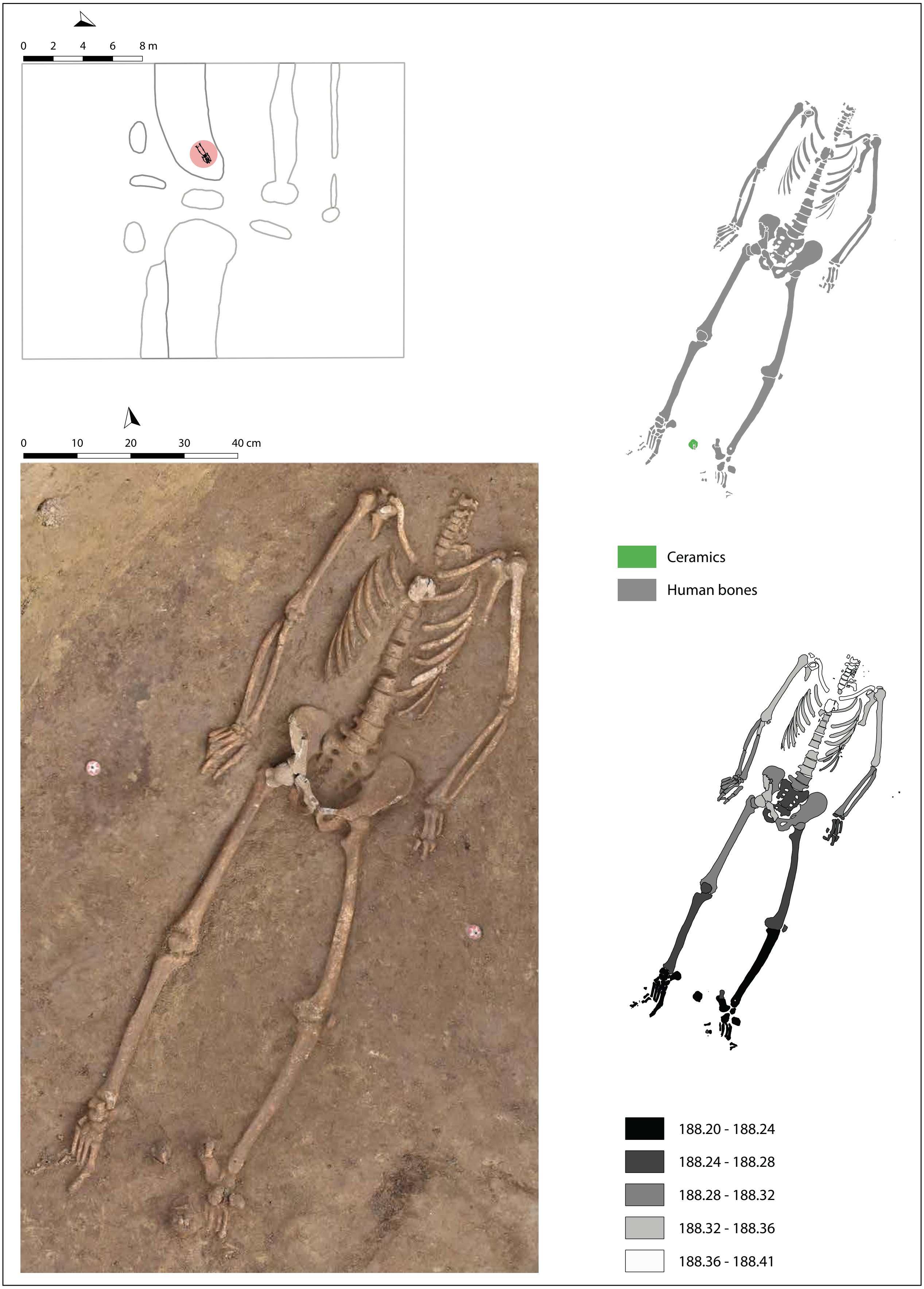
The individual was lying on its back, with the legs stretched and the arms resting beside the body with the palms facing downwards. The head originally pointed in north-easterly direction, to the entrance of the enclosure, and followed the slope of the ditch, so that the shoulder girdles were about 20 cm higher than the feet.

The individual was well preserved, which makes the fact that the cranium, lower jaw and the atlas are missing all the more striking. The anthropological analysis (see below) revealed no traces of cutmarks or similar signs of violence, so that the head was probably removed when the ligatures were already severely weakened.

A scattered ceramic sherd associated with the individual probably does not represent a burial good.

Burial goods	-
Sex	female?
Age	20-24
Pathologies	fully healed fracture of the mid-shaft of tibia; antemortem fractured lumbar vertebra (spondylolysis); spina bifida; degenerative joint disease signs on the vertebrae; perimortem fractures to the bones (esp. forearms); squatting facets
^{14}C	Poz-98444 (rib): 6080 ± 40
$\delta^{15}N$	10.6
$\delta^{13}C$	−19.8

Figure 3.2.18 (right). G12/S23. Top left: location in Trench 23; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.


0 2 4 6 8 m
0 10 20 30 40 cm
Ceramics
Human bones
188.20 - 188.24
188.24 - 188.28
188.28 - 188.32
188.32 - 188.36
188.36 - 188.41

G13/S23 (Fig. 3.2.19)

In the western branch of the outer ditch in Trench 23 (object S23/203), at about 188.10 m a.s.l., human bones were encountered. The individual was deposited close to the bottom of the ditch, in the same layer as G12/S23 (Fig. 3.2.22), whose feet were less than 80 cm distance to the north.

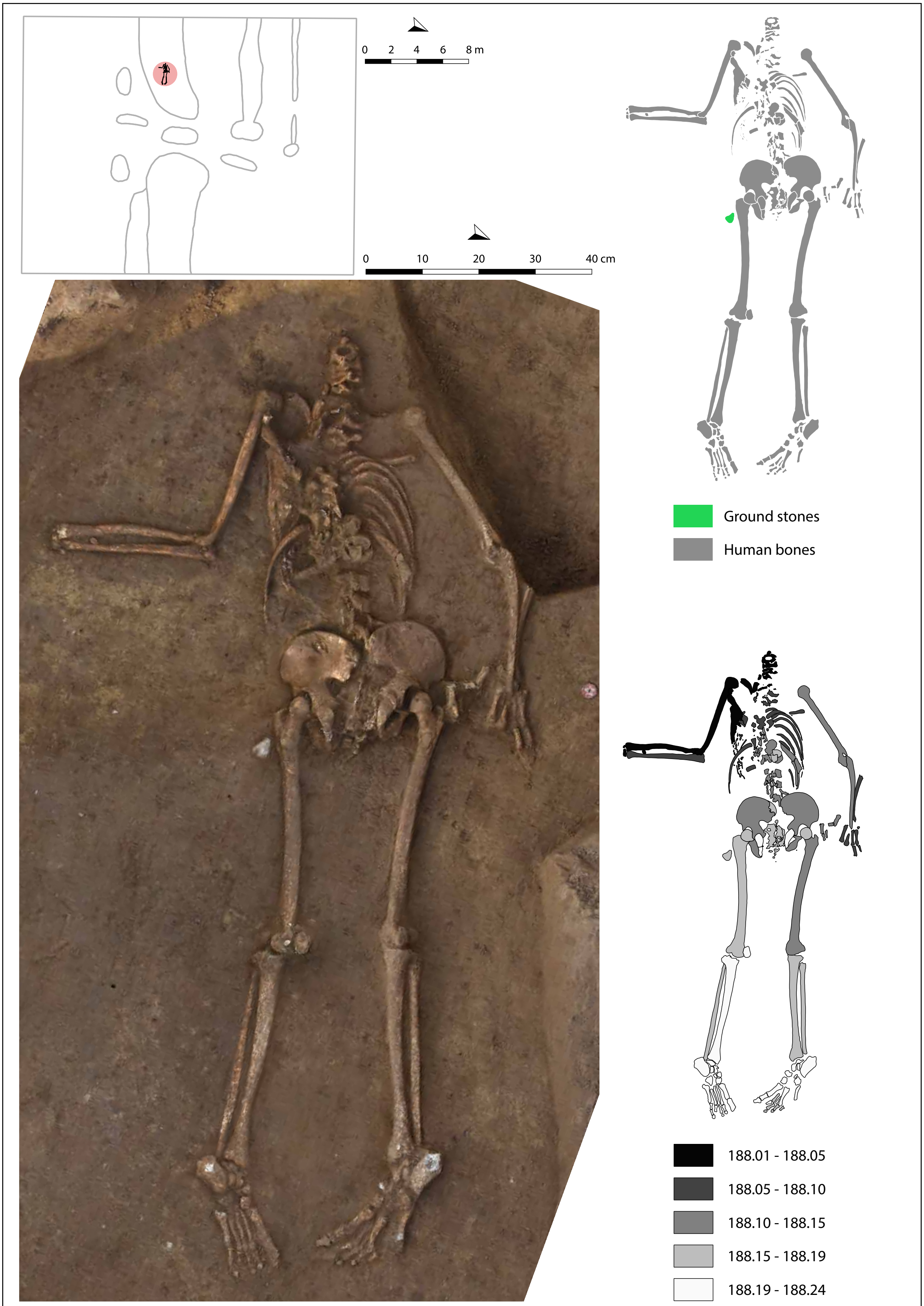
The individual was lying on its belly, with the stretched legs turned in a little bit, so that the feet were pointing at each other. The right arm was resting beside the body with the palm facing upwards, while the left was braced. The head originally pointed away from the entrance of the enclosure, in westerly direction. The body followed the slope of the ditch, so that the shoulder girdles were about 20 cm lower than the feet.

The individual was well preserved, which makes the fact that the cranium, lower jaw and atlas, as well as the complete left hand, are missing all the more striking. The anthropological analysis (see below) revealed no traces of cutmarks or similar signs of violence, so that both head and hand were probably removed when the ligatures were already severely weakened.

There were no burial goods associated with the skeleton.

Burial goods	-
Sex	male
Age	35-49
Pathologies	healed fracture of the left clavicle; Schmorl's node; probably fractured and healed right metacarpal 5; squatting facets
^{14}C	Poz-98369 (rib): 6210 ± 40
$\delta^{15}N$	10.7
$\delta^{13}C$	−19.6

Figure 3.2.19 (right). G13/S23. Top left: location in Trench 23; bottom left: photogrammetry; top right: characterisation of finds; bottom right: height of finds.


0 2 4 6 8 m
0 10 20 30 40 cm
Ground stones
Human bones
188.01 - 188.05
188.05 - 188.10
188.10 - 188.15
188.15 - 188.19
188.19 - 188.24

G14/S21

Close to the western wall of Trench 21, about 3.5 m north of the outer ditch, at about 189.80 m a.s.l., some scattered and very poorly preserved human bones and ceramic sherds were encountered. Because of multiple animal burrows nearby, it was impossible to decide if it had once been deposited in a burial pit or not.

A small ceramic vessel can perhaps be regarded as a burial good.

Burial goods	possibly 1 ceramic vessel (Pl. 3.2.2,10)
Sex	indeterminate
Age	4-6
Pathologies	-
^{14}C	Poz-98793 (unspecified bone): 5840 ± 35
$\delta^{15}N$	11.0
$\delta^{13}C$	−20.9

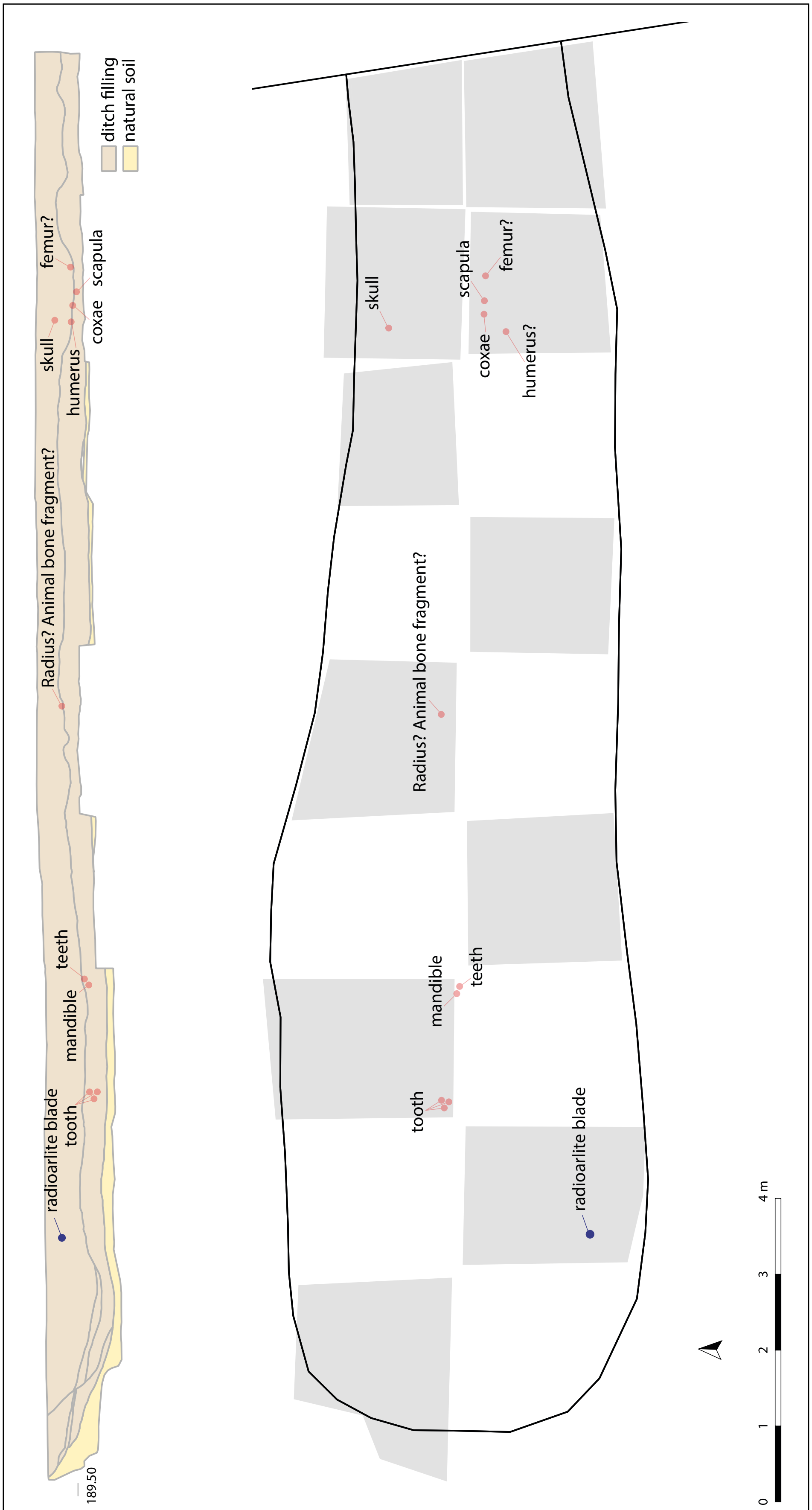


Figure 3.2.20. Human bones attributed to I15/S21 in object S21/1. Top: profile section; bottom: outline of object S21/1 on Planum 1, the excavated quadrants are indicated by shading.

I15/S21 (Fig. 3.2.20)

Scattered along a length of more than 12 m in the fill of the eastern branch of the outer ditch in Trench 21, several human bones were found. The bones include those from the skull as well as long bones. Most of them were found close to the cross-section and thus at the deepest part of the ditch, but especially the skull was located closer towards the border of object S21/1. This easily explains the differences in height, the skull having been found c. 20 cm higher than the other bones nearby. Thus, it seems that the bones were all deposited close to the interface between the lower and the upper main fill of this ditch segment (Fig. 3.2.20 top).

Although it cannot be excluded that the bones represent more than one individual, anthropological analysis (see below) found no indications of this. Furthermore, the ^{14}C dates conducted on different skeletal elements and from different parts of the fill all yielded similar time spans, and the stable isotope values are also almost identical. Therefore, it seems justified to treat these bones as originating from one individual.

While none of the bones were found in articulation, those in the eastern part (hips, shoulder, upper leg, upper arm) may mark the area where the body was originally deposited. Because not all quadrants of object S21/1 were excavated, it is to be expected that additional bones of this individual remain in the unexcavated sections.

A radiolarite blade found close to the western end of object S21/1 and at a similar height may be associated with the human bones.

Burial goods	possibly 1 radiolarite blade (Pl. 3.2.3,3)
Sex	male?
Age	15-19
Pathologies	-
^{14}C	Poz-98344 (cranial bone): 6150 ± 40 Poz-98345 (femur): 6170 ± 40 Poz-98349 (lower jaw): 6130 ± 40
$\delta^{15}N$	10.5 (Poz-98344) 10.7 (Poz-98345) 10.5 (Poz-98349)
$\delta^{13}C$	−20.1 (Poz-98344) −20.3 (Poz-98345) −20.0 (Poz-98349)

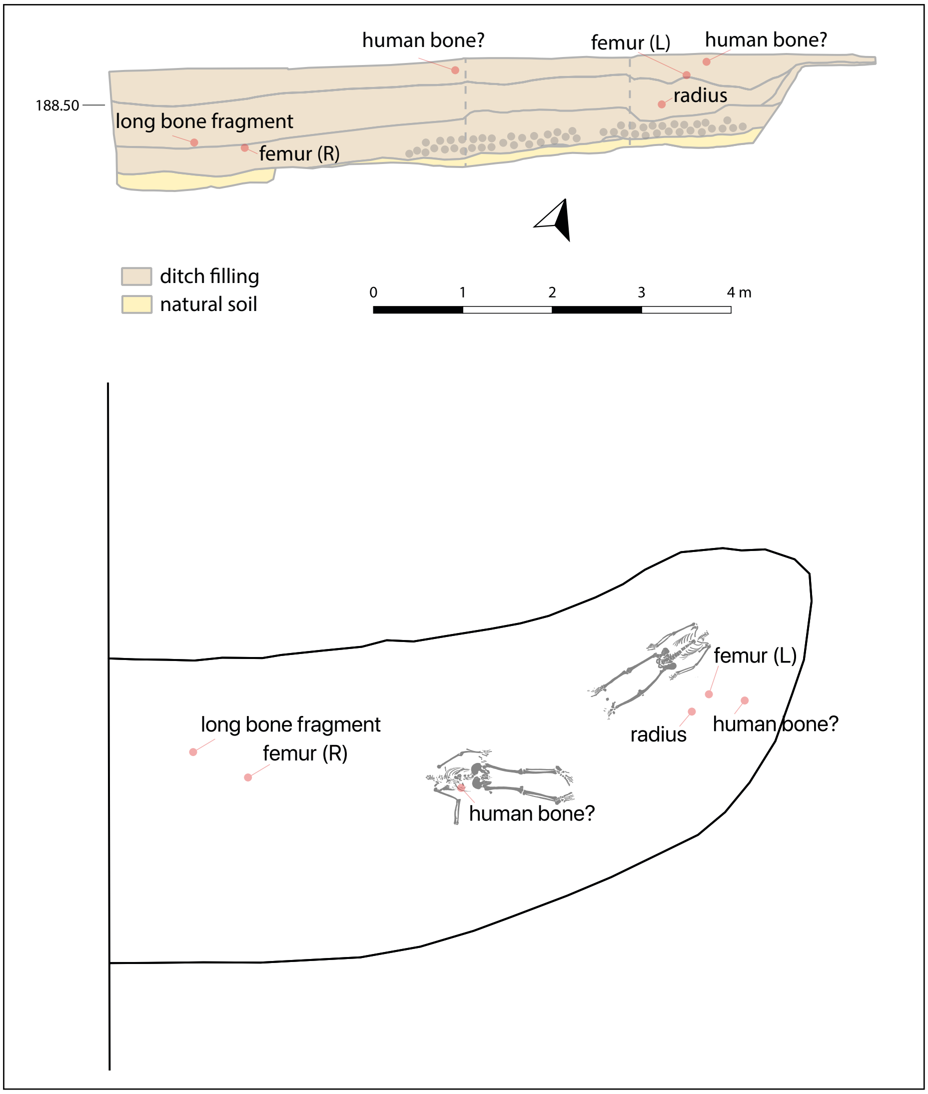


Figure 3.2.21. Human bones attributed to I16/S23 in object S23/203. Top: profile section; bottom: outline of object S23/203 on Planum 1.

I16/S23 (Fig. 3.2.21)

Scattered across a length of more than 6 m in the fill of the western branch of the outer ditch in Trench 23, several human bones were found, at heights between 187.9 and 188.9 m a.s.l. The bones include long bones from the upper and lower body. Most of them were found close to the cross-section and thus at the deepest part of the ditch, but at different heights. Thus, it seems that the bones were either deposited close to the interface between the lower and the middle fill or between the middle and the upper main fill of this ditch segment, but clearly in a different fill than G12/S23 and G13/S23 (Fig. 3.2.21 top).

Although it cannot be excluded that the bones represent more than one individual, anthropological analysis (see below) found no indications of this. While the ^{14}C dates of two of the bones do not help, as one returned a date that is clearly far too young, the stable isotope values are very similar. Therefore, it seems justified to treat these bones as coming from the same individual.

No finds were associated with the bones which could be regarded as burial goods.

Burial goods	-
Sex	indeterminate
Age	18+
Pathologies	-
^{14}C	Poz-98445 (unspecified postcranial bone): 5870 ± 40 Poz-98449 (right femur): 6140 ± 40
$\delta^{15}N$	11.0 (Poz-98445) 10.6 (Poz-98449)
$\delta^{13}C$	−20.0 (Poz-98445) −19.7 (Poz-98449)

Figure 3.2.22 (right). Human bones attributed to I17/S22 in object S23/209. Top left: location in Trench 23; bottom left: photogrammetry; middle: characterisation of finds; right: height of finds.


Human bones
188.97 - 188.98
188.98 - 189.00
189.00 - 189.01
189.01 - 189.02
189.02 - 189.04
0 2 4 6 8 m
0 10 20 30 40 cm

I17/S23 (Fig. 3.2.22)

Scattered over a length of 5 m in the fill of the western branch of the smaller ditch in Trench 23, several human bones were found, at around 189.0 m a.s.l. The bones include long bones from the upper and lower body. They were poorly preserved and partly damaged by the excavator; therefore, it is difficult to say if some of them were still in articulation.

Although it cannot be excluded that the bones represent more than one individual, anthropological analysis (see below) found no indications of this. While the ^{14}C samples of three of the bones yielded slightly different dates, the stable isotope values are very similar. Therefore, it seems justified to treat these bones as coming from one individual.

No finds were associated with the bones which could be regarded as burial goods.

Burial goods	-
Sex	indeterminate
Age	18+
Pathologies	-
^{14}C	Poz-98446 (femur): 6180 ± 40 Poz-98447 (unspecified postcranial bone): 6100 ± 40 Poz-98448 (femur): 6090 ± 40
$\delta^{15}N$	11.1 (Poz-98446) 11.0 (Poz-98447) 10.8 (Poz-98448)
$\delta^{13}C$	−20.1 (Poz-98446) −19.9 (Poz-98447) −20.0 (Poz-98448)

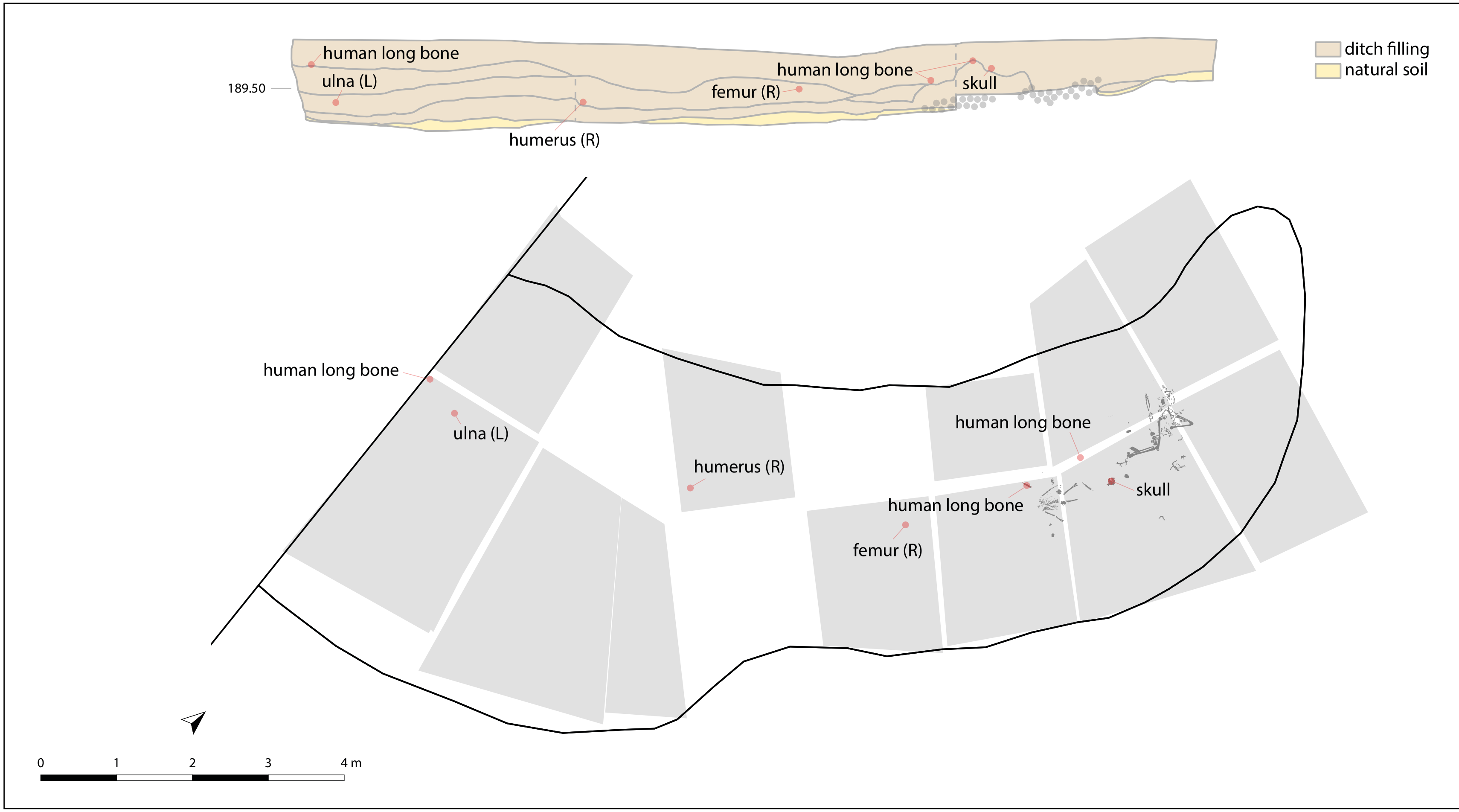


Figure 3.2.23. Human bones attributed to I18/S21 in object S21/3. Top: profile section; bottom: outline of object S21/3 on Planum 1, the excavated quadrants are indicated by shading.

I18/S21 (Fig. 3.2.23)

Scattered across a length of 10 m in the fill of the western branch of the outer ditch in Trench 21, several human bones were found, at heights between 189.2 and 189.7 m a.s.l. The bones include skull fragments as well as long bones from the upper and lower body. None of the bones were in articulation. From the profile (Fig. 3.2.23 top), it seems that some of them are lying near the interface between the upper and the middle layers of object S21/3, while some others in the western half are associated with a deeper layer. However, this attribution to different layers may also be due to the general difficulty in consistently differentiating between strata across several quadrants. Therefore, this association with different layers should not be taken as a proof that the bones cannot belong to the same individual.

Indeed, anthropological analysis (see below) found no indications that more than one individual is represented in these bones. Furthermore, three of the four ^{14}C samples of the bones yielded almost identical dates. But the stable isotope values differ more strongly. Therefore, while doubts persist, it still seems justified to treat these bones as coming from one individual. Because not all quadrants of object S21/3 were excavated, it is to be expected that more bones of this individual remain in the unexcavated sections.

Two vessels found stacked together in the upper layer of S21/3 at a height of 189.7 m a.s.l., close to the skull fragments (Pl. 3.2.3,1-2), possibly also belong to this individual.

Burial goods	possibly 2 ceramic vessels
Sex	indeterminate
Age	18+
Pathologies	-
^{14}C	KIA-52451 (cranial bone): 6166 ± 24 Poz-98346 (right femur): 6180 ± 40 Poz-98347 (right humerus): 6170 ± 40 Poz-98361 (unspecified postcranial bone): 6100 ± 40
$\delta^{15}N$	9.5 (Poz-98346) 10.5 (Poz-98347) 9.8 (Poz-98361)
$\delta^{13}C$	−20.7 (Poz-98346) −19.7 (Poz-98347) −20.1 (Poz-98361)

I19/S10

In the fill of H262/1, the western long pit of the over-long house 262, at 188.25 m a.s.l., a human frontal bone was recovered. It was positioned at the deepest part of the pit, c. 20 cm above the bottom.

Burial goods	-
Sex	indeterminate
Age	indeterminate
Pathologies	-
^{14}C	KIA-52708 (os frontale): 6075 ± 35
$\delta^{15}N$	-
$\delta^{13}C$	-

Anthropological evaluation of the skeletal remains from Vráble

Methods

The sex of individuals was determined according to the morphological features on the skull and pelvis (Phenice 1969; Acsádi and Nemeskéri 1970; Rogers and Saunders 1994; Walker in Buikstra and Ubelaker 1994; Graw et al. 1999; Brickley and McKinley 2004). Dimensions of the long bones were used as a complementary method (Dwight 1894; Thieme 1957; Black 1978; Stewart 1979; Symes and Jantz 1983).

In subadults, tooth eruption times were used as a key method for estimating the age at death (Ubelaker 1989). Additionally, lengths of the long bones were also used (Stloukal and Hanáková 1978; Fazekas and Kósa 1978), with the use of Buikstra and Ubelaker's (1994) scoring system. Times of epiphyseal fusion based on morphological summaries by Schaefer et al. (2009) were also taken into account when evaluating age at death of adolescent individuals. In adults, the age at death was established using following methods: level of dental wear (Brothwell 1981; Lovejoy 1985; Miles 2001) and morphology of the auricular surface of the ilium (Lovejoy et al. 1985; Buckberry and Chamberlain 2002), the pubic symphysis (Todd 1930; Meindl et al. 1985; Brooks and Suchey 1990), and the sternal ends of the ribs (Ïsçan et al. 1984a; 1984b; 1985; Ïsçan and Loth 1986; Yoder et al. 2001; Kurki 2005; DiGangi et al. 2009). Closure times of cranial sutures were not addressed, as the remains were very fragmented and sometimes poorly preserved. Moreover, this is one of the least accurate methods for age estimation (Falys and Lewis 2011). Dental wear is also perceived as rather inaccurate (ibid.); however, in the assemblage from Vráble it was often the only method that could be used.

Where possible, stature was calculated. In his work, Siegmund (2010) has compared different methods for stature estimations (namely, those published by Pearson 1899; Breitinger 1938 and Bach 1965; Telkkä 1950; Trotter and Gleser 1952; Olivier et al. 1978; Sjøvold 1990; Feldesman et al. 1990; Formicola and Franceschi 1996; Raxter et al. 2008; Vercellotti et al. 2009; Maijanen and Niskanen 2009) and established that especially three methods are suitable for central European populations: Pearson's, Trotter and Gleser's (especially formulas for African American populations), and Formicola and Franceschi's. This is why these three methods were primarily used for the individuals from Vráble. Stature estimations based on the formulas of other authors are, however, also provided.

Pathologies and other abnormal lesions were assessed macroscopically.

Results

Sex and age of the individuals

The bones suggest that at least 19 individuals were buried at the site, the majority of them adults. Among the sexed individuals, males significantly prevailed over females. A large number of individuals could not be sexed. Only one skeleton of a child was present. The majority of adult individuals died at young or prime age (18-35 years old), and only three adults (two males, G7/S21 and G13/S23, and one female, G9/S21) were presumably older than 35. No senile adults were present among the individuals that could be aged. In three individuals, the age at death could not be determined (Table 3.2.1; Fig. 3.2.24).

Individual	Trench	Object	Sex	Min Age	Max Age	Preservation	burial goods
G1/S14	14	145	M?	20	34	fairly complete	-
G2/S21	21	3	M	25	34	fairly complete, partly disarticulated, crouched	1 ceramic vessel
G3/S21	21	3	M?	25	34	complete, crouched	1 ceramic vessel
G4/S21	21	3	U	3	6	fairly complete, skull missing	-
G5/S21	21	3	M?	20	24	fairly complete, disarticulated	-
G6/S21	21	4	U	18	22	complete, crouched	1 ceramic vessel, 1 obsidian bladelet
G7/S21	21	21	M	30	44	complete, crouched	1 ceramic vessel, 1 rubbing stone, 1 adze, 2 flint blades, meat
G8/S21	21	10	M	20	29	complete, crouched	6 ceramic vessels, 1 flint blade
G9/S21	21	14	F	40	49	complete, crouched	-
G10/S21	21	16	U	15+		partly preserved, disarticulated	likely 1 obsidian blade
G11/S22	22	102	U	20	29	fairly complete, disarticulated	-
G12/S23	23	203	F?	20	24	fairly complete, skull missing	-
G13/S23	23	203	M	35	49	fairly complete, skull missing	-

Table 3.2.1. Basic information for the individuals from Vráble.

pathology and observations	Lab-code	14C yr BP	1-sigma	Material	collagen in %	N-content	C-content
healed cranial trauma posteriorly on the parietals, Schmorl's node on C2 and C3; perimortem fractured bones; signs of animal gnawing	Poz-87474	6060	35	cranial bone	0.7	0.5	2.8
	Poz-87473	5960	40	right rib	0.9	16.4	45
cranial porosity (esp. occipital bone); ilium with signs of reduced bone density; perimortem fractured bones; signs of animal gnawing, especially upper part of the skeleton	KIA-52446	6060	24	cranial bone	4.7		
	Poz-98358	6090	40	rib	3.7	17.1	46.9
cribra orbitalia; dental calculus; perimortem fractured bones; signs of animal gnawing	Poz-98348	6000	40	cranial bone	1.4	17.6	48.5
	KIA-52449	6119	25	left rib	4.3		
	Poz-98359	6170	40	right tibia	2.8	17.7	48.2
antemortem trauma or a cyst on the 1st proximal hand phalanx; fused cervical vertebrae (C2+C3) – possible case of Klippel-Feil syndrome; notochord defect (linear cleft) on a lower thoracic vertebra; perimortem fractured bones; signs of animal gnawing	Poz-98350	6240	40	rib	1.5	17.9	48.8
perimortem fractured bones; signs of animal gnawing	Poz-98342	5920	40	cranial bone	0.7	14.8	52
	KIA-52448	6119	25	right fibula	1.7		
calculus, esp. on the rear teeth; perimortem fractured bones	Poz-98364	6080	40	cranial bone	2.8	17	46.8
	KIA-52445	6044	25	rib	6.6		
	Poz-98362	6030	40	lamb	2.6	16.4	45.2
badly healed fracture of the left clavicle, lateral side; calculus, esp. on the rear teeth; slight signs of hypoplasia on the front teeth (at the age of 0.5-3 years); cribra orbitalia; perimortem fractured bones; used front teeth as tools; squatting facets	Poz-98360	6150	40	cranial bone	2.9	17.8	48.7
	KIA-52444	6155	20	rib	7.3		
calculus, esp. on the front teeth; signs of osteopenia/osteoporosis; perimortem fractured bones	KIA-52447	6081	25	cranial bone	4.3		
	Poz-98352	6100	40	rib	1.5	16.9	46.3
perimortem fractured bones	KIA-52450	6002	25	cranial bone	1		
	Poz-98357	6050	40	right humerus	1	16.7	45.8
perimortem fractured bones	Poz-98366	5840	40	ulna/ radius	2.8	16.3	44.8
fully healed fracture of the mid-shaft of tibia; antemortem fractured lumbar vertebra (spondylolysis); spina bifida; DJD signs on the vertebrae; perimortem fractured bones (esp. forearms); without skull; squatting facets	Poz-98444	6080	40	rib	3.6	17.6	46.6
healed fracture of the left clavicle; lytic circular lesions of unknown origin on two vertebrae; Schmorl's node; probably fractured and healed right MC5; squatting facets; skull and left hand missing	Poz-98369	6210	40	rib	4.8	17.5	47.5

Individual	Trench	Object	Sex	Min Age	Max Age	Preservation	burial goods
G14/S21	21	19	U	4	6	scatter of teeth and bones	possibly 1 ceramic vessel
I15/S21	21	1	M?	15	19	only single bones which not necessar-ily belong together, scattered	-
I16/S23	23	203	U	18+		only single bones which not necessar-ily belong together, scattered	-
I17/S23	23	209	U	18+		only single bones which likely belong together, scattered	-
I18/S21	21	3	U	18+		only single bones which not necessar-ily belong together, scattered	-
I19/S10	10					Os frontale	

Table 3.2.1 continued.

pathology and observations	Lab-code	14C yr BP	1-sigma	Material	collagen in %	N-content	C-content
	Poz-98793	5840	35	unspec-ified bone	0.04	0.5	4
	Poz-98344	6150	40	cranium	3.3	18.	49.3
	Poz-98345	6170	40	left femur	3	18.1	49.4
	Poz-98349	6130	40	mandible	1.4	18.2	49.9
	Poz-98445	5870	40	unspec-ified post-cranial bone	1.3	12.9	37
	Poz-98449	6140	40	right femur	3.6	18.5	50.3
	Poz-98446	6180	40	femur	1.8	17.2	47
perimortem fractured bones	Poz-98447	6100	40	unspec-ified post-cranial bone	2.2	17.2	47.2
	Poz-98448	6090	40	femur	2.2	16.9	46.8
	KIA-52451	6166	24	cranial bone	4.7		
	Poz-98346	6180	40	right femur	3	16.8	42.4
	Poz-98347	6170	40	right humerus	2.1	16.9	45.7
	Poz-98361	6100	40	unspec-ified post-cranial bone	2	18.3	50.3
	KIA-52708	6075	35	os frontale	9		

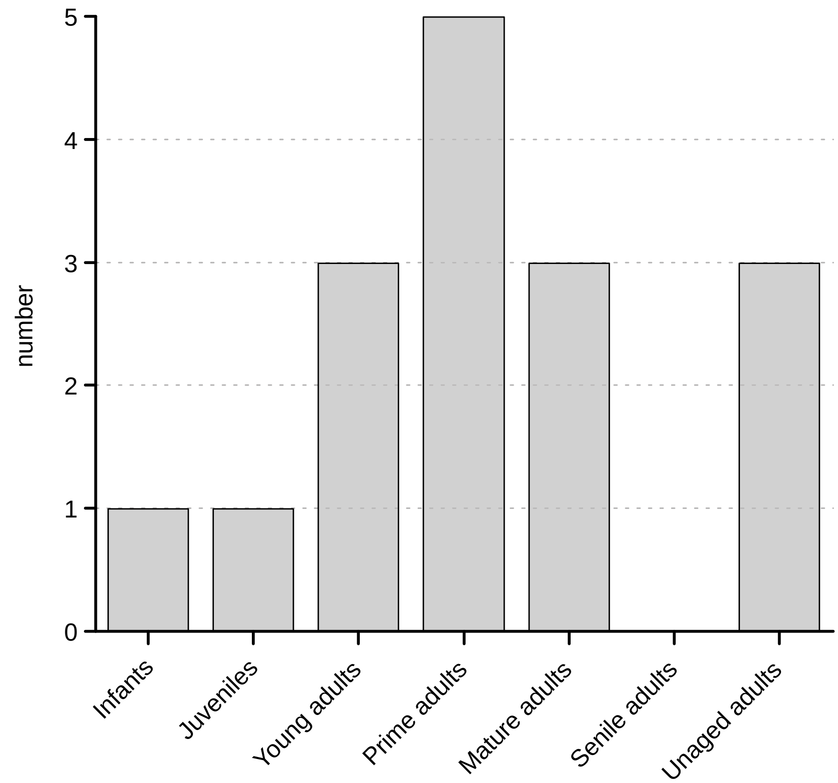


Figure 3.2.24. Age composition of the human remains in the Vráble assemblage.

Stature of adult individuals

Stature could be calculated for eight individuals, six males and two females. Using the most suitable methods for the central European populations (Pearson 1899; Trotter and Gleser 1952 [formulas for African American populations]; Formicola and Franceschi 1996), the statures of males were usually between 160 and 170 centimetres, whereas females were about 10 centimetres shorter, between 150 and 156 centimetres. Individual stature ranges by individual methods are provided in Table 3.2.2.

		Stature (in cm)			
Individual	Method	Min.	Max.	Average	Overall average
G1/S14	Meadows and Jantz 1992/Byers et al. 1989	171.4	171.4	171.4	-
G2/S21	Pearson 1899	164.4	167.0	165.7	168.3
	Trotter/Gleser 1952 (White)	168.3	172.8	170.5	
	Trotter/Gleser 1952 (African American)	165.1	167.7	166.4	
	Formicola/Franceschi 1996	166.5	168.9	167.7	
	Breitinger 1938/Bach 1965	168.2	170.7	169.4	
	Telkkä 1950	168.0	176.5	172.3	
	Olivier et al. 1978	167.1	171.5	169.3	
	Sjøvold 1990	167.5	168.7	168.1	
	Feldesman et al. 1990	167.9	167.9	167.9	
	Raxter et al. 2008	165.3	167.9	166.6	
	Vercellotti et al. 2009	168.5	170.6	169.5	
	Maijanen/Niskanen 2009	164.3	168.2	166.2	
	Meadows and Jantz 1992/Byers et al. 1989	165.0	165.0	165.0	

Table 3.2.2. Stature estimations for the individuals from Vráble.

		Stature (in cm)			
Individual	Method	Min.	Max.	Average	Overall average
G5/S21	Pearson 1899	161.1	161.1	161.1	162.7
	Trotter/Gleser 1952 (White)	166.1	166.1	166.1	
	Trotter/Gleser 1952 (African American)	162.0	162.0	162.0	
	Formicola/Franceschi 1996	160.2	160.2	160.2	
	Breitinger 1938/Bach 1965	164.6	164.6	164.6	
	Telkkä 1950	166.3	166.3	166.3	
	Olivier et al. 1978	162.1	162.1	162.1	
	Sjøvold 1990	161.5	161.5	161.5	
	Feldesman et al. 1990	-	-	-	
	Raxter et al. 2008	158.7	158.7	158.7	
	Vercellotti et al. 2009	164.1	164.1	164.1	
	Maijanen/Niskanen 2009	162.8	162.8	162.8	
	Meadows and Jantz 1992/Byers et al. 1989	171.4	171.4	171.4	
G7/S21	Pearson 1899	160.4	164.1	162.2	164.5
	Trotter/Gleser 1952 (White)	165.8	169.4	167.6	
	Trotter/Gleser 1952 (African American)	160.1	163.3	161.7	
	Formicola/Franceschi 1996	162.6	163.3	162.9	
	Breitinger 1938/Bach 1965	168.0	168.0	168.0	
	Telkkä 1950	164.1	174.8	169.5	
	Olivier et al. 1978	162.8	167.6	165.2	
	Sjøvold 1990	161.2	165.0	163.1	
	Feldesman et al. 1990	-	-	-	
	Raxter et al. 2008	164.0	164.3	164.1	
	Vercellotti et al. 2009	164.1	168.9	166.5	
	Maijanen/Niskanen 2009	154.9	161.8	158.4	
	Meadows and Jantz 1992/Byers et al. 1989	166.6	170.0	168.3	
G8/S21	Pearson 1899	161.2	166.7	164.0	166.0
	Trotter/Gleser 1952 (White)	164.9	172.4	168.7	
	Trotter/Gleser 1952 (African American)	162.1	166.0	164.1	
	Formicola/Franceschi 1996	163.0	166.1	164.5	
	Breitinger 1938/Bach 1965	165.9	170.4	168.1	
	Telkkä 1950	164.9	178.7	171.8	
	Olivier et al. 1978	163.7	171.0	167.4	
	Sjøvold 1990	163.6	168.1	165.8	
	Feldesman et al. 1990	162.7	162.7	162.7	
	Raxter et al. 2008	162.1	166.1	164.1	
	Vercellotti et al. 2009	165.0	170.4	167.7	
	Maijanen/Niskanen 2009	159.8	167.3	163.6	
	Meadows and Jantz 1992/Byers et al. 1989	168.2	174.1	171.1	

Table 3.2.2. continued.

		Stature (in cm)			
Individual	Method	Min.	Max.	Average	Overall average
G9/S21	Pearson 1899	151.0	153.1	152.0	153.9
	Trotter/Gleser 1952 (White)	155.5	158.1	156.8	
	Trotter/Gleser 1952 (African American)	152.0	153.6	152.8	
	Formicola/Franceschi 1996	150.3	150.7	150.5	
	Breitinger 1938/Bach 1965	152.4	158.3	155.4	
	Telkkä 1950	155.5	164.1	159.8	
	Olivier et al. 1978	154.9	159.9	157.4	
	Sjøvold 1990	153.9	156.0	155.0	
	Feldesman et al. 1990	-	-	-	
	Raxter et al. 2008	149.4	150.7	150.0	
	Vercellotti et al. 2009	151.8	152.7	152.2	
	Maijanen/Niskanen 2009	148.6	153.8	151.2	
	Meadows and Jantz 1992/Byers et al. 1989	153.6	163.5	158.6	
G12/S23	Pearson 1899	151.9	156.4	154.2	155.1
	Trotter/Gleser 1952 (White)	151.9	158.1	155.0	
	Trotter/Gleser 1952 (African American)	153.0	156.4	154.7	
	Formicola/Franceschi 1996	151.4	155.3	153.3	
	Breitinger 1938/Bach 1965	153.1	160.4	156.8	
	Telkkä 1950	153.6	164.1	158.8	
	Olivier et al. 1978	153.4	163.3	158.4	
	Sjøvold 1990	155.9	159.8	157.5	
	Feldesman et al. 1990	153.0	153.0	153.0	
	Raxter et al. 2008	150.5	154.3	152.4	
	Vercellotti et al. 2009	152.9	156.1	154.5	
	Maijanen/Niskanen 2009	148.7	155.0	151.9	
	Meadows and Jantz 1992/Byers et al. 1989	158.2	164.0	161.1	
G13/S23	Pearson 1899	162.7	170.9	166.8	169.9
	Trotter/Gleser 1952 (White)	168.4	176.4	172.4	
	Trotter/Gleser 1952 (African American)	165.8	171.0	168.4	
	Formicola/Franceschi 1996	166.5	171.7	169.1	
	Breitinger 1938/Bach 1965	170.0	172.7	171.4	
	Telkkä 1950	166.3	174.9	170.6	
	Olivier et al. 1978	165.3	172.8	169.1	
	Sjøvold 1990	165.2	175.7	170.5	
	Feldesman et al. 1990	172.0	172.0	172.0	
	Raxter et al. 2008	166.3	169.2	167.8	
	Vercellotti et al. 2009	166.6	176.0	171.3	
	Maijanen/Niskanen 2009	161.8	177.0	169.4	
	Meadows and Jantz 1992/Byers et al. 1989	167.5	178.3	172.9	

Table 3.2.2. continued.

Non-metric traits

Four individuals exhibit vastus notch and/or squatting facets, and one exhibits a double-rooted premolar (Table 3.2.3). Squatting facets and vastus notch often co-occur and are usually a result of frequent squatting (Schwartz 1995, 271; Han et al. 2017). A double root in a normally single-rooted tooth is a rather rare anomaly (*e.g.* Vertucci and Haddix 2011; Kong et al. 2015), and the occurrence of the trait has no specific cause. No other non-metric traits were observed, perhaps because of the generally poor preservation of the remains.

Pathological lesions and developmental anomalies

Dental pathologies

Among the possible dental pathologies, caries (G7/S21), dental calculus (G3/S21, G7/S21, G8/S21, G9/S21) and dental enamel hypoplasia (G1/S14, G8/S21) were recorded (Pl. 3.2.4,2; 3.2.6,3).

Traumata

In five individuals, healed antemortem injuries were recorded (Table 3.2.3). These include a healed fracture of the right distal tibia and a possible trauma in the sacro-lumbar area (G12/S23); a blunt-force trauma observed across the parietal bones at the top-posterior area of the cranium (G1/S14); poorly healed fractures to the clavicles (G1/S14, G8/S21); possible trauma to a hand phalanx (G5/S21); and a possible fracture of the right fifth metacarpal (G13/S23).

A healed fracture of the right tibia was observed in individual G12/S23. The bone was fractured and fully healed at its distal third (Pl. 3.2.8,1). Spondylolysis of the fifth lumbar vertebra (L5) was also recorded in this individual. The right lamina and the inferior articular process were fractured and found inside the sacral canal. The edges of the fractured bone fragments manifested signs of healing (Pl. 3.2.8,3).

The cranial injury in male G1/S14 was inflicted across the parietal bones at the top of the posterior side of the cranial vault. The lesion was 5 mm deep and was regularly oval in shape. Increased post-traumatic porosity was present in the entire posterior part of the vault. Despite the depth of the lesion, the inner table was unaffected, with no bulge observed inside the vault (Pl. 3.2.4,1).

Two individuals had a fractured left clavicle (G8/S21 and G13/S23). These clavicles were broken and poorly healed, indicating rather severe injuries. The clavicle of individual G8/S21 was fractured at the lateral end, close to the shoulder girdle. The bone had significantly shifted and healed (Pl. 3.2.6,1). The right humerus was not sufficiently preserved to be able to see any pathological changes related to the trauma to the clavicle. The clavicle of individual G13/S23 was fractured at the anterior angle, at the bone's medial third. The ends of the bone shaft had shifted from their anatomical position; the ends probably slid towards each other at the time of the injury (Pl. 3.2.9,1). In addition to the clavicular fracture, additional manifestations related to the fracture were observed in the bones of the shoulder area of this individual, including asymmetrical humeri, increased porosity at the acromial end of the clavicle and at the acromion of the scapula (Pl. 3.2.9,2). The right fifth metacarpal of the same individual had also been fractured and healed (Pl. 3.2.9,3).

Perimortem fractures were detected in the majority of the skeletons (Table 3.2.3).

Individual	Non-metric traits	Lesions and anomalies
G1/S14		cribra orbitalia; dental enamel hypoplasia; healed cranial trauma posteriorly on the parietals, about 6 cm long, across the sagittal suture, perpendicular to the suture; Schmorl's node on C2 and C3
G2/S21	vastus notch	cranial porosity (esp. occipital bone); ilium with signs of reduced bone density
G3/S21	double-rooted right upper 1st premolar	cribra orbitalia; dental calculus
G4/S21		
G5/S21		antemortem trauma or a cyst on the 1st proximal hand phalanx; fused cervical vertebrae (C2+C3), indicating possible case of Klippel-Feil syndrome; notochord defect (linear cleft) on a lower thoracic vertebra, possibly related to Klippel-Feil syndrome
G6/S21		
G7/S21	wormian bones	dental calculus, esp. on the rear teeth; caries
G8/S21	vastus notch on both patellae; squatting facets	poorly healed fracture of the left clavicle, lateral side; dental calculus, esp. on the rear teeth; slight signs of hypoplasia on the front teeth (at the age of 0.5-3 years); cribra orbitalia on both orbits
G9/S21		dental calculus, esp. on the front teeth; signs of reduced bone density
G10/S21		
G11/S22		
G12/S23	squatting facets	antemortem fractured lumbar vertebra (spondylolysis); spina bifida; degenerative joint disease signs on the vertebrae; notochord defect on cervical vertebrae; healed fracture of the right tibia
G13/S23	squatting facets	healed fracture of the left clavicle and associated signs of increased vascularity on the left acromion; slightly different dimensions of right and left humeri; lytic circular lesions of unknown origin on the inferior body of T5 (5 mm in diameter), superior body of T12 (10 mm in diameter); Schmorl's node on the inferior body of T11; notochord defect on T7; probably fractured and healed right metacarpal 5
I15/S21		
I16/S23		
I17/S23		
I18/S21		
I19/S10		

Table 3.2.3. Non-metric traits, pathological lesions and developmental anomalies in individuals from Vráble.

Congenital anomalies

Congenital spinal defects were recorded in three skeletons: G5/S21, G12/S23 and G13/S23. In individual G5/21, two of the cervical vertebrae (C2 and C3) were fully fused, suggesting that the person suffered from a condition called Klippel-Feil syndrome, associated with improper embryonic development. A lower thoracic vertebra of the same individual manifested a notochord defect (a linear cleft) at the spinal canal (Pl. 3.2.8,3). In individual G12/S23, spina bifida was scored (Pl. 3.2.8,4). Unknown circular lytic lesions were recorded on the vertebral bodies of individual G13/S23; a notochord defect of the anterior vertebral body, termed 'butterfly vertebra', was observed in the same individual (Pl. 3.2.9,4).

Other pathologies

In the older female G9/S21, reduced bone density is suspected, as the bones are unusually light and porous (Pl. 3.2.7). Non-specific stress indicators, such as non-specific porosity of the cranial vault and cribra orbitalia, occurred in three individuals. Descriptions of all pathological finds are summarised in Table 3.2.3.

Stable isotopes

We have stable isotope data (C, N) available for 16 of the human individuals, and for four of them we have multiple analysed samples from different bones, for a total of 23 samples (for a detailed discussion of the stable isotope data from Vráble, also including samples from animals and plants, see Chapter 5.8). These samples varied between −20.7 and −19.6 for δ^{13}C and between 6.4 and 11.1 for δ^{15}N. This translates to means for δ^{13}C of −20.03 and for δ^{15}N of 10.39 and standard deviations of 0.271 and 0.957, respectively. Thus, for δ^{15}N, the spread of values is far greater than for δ^{13}C. If the individual with an unusually low δ^{15}N value (G8/S21, δ^{15}N=6.4) is excluded, the standard deviation for δ^{15}N is 0.41. These values are consistent with other LBK sites in the region (especially Nitra; Whittle et al. 2013b, 150), in terms of both mean and standard deviation.

Discussion

Burial goods

Two individuals were comparatively richly equipped, one with six ceramic vessels and one flint blade (G8/S21) and the other with two ceramic vessels, one adze, one rubbing stone, two flint blades and a piece of meat (represented by bones of sheep; taxonomic identification by Ulrich Schmölcke) (G7/S21). Both individuals were older males. Three other individuals (G2/S21, G3/S21, G6/S21) had one or two ceramic vessels in their burial pit, and additionally, individual G6/S21 had an obsidian bladelet. Of the burials in crouched position, only individual G9/S21 had no item nearby that could be considered a grave good. This is also true for the three head-less individuals (G4/S21, G12/S23, G13/S23).

Further remarkable items found are two ceramic vessels in object 3 and one spondylus (a marine mollusc in the genus Spondylus) medallion and two flint blades. The two ceramic vessels were found 0.3-0.5 m above individual G5/S21, one inside the other, upside down (Fig. 3.2.7; Pl. 3.2.3,1-2). However, it may also be that these vessels originally belonged to G4/S21 or I18/S21, or even a further, otherwise completely destroyed, burial. The spondylus medallion was discovered in an animal burrow and cannot be associated with any human bones. Such medallions are very diagnostic burial items (Müller-Scheeßel 2019) and were almost exclusively used by women of probably higher status. As they are only found in burials (with rare exceptions, see Bardec'kyj et al. 2016), we have to conclude that it was part of a now destroyed grave. One further obsidian bladelet (Pl. 3.2.2,9) was discovered close to the disarticulated bones of individual G10/S21, so this could be regarded as burial good, too. A radiolarite blade (Pl. 3.2.3,3) was found in object S21/1, at less than 2 m distance from the disarticulated bones of possible individual I15/S21. It therefore may also represent a burial good. No further flint artefacts were found in Trench 21. In Trench 23, where two of the three headless individuals and some disarticulated bones were found, no artefacts which could be considered as burial-goods were encountered.

Palaeopathology

Vráble

The pathological finds observed are dental lesions, indications of bone density loss, degenerative lesions of the spine, and traumas. In addition to dental calculus, which is a normal finding in the prehistoric populations, one case of caries was observed (G7/S21). There are indications of quite good dental health for the individuals recovered at Vráble, which may be due in part to the young age of the majority of the individuals. Dental enamel hypoplasia, a defect of the enamel indicating disruptions during the formation of a tooth, was observed in two individuals. The aetiology of dental enamel hypoplasia is believed to be multifactorial (Goodman 1989; King et al. 2005; Starling and Stock 2007) but predominantly related to a metabolic disturbance – dietary or disease stress (Hillson 2005, 175). Because the times of mineralisation in human teeth are known, the location of the defect can indicate the age at which the stress occurred (Hillson 2005, 172). In male G8/S21, the stress period was the age of 0.5-3 years, whereas in male G1/S14, it was 2-4 years. In many societies, these are the ages when weaning takes place (Kennedy 2005), a period when children face nutritional stress and are more susceptible to various pathogens (Schultz and Schmidt-Schultz 2014). In both individuals, cribra orbitalia were observed as well. This is a non-specific stress indicator which could point to an insufficiently rich diet. Walker (1986) suggests it may point to the loss of nutrients associated with such conditions as diarrheal disease. Lewis (2007) concludes that abnormal cranial and orbital porosity may be caused by the mal-absorption of iron. In summary, it is possible that the affected individuals suffered from lower intake of vitamins and/or from improper absorption of nutrients in childhood (also see Dupras and Tocheri 2007; Walker et al. 2009). Non-specific stress indicators were further observed in G2/S21 (cribra orbitalia) and G3/S21 (non-specific cranial porosity), although no dental enamel hypoplasia was recorded in these individuals.

The bones of female G9/S21 were lighter and slightly more porous than normal, showing signs of decreased density of the cancellous bone, possibly suggesting osteopenia – the primary stage of osteoporosis, when the susceptibility to fracture is not as high as it is in osteoporosis (Riggs and Melton 1988; Kanis 1994; Jergas and Genant 2001; Melton et al. 2003). Bone mass decline has mostly been associated with age (Riggs et al. 1998; Mundy 1999; Mays 2000; Mays et al. 2006). Especially in females, menopause also greatly contributes to bone loss, owing to the hormonal changes (Riggs et al. 1998; Brickley and Ives 2008, 151-153). In most modern populations, menopause usually occurs around the age of 50 (Gold 2011). Women in developing countries experience menopause earlier (McCarthy 1994; Gonzales and Villena 1997; Castelo-Branco et al. 2006), as do women who live in rural areas (MacMahon and Worcester 1966). The onset of menopause in Neolithic women can therefore be expected before the age of 50, and the bone changes observed in individual G9/S21 could have occurred in association with (post)menopausal changes.

Two cervical vertebrae (C2 and C3) of individual G5/S21, a young man aged 20-25, were merged together. The fusion was visible on both the bodies and the arches of the vertebrae. The causes of fused cervical vertebrae may be congenital or acquired (related to disease, such as tuberculosis, or to infection or trauma) (Sherekar et al. 2006). The skeleton of the individual from Vráble was almost complete, although it was very fragmented. No indications of major trauma or any pathological changes were observed. Hence, a congenital cause seems to be a more plausible explanation, especially when co-occurring with a notochord defect that was observed in a lower thoracic vertebra of this individual. The combination of such malformations could be a manifestation of an uncommon disorder known as Klippel-Feil syndrome (Barnes 1994; Martin 1994; Clarke et al. 1998; Jones and Mayer 2000; Larson et al. 2001). Fusion of C2 and C3 and spinal defects are especially common in Type II, the most common of the three types of Klippel-Feil syndrome (Gunderson et al. 1967). Klippel-Feil syndrome, in general, is a rare condition. Studies agree on very low incidence of the syndrome: Clarke et al. (1998) and Jones and Mayer (2000) mention prevalence rates of 0.5-1% of births; other authors indicate that the rates are even lower (1 : 40 000 births) (González-Reimers et al. 2001; Larson et al. 2001). Unfortunately, individual bones that could reveal other anomalies associated with the Klippel-Feil syndrome, such as fusion of the ribs, curvature of the spine, Sprengel's deformity (*e.g.* Pany and Teschler-Nicola 2006), were either absent or too poorly preserved to observe such anomalies.

Degenerative spinal changes include Schmorl's nodes and non-specific porous lesions on the articular facets of the vertebrae. The aetiology of Schmorl's nodes has not yet been established. Research suggests that the development of the lesions could be related to the anatomy of the spine (Waldron 2009, 45; Burke 2012; Dar et al. 2010), trauma (Burke 2012), excessive loading (Dar et al. 2010), or heredity (Kyere et al. 2012). At Vráble, Schmorl's nodes were observed on the cervical vertebrae of a prime-aged male (G1/S14) whose skull had been injured by a blunt-force trauma from a weapon (see below). Owing to the depth of the cranial injury (about 5 mm), it can be presumed that the applied force was strong to have affected the (cervical) spine as well. Due to the anatomy of the spine, Schmorl's nodes are especially common in the lower thoracic and lumbar areas (Waldron 2009, 45; Burke 2012; Dar et al. 2010). The presence of Schmorl's nodes in the cervical spine of the male from Vráble may thus be related to a different cause, in this case possibly to the healed cranial trauma.

Thus, of eleven individuals with sufficiently preserved spine for meaningful conclusions, four (= 36.4 %) showed spinal diseases in different form.

LBK in general

Unfortunately, it is not straightforward to obtain an overview of the level of pathologies and traumata among LBK individuals in general, nor of their health status. The recent paper by A. Ash and colleagues (2016) focusses on diet and non-specific stress-related pathologies. The project of Penny Bickle and Alaisdair Whittle (2013a) mainly dealt with stable isotope data. However, in the context of the latter project, Linda Fibiger reanalysed a number of skeleton series and individualised the information on pathologies and traumata (ibid.). From this set of data, a crude prevalence can thus be computed, but it is difficult to assess the true prevalence, because it can safely be assumed that the individuals were differentially preserved. Without detailed knowledge on preservation, there is therefore a danger that the true number of deficiencies is underestimated.

Therefore, for palaeopathologies we rely on of the detailed recent publication on the cemetery of Nitra (Tvrdý 2016), where it is possible to roughly translate crude rates to true prevalence. For each skeleton and for the cranium and post-cranial skeleton separately, the anthropologist marked the preservation on a three-point scale. We assumed that a medium-preserved skeleton (preservation 2+) would provide the opportunity to distinguish more severe pathologies or traumata.

For 14 individuals, Tvrdý lists observations on pathological changes of the spine, which translates to an estimated true prevalence of 37.8 % (14 out of 37 adult individuals of preservation class 2+).

It seems that the level of spinal pathologies was more or less the same at Vráble and Nitra.

Traumata

Vráble

As regards traumatic lesions, the prevalence was quite high at Vráble. Spondylolysis, observed in female G12/S23, is defined as a defect or a stress fracture of the vertebral arch (Iwamoto et al. 2004; Massgeneral 2019). The injury most often occurs in young individuals, especially children and adolescents, who participate in activities involving repeated stress on the lower back, in modern times especially sports with frequent overstretching of the lumbar spine (McCleary and Congeni 2007; Canzonieri and Pilloud 2012). In the case of woman G12/S23, the spondylolysis of L5 could have occurred at the same time as the fracture at the distal third of the right tibia, being a result of strenuous and physically demanding activity or an accident.

Individual G13/S23 had a fracture of the fifth metacarpal bone. This is also known as a 'boxer's fracture'. The injury commonly occurs during fist fights, the fifth metacarpal being the most commonly involved (Gudmundsen and Borgen 2009; Malik and Rosenberg 2018).

The deep, regular, oval shape of the healed cranial trauma in individual G1/S14 seems to correspond with the shape of a stone axe or similar item. The location of the wound suggests that the man was not facing his opponent and was, more probably, a victim of unexpected assault or was lying on the ground when attacked. As suggested by the state of healing, the individual survived the attack. From the fact that the inner table was unaffected, with no bulge observed inside the vault, it can be presumed that the soft tissues had probably remained unhurt, which may be the reason why the individual survived the attack.

As regards the healed injuries of other individuals, the causes are difficult to estimate. The poorly healed clavicular fractures of individuals G8/S21 and G13/S23 suggest continuous load on the bones, *i.e.* the individuals did not stop using their arms despite the injuries. Following the classification of Robinson (1998), the clavicle of individual G8/S21 represents fracture type 1B (1 or 2) and the clavicle of individual G13/S23 type 2B1. In modern populations, both types are mostly connected with contact sports, such as football and hockey, but also with climbing and skiing – in other words, demanding activities where one is exposed to frequent collisions (Robinson 1998; Kihlström et al. 2017). In the past, especially in agricultural societies, the causes may have been strenuous occupations, everyday chores, and accidents relating to these, including hunting, building, cutting down trees, falls from ladders, animal assaults, but also adolescent 'games' or training (for example, see Judd and Roberts 1999). Robinson (1998) suggests that type 2B1 and 1B1/2 fractures are also highly associated with violence, which seems to represent another plausible explanation of the traumas observed in the individuals from Vráble.

Thus, there is one cranial trauma compared to eleven skulls where such an observation would have been possible (= 9.1 %). On the other hand, two individuals showed altogether three fractures of the post-cranium. Assuming 16 individuals with post-cranial skeletal elements preserved, we arrive at a rate of 18.8 %. If we transform these crude prevalence to true prevalence - that is, taking into account only those individuals where the related traumata could have been observed - we see that roughly one tenth of the Vráble individuals suffered from head injuries and one fifth from injuries to the post-cranial skeleton.

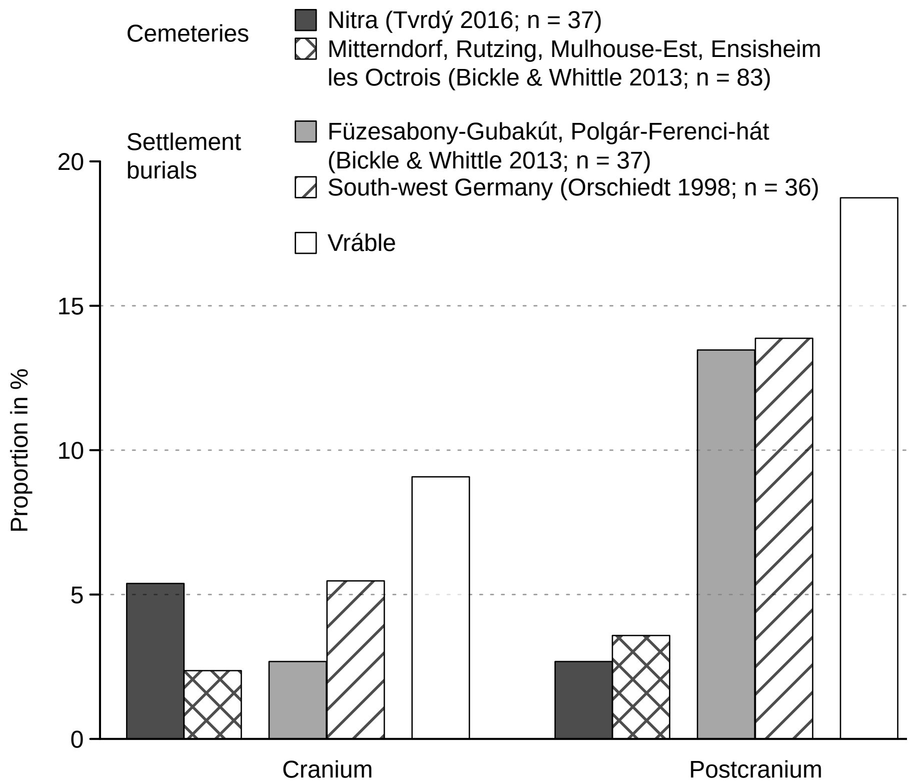


Figure 3.2.25. Rates of cranial and post-cranial traumata observed on LBK individuals from either ‚regular' cemeteries or settlement contexts in comparison to Vráble.

LBK in general

In order to compare these proportions to the rates observed among other LBK populations, we rely on the lists provided by Bickle & Whittle (2013a) for Füzesabony-Gubakút, Polgár-Ferenci-hát (both Hungary), Nitra (Slovakia), Mitterndorf, Rutzing (both Austria), Otzing (Germany), Mulhouse-Est (Rixheim) and Ensisheim les Octrois (both France). According to these data, 467 individuals were scrutinised for palaeopathologies. Of these, 194 were adult or close to adult. Among the subadults, four individuals showed perimortem trauma to the head. In contrast, five adults – one male and four females – suffered from cranial trauma. Nine adult individuals were diagnosed with fractures of the post-cranial skeleton: One female individual suffered from a fracture of both ulna and radius (a so-called parrier, or nightstick, fracture) and another female suffered from a fracture of the radius; otherwise only males were affected. Regions where fractures occurred are especially the lower arm (ulna, radius) or the upper body (clavicle, spine, rib). Additionally, one foot phalanx and one metacarpal bone showed healed fractures. Similar to the Vráble case (G13/S23), a possible explanation for the latter is hand-to-hand combat (Hedges et al. 2013, 371).

The contrast between males and females is striking: While females suffered predominately from head injuries, males suffered mostly from trauma to the post-cranial skeleton (as noted previously by Hedges et al. 2013, 371 for the site of Polgár-Ferenci-hát). Still, it is worth repeating that the overall proportions of head injuries are very low. The site with one of the highest incidences of head injuries is the cemetery of Nitra, located only 20 km west of Vráble, where two were reported for subadults and two for adults. At Nitra, one post-cranial trauma was observed. For cranial and post-cranial trauma alike, the true prevalence rate is below 10%. This is in good accordance with the data from central Europe (Petrasch 1999, 507: 2.2% of violence-induced trauma in 'regular' cemeteries).

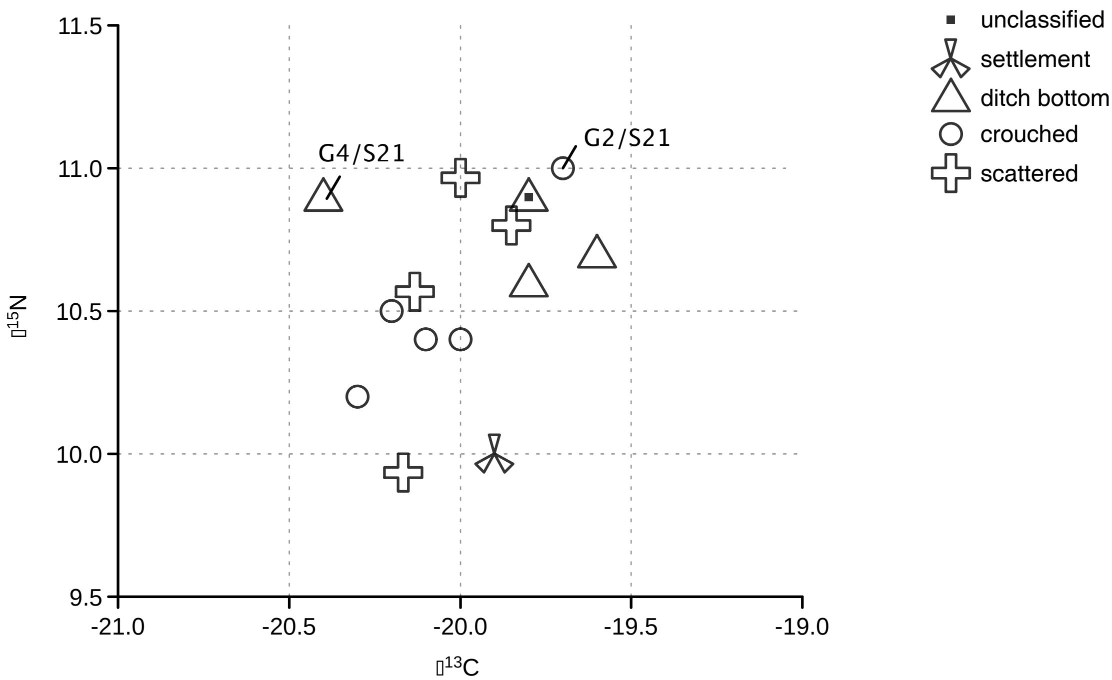


Figure 3.2.26. $\delta^{13}C$ and $\delta^{15}N$ stable isotopes of the human individuals from Vráble, differentiated according to burial characteristics. G8/S21 with an unusually low $\delta^{15}N$ value is not shown. For individual values see Table 3.2.1.

There are also differences between individuals from ‚regular‘ cemeteries and those from settlement contexts. In the samples from Bickle and Whittle (2013a), the Hungarian individuals stem from settlements (Füzesabony-Gubakút, Polgár-Ferenci-hát), while the others – Nitra, Mitterndorf, Rutzing, Mulhouse-Est (Rixheim) and Ensisheim les Octrois – can be considered to come from cemeteries. Additionally, Jörg Orschiedt (1998) dealt with settlement burials from south-west Germany.

While individuals from cemeteries and settlements alike show low incidences of cranial trauma of little more than 5 % (Fig. 3.2.25), there are marked differences in terms of post-cranial trauma. Here, ‚regular‘ burials exhibit also very low numbers of less than 5 %. In contrast, nearly 15 % of the settlement burials from Hungary as well as south-west Germany suffered trauma to the post-cranium.

In the light of these low proportions in ‘regular’ cemeteries, the number of trauma which affected the Vráble individuals is astonishing. Roughly one tenth of the Vráble individuals suffered from head injuries and one fifth from injuries to the post-cranium. Thus, Vráble shows a far higher incidence of traumata than the LBK in general. Especially the high percentage of post-cranial trauma is, however, in line with settlement burials elsewhere.

Stable isotopes

The individuals who were treated differently in death also showed some differences during life in terms of diet, as reflected in stable isotopes (Fig. 3.2.25). Those individuals found on the bottom of the ditch (the three headless individuals, as well as the partly displaced individual G5/S21, perhaps also headless) all show much higher $\delta^{15}N$ and slightly higher $\delta^{13}C$ than the average. In contrast, most of the crouched burials show lower values (with the exception of individual G2/S21). Those individuals who are difficult to classify are spread over both groups.

Post-depositional manipulations

Bones of several individuals appear to have been broken perimortem, but, as indicated by the signs of animal gnawing, the fractures were probably caused after death. The traces of animal activity on the bones point to smaller animals (*e.g.* rats, wild cats).

The position of the remains of individual G5/S21 suggests disarticulation of part of the skeleton, especially of smaller bones (*e.g.* those of the rib cage). But its long limb bones were not disarticulated. The rib cage, pelvis, and the bones of a pectoral girdle would have been the skeletal area closest to the surface and so most vulnerable to taphonomic damage. Some of the bones may thus have been re-located by small animals. Animal activity also implies that the bodies were probably unshielded for some time after death or were covered only by a thin layer of earth or a shroud. In addition to G5/S21, this seems likely also in the case of individuals G1/S14, G2/S21, G3/S21, G6/S21 and G11/S22. Of these, G2/S21 and G11/S22 showed the most severe displacements of bones.

Furthermore, in some individuals from Vráble, post-mortem anthropogenic manipulation of the bodies is suggested, especially from the position of the remains. These include child G4/S21 and the individuals from Trench 23 (G12/S23, G13/S23). Unlike the rest of the skeletons from Trench 21, who were buried in crouched positions, with hands in front of the face or in the lap, sometimes including additional grave inventory, the three above-mentioned individuals were found in positions suggesting anomalous post-mortem treatment. The child (aged 3-6) lay on its abdomen. Its arms and legs were spread, suggesting that the individual may have been thrown in the pit. A similar scenario is suggested for individual G13/S23, who was also lying on his abdomen, but in straight position. Unlike these two, female G12/S23 was lying on her back. Interestingly, in the case of these three individuals, no heads (including the lower jaws) were associated with the remains. Eroded small skull fragments were found close to child G4/S21, but it was impossible to associate them with the child or with individual G5/S21, located nearby. Therefore, it may be that individual G5/S21 has to be added to the group of head-less individuals, as neither his skull nor his lower jaw were found nearby.

No traces of violent decapitation were observed, and so it can be presumed that the skulls were removed manually, once the soft tissues had decomposed and become weak enough for the head to be removed with a minimum of force. At the same time, judging from the fact that the bones were clearly articulated at the time of interment, we conclude that the soft tissues were probably still strong enough to hold the bones together. Forensic anthropologists agree that it is until the phase of early decomposition, when the body still 'holds together' but when the soft tissues are already decomposed enough to be parted (Rodriguez and Bass 1983; Bass 1997; Galloway 1997). The rate of decomposition is dependent on many factors, including the barriers between the body and external environment and the temperature (Pope 2010, Table 3.1). It is hence difficult to generalise about the time at which a body passes through the different stages. In optimal (warm and humid) conditions, the second stage of decomposition takes place approximately within the first week after death (Galloway et al. 1989; Bass 1997). Komar (1998, 59), who studied decomposition in outdoor surface conditions of colder Canadian climates, found out that complete skeletisation of the remains was accomplished within six weeks in summer and in less than four months in winter. It can, therefore, be presumed that also at Vráble the bodies were deposited in the ditch shortly after death, possibly within the first week.

Chronology

We were able to establish the temporal relationship for some of the human remains in the ditches to each other based on the archaeological observations (see also Chapter 3.1). In object S21/3, the stratigraphy indicates that G4/S21 and G5/S21 are contemporaneous to each other but clearly older than I18/S21. Likewise, in object

S23/203, G12/S23 and G13/S23 have to be considered as deposited more or less at the same time, while the bones above them (I16/S23) must be younger.

The finds and ^{14}C dating clarify the relative and absolute chronological position of the burials. As elaborated in Chapter 4.1, the pottery securely related to some of the individuals (G2/S21, G3/S21, G6/S21, G7/S21, G8/S21) unambiguously dates to the very end of the Early Neolithic and may already be considered Pre-Lengyel. This fits the absolute dates very well. From that, it follows that the deposition of humans in the ditches started in the first half of the 51st century cal BCE, around 5075 cal BCE. Towards the end of this process or shortly after it, shortly after 5050 cal BCE, the first 'regular' burial was interred. This practice was kept up for several decades, and the last human individual was buried around 4975cal BCE, perhaps about 50 years, or two generations, later. Therefore, the first individual buried in crouched position could still have been in living memory of the oldest inhabitants of the settlements of Vráble when the last one was deposited. The deposition of crouched burials started with G8/S21, the individual in the centre of the main entrance in Trench 21. The next in the sequence seems to be G9/S21, then G3/S21, G6/S21, G2/S21, and finally G7/S21.Thus, the burials with the richest burial goods form the beginning and the end of the sequence.

Burial practices at Vráble

The treatment of the dead as attested in the burials in the vicinity of the ditch system is remarkable from different points of view. First, the signs for a staging of the deceased, with the possibility of exposure of the body to the open air for a longer period of time, not only open up a view on a distinct burial ritual, but also offer an explanation for some seemingly disturbed burials elsewhere (*e.g.* Sondershausen and Bruchstedt: Kahlke 2004). Occasional reports of postholes in or near burial pits (Kahlke 2004, SO/24, SO28; Bickle et al. 2013, 303) or wooden constructions (Baumann 1960) may thus represent only the tip of the iceberg. For Alsace, it was suggested that voids close to the body, attributed to since-decayed internal structures, represent a later development during the LBK (Bickle et al. 2013, 301). The staging of the dead, including a thorough examination of the displacement of bones along the lines of an 'anthropologie de terrain' (Duday et al. 1990; Duday 2009) certainly merits more attention in the future.

Second, the differences in the treatment of the dead are striking. While some dead were buried very much in accordance with LBK burial practices elsewhere (Bickle and Whittle 2013b), that is: in crouched position with investment in terms of time and burial goods, others were obviously left lying for a considerable length of time in the open. In addition, at least three, possibly four skeletons had their skulls removed in a stage of advanced decomposition. It may be that additional skeletons had their skulls removed this way, but we simply cannot assess this properly because some of the bone scatters were too poorly preserved to assess whether or not the head had still been in anatomical position. Still, as the modus operandi with the three better preserved skeletons was identical, it is clear that this behaviour was part of a regular ritual practice within the Vráble community at any rate.

At least superficially similar finds of skeletons from LBK contexts without skulls are known, for example, from France (Lefranc and Boës 2009, 202ff.), Germany (Kahlke 2004, 76 BR/8; Veit 1996, 121 B38) and Hungary (Whittle et al. 2013a, 75), but none showed as clear a modus operandi as Vráble. A heightened interest in the skull seems more or less a universal human characteristic (Armit 2012; Zalai-Gaál 2009); however, one should be careful not to be too quick to postulate a pan-Neolithic skull cult related to some kind of ancestor worship (Perschke 2013). Ancestor worship as a possible explanation seems especially unlikely in the case of the child from Vráble.

The reason why some skeletons from the Neolithic lacked skulls may be relate to the fact that all but one individual without skull manifested signs of developmental spinal anomalies. The remains of child G4/S21 were not preserved well enough to assess if the child suffered from any congenital anomalies. In the sacrum of individual G12/S23, spina bifida was apparent. Clinical studies affirm that adult individuals with spina bifida can experience grave physical complications, such as loss of bladder and/or bowel control or insensitivity (Avrahami et al. 1994; Kamanlı and Genç 2002; Iddon et al. 2004; Petronic et al. 2011), often leading also to negative social consequences (Roach et al. 2010). In individual G13/S23, a butterfly-shaped thoracic vertebra, indicating a notochord defect of the spine (Barnes 2012, 75-77; Hopkins and Abbott 2015), and two circular lytic lesions (5-10 mm in diameter) of unknown origin scored in two of his other thoracic vertebrae (probably T5 and T12) represent anomalies that often affect other systems, such as the gastro-intestinal, genito-urinary, or central nervous systems (*e.g.* Delgado et al. 1996). In association with their spinal lesions, it is also very probable that individuals from Trench 23 suffered from back pain (Patinharayil et al. 2008; Cofano et al. 2014; Hopkins and Abbott 2015). The fusion of the cervical vertebrae in combination with congenital vertebral defects observed in individual G5/S21, could indicate that the individual suffered from Klippel-Feil syndrome (see above). The main symptoms of Klippel-Feil syndrome include shortened neck and limited mobility of the neck and upper spine (Chaumien et al. 1990; NORD 2016). Other associated abnormalities may include scoliosis and problems associated with the kidneys, respiratory tract and heart (Marchiori 2004; Paradowska et al. 2007; NORD 2016). Moreover, sagittal clefts may be connected with defects in the gastrointestinal and nervous system (Barnes 1994), and hence it is quite possible that individual G5/S21 suffered from (a number of) health complications accompanying Klippel-Feil syndrome, probably affecting his life and contributing to his death at such a young age.

Considering the health complications accompanying the spinal conditions of the three above-mentioned individuals, it can be presumed that their social life would also have been affected. The presence of multiple healed traumas in individual G13/S23 seems to be consistent with such a hypothesis. There is a possibility that the injuries were caused as a consequence of social discrimination related to individual's appearance and/or health condition. We cannot be sure that individual G5/S21 had been subjected to post-mortem decapitation. However, we can be sure that at least two individuals suffering from a spinal anomaly were buried in an anomalous position and were missing their skulls (G12/S23, G13/S23). No other individuals from Vráble were encountered without skull or with a developmental anomaly. As stated by Bass (1997), mammalian carnivores are capable of carrying off a human skull, and therefore head removal by animals cannot be entirely excluded. However, the clustering of these individuals within the trenches (G5/S21 placed close to G4/S21 and G12/S23 buried next to G13/S23) underline our hypothesis that specific members of the community were buried in a different way than others. While the specific reasons for that are problematic to assess, as many reasons are conceivable, our results suggest that the motivation for placing some of the individuals in 'regular' burials and others in the ditch was grounded in what people did or were in life, not in how they died.

Summary and conclusion

Owing to the small size of the assemblage and the poor preservation of some of the remains, no firm conclusions can be made as regards demographic composition. The stature of individuals from Vráble seems to correspond with the values recorded for other Neolithic populations in the region (Dobisíková et al. 2007; Hukeľová 2017). Different methods used for stature estimations result in only minor differences. The studied assemblage comprises the remains of at least 19 individuals: 11 adults, 3 adolescents/young adults, 1 child, and 4 individuals of undetermined age. Thus, except for elderly individuals, all adult age categories were represented in the sample. Among the remains that could be assigned a biological age, prime-aged individuals prevail. Males outnumber females among the 10 sexed individuals, in a ratio of 8:2. A further 9 individuals are of unknown sex.

Interpersonal violence has been indicated in one case of healed cranial trauma. Other traumas are associable with either accidents or interpersonal violence.

As suggested by the poor preservation of some remains, the position of the bodies, and the signs of animal gnawing, perimortem damage detected on the skeletal remains from Vráble is most probably a result of post-mortem manipulation of the bodies shortly after death, either by small animals or by humans. Exposure to the activity of small animals suggests that the bodies were probably left uncovered for some short period of time or placed in a shallow pit and buried under a thin layer of cover (earth, shrouds, etc.).

Skeletal evidence suggests that individuals with a developmental defect (*i.e.* 'deviating' from 'normal' members of community) may have been buried in a different way. While the majority of the skeletons lay on their side, either right or left, with hands in front of the face or in the lap, the 'deviants' were placed on their back or abdomen, some apparently after having been thrown in the pit, and their skulls were removed.

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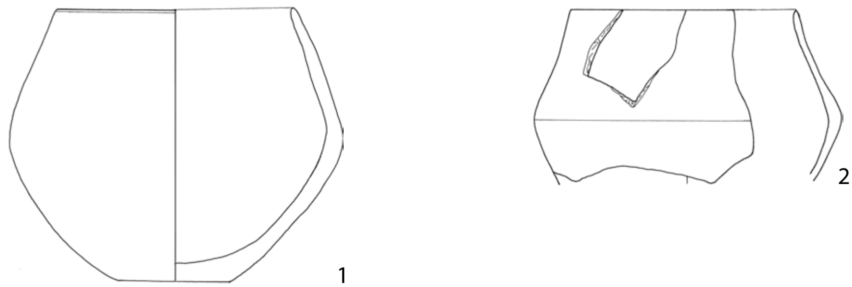
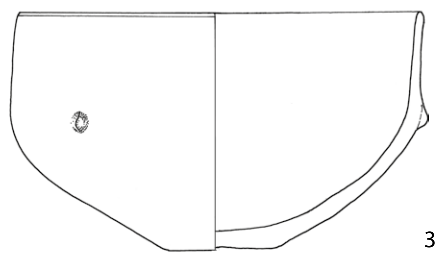
G2/S21



G3/S21



G6/S21

G7/S21

Plate 3.2.1. Burial goods. 1-6 ceramics; 7 ground stone; 8-9 chert. 1-6 scale 1 : 3; 7-9 scale 1 : 2 (drawings: E. Bakytová; photos: G. Müller-Scheeßel).

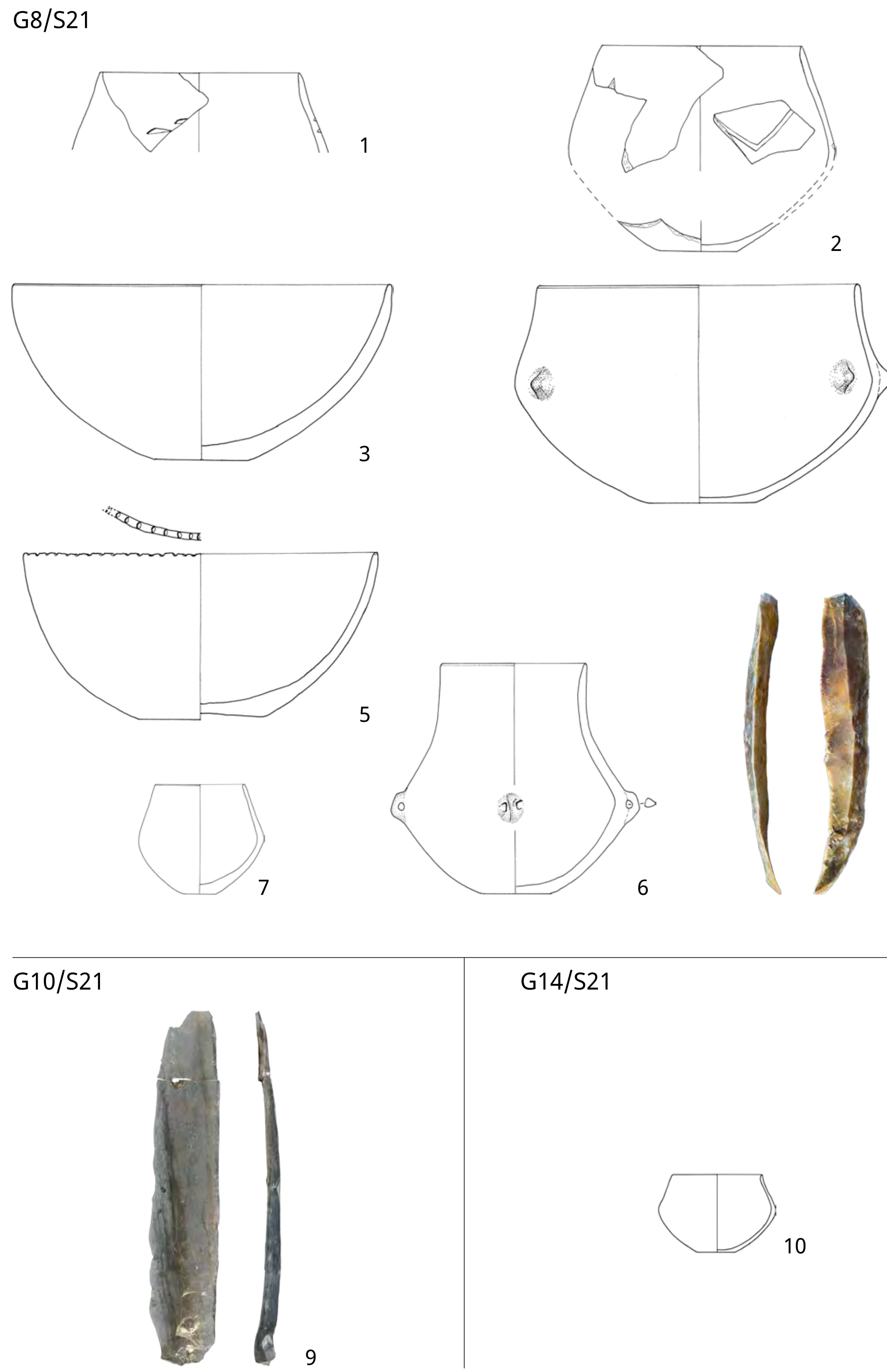


Plate 3.2.2. Burial goods. 1-7, 10 ceramics; 8 chert; 9 obsidian. 1-7, 10 scale 1 : 3; 8 scale 1 : 2; 9 scale 1 : 1 (drawings: E. Bakytová; photos: G. Müller-Scheeßel).

G 4/S21

Plate 3.2.3. Possible burial goods. 1-2 Object S21/3; 3 Object S21/1; 4 Object S21/13. 1-2 ceramics; 3 chert; 4 spondylus. 1-2 scale 1 : 3; 3-4 scale 1 : 1 (drawings: E. Bakytová; photos: G. Müller-Scheeßel).

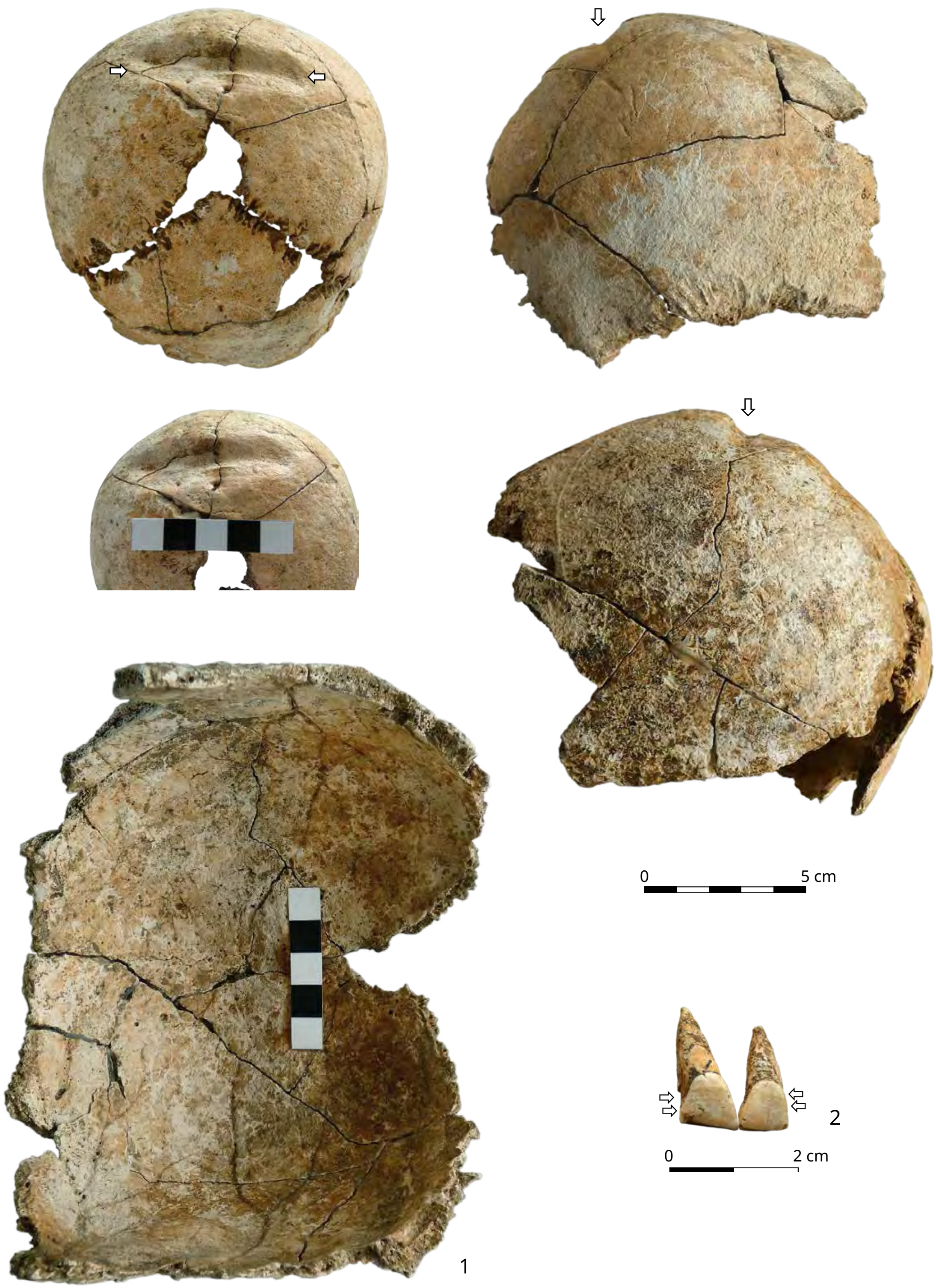


Plate 3.2.4. G1/S14. Palaeopathological features. 1 Healed cranial trauma; 2 dental enamel hypoplasia (photos: Z. Hukeľová).

Plate 3.2.5. G3/S21. Palaeopathological features. 1 Distal end of the left humerus with signs of animal gnawing; 2 left clavicle with signs of animal gnawing (photos: Z. Hukeľová).

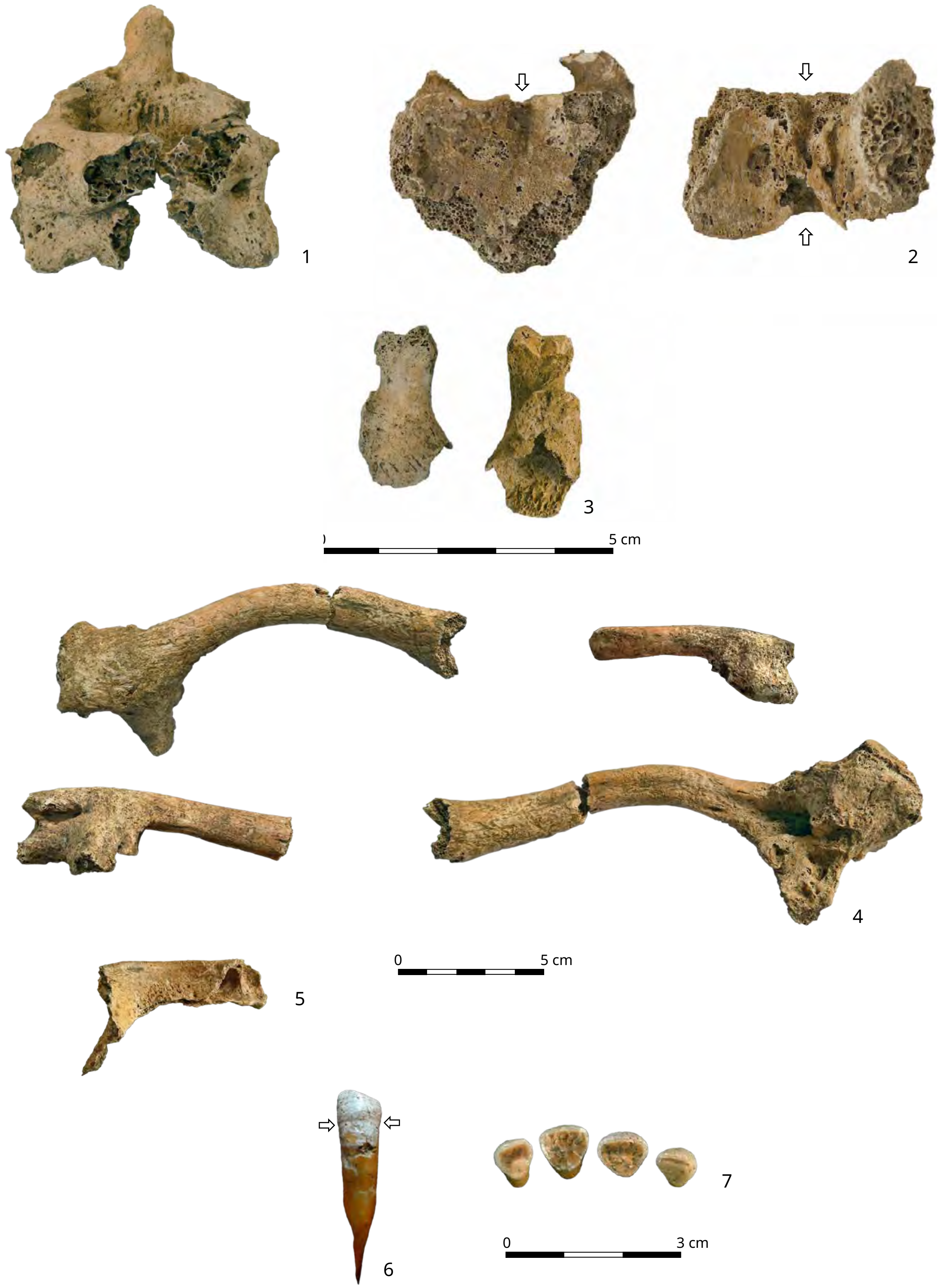


Plate 3.2.6. Palaeopathological features. G5/S21: 1 Fused cervical vertebrae (C2 + C3); 2 notochord defect (linear cleft) on a lower thoracic vertebra; 3 antemortem trauma or a cyst on the 1st proximal hand phalanx. – G8/S21: 4 Healed fracture of the left clavicle; 5 cribra orbitalia; 6 dental enamel hypoplasia; 7 occupational dental wear of the front teeth (photos: Z. Hukeľová).

Plate 3.2.7. G9/S21. Palaeopathological features. 1-3 Signs of reduced bone density (photos: Z. Hukeľová).

Plate 3.2.8. G12/S21. Palaeopathological features. 1 Healed fracture of the right tibia; 2 Spondylolysis of L5; 3 notochord defects on the spine; 4 destructive lesions on the articular facets of a cervical vertebra (photos: Z. Hukeľová).

Plate 3.2.9. G13/S21. Palaeopathological features. 1 healed fracture of the left clavicle; 2 lesions probably related to shoulder trauma; 3 healed 'boxer' fracture of the right metacarpal 5; 4 lytic lesion on the vertebral bodies of T5 and T12; 5 Schmorl's node on T11; 6 notochord defect (butterfly vertebra) on T7; 7 humeri of different sizes (photos: Z. Hukeľová).

Section 4: Chronology

4.1. Chronological analyses of the ceramic material from the LBK and Želiezovce settlement site of Vráble

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Abstract

Dating to the younger LBK and Želiezovce phase, the site of Vráble 'Veľké Lehemby'/'Farské' offers an interesting material basis, especially with regard to the pottery. For a typochronological analysis of the pottery material, we followed a twofold approach: On the one hand, we compared the ceramic material qualitatively with already existing chronologies. This allowed a typochronological characterisation of the settlement inventories, which represent the younger LBK, the Želiezovce group and some elements of Prelengyel. On the other hand, we catalogued the motifs and decorative technique on all sherds that showed these features from the different settlement objects at Vráble, using a site-specific recording system similar to the one developed by Juraj Pavúk for the site of Štúrovo. These decorative elements were then quantitatively analysed using correspondence analysis (CA). The CA of decorative motifs did not show a chronologically significant pattern of change, but it did show farmstead-specific patterns. By contrast, the CA of decorative techniques showed a chronologically significant pattern. We were able to identify an overall development, from pottery assemblages dominated by plastic techniques, such as knobs and ledges, to coarse impressions, to more delicate lines and impressions. In the later period, painted decorative techniques become more frequent.

Keywords: Pottery, Typochronology, younger LBK, Želiezovce group, correspondence analysis

Introduction

The pottery typology at Vráble was described and analysed with two different approaches. One uses the established typochronological scheme for south-western

Slovakia, while the other is based on a site-specific recording system of decorative techniques and a correspondence analysis of the house-accompanying long pits carried out in the course of two BA theses at the University of Kiel (Wolthoff 2017; Mainusch 2018). As both recording systems address different elements of the ceramic inventory, they are not easily combined in a single account. However, they can both be synchronised with the results of the ^{14}C dating of the site.

Qualitative analysis

In settlements with a larger number of houses, it is important to identify individual chronological horizons, which are assumed to reflect the time sequence of established typochronologies, most prominently of pottery. We want to be able to compare such relative chronologies with the absolute chronology, established by natural scientific dating methods and Bayesian modelling. For the site of Vráble, 97 ^{14}C dates belonging to 15 houses are available. Based on these dates, the total duration of settlement in the three neighbourhoods of the site is estimated to be 250 to 300 years (Chapter 4.2). In 2017, a further 134 corings were made in the enclosed south-western neighbourhood (area I). The house-accompanying long pits of 34 houses, clearly visible on the geophysical plan and with different orientations, were randomly selected for coring. On average, three to five corings were made in each selected long pit. After applying rigid quality criteria for a long pit to be securely dated, we found that only nine houses (including the excavated parts of houses H39, H23 and H317) could be used for further modelling. This modelling made it possible to conclude that the neighbourhood area I has a duration in the range of 5250-5000/4950 cal BCE, area II 5200-5000/4950 BCE and area III 5200-5000/4950 cal BCE.

In chapter 5.1, the ceramic inventory of the 15 excavated houses and buildings that contained such material are documented and characterised. Although the number of excavated houses and pits is relatively low and the volume excavated differs from house to house, the pottery assemblage nevertheless suffices for us to be able to point to a tangible chronological sequence within and between the individual areas. In the pottery material recovered from the settlement at Vráble, several typochronological stages of the younger LBK and the Želiezovce group were encountered. Each of the houses and objects excavated complements and can be classified within this framework.

This classification is based on a comparison of the characteristic features of the decoration, the predominant elements of the ornamentation of which the motifs on the vessels are composed. The chronological division of the younger LBK and the Želiezovce group in south-western Slovakia is based on the idea of a continuous development of ornamentation styles, which is obviously a problematic premise. It is questionable whether the so-called Notenkopf (music note) impressions connect basically with the younger LBK and the notch is exclusive to the Želiezovce group, in particular since there are instances where both of these decorative elements appear on the same vessel fragment. The typological analysis of the ceramic material shows that the youngest settlement horizons provide the most surprising inventory in terms of decoration. However, it should be pointed out that not every house has a similarly representative sample of ceramics, which is necessary to create a relative chronology based on decorative motifs. An extensive summary of ^{14}C dates makes it possible to identify groups of houses that belong to a certain time horizon, but the typology of ceramics in use may not at first glance correspond. But the reverse is also true. Both the ^{14}C samples and the pottery have been subject to a variety of taphonomic processes, blurring the chronological determination of any individual object. The relative chronological dating of each house is presented in the tables of Chapter 3.1.

The oldest chronological group – according to pottery typology – is represented by houses dominated by decorative elements of a younger LBK. These are characterised in particular by incised lines with a separate music note impression, or two or three impressions arranged in a row and connecting several lines. The second group includes houses dominated by an incised line with a music note impression, but the oval impression resembling a notch begins to appear. The third group consists of houses in which ceramics are characterised by the predominant decoration of the Želiezovce group, but there is also an example of an incision in combination with a pair of impressions. In the fourth settlement horizon, there are houses whose ceramics have elongated cuts at the breaking point between double incised lines, and an engraved wavy line begins to appear. We included houses that provided pottery decorated with a long notch applied to bundles of engraved lines, and also T-shaped incisions, in phase III of the Želiezovce group. Spherical, unornamented vessels, some with a hint of a neck, are beginning to appear in the ceramic inventory of this group of houses.

The youngest typological horizon of houses, which can also be associated with the gradual decline of the settlement complex, is characterised by undecorated, spherical vessels with a biconically shaped body and S-shaped bowls with three bulges on the body profile. The inhumation graves uncovered near the enclosure, in excavation area 21, also fall within this horizon. These contained shapes hinting at further developments during the Neolithic period in south-western Slovakia (Prelengyel).

These graves, situated in the area of the main entrance (1) to the enclosed part of the south-western neighbourhood (area I) provide a complex of chronologically significant ceramic inventories. Of the 19 complexes with human remains explored so far, seven burials were found in this area. Three other skeletal complexes were uncovered in trench 21, but they contained no pottery finds. The burial goods inventory is represented by spherical vessels, bowls and amphoras. Among the spherical vessels, three variants can be distinguished, which, as has been shown in the settlement in Bajč, represent a developmental sequence (Cheben 2000, Fig. 19). The first is a container with a slightly curved neck and a rounded body (Pl. 3.2.3,2). It was accompanied by a spherical vessel (Pl. 3.2.3,1) decorated with an engraved ornamentation, which indicates a departure from the usual motifs at the beginning of Phase III of the Želiezovce group. The second group consists of spherical containers with a conically shaped body (Pl. 3.2.1,1.6; 3.2.2,2.7). This type also includes a cup from grave G14/S21 (pl. 3.2.2,10). The third, representing the youngest development, includes containers with a curved neck (Pl. 3.2.1,2.5). Hemispherical bowls occurred in grave G8/S21 (Pl. 3.2.2,3.5), but together with a bowl that exhibits an S-shaped profile (Pl. 3.2.2,4). A similarly profiled bowl formed an inventory of grave G3/S21 (Pl. 3.2.1,3). The chronological marker of the final development of the Želiezovce group is the application of three knobs along the perimeter of the maximum width of profiled bowls. This type of bowl was documented in the Želiezovce phase III complexes at Bajč (Cheben 2000, Fig. 12,7; 14,1.5). The amphorae from burial G6/S21 (Pl. 3.2.1,4), but in particular the vessel from burial G8/S21 (Pl. 3.2.2,6) indicate the beginning of the Prelengyel development.

The fifth spit of two quadrants of object S12/9a (in excavation area 12, in the south-eastern neighbourhood) yielded fragments of several undecorated, thin-walled containers, including spherical containers with a biconical body (Pl. 3.2.42,12-13.17; 3.2.43,1.5). Some specimens show a slightly curved neck. Together with objects S11/10, S11/11, S11/12 and the lower spits in object S11/24 (Pl. 3.2.43,18; 3.2.44,1-2), in which undecorated shapes of thin-walled ceramics also occurred (Pl. 3.2.42,4), they belong to the youngest settlement horizon and can be synchronised chronologically with finds from grave units. It turns out that it is precisely the conclusion of the development of the Želiezovce group that is best represented in the ceramics.

The end of the enclosure in terms of the gradual loss of its function, falls within this youngest time horizon, as evidenced in particular by the vessel from grave G4/S21 (Pl. 3.2.3,1) deposited at the bottom of the ditch. This spherical vessel carries an ornamentation belonging to the very end of the youngest phase of the Želiezovce group and is accompanied by an unadorned spherical vessel (Pl. 3.2.3,2).

Unadorned spherical vessels with a biconical body and a curved neck and profiled bowls indicate the beginning of the decomposition of the incised ornamentation on the ceramics at the final stage of the development of the Želiezovce group. In the Prelengyel horizon, the engraved ornamentation completely disappeared, later to be replaced by almost exclusively painted patterns. The biconical or S-shaped bowls that occurred in graves G3/S21 and G8/S21 (Pl. 3.2.1,3; 3.2.2,4) have their continuation both in the Lužianky group and in the first stage of the Lengyel culture. The Lengyel culture, in the form of decoration consisting of a hemispherical bulge below the edge, is evidenced by the sherd from object S11/37a (Pl. 5.1.46,9), which occurred in the fifth spit.

The Vráble ceramic inventory includes fragments of vessels that, by their decoration, are outside the usual ornamentation spectrum of the LBK and Želiezovce group. As a rule, these are traits that occur in contemporary cultures and thus document mutual contacts and interregional interaction. A band enclosed by an incised line and filled with punctates is considered to represent an influence (in terms of decoration) or direct import of the Vinča pottery style. At the end of the Middle Neolithic, two types of filled bands are known from south-western Slovakia. The first are short scratches (Pavúk 1969, Fig. 56,5-8; 1994, Pl. 8, 29) and the second are punctates or grooves. One similar sherd of this pottery type is known from the settlement site of Bajč, which overall is assigned to stage III of the Želiezovce group (Cheben 2000, Table 30,233/51). Finds of this type of ceramic were documented in the northern neighbourhood (III) (Pl. 5.1.33,6), and Vráble should therefore also be included in the distribution area of this ceramics type. The punctate-filled band also occurs in southern Transdanubia, where it is considered to represent the influence of the Vinča culture, via the Szakálhát Group (Kalicz/Makkay 1977, 108-109), as a result of intensified mutual contacts.

Description of the pottery recording system

The typochronological investigations on pottery decoration at Vráble presented here are based on the ceramic material of the 2012-2017 excavations. We developed a site-specific ornamental recording system adapted to the Vráble material, which distinguishes between ornamental motifs and ornamental techniques. This system differs in detail from the recording system used by Pavúk (2009; 1994) for the site of Štúrovo.

The ornamental technique refers to the means, with which an ornamentation is created, such as a carved line, as opposed to an impression or painting of different colours. A distinction is also made between a narrow and a wider line, since a different instrument was used, as well as between impressions of different forms. An ornamental motif designates the shape of the pattern, regardless of the technique used to create it. The reason for making this distinction is that the choice of ornamental techniques and motifs can be traced back to the potter's decision-making. The selection of an instrument for the creation of a motif is partly decoupled from the decision of how the motif should look in the end. The former choice requires a higher degree of preparatory work – making and selecting *e.g.* between a bone awl and a stamp – while the latter to some extent leaves space for the individual creativity of the potter at the time of decorating the vessel. This is even true if culture-specific traditions played the greatest role in both decision-making processes. We are aware that the distinction between ornamental technique and motif is not 100 per cent clear – *e.g.* it could be discussed whether a 'notch' is a particular ornamental technique or a motif. The two classification levels are also not independent of each other, since, for example, no lines can be created with a stamp. But using a pointed bone awl, one can carve a line as well as create fine punctates. An ornamental technique is therefore not only the instrument with which the ornamentation is applied, but also the way in which the instrument is used. In this way, a distinction is made between a 'wide line' and a 'wide, deeply impressed line'. However, we consider our subdivision to be meaningful, because as can be seen below, correspondence analysis (CA) revealed patterns that are in line with the overall archaeological findings.

The seriation of the ornamental motifs did not produce a chronologically significant sequence. We interpret this in such a way that the differences between the different yards, or farmsteads, are so clear that their chronological significance recedes into the background. In contrast, a chronologically significant sequence was observed in CA of the ornamental techniques.

The ceramics from Vráble were classified according to the catalogue of ornamental techniques in table 4.1.1 and included in the Vráble project database. In this way they can be assigned to individual features, objects and houses, many of which have been ^{14}C dated.

A CA was performed, using the pottery ornamental techniques, classified according to Table 1 as variables of the objects, consisting of the house-accompanying longitudinal pits or other features that in most cases can be assigned to a specific house structure. However, rare ornamental techniques were excluded from the analysis. The CA was performed with the R-package FactoMineR (Lê et al. 2008). Five eigenvectors were calculated, of which Figure 4.1.1 shows eigenvectors 1 and 2, which explain 32.8 per cent (eigenvector 1: 17.8%; eigenvector 2: 15.0%) of the variance in the dataset.

Correspondence analysis results

Figure 4.1.1 shows the arrangement of ornamental techniques on eigenvectors 1 and 2. The first eigenvector shows the difference between inventories where painting is more or less common. The second eigenvector groups the inventories based on their differentiation in ornamental techniques. Inventories seen in the positive range of the y-axis include more plastic ornamental elements, such as knobs and strips, as well as impressions of the coarser variety (finger and fingernail impressions) while finer impressions, *e.g.* 'drop-shaped' or 'music note head' impressions, as well as deep lines, are rather found in the negative range of the second eigenvector. In the centre there are, as expected, elements which are common in all inventories, such as thin lines, round impressions and notches.

Figure 4.1.2 shows the arrangement of the objects in the CA. What is noticeable at first glance is the fact that most objects assigned to a house are close to each other. An exception is house 132, whose longitudinal pits are far apart. This can be explained by the fact that this is the oldest of a sequence of houses lying very close to each other. Also, the ^{14}C data obtained indicate that the longitudinal pits of house 132 were still open while the adjacent houses 131 and 133 were already in use. In fact, the objects from house 132 are close to the objects from houses 131 and 133 in relation to the first eigenvector, while they are where they could be expected in relation to the second eigenvector. As the ^{14}C data show, the arrangement of the objects is chronologically significant.

The houses that date from 5250-5050 cal BCE are all in the upper left area of the graph, namely houses 258, 245 and 259. House 132, which also yielded such early ^{14}C dates, shows its connection to this chronological phase in its closeness to the other house on the y-axis. However, the addition of a few painted sherds by more recent activities could have caused the shift on the x-axis towards the more positive values to the other houses from trench 2016, namely 131, 133 126 and 127. Apart from this anomaly, a clear chronological sequence can be depicted from top left to bottom centre and then back to top right: houses 103 and 244, 102, 37 and 319 also

ID	Beschreibung	Description
1	Linie, dünn	line, thin
2	Linie, breit	line, wide
3	Linie, breit und tief	line, wide and deep
4	Fingertupfen	finger dab
5	Eindruck, Linsenform	impression, lenticular
6	Kerbe	notch
7/48	Zierleiste	decorative moulding
8	Fingernageleindruck	fingernail impression
9	Einstich, oval	punctuation, oval
10	Notenkopf	impression, like head of music note
11	Linie, dünn und tief	line, thin deep
12	Knubbe, klein rund	knob, small round
13	Henkelaufsatz; langezogen/ "vogelartig"	handle application; elongated/„bird-like"
14	Kerbe, lang	notch, long
15	Knubbe, klein unregelmässig	knob, small irregular
16	Knubbe, klein oval	knob, small oval
17	Linie, sehr breit	line, very wide
18	Knubbe, klein rund, oben eingedrückt	knob, small round, with impression
19	Knubbe, gross rund, eingedrückt	knob, big round, with impression
20	Einstich, tropfenförmig	punctuation, drop-like
21	Knubbe, klein rund flach	knob, small round flat
22	Knubbe; gynaikomorph	knob; gynaikomorph
23	Kerbe, lang gezahnt	notch, long toothed
24	Knubbe, groß oval flach	knob, big oval flat
25	Henkelaufsatz in Form zweier "Ohren"	handle application in the shape of two ears
26	Henkelaufsatz, ambossförmig	handle, anvil-shape
27	Knubbe, mondförmig	knob, moon-shaped
28	Eindruck, unregelmäßig	impression, irregular
29	Knubbe, klein spitz	knob, small pointed
30	Knubbe, langoval, hoch gebogen	knob, elongated oval bent upward
31	Knubbe, klein rund, eingedellt und durchlocht	knob, small round, with impression on top and perforation
32	Einstich unregelmäßig	punctuation, irregular
33	***Ösenhenkel, oval hoch***	loop-handle oval high
34	Einstich, dreieckig	punctuation, triangular
35	Ausguss	spout
36	Nagelfinger mit Wulst	fingernail imprint with bulge
37	Eindruck mit Zahnstock, Rand wulstig	impression made with toothed instrument, bulge on edge
38	Stabhenkel	bar-handle
40	Furchenstichlinie	line, grooved
41	Bemalung, rot	painting, red
42	Knubbe, klein, "Knopfform", eingedellt	knob, small button-like impressed
43	Schüsselloch	keyhole
44	Knubbe, groß oval hoch	knob, big oval high
45	Eindruck, klein oval	impression, small oval

Table 4.1.1. List of ornamental techniques observed on the pottery from Vráble.

ID	Beschreibung	Description
46	Knubbe, groß rund	knob, big round
47	Henkel, hoch breit	handle, high thick
49	Knubbe, groß oval, eingedellt	knob, big oval impressed
50	Knubbe, groß dreieckig eingedellt	knob, big triangular impressed
51	Knubbe, groß rund spitz	knob, big round pointed
52	Knubbe, groß, Knopfform eingedellt	knob, button-like large impressed
54	Eindruck, gross, oval	impression, large, oval
55	Knubbe, groß oval	knob, big oval
56	Kerbe, gezahntes Instrument	notch made with toothed implement
57	Eindruck, Zahn	tooth impression
58	Henkelaufsatz, unbestimmt	handle, indeterminate
59	Einstich; danach weggezogen	punctate; then whisked away
60	Kerbe, sehr klein	notch, very small
61	Knubbe, groß rund abgeflacht	knob, big round flattened
62	Einstich, rautenförmig	punctuation, rhomboid
63	Eindruck, 8-förmig	impression, figure-of-eight-like
64	Eindruck, rund klein	impression, round small
65	Eindruck, dreieckig	impression, triangular
66	Knubbe, groß unregelmäßig eingedellt	knob, big irregular impressed
67	Einstich, rund sehr klein (Zahnstocher)	punctate, round very small (toothpick)
68	Knubbe, groß dreieckig	knob, big triangular
69	Linie, dünn abgesetzt; weitergeführt	line, thin; dashed
70	Eindruck, langoval/"Reiskorn"	impression, elongated oval, like a rice grain
71	Knubbe, zoomorph, Rind	knob, zoomorphic, cattle
72	Knubbe klein rund eingedellt mit Kerbe	knob, small round impressed with notch
73	Knubbe klein rund abgeflacht	knob, small round flattened
74	Einstich 8-förmig	punctuation, figure-of-eight-like
75	Doppel-Knubbe, groß unregelmäßig	double knob, big irregular
76	Einstich, rund	punctuation, round
77	Knubbe, groß oval dreifach eingedellt	knob big oval triple impressed
78	Knubbe, sehr klein flach	knob very small flat
79	Daumentupfen	thumb imprint
80	Knubbe, klein; Dreieck abgeflacht	knob small; triangular flattened
81	Knubbe, klein dreieckig	knob small triangular
82	Knubbe, sehr klein spitz	knob very small pointed
83	Eindruck, tropfenförmig	impression drop-like
84	***Ösenhenkel, klein rund abgeflacht***	loop-handle, small round flattened
85	Knubbe, groß unregelmäßig abgeflacht	knob, big irregular flattened
86	Knubbe, groß oval doppel eingedellt	knob, big oval double impressed
87	Knubbe, groß rund hoch abgeflacht	knob, big round high flattened
150	Knubbe, groß rund hoch	knob, big round high
151	***Ösenhenkel, hoch rechteckig***	loop-handle, high rectangular
152	Zoomorpher Ösenhenkel	loop-handle, zoomorphic

Table 4.1.1. continued.

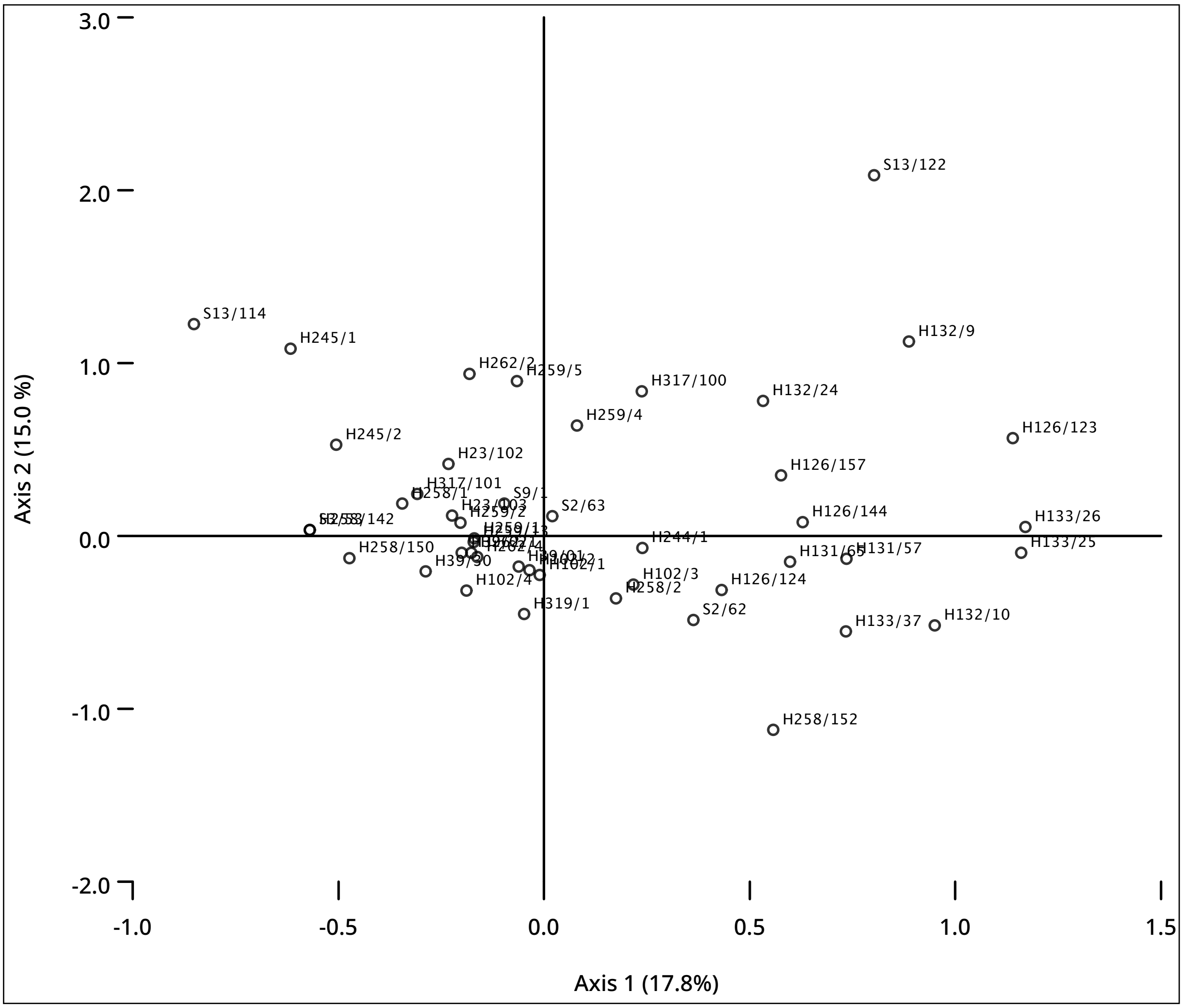

Figure 4.1.1. CA of the inventories of pit features assigned to house structures. Shown are the variables (ornamental techniques), with their second eigenvector values plotted on the first and second eigenvectors.

are younger according to ^{14}C dates (either 5100-4950 cal BCE or 5050-4950 cal BCE). Those are followed by houses 131 and 133, and at the end by houses 126 and 127.

The chronological sequence is characterised by a development during which the proportions of ornamental techniques evolved from a greater number of plastic elements and coarse impressions to less variable and finer impressions. In the last part of the sequence, painted pottery became more frequent.

Comparison of typological assignments and radiocarbon dates

When we compare the absolute chronology of houses with the typochronological assessments, there is in general a good fit. The taphonomy of LBK longpits is a complicated issue, and it is likely that the relationship between their fill and the use-life of the houses they are connected to is variable, which blurs our data. However, this affects both the pottery and the samples used for ^{14}C dating in the same way.

There are houses assigned to the younger LBK and houses assigned to the Želiezovce group. The younger LBK is supposed to be older than the Želiezovce group. Internal divisions of the Želiezovce group, normally classified as I-III (Cheben 2000), cannot be made for a single house. Instead, elements belonging to these different subgroups are found in the longpits of the same houses.

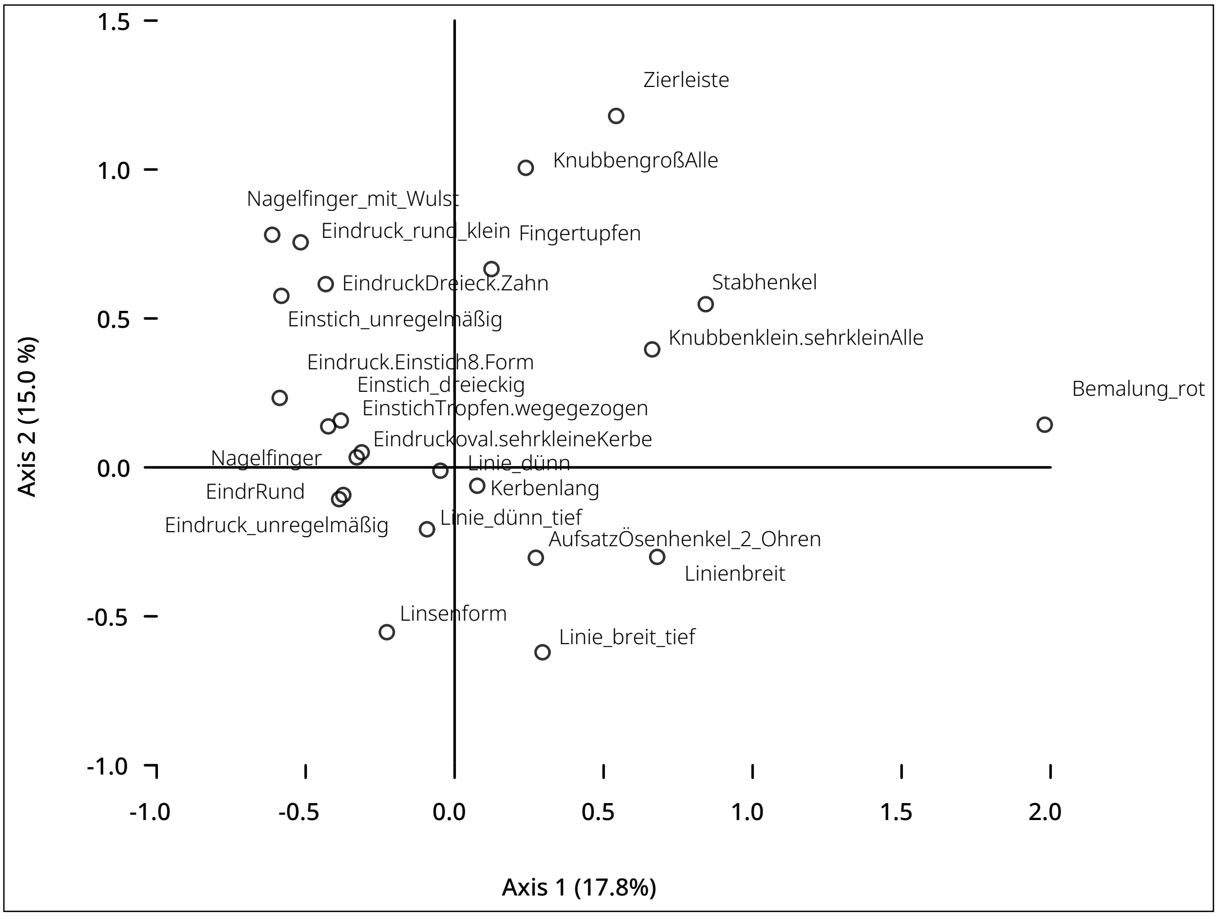

Figure 4.1.2. CA of the inventories of pit features assigned to house structures. Shown are the objects (pit features assigned to house structures) plotted on the first and second eigenvectors.

Looking at Table 4.1.2, we can see that of the four houses classified as younger LBK, one (319) was not dated and two (103, 244) date before 5050 cal BCE. A third house with younger LBK pottery (245) shows two different dates, dating either before 5150 or after 5100 cal BCE. The younger of the two samples showed less than 1 per cent of collagen, and was thus discarded by Meadows et al. (2019), leaving this house with only one radiocarbon date, which led to its dismissal in Meadows et al. (2019). However, the one radiocarbon date corresponds well with the typochronological dating.

Three houses have both younger LBK and Želiezovce pottery. Two of them are located directly beside each other, and from the magnetic plan, it looks as if House 259 is younger and that its eastern longpit (H259/2) destroyed the western longpit of House 258. Given this spatial proximity and the stratigraphic relationship, it is likely the material in the fills of these pits are mixed, either by redeposition of material from House 258 during the destruction of its western longpit, or by continuous deposition in the eastern longpit of House 258 while the successor House 259 was in use. Both houses date into the period 5200-5000 BCE, which would be consistent with an overlap or transition from the younger LBK to the Želiezovce phase. The third house with both styles, 262 is dated between 5050 and 5000 BCE, and what would be as young as the majority of the Želiezovce houses.

Of the seven houses that are dominated by Želiezovce-style decoration, five date between 5050 and 5000 cal BCE and two show deviating absolute dates. House 39 is slightly older (5150-5050 BCE), which does not cause too much trouble. House 32 is, however, one of oldest dated houses. However, this is another example of a house that was flanked by two younger ones, and there is a good chance that the longpits of 132 were still being filled up while houses 131 and 133 were in already use. This is

House	Pottery Style	Radiocarbon cal BCE
244	younger LBK	5250-5050
245	younger LBK	5250-5150 and 5100-4950
103	younger LBK	5050 terminus ante quem
319	younger LBK	not dated
258	younger LBK-Želiezovce	5200-5000
259	younger LBK-Želiezovce	5200-5000
262	younger LBK-Želiezovce	5050-5000
39	Želiezovce	5150-5050
102	Želiezovce	5050-5000
131	Želiezovce	5050-5000
132	Želiezovce	5220-5050
133	Želiezovce	5200/5050-5050
126/127	Želiezovce	5050-5000
23	Želiezovce	5050-5000
317	Želiezovce	5050-5000

Table 4.1.2. Comparison of typological assignment and radiocarbon chronology of the houses at Vráble.

also reflected in the CA of the decorative techniques (see above), where the longpits belonging to this house deviated from the chronological sequence.

This comparison of ^{14}C dates and typological groups would make it possible to argue that the younger LBK style prevailed in the early period of the site, from 5250 BCE until somewhen between 5100 and 5050 BCE and that the Želiezovce style dominated from 5050 BCE until the end of the site occupation, about 5000-4950 BCE. However, there is no good reason to believe in a sharp temporal division between the two styles, and both the houses with mixed materials, as well as house 39, which shows Želiezovce but is 'too old', would speak for a temporal overlap between the styles. Overlap can also be seen when we draw the burial pottery into the picture. Here, several vessels that are classified as Prelengyel date to around 5050 BCE. The burials that seem to be more or less contemporary show a typological sequence, which demonstrates the possibility either of vessels with different use-life or of several of the typologically sequential developments having taken place synchronously, for example through more conservative vs. more progressive potters. Overall, we can argue for a tentative pottery sequence which starts with the younger LBK style, from 5250 to 5050, continues with the Želiezovce style, from 5100 to 5000/4950, and ends with Prelengyel, with the first Prelengyel-style pots appearing by 5050 BCE (Table. 4.2.3).

younger LBK	5250-5050 cal BCE
Želiezovce	5100-5000/4950 cal BCE
Prelengyel	present by 5050 BCE

Table 4.1.3. Tentative absolute chronological position of pottery styles at Vráble.

Conclusions

It is not to be expected that the constructional horizons (*i.e.* individual houses) within farmsteads can be chronologically divided according to the period of activity for each generation living in the house, which on average represents about 30 years. When determining the building horizons, *i.e.* the period from the construction of the house to its demise, it is necessary to consider different lengths of time. At the same time, it could be that the inventory obtained from the buildings belonging to one house represents different periods of the house's use, and also activities taking place after the end of the house's use. The arrangement of houses and yards into relative chronological horizons is based on a stylistic comparison of the main decorative features and indicates their typochronological similarity, and is thus only a coarse approximation of real chronological patterns. When comparing the typochronological data with the ^{14}C data, it should be taken into account that both pottery and the organic material sampled for ^{14}C dating could have entered the pit over a longer period of time than in the case of graves, as they do not represent 'closed' find complexes in the classical sense. Nevertheless, the ^{14}C dates and the qualitative and quantitative analyses of pottery typology correspond well enough to enable us to reconstruct the overall chronological trends. This is further supported by the observation of a correlation between house orientation and absolute chronology (Müller-Scheeßel et al. 2020), which gives us a further source of dating, this time referring to the initial construction of houses.

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4.2. Radiocarbon dating at the LBK and Želiezovce settlement site of Vráble

Robert Staniuk, Maria Wunderlich, John Meadows, Nils Müller-Scheeßel, Martin Furholt, Ivan Cheben

Abstract

This chapter describes the dating programme and Bayesian modelling developed for the settlement complex of Vráble 'Veľké Lehemby'/'Farské' (Nitriansky kraj, Slovakia), including the sampling of archaeological features, the selection of ^{14}C samples, the methodology behind the dating programme, and an outline of the developed models. For a detailed overview of the applied methodology, sampling strategy and models, the reader is referred to specialised publications (Meadows *et al.* 2019; Müller-Scheeßel *et al.* in press).

Keywords: Absolute chronology; younger LBK; Želiezovce; radiocarbon dating; Bayesian modelling

Introduction

The focus on studying settlement duration, house longevity and the temporality of early agricultural communities remains essential in LBK research (cf. Jakucs *et al.* 2016; Oross *et al.* 2016; Jakucs *et al.* 2018). The importance of these determinations is embedded in the broader interest in settlement size, the emergence of agglomerations and the social organisation of early agricultural communities (cf. Zimmermann *et al.* 2009; Bentley *et al.* 2012; Whittle 2018).

The investigation of the settlement complex of Vráble 'Veľké Lehemby'/'Farské' focused on determining the chronological trajectory of the neighbourhoods and their relationship with the emergence of burial practices. To this end, an extensive sampling programme was implemented throughout the duration of the project, followed by Bayesian modelling of the ^{14}C results.

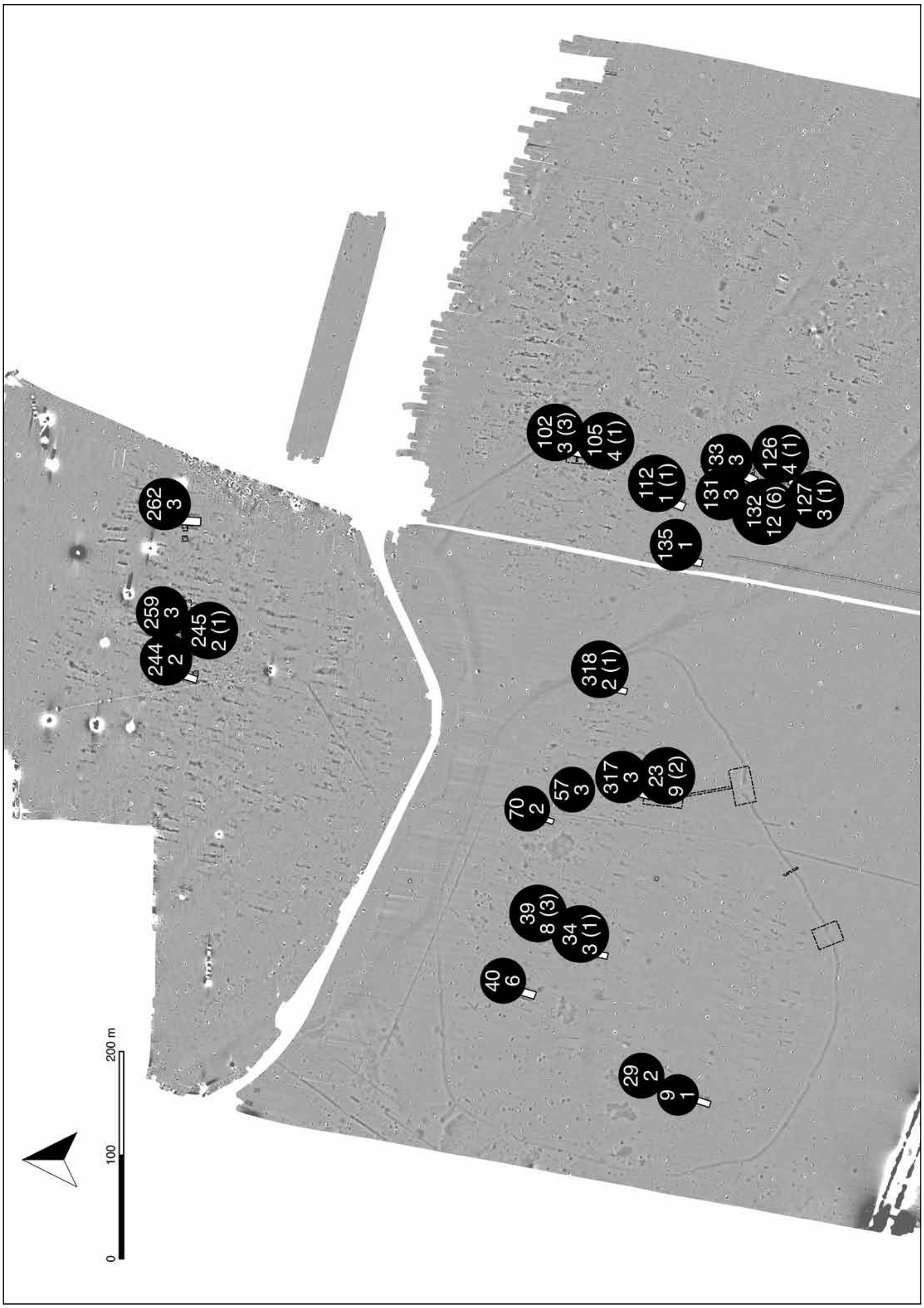

Figure 4.2.1. Spatial distribution of 14C-dated materials per house. Numbers in parentheses indicate failed samples.

Sampling strategy

Samples for radiocarbon dating were collected during excavation and during the coring of selected magnetic anomalies. Magnetic prospection of the entire Vráble settlement complex provided the means of obtaining a holistic perspective on the temporal relations between the different neighbourhoods and the excavated burials.

The excavation-based sampling of settlement features focused on long pits, following the assumption that the materials found inside the objects were deposited by the inhabitants of the associated houses (Meadows *et al.* 2019, 1658; Müller-Scheeßel *et al.* 2016). Additionally, samples were extracted from beehive-shaped pits (cf. Chapter 3.1). Despite explicit attempts, it was not possible to obtain datable material from the postholes, which would have dated the buildings directly. The coring-based sampling targeted the anomalies identified on the basis of the magnetometric prospection and involved collecting a minimum of three samples from the long pits adjacent to the identified house areas. Random sampling was constrained by the desire to avoid long pits that could not be definitely attributed to house areas. In total, 34 houses were targeted with the coring programme. Radiocarbon dating of human remains was conducted on 19 putative individuals found buried in the ditch system or in long pits (cf. Chapter 3.2).

In total, 129 ^{14}C dates were obtained from 110 samples (Meadows *et al.* 2019; Müller-Scheeßel *et al.* in press). The sampling strategy proved successful in terms of acquiring short-duration materials for dating, namely animal bones and remains of short-lived botanical taxa (Fig. 4.2.1). During the analytical part of the investigation, it became clear that a significant number of the sampled bones, both human and animal, exhibit a low proportion of collagen (<1%), thus producing uncertainties and deviations in the ^{14}C dates (Meadows *et al.* 2019).

Four different laboratories were selected for dating of the samples, in order to ensure quality control: 1) Poznan Radiocarbon Laboratory, Poland (Poz-); 2) Centre for Isotope Research, Groningen University, the Netherlands (GrM-); 3) Royal Institute for Cultural Heritage, Brussels, Belgium (RICH-); and 4) Leibniz-Laboratory, Kiel, Germany (KIA-) (Meadows *et al.* 2019, 1656-1657; Müller-Scheeßel *et al.* in press).

Results of the radiocarbon dating

The results of the ^{14}C dating indicate that the majority of samples fall within the period 6300-6100 BP (*c.* 5250-5000 cal BCE), coinciding with the duration of the LBK and Želiezovce groups (Meadows *et al.* 2019, 1657).

Overall, 23 of the houses, or 8% of 304, were dated for the purpose of the investigation. While the entire settlement was subject to analysis, the extensive coring programme in the south-western neighbourhood has resulted in the best spatial coverage occurring in that area.

Bayesian modelling

The two main models explored in the investigations started with the following *a priori* assumptions for the modelling of its chronology (Meadows *et al.* 2019, 1657; 1661):

A. Neighbourhoods represent independent developments with potential overlap; determination of the settlement complex duration has to focus on the duration of houses.
B. Neighbourhoods represent contemporary developments; determination of the settlement complex duration has to focus on the entire sequence.

Model A

No overall boundaries were in effect for the Vráble settlement complex; therefore the model worked only with separate bounded phases of the neighbourhoods. Under model A, abandonment of the settlement would had to have taken place *c.* 5000 cal BCE, with differences primarily related to the formation of the neighbourhoods. The south-western neighbourhood would had to have been founded *c.* 5250 cal BCE. The chronology of the northern neighbourhood remains unclear, and the south-eastern neighbourhood would have been short-lived.

Model B

Placing all of the dates in one bounded phase provided an acceptable index of agreement (A_{model} = 60.9%). Under model B, the settlement span had to have been 200-330 years (95% probability) or 220-290 years (68% probability), with the initiation of settlement formation possibly taking place *c.* 5280 cal BCE. The high frequency of younger-dated houses may impact the model, and therefore the initial phase of the settlement may be underrepresented in the radiocarbon model. Based on model B, houses remained in use for to up to a few decades, supporting the traditional estimate of house duration (Meadows *et al.* 2019, 1667, Fig. 11). Further modifications of the model based on kernel-density estimates suggest that the median house life span was 27-28 years, which is close to the original 25-year estimate.

In light of the available data, the determinations provided by model B were selected as the valid chronological model for the Vráble settlement complex.

Dating of the burials

A total of 35 human bones attributed to 19 putative individuals were dated at the Poznan Radiocarbon Laboratory or at the Leibniz-Laboratory, and one sample was replicated at the Royal Institute for Cultural Heritage. The purpose of the original investigation was to determine the chronological relationship between the different burial rites identified during the excavations of the long pits and the ditch system (Müller-Scheeßel *et al.* in press). Burials are categorized as ‘irregular’ or ‘regular’. The former show clearly distinguishable arrangements indicating complex practices of dismemberment, display and *post-mortem* disturbances, whereas the latter show well-defined and structured burial practices (cf. Chapter 3.2.).

Based on the combined stratigraphic, archaeological and anthropological observations, a chronological model for the burial data was developed (Müller-Scheeßel *et al.* in press, Fig. 6, supp. 2). Based on the burial model, ‘irregular’ burials started to appear in the first half of the 51st century cal BCE, while ‘regular’ burials started to appear after *c.* 5050 cal BCE (Müller-Scheeßel *et al.* in press, Fig. 7). The final burial was dated to shortly before 4950 cal BCE (Müller-Scheeßel *et al.* in press).

The chronological model of the burial data suggests that the settlement was already well developed when the burial of individuals started taking place, since 5280 cal BCE marks the start of the settlement and 5100 cal BCE marks the start of the burial practices. However, because the temporal overlap is significant, we can be certain that the settlement was still inhabited when the ‘irregular’ burials in the ditches as well as, later on, the ‘regular’ burials in the surroundings of the ditches were deposited. On the other hand, the latest burials date to the very end of the settlement sequence. They either mark the end of settlement activities or are temporally closely related in some other way to the abandonment of Vráble.

Conclusions

The analysis indicates the contemporaneity of the three neighbourhoods and the relatively constrained duration of the settlement, of *c*. 200-300 years. The duration of the houses (*c*. 20-30 years) as determined from radiocarbon dates suggests that only a few houses were occupied at the same time, suggesting that the "Hofplatzmodel" (Zimmerman 2012), or house yard model, can be considered valid for the communities of the Vráble 'Veľké Lehemby'/'Farské' settlement complex.

The later chronological positioning of the dates from burial contexts indicates that the burial of individuals within the documented settlement areas coincided with the final stage of the life of the settlement. The overlap between the chronological trajectories of these two different types of contexts suggests that the two processes – an increase in the number of contemporary houses and the appearance of burial practices – are interrelated.

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settlement	house	laboratory code	type	Sample code	context details
N	244	Poz-67229	macro	S70048	trench 7, object 2014/1, context 27
N	244	Poz-67228	macro	S70003	trench 7, object 2014/1, context 3
N	245	Poz-69565	bone	S80343	trench 8, object 2014/2, context 12
N	245	Poz-69567	bone	S80330	trench 8, object 2014/2, context 12
N	258	Poz-69570	bone	S80300	trench 8, object 2014/7, context 1
N	259	Poz-69566	bone	S80288	trench 8, object 2014/5, context 6
N	259	Poz-69568	bone	S80183	trench 8, object 2014/5, context 6
N	262	Poz-69571	bone	S100095	trench 10, object 2014/8, context 3
N	262	Poz-69564	bone	S100088	trench 10, object 2014/8, context 3
N	262	Poz-69563	bone	S100085	trench 10, object 2014/8, context 3
SE	102	Poz-60610	bone	P60076	trench 6, object 2013/2, context 9
SE	102	Poz-60640	bone	P40090	trench 4, object 2013/2, context 12
SE	102	Poz-60639	bone	P40074	trench 4, object 2013/2, context 9
SE	105	Poz-60643	bone	P60091	trench 6, object 2013/4, context 10
SE	105	Poz-60641	bone	P60064	trench 6, object 2013/4, context 10
SE	105	Poz-60642	bone	P60055	trench 6, object 2013/4, context 10
SE	105	Poz-60609	bone	P60002	trench 6, object 2013/4, context 10
SE	112	Poz-90171	charcoal	vel16_bohr-dat001_t86	depth 86-100 cm
SE	126	Poz-87476	bone	14156	trench 14, object 123, context 35
SE	126	Poz-87475	bone	14153	trench 14, object 123, context 36
SE	126	Poz-87456	bone	14075	trench 14, object 124, context 44
SE	126	Poz-87455	bone	14066	trench 14, object 124, context 16
SE	127	Poz-87477	bone	14189	trench 14, object 144, context 57
SE	127	Poz-87472	bone	14100	trench 14, object 144, context 56
SE	127	Poz-87470	bone	14076	trench 14, object 157, context 69
SE	131	Poz-87447	bone	12663	trench 12, object 57, context 161
SE	131	Poz-87445	bone	12342	trench 12, object 57, context 128
SE	131	Poz-87443	bone	12150	trench 12, object 65, context 53
SE	132	Poz-87387	bone	13224	trench 13, object 24, context 83

Table 1. List of radiocarbon samples.

Species	collagen yield %wt	collagen %C	collagen %N	atomic C/N	δ13C (‰)	δ15N (‰)	14C age
unidentified charred grain							6190±40
unidentified plant macrofossil							6180±40
cattle occipital	1,4						6260±40
cattle lumbar vertebra	0,8						6110±40
sheep/goat distal tibia	0,5						6100±35
dog mandible	1,0						6080±40
pig distal humerus	0,5						6190±40
cattle second molar	0,4						6130±40
pig axis	0,4						6080±40
cattle proximal calcaneum	0,5						6140±40
large mammal humerus	0,6				-20,7	11,3	5920±35
large mammal tibia	0,2				-21,0	9,0	5885±35
sheep/goat radius	0,1				-21,3	10,7	6015±35
large mammal humerus	0,8				-20,8	9,3	6115±35
cattle radius	0,7				-22,8	10,0	6080±30
cattle vertebra	0,5				-21,1	10,2	6145±30
cattle astragalus	0,9				-22,1	9,1	5985±35
charcoal (ash, Fraxinus sp.)							6250±40
unidentified animal bone	2,0						6080±40
unidentified animal bone	1,5						6115±35
unidentified animal bone	0,8						6130±40
unidentified animal bone	0,1						5860±40
unidentified animal bone	1,3						6110±40
unidentified animal bone	4,6						6080±35
unidentified animal bone	0,2						5880±40
unidentified animal bone	1,6						6140±35
unidentified animal bone	0,9						6100±35
sheep/goat mandible	1,8						6170±35
unidentified animal bone	0,0						5590±120

settlement	house	laboratory code	type	Sample code	context details
SE	132	Poz-87449	bone	13116	trench 13, object 24, context 31
SE	132	Poz-87448	bone	12698	trench 12, object 9, context 159
SE	132	Poz-87446	bone	12654	trench 12, object 9, context 140
SE	132	Poz-87444	bone	12328	trench 12, object 9, context 85
SE	132	Poz-87441	bone	11279	trench 11, object 24, context 605
SE	132	Poz-87438	bone	11177	trench 11, object 24, context 66
SE	132	Poz-87437	bone	11166	trench 11, object 9, context 44
SE	132	Poz-87436	bone	11147	trench 11, object 24, context 51
SE	133	Poz-87454	bone	13248	trench 13, object 26, context 995
SE	133	Poz-87453	bone	13247	trench 13, object 26, context 105
SE	133	Poz-87451	bone	13245	trench 13, object 26, context 995
SE	133	Poz-87450	bone	13231	trench 13, object 26, context 104
SE	133	Poz-87440	bone	11231	trench 11, object 37, context 142
SE	133	Poz-87439	bone	11216	trench 11, object 37, context 110
SE	135	Poz-90167	charcoal	vel16_bohr-dat002_t90	depth 90-100 cm
SE	140	Poz-90168	charcoal	vel16_bohr-dat014_t62	depth 62-70 cm
SE	East of house 132	Poz-90137	macro	vel16_13081	trench 13, object 114, context 28
SE	East of house 132	Poz-90138	macro	vel16_13060	trench 13, object 114, context 45
SW	9	GrM-12694	bone	bc14_217_4	depth 85-100 cm
SW	9	GrM-12564	macro	bc14_217_1	depth 39-54 cm
SW	23	Poz-98368	bone	VEL17_221320-1	trench 22, object 2017/102, context 158
SW	23	Poz-98367	bone	VEL17_221280	trench 22, object 2017/102, context 101
SW	23	GrM-14305	macro	P221292	trench 22, object 2017/102, context 101
SW	23	GrM-14303	macro	P221134	trench 22, object 2017/102, context 8
SW	23	GrM-12569	bone	KNRC221355	trench 22, object 103, context 165
SW	23	KIA-52818	bone	KNRC221355	trench 22, object 103, context 165

Table 1. (continued)

Species	collagen yield %wt	collagen %C	collagen %N	atomic C/N	δ13C (‰)	δ15N (‰)	14C age
unidentified animal bone	1,2						6200±40
unidentified animal bone	0,3						6220±40
unidentified animal bone	3,2						6270±40
unidentified animal bone	0,1						6050±50
unidentified animal bone	1,7						6130±40
unidentified animal bone	2,4						6000±35
unidentified animal bone	0,3						6070±40
unidentified animal bone	0,2						6300±50
unidentified animal bone	0,3						6130±40
unidentified animal bone	2,4						6190±40
unidentified animal bone	5,8						6110±40
unidentified animal bone	2,7						6110±40
unidentified animal bone	3,8						6080±40
unidentified animal bone	1,8						6140±40
charcoal (oak, Quercus sp.)							6100±40
charcoal (oak, Quercus sp.)							7030±50
charred grains (emmer/einkorn)							6100±40
charred grains (emmer/einkorn)							6180±40
unidentified animal bone	0,5	21,9	7,9	3,3	-20,8	8,9	6060±55
unidentified charred fruit					-27,7		modern±
cattle, sacrum?	2,8				-21,2	9,8	6100±40
long bone, large animal	0,6				-20,1	10,7	5860±40
lentil, single seed, charred							6200±20
einkorn single grain, charred							6170±20
large ruminant or horse vertebra	3,0	44,2	16	3,2	-21,4	10,1	6115±25
large ruminant or horse vertebra	5,5						6101±26

settlement	house	laboratory code	type	Sample code	context details
SW	23	RICH-25884	bone	KNRC-221332	context 165. spit 4
SW	23	GrM-12571	bone	KNRC221329	trench 22, object 102, context 159
SW	23	KIA-52749	bone	KNRC221322	trench 22, object 102, context 149
SW	23	RICH-25474	bone	KNRC221322	trench 22, object 102, context 149
SW	23	GrM-12570	bone	KNRC221312-2	trench 22, object 102, context 8
SW	23	RICH-25883	bone	30108	context 165. spit 4
SW	29	RICH-25441	macro	bc14_405_4	depth 65-78 cm
SW	29	RICH-25442	macro	bc14_401_3	depth 78-97 cm
SW	34	KIA-52748	bone	bc14_340_1	depth 38-58 cm
SW	34	RICH-25476	bone	bc14_340_1	depth 38-58 cm
SW	34	GrM-12576	bone	bc14_337_7	depth 116 cm
SW	37	KIA-52816	bone	P30135-1	trench 3, context 35
SW	37	GrM-12574	bone	P30135-1	trench 3, context 35
SW	37	RICH-25472	bone	P30114	trench 3, context 35
SW	39	GrM-14301	macro	P20052	trench 2, object 2012/1, context 4
SW	39	GrM-14300	macro	P20047	trench 2, object 2012/1, context 5
SW	39	GrM-14299	macro	P20023	trench 2, object 2012/1, context 6
SW	39	Poz-60611	bone	P30107	trench 3, object 2012/1, context 4
SW	39	Poz-60638	bone	P20061	trench 2, object 2012/2, context 40
SW	39	Poz-60637	bone	P20009	trench 2, object 2012/2, context 41
SW	40	RICH-25440	macro	bc14_143_5	depth 35-50 cm
SW	40	GrM-12562	macro	bc14_143_4	depth 85-95 cm
SW	40	GrM-12559	macro	bc14_143_2(b)	depth 50-70 cm
SW	40	RICH-25446	macro	bc14_143_2	depth 50-70 cm
SW	40	GrM-12567	macro	bc14_143_1	depth 35-50 cm
SW	40	RICH-25473	bone	bc14_141_5	depth 132-150 cm
SW	40	GrM-12561	macro	bc14_141_3	depth 65-85 cm
SW	57	RICH-25444	macro	bc14_200_2	depth 40-57 cm

Table 1. (continued)

Species	collagen yield %wt	collagen %C	collagen %N	atomic C/N	δ13C (‰)	δ15N (‰)	14C age
cattle calcaneum	3,6						6184±33
large ruminant or horse long bone	3,7	45,6	16,6	3,2	-20,0	9,2	6125±25
large ruminant or horse long bone	2,5						6091±28
large ruminant or horse long bone	1,6	18,0	6,3	3,3	-20,7	8,2	6048±32
unidentified animal bone	1,6	42	15,2	3,2	-21,4	9,8	6125±25
pig left tibia	3,1						5517±29
einkorn single grain, charred							6179±34
indeterminate grain							6211±34
unidentified animal bone	3,9						6190±26
unidentified animal bone	<1	12,4	4,4	3,3	-21,4	8,0	6020±36
unidentified animal bone	1,1	36,3	13,4	3,2	-21,5	11,2	6130±30
cattle humerus	1,8						6266±27
cattle humerus	2,0	21,8	7,6	3,3	-22,3	8,1	6150±30
large mammal rib	1,4	33,1	11,7	3,3	-21,3	10,0	6001±32
einkorn single grain, charred							6150±20
einkorn single grain, charred							6170±20
emmer single grain, charred							6190±20
cattle rib	1,1				-20,6	9,6	6050±35
cattle vertebra	1,1				-20,2	4,2	6220±35
cattle phalanx	0,8				-20,6	8,1	6000±50
indeterminate cereal single grain, charred							6097±35
einkorn single grain, charred					-22,9		6240±25
einkorn single grain, charred					-23,7		6155±25
einkorn single grain, charred							6157±35
charcoal (hornbeam, Carpinus sp.)					-24,5		3340±20
unidentified animal bone	1,6	26,2	9,2	3,3	-20,7	7,5	6064±34
indeterminate cereal single grain, charred					-24,6		6150±25
einkorn single grain, charred							6206±35

settlement	house	laboratory code	type	Sample code	context details
SW	57	GrM-12560	macro	bc14_198_3(a)	depth 50-70 cm
SW	57	RICH-25443	macro	bc14_198_3	depth 50-70 cm
SW	57	RICH-25445	macro	bc14_196_1	depth 29-49 cm
SW	317	GrM-12784	bone	KNRC221146	trench 22, object 101 context 4
SW	317	RICH-25478	bone	KNRC221125	trench 22, object 101 context 4
SW	317	GrM-12693	bone	KNRC221116	trench 22, object 101 context 6
SW	317	RICH-25475	bone	KNRC221112-1	trench 22, object 101 context 6
SW	317	KIA-52747	bone	KNRC221112-1	trench 22, object 101 context 6
SW	317	GrM-12572	bone	KNRC221075-1	trench 22, object 100 context 3
SW	318	GrM-12566	macro	bc14_096_2	depth 40-60 cm
SW	318	GrM-12697	bone	bc14_096_1	depth 40-60 cm
SW		Poz-87473	human, fairly complete	G1/S14	trench 14, object 145, context
SW		Poz-87474			
SW		Poz-98358	human, fairly complete, partly disarticulated, crouched	G2/S21	trench 21, object 3, context 3, 377
SW		KIA-52446			
SW		KIA-52449	human, complete, crouched	G3/S21	trench 21, object 3, context 200
SW		Poz-98348			
SW		Poz-98359	human, fairly complete, skull missing	G4/S21	trench 21, object 3, context 379
SW		Poz-98350	human, fairly complete, disarticulated	G5/S21	trench 21, object 3, context 287
SW		KIA-52448	human, complete, crouched	G6/S21	trench 21, object 4, context 4
SW		Poz-98342			
SW		Poz-98364	human, complete, crouched	G7/S21	trench 21, object 21, context 421
SW		KIA-52445			
SW		Poz-98360	human, complete, crouched	G8/S21	trench 21, object 10, context 400
SW		KIA-52444			
SW		Poz-98352	human, complete, crouched	G9/S21	trench 21, object 14, context 328
SW		KIA-52447			

Table 1. (continued)

Species	collagen yield %wt	collagen %C	collagen %N	atomic C/N	δ13C (‰)	δ15N (‰)	14C age
einkorn single grain, charred					-22,2		6200±25
einkorn single grain, charred							6260±34
Prunus spinosa fruit stone							737±27
unidentified animal bone	1,2	40,4	14,6	3,2	-20,8	7,0	6170±25
unidentified animal bone	<1	7,5	2,7	3,3	-21,9	7,2	5388±35
unidentified animal bone	0,0						5300±80
unidentified animal bone	1,2	24,3	8,5	3,3	-21,7	7,2	6112±32
unidentified animal bone	0,9						5751±27
unidentified animal bone	2,3	36,8	13,2	3,3	-21,0	8,0	6070±25
einkorn single grain, charred					-23,4		6290±25
unidentified animal bone	0,3	31,3	10,2	3,6	-22,0	10,6	5890±80
human right rib M? 20-34	0,9						5960±40
human cranial bone -	0,7						6060±35
human rib M 25-34	3,7						6090±40
human cranial bone -	4,67						6060±24
human left rib M? 25-34	4,29						6119±25
human cranial bone -	1,4						6000±40
human right tibia U 3-6		2,8					6170±40
human rib M? 15-24		1,5					6240±40
human right fibula U 18-22		1,74					6119±25
human cranial bone -		0,7					5920±40
human cranial bone M 30-44		2,8					6080±40
human rib -		6,55					6044±25
human cranial bone M 20-29		2,9					6150±40
human rib -		7,33					6155±20
human rib F 40-49	1,5						6100±40
human -	4,33						6081±25

settlement	house	laboratory code	type	Sample code	context details
SW		KIA-52450	human, partly preserved, disarticulated	G10/S21	trench 21, object 16, context 345, 356
SW		Poz-98357			
SW		Poz-98366	human, fairly complete, disarticulated	G11/S22	trench 22, object 102, context 8, 101
SW		Poz-98444	human, fairly complete, skull missing	G12/S23	trench 23, object 203, context 3
SW		Poz-98369	human, fairly complete, skull missing	G13/S23	trench 23, object 203, context 3, 31
SW		Poz-98793	human, scatter of teeth and bones	G14/S21	trench 21, object 19, context 396
SW	Poz-98344		single bones which not necessarily belong together, scattered	I15/S21	trench 21, object 1, context 30, 37, 91, 119, 141, 219
SW		Poz-98345			
SW		Poz-98349			
SW	Poz-98445		human, only single bones which not necessarily belong together, scattered	I16/S23	trench 23, object 203, context 3, 88, 89
SW		Poz-98449			
SW	Poz-98446		human, only single bones which likely belong together, scattered	I17/S23	trench 23, object 209, context 9
SW		Poz-98447			
SW		Poz-98448			
SW		KIA-52451	human, only single bones which not necessarily belong together, scattered	I18/S21	trench 21, object 3, context 401, 404, 145
SW		Poz-98346			
SW		Poz-98347			
SW		Poz-98361			
SW		KIA-52708	human, Os frontale	I19/S10	trench 10, object , context

Table 1. (continued)

Species	collagen yield %wt	collagen %C	collagen %N	atomic C/N	δ13C (‰)	δ15N (‰)	14C age
human cranial bone U 15+-	1						6002±25
human right humerus -	2						6050±40
human ulna/radius U 20-29	2,8						5840±40
human rib F? 20-24	3,6						6080±40
human rib M 35-49	4,8						6210±40
human unspecified bone U 4-6	0,04						5840±35
human left femur M? 15-19	3						6170±40
human cranium -	3,3						6150±40
human mandible -	1,4						6130±40
human unspecified postcranial bone U 18+-	1,3						5870±40
human right femur -	3,6						6140±40
human femur U 18+-	1,8						6180±40
human unspecified postcranial bone -	2,2						6100±40
human femur -	2,2						6090±40
human cranial bone U 18+-	4,67						6166±24
human right femur -	3						6180±40
human right humerus -	2,1						6170±40
human unspecified postcranial bone -	2						6100±40
human Os frontale -	9						6075±35

Section 5: Material culture, plants and animal data

5.1. Pottery and ornamental styles from the LBK and Želiezovce settlement site of Vráble

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Abstract

This chapter presents a description of the technological and typological features of the pottery materials excavated from the site of Vráble 'Veľké Lehemby'/'Farské' (Nitriansky kraj, Slovakia). Their relationships to the settlement features are made clear and are illustrated through detailed object plans. The inventory represents the styles of the younger LBK, the Želiezovce style, and some features also contain Bükk- and Lengyel-style pottery. All of those stylistic groups are well known in south-western Slovakia. The different settlement areas at Vráble show a common overall technology and uniform vessel shape repertoire, but the decorative motifs are more yard or neighbourhood specific.

Keywords: Neolithic pottery; younger LBK; Želiezovce group; Bükk culture; Prelengyel; Lengyel culture; Vinča culture

Introduction

One of the main goals of the excavations was to extract finds that can help determine the chronology, duration and relationship of the three settlement areas. In the course of five excavation seasons, the floor plans of 15 houses with post constructions were uncovered in part or almost in their entirety and investigated (houses H23, H39, H102, H103, H126, H131, H132, H133, H244, H245, H258, H259, H262, H317, H319). In addition to the floor plans, several settlement objects were investigated, which were located either within the demarcated house areas, including the lateral long pits, or outside these areas. The excavation strategy was based on the observation that during the surface inspection only a small amount of decorated pottery was obtained. Most of the fragments come from unornamented vessels, and these did not yield the expected result for a more detailed typochronological classification.

Figure 5.1.1. Ceramic sherds indicating the manufacturing process.

In general, it can be said that the different objects yielded very different quantities of ceramic sherds. In some cases, the low density of ceramic finds proved to have a negative effect on the possibility to characterise the inventory of the find complex. The occurrence of ceramics also often varied considerably in the individual quadrants of the same object of the house-accompanying long pits. Ornamented and unornamented vessel fragments also show varying proportions, but those differences are not very pronounced. This is shown in the tables in Chapter 3.1, which present the numbers of the different find categories connected to each house. In these tables, both the total weight and the quantity or the number of ceramic finds is indicated. We have not further explored the relations between decorated and undecorated sherds, due to the uncertainties stemming from the high degree of fragmentation.

The typological evaluation of ceramic finds presented here is based on an ornamental analysis, which can be used to determine the relative chronology of the house features. We largely left out the evaluations of single incised lines without any additionally ornamental additions, as they are numerous and often are found on very small sherds. In the accompanying illustrations (Fig. 5.1.2-21), vessel fragments of the individual quadrants are depicted in such a way that the fill (feature) and spit can be distinguished for the individual objects.

Observations relating to pottery technology

During the analysis of the ceramic finds, attention was paid to the type or process of vessel manufacture. The lower part of the body was shaped first, then the inside was roughened with grooves, and then a thin layer of slightly washed out, fine clay was applied. Evidence for this manufacturing process was also found in the vessel shown on Figure 5.1.1. The application of some ornamental elements was also observed, which is indicated below in the description in the associated inventories.

In general, from the evaluation of the ceramics, it can be stated that the pottery production was performed with relatively unprocessed or less processed clay. This is reflected, on the one hand, in the surface treatment of the thin-walled vessels and, on the other hand, in the incised decoration, which shows itself to be unpronounced on the uneven surface. It is important to mention that the thin-walled pottery has also yielded small body or rim fragments on which a single inscribed line can be seen, or parts of a double line, in some cases with an impression or incision.

According to macroscopic observations, a large proportion of the ceramics from the site contain a higher proportion of sandy components. This resulted in the surface of most of the thin-walled vessels not being very smoothed or polished. In LBK contexts in Slovakia, it is very common to coat the surface with a thin layer of fine clay. These thin layers are destroyed due to taphonomic processes while the sherds were still in the ground. The use of non-washed out clays has been shown to be particularly present with regard to thin-walled vessels where the incised and impressed ornamentations are not applied in a very precise way, due to irregularities in the clay. The incised ornamentations are thus sometimes difficult to identify.

In the vessel inventory of the Želiezovce group of the younger LBK, we find an absence of red- or yellow-painted pottery, in contrast to other contemporary settlements in south-western Slovakia. The occurrence of unpainted pottery of the Želiezovce group at the settlement of Vráble may be due to the surface treatment of the vessels. The ceramic ensemble lacks the 'highly' polished surface, especially in the case of spherical and hemispherical vessels, that would enhance the quality and visual effect of the painting. Some fragments look like they may have been painted, but we cannot be certain.

Pottery from the disturbed areas between the houses in trench 8

While the great majority of potsherds came from clearly delineable pit structures, in trench 8, where the area between several houses was excavated, deep ploughing had dislocated materials from the pits, even down at the Planum 1 level. Therefore, trench 8 was divided into quadrants, marked with letters and gradually deepened by 15 cm (creating Planum 2) between the house-accompanying long pits belonging to H245, H258, H259 and H319. Ceramic fragments were found in each of the five quadrants (Q1-Q5), with ornamented fragments forming only a small proportion (Fig. 5.1.2). The quadrants were subdivided into subquadrants. Only nine of the 56 subquadrants did not contain any ceramic fragments. Especially in Q1, the scattering of the fragments indicates that they were either deposited in shallow pits, which left no trace in the surface at level Planum 1 or, instead, dislocated by the plough. The highest concentration of sherds was recorded in the section marked Q4/J, represented by thin- and thick-walled vessel fragments. Section Q5/D yielded a rim of a larger vessel with a neck (Pl. 5.1.37,6) and sections Q5/F and Q5/H yielded fragments of several vessel types ornamented with a double incised line, either interrupted by or terminating in an impression (Pl. 5.1.37,7.10.12). The fragments of spherical vessels in sections Q1/F, Q1/G and Q1/L (Pl. 5.1.37,14-15.17) were also decorated with a double incised line, supplemented by a slightly oval impression.

Pottery from the houses at Vráble

The analysis of the pottery obtained from the objects, especially from the fill of house-accompanying long pits, is based on the typological classification of the vessel shapes and the use of individual ornamental elements, which in combination form an ornamental motif. The description of the ornamentation and motifs follows the same structure as used in the correspondence analysis of the pottery from Štúrovo (Pavúk 1994, Supplements 2 and 3) and Bajč (Cheben 2000, Table 8). The evaluation of the ceramics was done in two parts. In the first part, each house was analysed independently, and in the second part, the ceramic production of three neighbourhoods of Vráble was analysed in general. Throughout, we focused on the similarities as well as the dissimilarities of the analysed ceramics.

In contrast to the seriation by Pavúk (1994), which needs finer-grained information than is available for Vráble, in our analysis some characteristics were not taken into account, *e.g.* vessel parts, shape of the rim, type of pottery clay (similar to the Correspondence analysis presented in Chapter 4.1).

For the typochronological assessment of objects in an overall relative chronological system, we focussed on sherds that show ornamentation and motifs which are assumed to have chronological significance. One such attribute is the occurrence and positioning of the 'note head' impression or the type and location of the Želiezovce

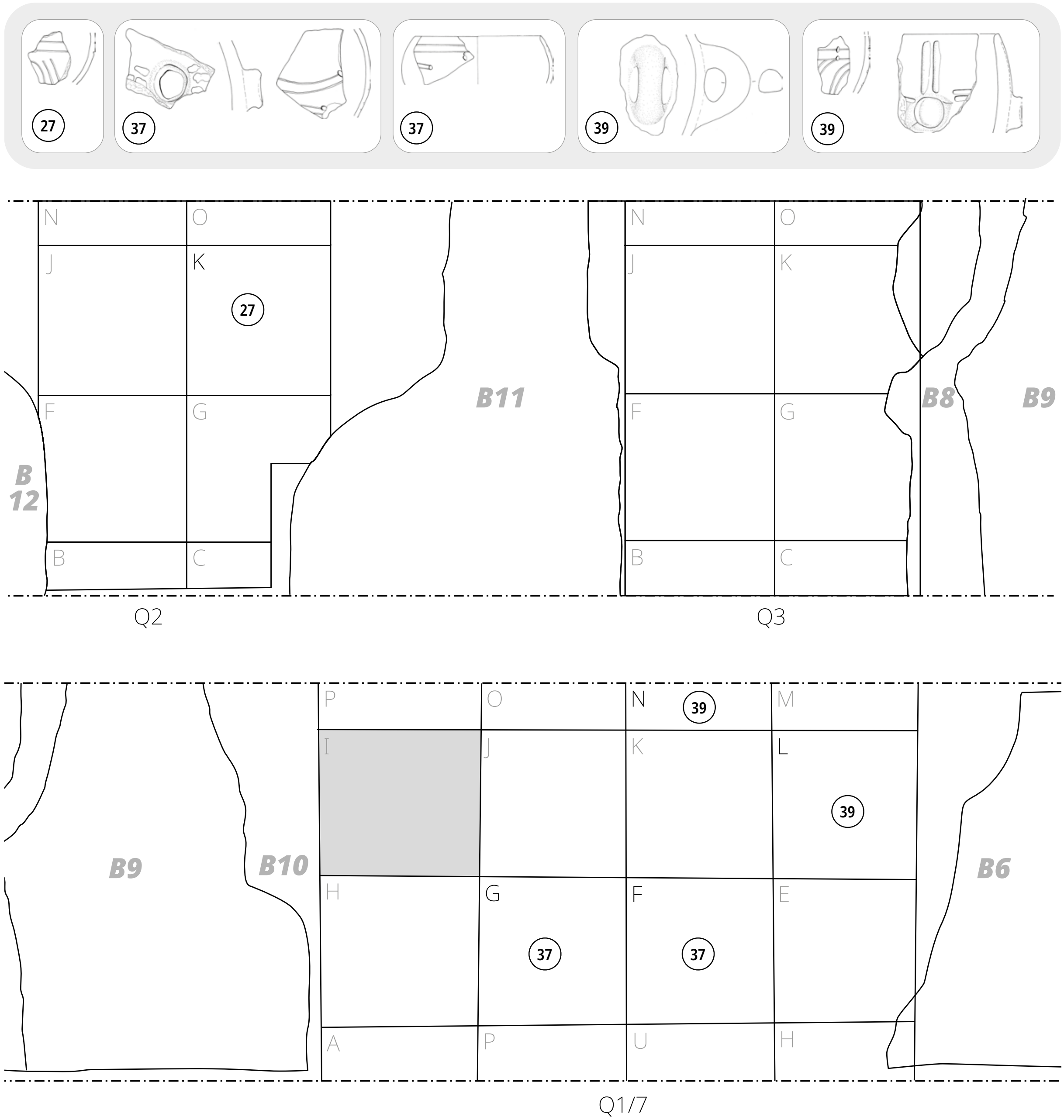
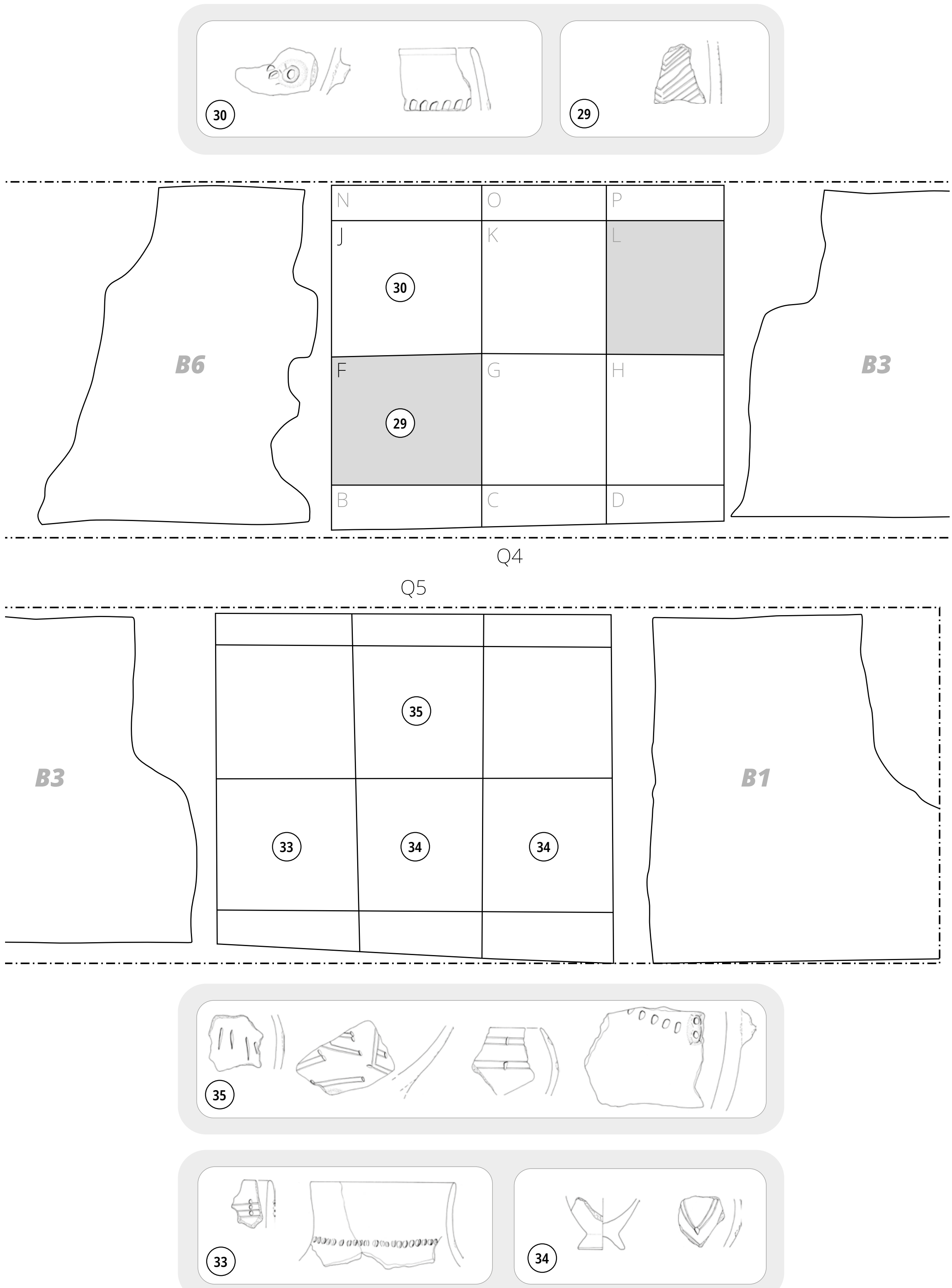


Figure 5.1.2. Ceramic finds in trench 8 between long pits.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B3
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34

incision (*i.e.* the typical kerb, notch or impression regularly imprinted onto two or three parallel incised lines). Due to the fragmentation of the materials, the full ornamental motifs and the composition of decorative elements on the vessel could only be used in exceptional cases. It was in most cases easier to identify and distinguish the individual ornamental elements, which could be used to represent specific ornamentation motifs. Even though a significant proportion of the pottery fragments with incised ornamentation derive from rather small fragments, it is important to mention that, in exceptional cases, bigger vessel portions were extracted from the settlement objects, which provided more fully reconstructable ornamental motifs.

Excavation areas 2-3: House 39

The vessel fragments assigned to house H39 were extracted from five sections of the western long pit, H39/1, and from five sections of the eastern long pit, H39/2. In trenches 2 and 3, the central and southern parts of house H39 were excavated. Both objects were excavated in a chequerboard pattern, leaving every second quadrant untouched. Only those potsherds that were visible in Planum 1 of the unexcavated quadrants were collected. The unexcavated quadrant (F) of object H39/1, yielded fragments from several vessels that were published earlier (Furholt *et al.* 2014, pl. 5,1-6). They may also stem from the assumed fill of the postholes of the outer wall of house H39. In object H39/2, the excavated object S3/30 can be recognised, which is older than object H39/2. In addition to the fill of the object, a small number of fragments of ceramics were found on Planum 1. They occurred close to posthole H39/22 and at the southern trench edge, and they were in the line of the western house wall.

Among the ceramic forms from house H39, the most common are spherical, thin-walled vessels (Pl. 5.1.1,2; 5.1.2,6.8.13.20; 5.1.3,11.20; 5.1.6,18), which are mainly represented in the form of rim fragments. This type was not further classified according to narrower or wider diameter of the rim, as it became apparent that rim diameter would not serve as reliable chronological indicator. Furthermore, taller, hemispherical vessels and bowls (Pl. 5.1.1,5-6; 5.1.2,3; 5.1.3,9; 5.1.5,16) were found. Exceptional shapes include, for example, a bowl with a hollow foot (Pl. 5.1.1,17; 5.1.5,2) and a vessel with a neck (Pl. 5.1.1,15; 5.1.4,6; 5.1.5,1).

With regard to the ornamentation, thin-walled ceramics are dominated by an incised double line, which occurs as a curved or angled line. This is supplemented by a vertical, diagonal or, exceptionally, horizontal incision. A triple line with subdividing kerbs (or short incisions) occurred in only two cases (Pl. 5.1.3,11; 5.1.6,19). Oval, round or triangular 'music note head' (*Notenkopf* in German) impressions can be found on the fragments of the spherical vessels. An unusual impression type is found on one vessel body fragment (Pl. 5.1.5,7), which was produced with the aid of a special pointed tool. The decoration formed a line under the rim, an ornamental main motif repeated farther down on the vessel body. These horizontal lines mostly form a double line (Pl. 5.1.2,21; 5.1.3,15; 5.1.4,17.20), in some cases two double lines (Pl. 5.1.1,2). Variants of this main ornamental motif, which consists of an incised double line supplemented by impressions or notches, can be observed on several fragments of thin-walled vessels. Horizontal, diagonal, vertical, curved and arched double lines do appear, suggesting a certain loss of ornamental unity. This notion is supported by fragments of vessels bearing an ornamentation that is rarely found in the excavated material. It is a design consisting of two double lines under the rim, in combination with two rows of angled double lines in the shape of the letter S (Pl. 5.1.1,2). Another example is a notch at the intersection of diagonal double lines (Pl. 5.1.1,16; 5.1.5,16). In some cases, a double line appears under the rim in combination with an arched line (Pl. 5.1.2,20; 5.1.4,20). A similar ornamental main motif is found on a spherical vessel whose lines have been supplemented by a 'note head' impression (Pl. 5.1.2,6). Two pieces of bowls show decoration on the inside (Pl. 5.1.3,18), with the application of an incised wavy line on one fragment (Pl. 5.1.4,2). Three fragments without incised decoration were also present in the inventory of the thin-walled ceramics (Pl. 5.1.1,5; 5.1.3,20). In one case, a knob was drilled vertically. It was applied to a smaller, thin-walled, hemispherical bowl, decorated with a double line under the rim and a series of punctates under the knob (Pl. 5.1.1,6).

The thick-walled pottery does not show a great variety of shapes. The most common decorations on this coarse ceramic ware are notched strips, knobs (Pl. 5.1.1,1; 5.1.2,5; 5.1.3,19; 5.1.6,21) impressions (Pl. 5.1.1,14) and incisions (Pl. 5.1.1,1; 5.1.4,19), often used in combination. This kind of ornamentation, or at least parts of it, can be traced on some rim fragments (Pl. 5.1.1,1; 5.1.4,19), and only in one case the rim is decorated with straight notches (Pl. 5.1.1,14). Functional additions of the vessels are handles, which are rare and only fragmentary.

In the evaluated ceramic inventory in QG of object H39/1 and in QB and QC3 of object H39/2 are fragments from a necked vessel. This presence is indicated not only by the ornamentation, but also by the ceramic ware, which differs markedly from the other pottery in the settlement at Vráble. Its ornamentation forms a strip of wide, incised lines filled with two rows of impressions. In the area of the break, the stripes are separated by three impressions or a pair of incisions. The filled horizontal line is placed at the point where the neck merges with the body (Pl. 5.1.4,1.7). The vertical lines form a breaking line (Pl. 5.1.4,1.13) or an arc (Pl. 5.1.3,17; 5.1.4,14; 5.1.5,4). In object 1 of house H39, two almost identical fragments occurred in quadrant QJ. One is decorated with a motif of two arched lines inside a bundle of horizontal lines. From the outside of the bundle comes an incised zigzag ornamentation (Pl. 5.1.1,3-4). Oval engravings in a bundle with three lines (Pl. 5.1.6,22-26)), discovered in quadrant QC of object 2 in house H39, should be considered as a foreign ornamental element in the Želiezovce group.

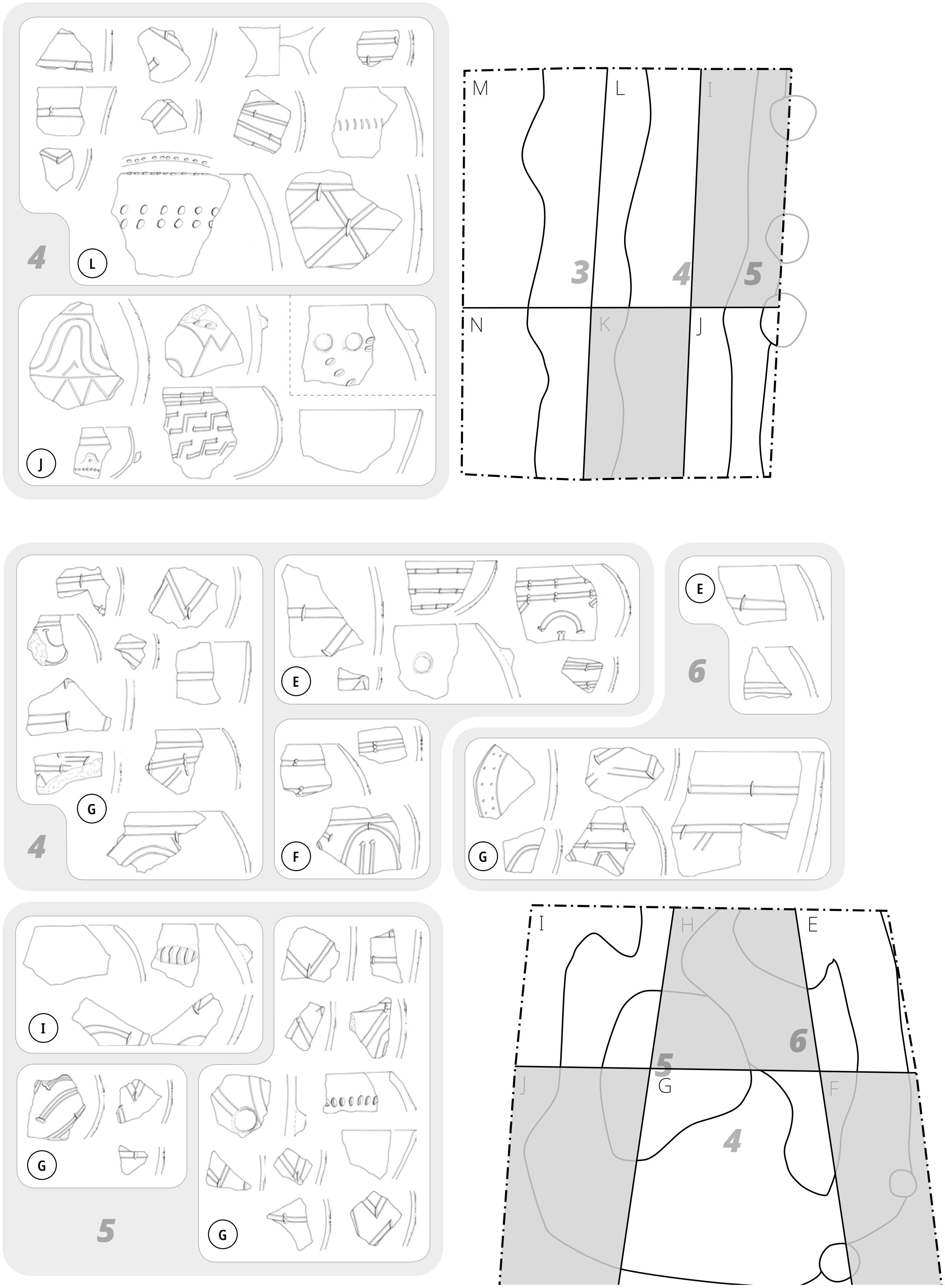


Figure 5.1.3. Ceramic finds in the western long pit of house 39 (trenches 2 and 3).

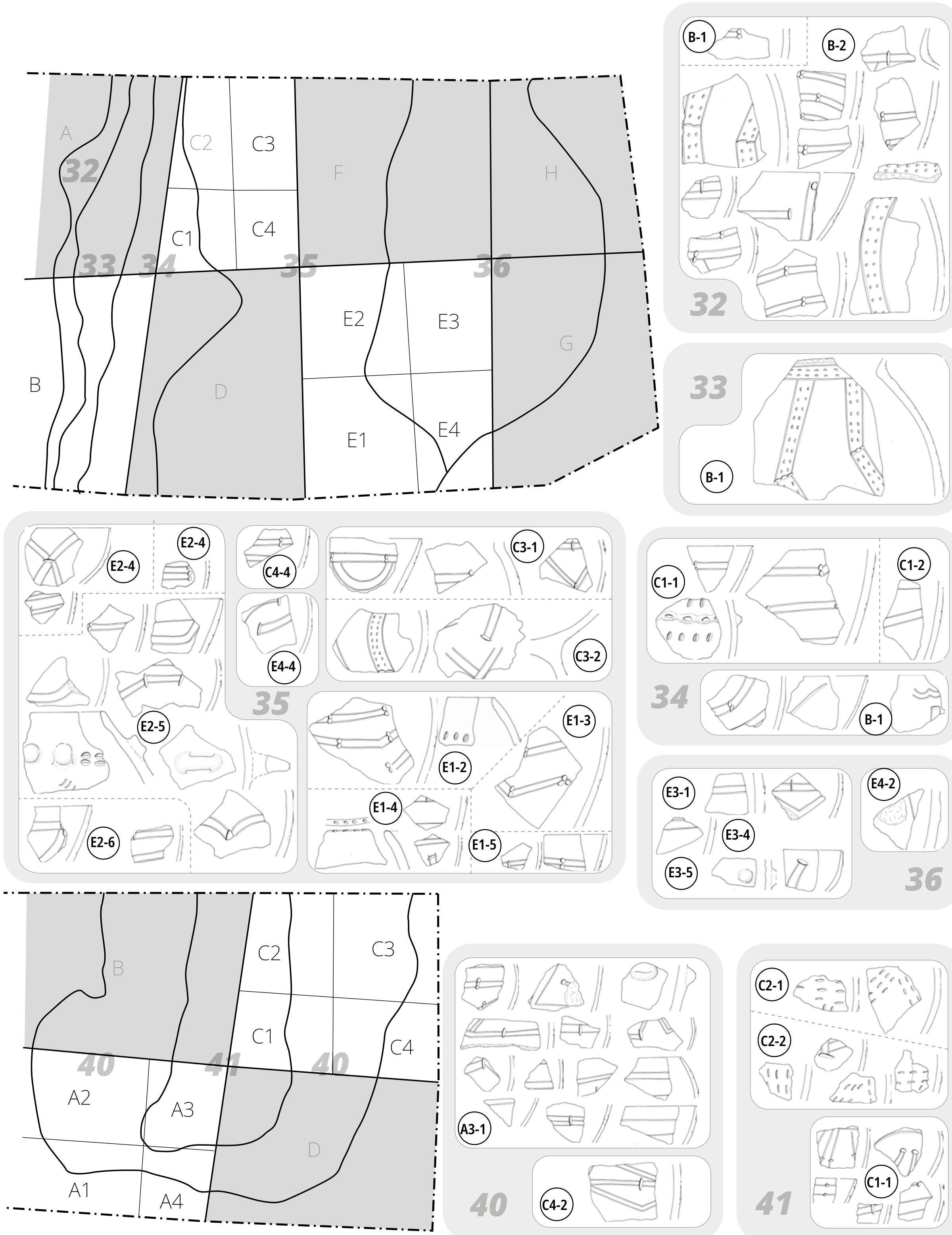
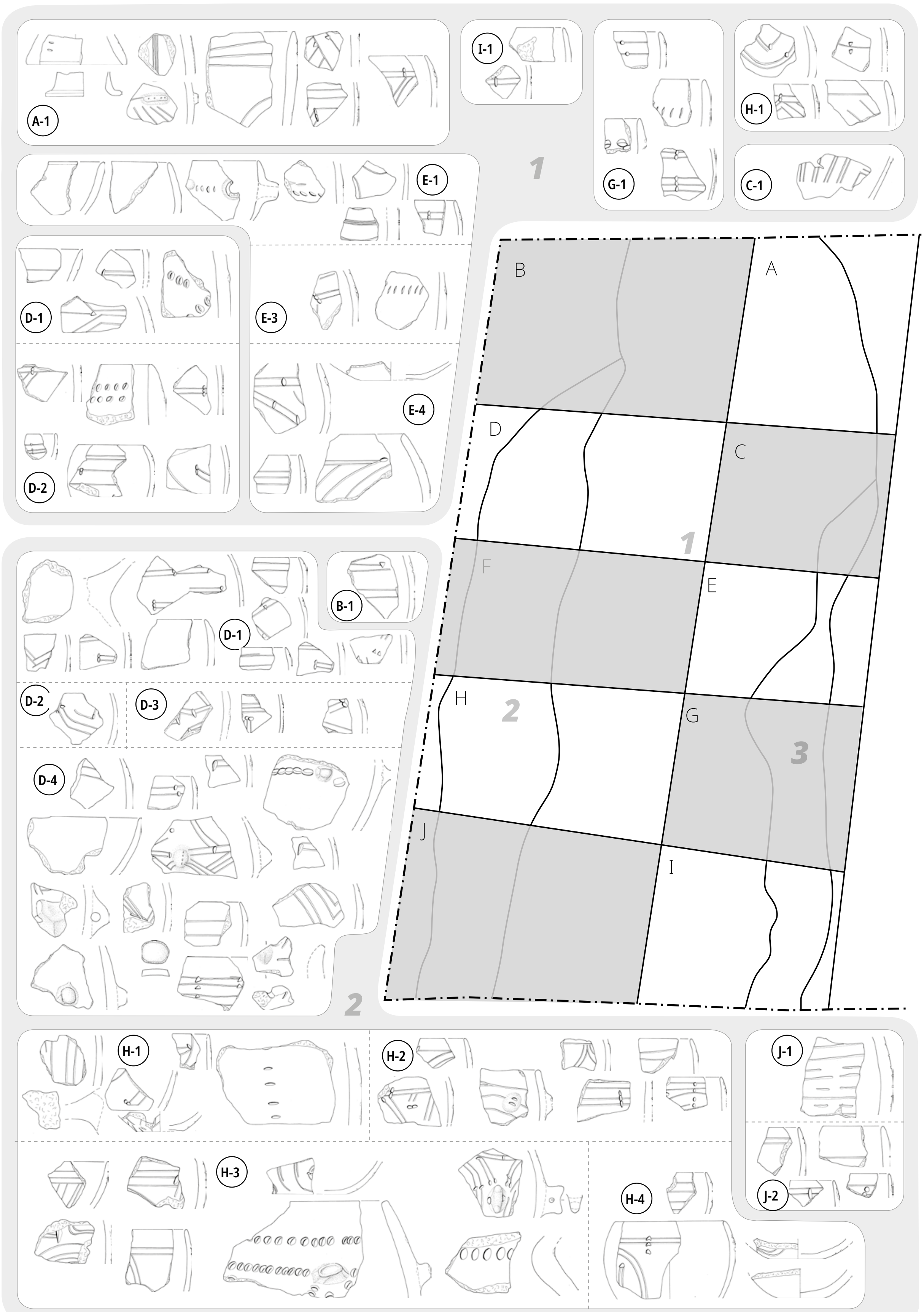


Figure 5.1.4. Ceramic finds in the eastern long pit of house 39 (trenches 2 and 3).


A-1
I-1
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1
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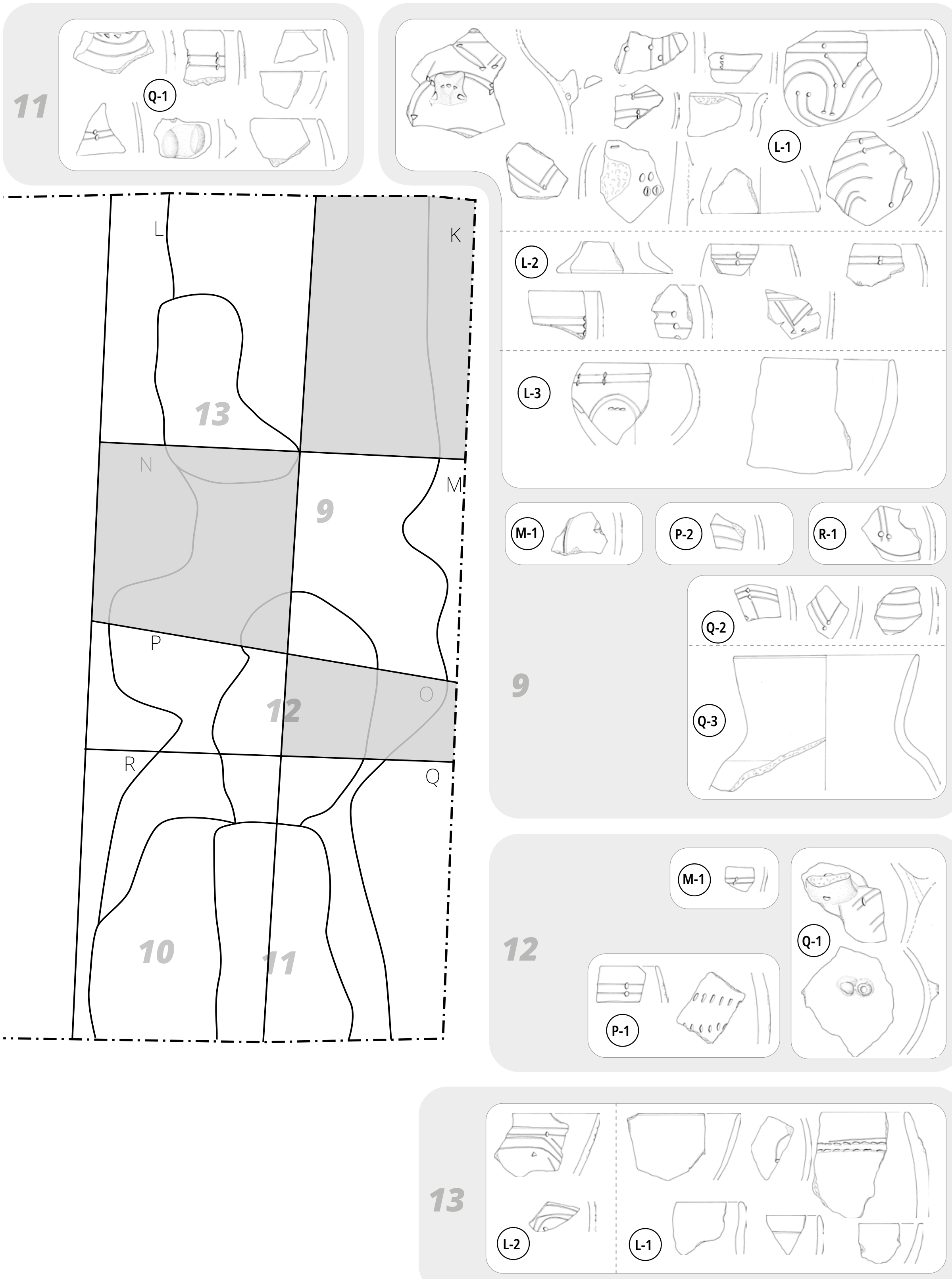

Figure 5.1.5. (left). Ceramic finds in the western long pit of house 102 (trench 4).

Figure 5.1.6. Ceramic finds in the eastern long pit of house 102 (trench 4).

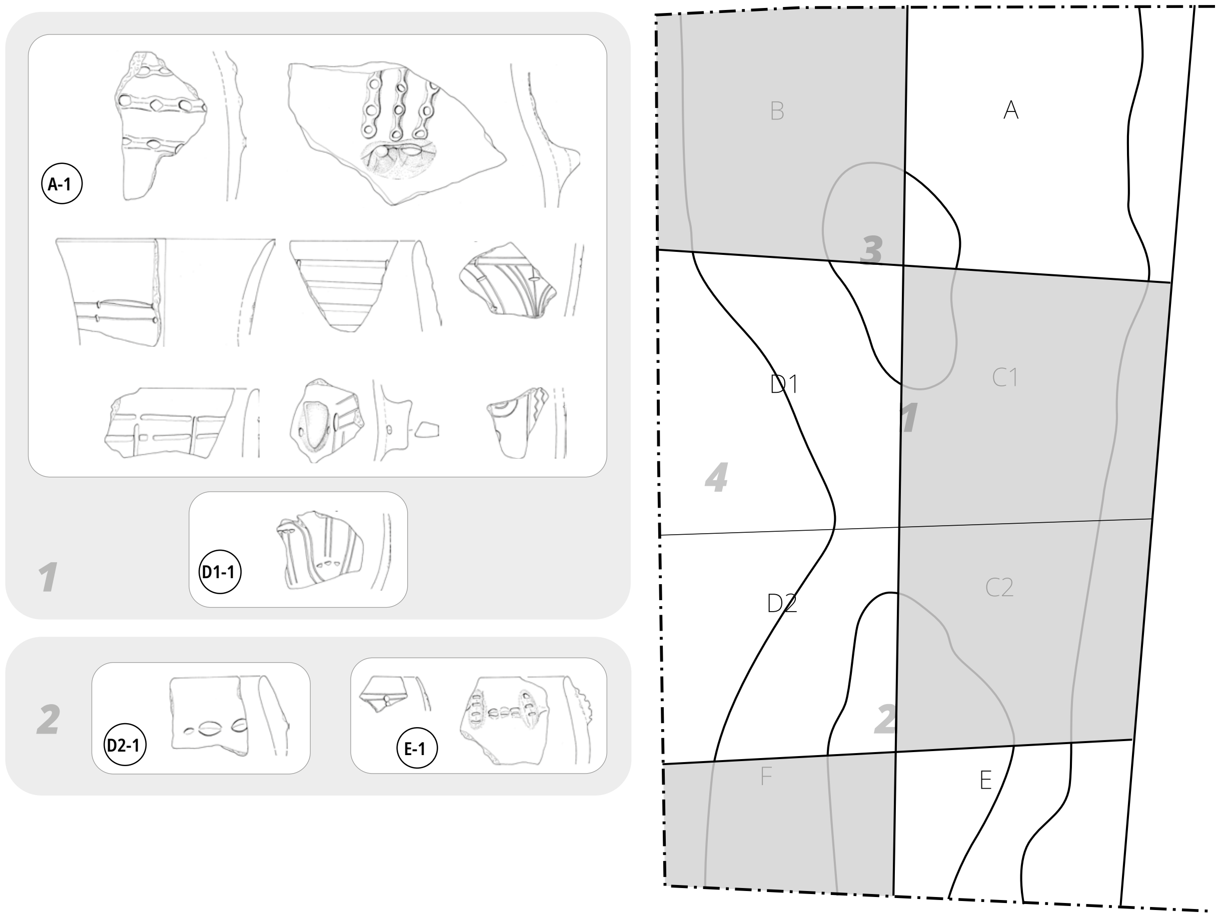

Figure 5.1.7. Ceramic finds in the western long pit of house 102 (trench 5).

Excavation areas 4-6: Houses 102 and 103

House 102

The two house-accompanying long pits of house H102, which were excavated in trenches 4-6, yielded a huge amount of ceramics, which represent above all fragments of decorated thin-walled vessels. The postholes, objects H102/3 and H102/23, did not contain any pottery. The western long pit (object H102/1) and the eastern long pit (object H102/2) were divided into quadrants, and not all of them could be excavated. Accordingly, the spatial distribution of the pottery is only accessible in these excavated quadrants.

The thin-walled pottery is represented by a variety of forms, as opposed to the more uniformly formed coarse, thick-walled ware. Spherical vessels are preserved to a greater extent in the form of body fragments. This type also includes bases, which document the application of the ornamentation in the lower part of the vessel (Pl. 5.1.9,2; 5.1.10,20). An abundant type in both long pits (objects H102/1 and H102/2) are hemispherical vessels with a relatively wide mouth (Pl. 5.1.7,12.14; 5.1.8,23; 5.1.9,15; 5.1.10,2.7.17; 5.1.11,20; 5.1.12,16; 5.1.15,3; 5.1.15,5; 5.1.21,2), which are also documented by numerous body fragments. A similar type are taller hemispherical vessels with a more or less open mouth (Pl. 5.1.7,2; 5.1.10,15; 5.1.12,11; 5.1.14,14; 5.1.21,1). In the inventory, several specimens are represented, for example, necked vessels (Pl. 5.1.8,28; 5.1.10,19; 5.1.13,15; 5.1.16,1.2.8.13), from which in one case evidence of repair below the rim is documented (Pl. 5.1.14, 5), and amphora-like vessels (Pl. 5.1.8,24; 5.1.9,11; 5.1.12,9; 5.1.13,10-11; 5.1.14,11; 5.1.16,7). Only marginal

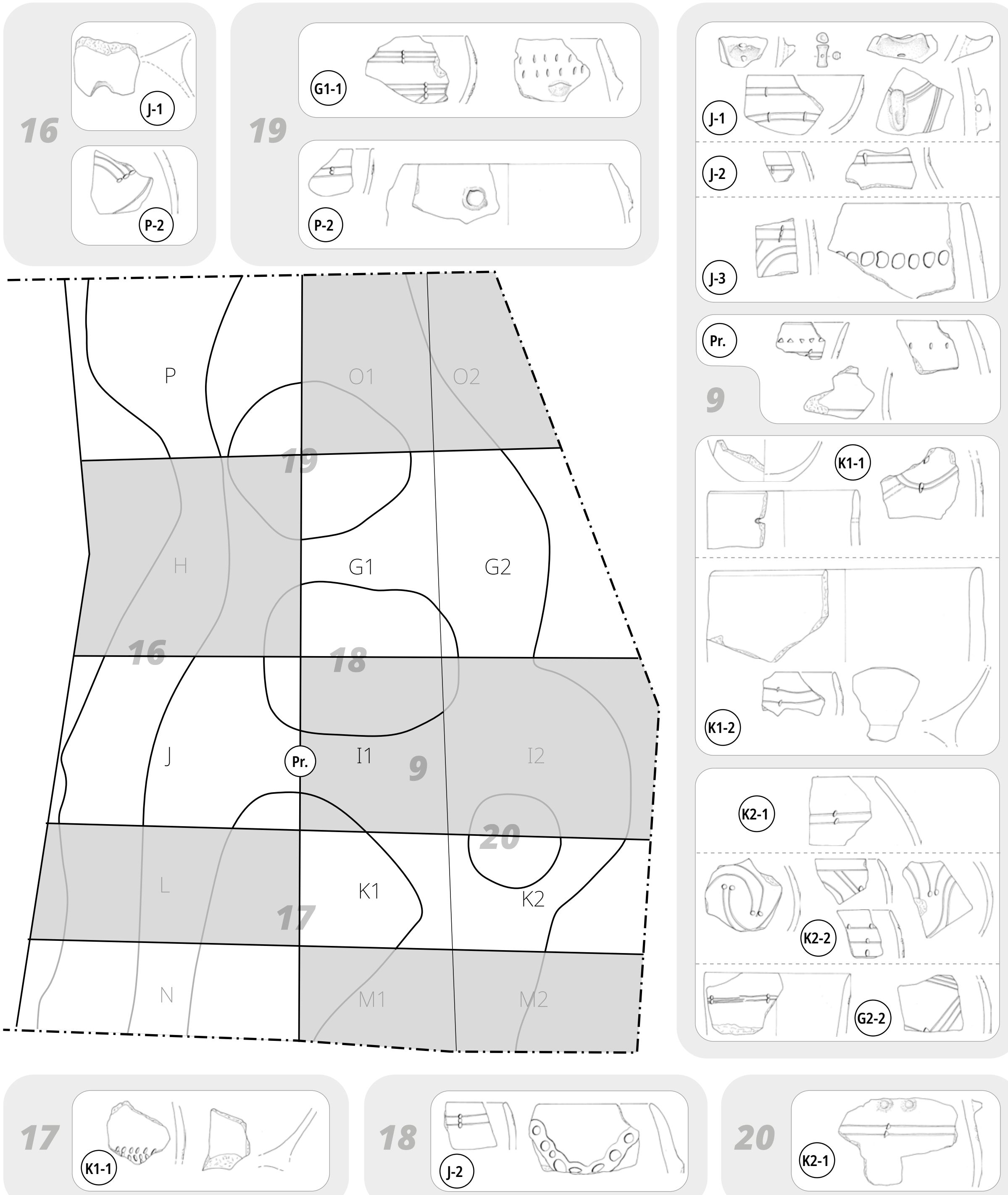

Figure 5.1.8. Ceramic finds in the eastern long pit of house 102 (trench 5).

parts were reliably assigned to the bowl category. According to the vessel profiles, hemispherical (Pl. 5.1.8,21.25; 5.1.9,10; 5.1.11,13.16; 5.1.12,17; 5.1.14,9) and conical (Pl. 5.1.7,7; 5.1.11,18) shapes occur. It was possible to identify the footed bowls from sherds from the interface of body and foot (Pl. 5.1.7,23; 5.1.10,13; 5.1.14,1.15). The lower parts of hollow feet have also been found (Pl. 5.1.7,3; 5.1.12,6; 5.1.20,21) and one specimen represents a tall hollow foot (Pl. 5.1.22,8).

An independent group is represented by vessels with a spout, which we consider to be an exceptional ceramic form in the LBK of Slovakia. QE/S4 of object H102/1 yielded a rim with a (Pl. 5.1.8,22) spout and QC/S6 of the same object yielded a spout on the body of a thin-walled, obviously hemispherical bowl (Pl. 5.1.18,9). The third fragment of the body of the vessel with tubular spout was located in QC3/S6 of object H102/1 (Pl. 5.1.18,1).

Further clay objects are a sherd whetted into a slightly oval shape (Pl. 5.1.9, 9) from QD-54 of object H102/1 and a bead made of clay from QJ-87 of object H102/2.

In the category of incised ornamentation, double lines are dominant, mostly made with the help of a tool with two points. Triple lines also often form a part of the main ornamental motif (Pl. 5.1.7,2; 5.1.9,11; 5.1.11,4.10; 5.1.12,10; 5.1.14,11; 5.1.15,3; 5.1.16,6; 5.1.19,9; 5.1.22,5). Bundles of incised lines are supplemented by notches or impressions that either subdivide or end them. The composition of an ornamentation consisting of a double line running around the rim is found on body and rim fragments. In the pottery collection of objects H102/1 and H102/2, some main ornamental motifs were found on spherical and hemispherical vessels and bowls, which are repeated on several vessels. These are incised lines in the form of the letter S, completed by a triangle below the line running around the rim (Pl. 5.1.11,20; 5.1.15,6.14). Another repeated ornamentation is a semi-arched double line (Pl. 5.1.8, 23; 5.1.10,17; 5.1.12,16; 5.1.15,12), or horizontal line (Pl. 5.1.18,7; 5.1.21,2-3). The main motif often consists of a combination of double and triple lines arranged horizontally, diagonally and in semicircles, which are supplemented by impressions. Such a combination can also be observed on amorphous vessels, where it is located in the area of the handle (Pl. 2.1.8,24; 5.1.12,9; 5.1.13,10; 5.1.14,11) or a knob (Pl. 5.1.9,11). An incised wavy line was found in only one case (Pl. 5.1.16,10). Another type of incision ornamentation are wider grooves, which were arranged horizontally (Pl. 5.1.16,5), in a branching pattern (Pl. 5.1.18,8) or in an interrupted pattern (Pl. 5.1.16,9). On some fragments, there are features we want to classify as 'failed attempts' at ornamentation, or as reflecting some kind of inconsistency in their execution, which are mainly seen in horizontal incision lines (Pl. 5.1.11,18-19).

The ornamentation on the thick-walled ceramics is limited primarily to the combination of knobs, pressed-through three-dimensional strips and bands of coarse impressions (Pl. 5.1.9,1; 5.1.15,17; 5.1.16,1) or deep incisions. Some fragments display only some of the mentioned decorative elements (Pl. 5.1.15,1.13).

House H102 is associated with fragments of spherical vessels, with incised double lines or triple lines, supplemented by 'note head' impressions, originating from QF/S6 (Pl. 5.1.17,4-5) and QG (Pl. 5.1.17,1-2) of object H102/1. The eastern half of object H102/2, in trench 6, yielded fragments of spherical vessels showing similar ornamentation as the same type of vessel from trench 4 and 5. The ornamentation consists of a horizontal line in the form of the letter S (Pl. 5.1.20,13-14.19) and semicircular lines completed by one or more impressions in a row (Pl. 5.1.20,20; 5.1.22,10).

House 103

In trench 6, the northern part of house 103 (H103) was excavated, which partially interfered with the southern part of house H102. When evaluating the ceramics, reference was made to the fact that objects H102/1 and H102/2 covered objects H103/1 and H103/2 in its southern section. On the basis of the finds of the individual quadrants excavated, it was found that the pottery of the Želiezovce group occurs in the western part of the two house-accompanying long pits and that the pottery of the younger LBK is concentrated in the eastern part. It is assumed that the ceramic material was mixed.

Diagnostic ceramic findings were obtained from QC1-2 and QG of object H103/1 (Fig. 5.1.9-10). Among the most striking forms are vessels with a neck (Pl. 5.1.17,18; 5.1.19,18), decorated with a double line interrupted by longer notches, and, above all, hemispherical bowls decorated with a double line, also terminated on the inside by a notch (Pl. 5.1.17,21; 5.1.19,15). T-notches were also found on this type of vessel, which ran through multiple horizontal lines (Pl. 5.1.17,20). In two cases from QC of object H103/1, it is assumed that the incised decoration was supplemented by red paintings (Pl. 5.1.19,2). In object H103/2, an ornamentation of double lines broken by a notch occurred only in QO (Pl. 5.1.20,7; 5.1.21,10), where fragments with 'note head' impressions were also discovered. This quadrant also yielded a fragment of a small clay spoon (Pl. 5.1.21,14). Its dating is uncertain, as it was discovered together with pottery that could belong to the LBK or to the Želiezovce group in terms of its ornamentation.

Excavation area 7: House 244

Trench 7 was located in the area of the southern end of the eastern house-accompanying long pit of house H244. The area of 5×5 m was divided into 25 squares, each measuring 1×1 m and excavated in a chequerboard pattern (resulting in 18 squares excavated or partly excavated). The object's borders were not easily discernible, because they showed no clear distinction from their surroundings. The evaluation of the profiles showed that a number of features had been excavated that may not have been related to object H244/1.

With regard to the observation of the ornamentation on the ceramic fragments, it is striking that the finds obtained from such a small area show such a lack of uniformity (Fig. 5.1.11). In general, the inventory, which is mainly represented by small fragments without ornamentation or with only a small part of ornamentation, can be described as less informative. Concerning decoration, a double line under the rim can be emphasised (Pl. 5.1.22,17; 5.1.23, 2.17-18), under which the main motif formed oblique (Pl. 5.1.23,2.17) or semicircular (Pl. 5.1.23,11.18; 5.1.24,4) lines. An unusual ornamental motif is the ornamentation consisting of a double line under the rim, followed by a vertical line with impressions on both sides (Pl. 5.1.22,13). A few fragments represent thick-walled ceramics decorated with an impressed three-dimensional band (Pl. 5.1.23,15), cantilevers (Pl. 5.1.22,20-21; 5.1.23,14; 5.1.24,1) or a series of notches (Pl. 5.1.23,1.16).

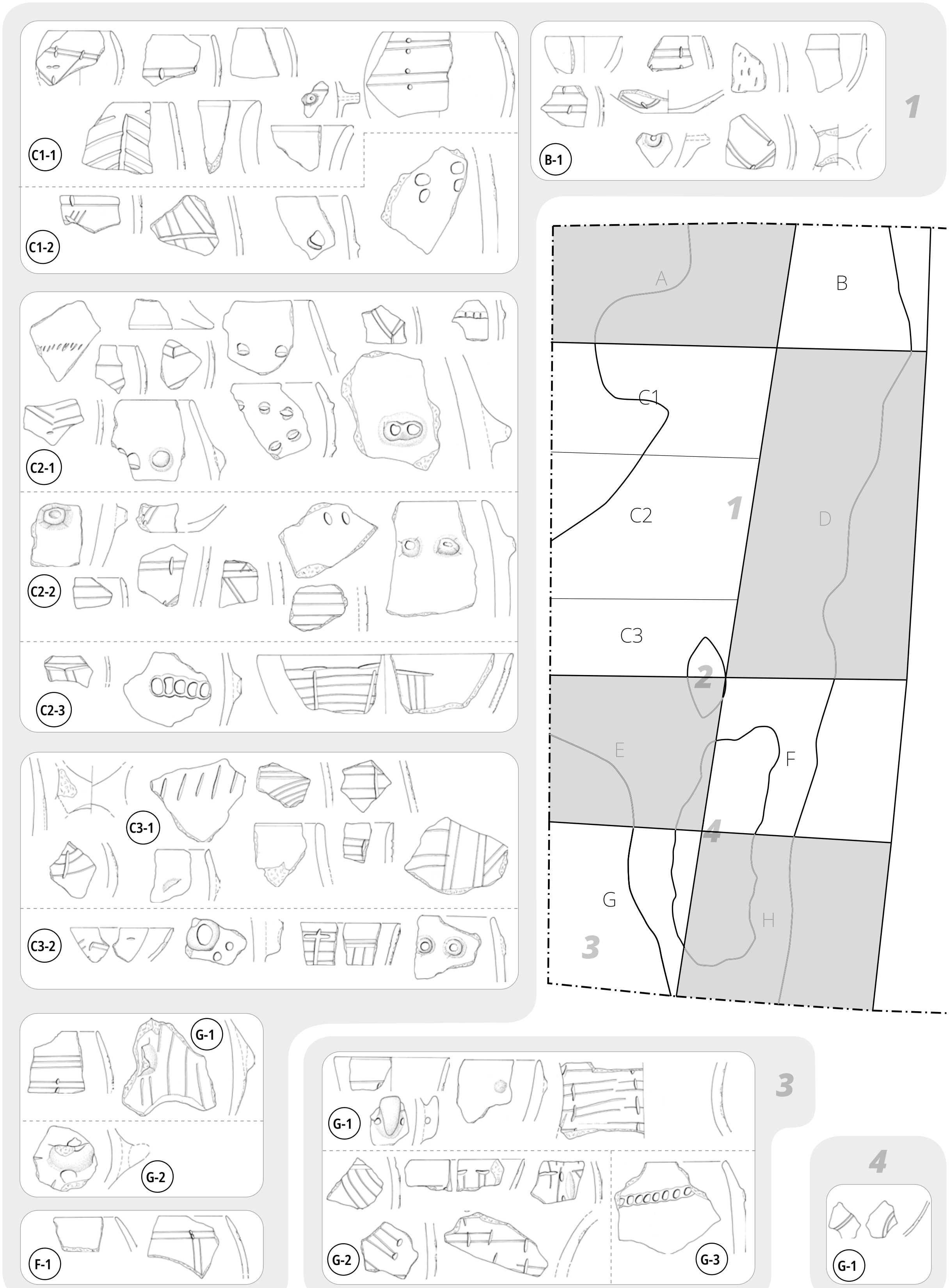

Figure 5.1.9. Ceramic finds in the western long pit of house 103 (trench 6).

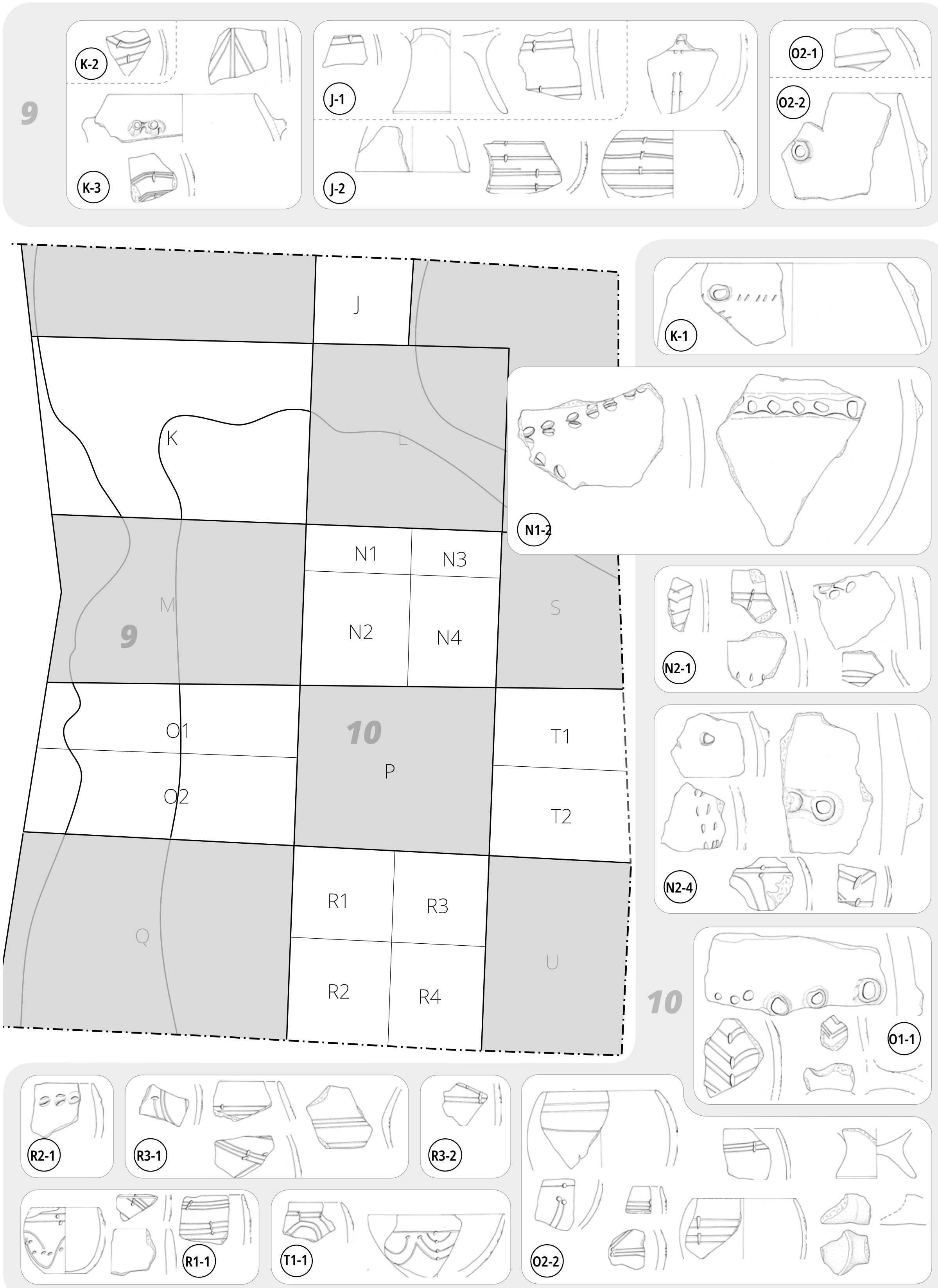

Figure 5.1.10. Ceramic finds in the eastern long pit of house 103 (trench 6).

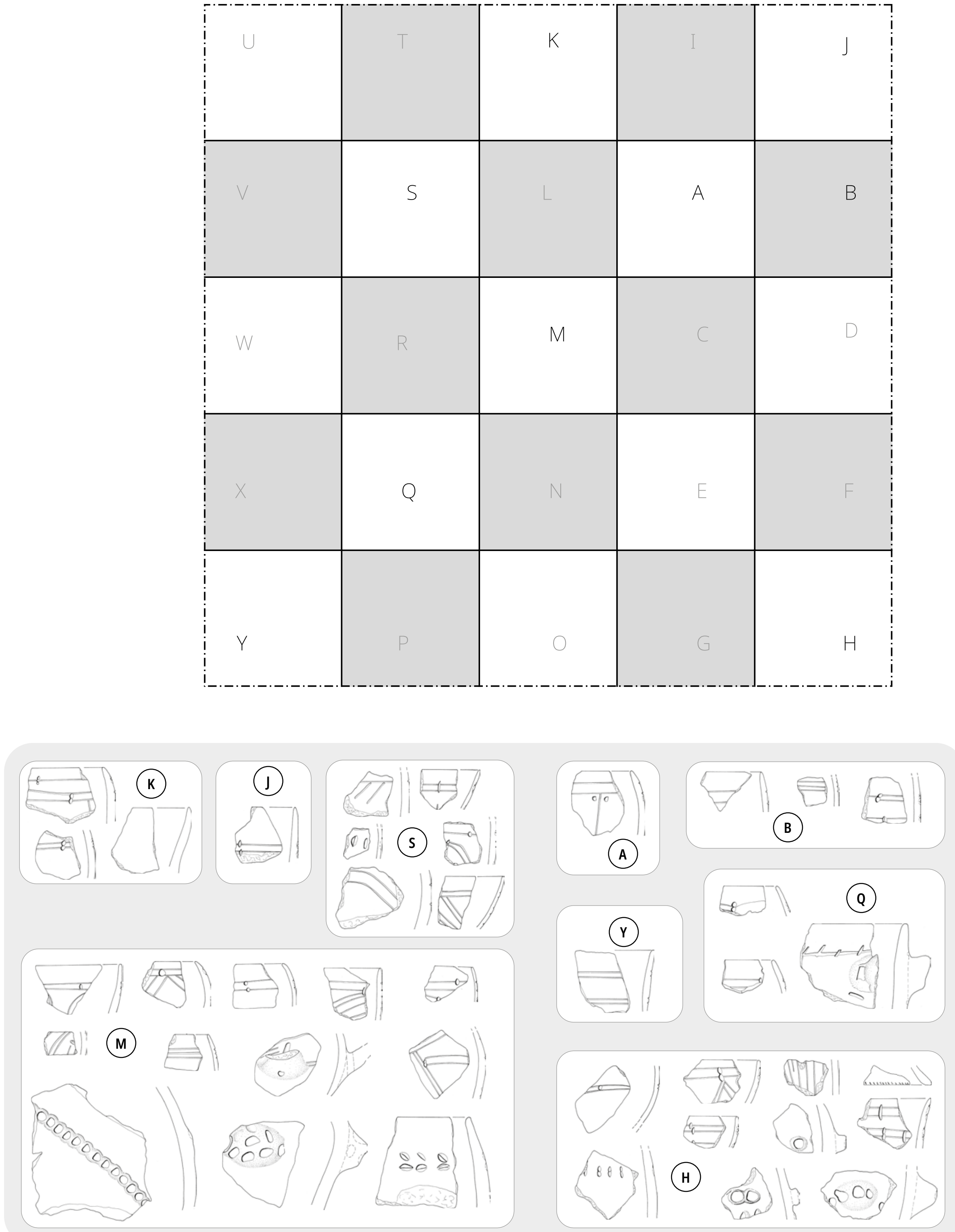

Figure 5.1.11. Ceramic finds in the western long pit of house 244 (trench 7). No further differentiation of objects was visible on Planum 1.

Excavation area 8: Houses 245, 258, 259 and 319

According to the geophysical plan, trench 8 cut through the middle parts of three houses (H245, H259 and H258). After the removal of the topsoil, only a few postholes could be documented. Because the subsoil is very loamy, there are no clear boundaries between the postholes and the subsoil, a situation that is quite usual, for example, on the Danube plain. This is in contrast to the situation for the long pits. The area between the house-accompanying long pits was excavated by hand onto the level of Planum 2, as in the area of the houses (Q2, Q1/7, Q5 and Q4), as well as between the accompanying long pits of the two houses (Q3). With the exception of nine quadrants, ceramic fragments were found in every house area, one to five fragments in each (Fig. 5.1.2). These were mainly small fragments of thin- and thick-walled vessels, without traces of decoration. Only sector J in Q4 yielded a greater amount of fragments from thick-walled, unornamented vessels.

House 245

A small ceramic inventory (Fig. 5.1.12) of house H245 was obtained from eight excavated quadrants in objects H245/1 and H245/2. Spherical vessels and hemispherical bowls are present, ornamented with a double line under the rim, under which a scale motif or oblique double lines are set (Pl. 5.1.24,12-14.18). A double line in the form of a semicircle is also recorded (Pl. 5.1.24,10). In individual cases, the line below the rim consisted of three lines (Pl. 5.1.24,18). One specimen also represents a vessel with a neck decorated with double circular lines with pairs of oval impressions (Pl. 5.1.25,3). The incised lines are completed by a pair of impressions, but there is also an oval to elongated impression reminiscent of a notch (Pl. 5.1.24,11.14; 5.1.25,2). An unusual element on a thick-walled, semi-spherical vessel, parts of which were found in both objects, was a horizontal or oblique incised line with short grooves. Such a finished ornament, supplemented by a cantilever, is reminiscent of stitching (Pl. 5.1.24,15.17.19).

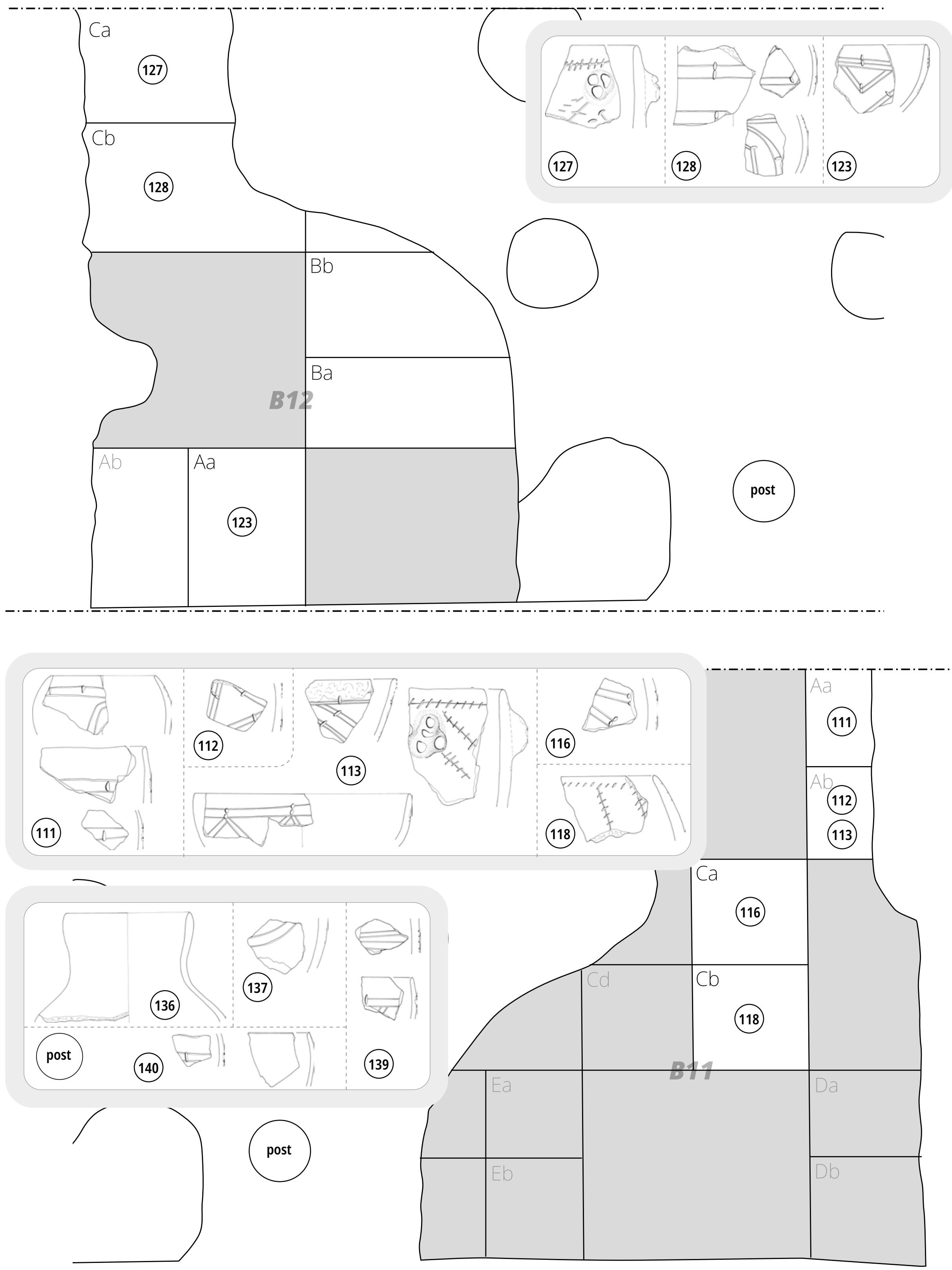

Figure 5.1.12. Ceramic finds in the long pits of house 245 (trench 8).

House 258

The magnetic plan – which showed two houses 'sharing' one long pit – and the occurrence of two different ^{14}C dates led to the interpretation that the western accompanying long pit of house H258 was completely destroyed by object 2 of house H259. The finds allocated to house H258 consist only of pottery obtained from 3 sectors of object 1, the eastern accompanying long pit of house H258 (Fig. 5.1.13). Thin-walled pottery is represented by spherical vessels with a wide open mouth. A single element represents a double line (Pl. 5.1.26,15; 5.1.27,4.14-15; 5.1.28,5) or a triple line (Pl. 5.1.26,5; 5.1.27,15; 5.1.28,8) placed under the rim. Similarly, as in the previous find complexes, the main motif on the spherical vessels consists of double lines arranged in a zigzag (Pl. 5.1.27) or arched pattern (Pl. 5.1.28,5) or a combination of the two (Pl. 5.1.26,15). There is also a multiple circular double line, which is supplemented by a pair of impressions (Pl. 5.1.28,4). Decorated thin-walled, hemispherical bowls bear an ornamentation consisting of a double line under the rim, supplemented by kinked lines (Pl. 5.1.27, 12). There is also a bowl whose entire surface is covered by an ornamentation of multiple horizontal lines with dimples (Pl. 5.1.26,2) and impressions. In addition to these two vessel types, fragments have appeared without any incised decoration (Pl. 5.1.27,7; 5.1.28,2). One specimen represents a bowl with a foot (Pl. 5.1.26,13). The collection also contains body fragments of amorphous vessels with a vertically drilled handle (Pl. 5.1.26,11) or a knob (Pl. 5.1.26,7). A single fragment of the body of an amphora-like vessel with an application of incised lines and a knob interrupting a double line occurred (Pl. 5.1.25, 13). On some sherds of thin-walled vessels made of clay with a higher sand content, the incised ornamentation was more difficult to distinguish because the surface had eroded.

Object H258/1 contained several fragments without decoration, which belonged to medium-thick and thick-walled vessels. The decorated specimens in this group have three-dimensional or impressed decoration. The spherical vessels show an application of a horizontal, oblique and vertical pressed strip in combination with knobs (Pl. 5.1. 27,2; 5.1.28,3). On semi-spherical bowls (Pl. 5.1.27,5) and vessels with necks, on the other hand, impressions form lines (Pl. 5.1.27,3; 5.1.28,1) or punctates in the form of coffee grains (Pl. 5.1.25,12). Hemispherical bowls with hooks (Pl. 5.1.26,3) or a prominent knob (Pl. 5.1.28,6) under the rim complete this group.

House 259

In the eastern object H259/1, as well as in the western object H259/2, the house-accompanying long pits of house H259, 6 quadrants were demarcated. In order to gain the long profile, as well as the cross profile, the individual sections were alternately excavated. After the deepening of the fourth layer in QC, the excavated object (marked B13 during excavation) became distinguishable. Already at first sight, it was evident that these two objects of house H259 contained qualitatively different ceramic inventories with regards to the representation of ornamented vessel parts (Fig. 5.1.14-16).

In object H259/1, ornamented fragments only occurred sporadically, in QA, QB, QC (Fig. 5.1.14), and only in the form of smaller vessel fragments. In terms of shape, these are mainly spherical vessels whose ornamentation consists of a double line under the rim and the motif forms oblique or arched double lines (Pl. 5.1.35,4.7.11). This type also includes a rim whose surrounding line under the rim is reminiscent of seams or stitches (Pl. 5.1.35,12). There is also a conical bowl with carved ornamentation on the inside (Pl. 5.1.35,6). The fragment with the triangular handle shows the presence of an amorphous vessel (Pl. 5.1.35,5).

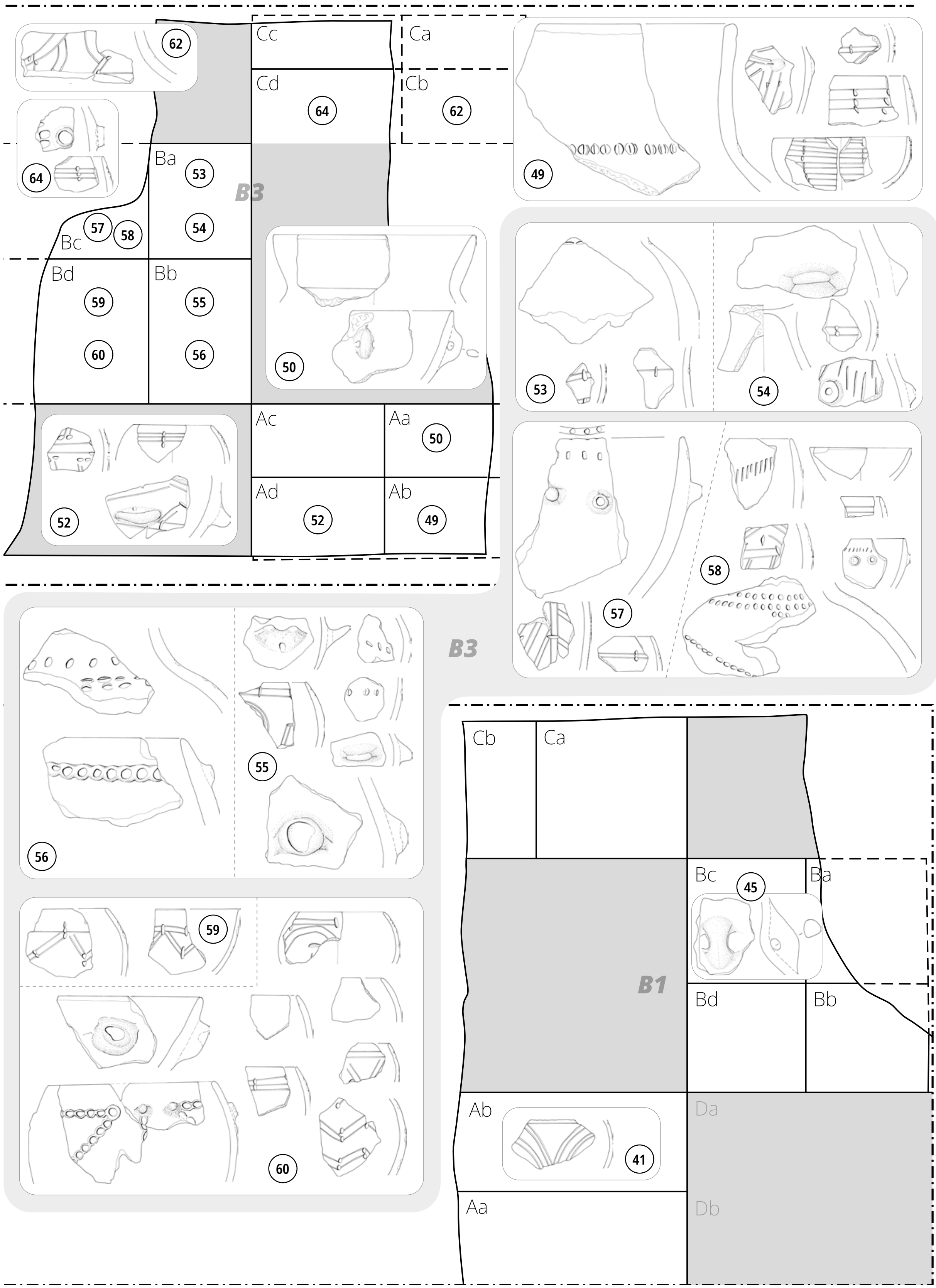

Figure 5.1.13. Ceramic finds in the eastern long pit of house 258 and the western one of house 319 (trench 8).

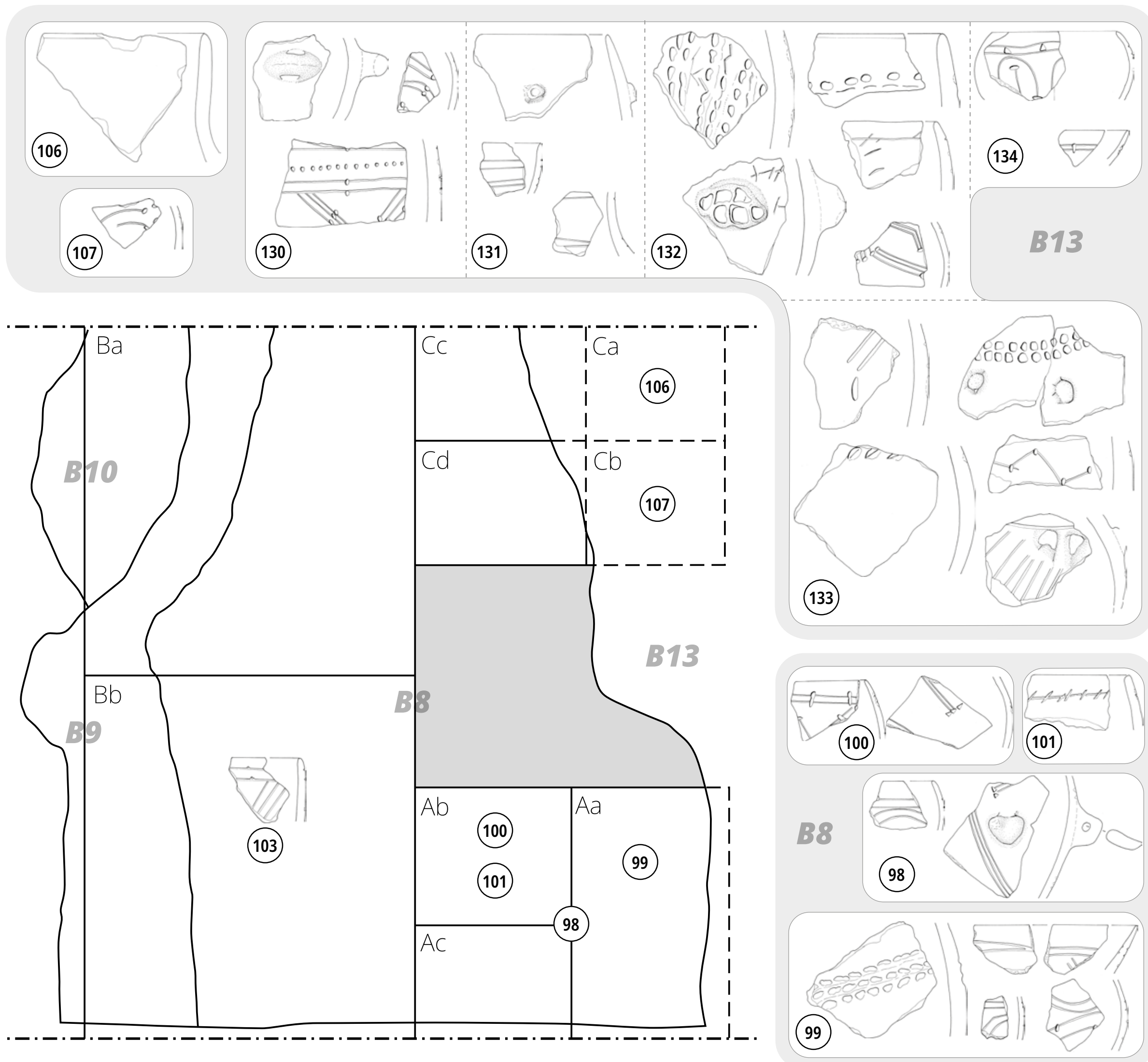

Figure 5.1.14. Ceramic finds in the western long pit of house 259 (trench 8).

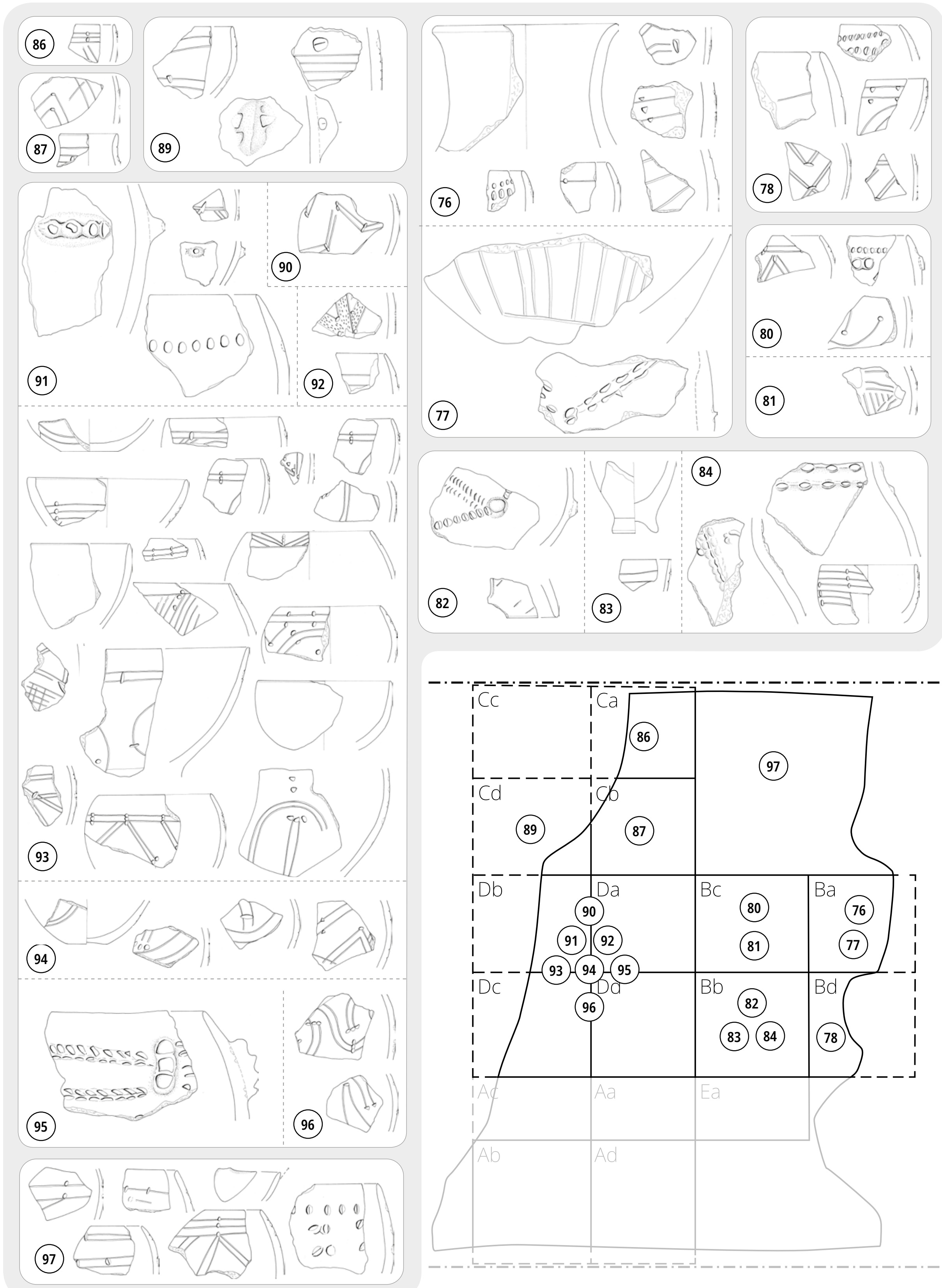

Figure 5.1.15. Ceramic finds in the eastern long pit of house 259 (trench 8).

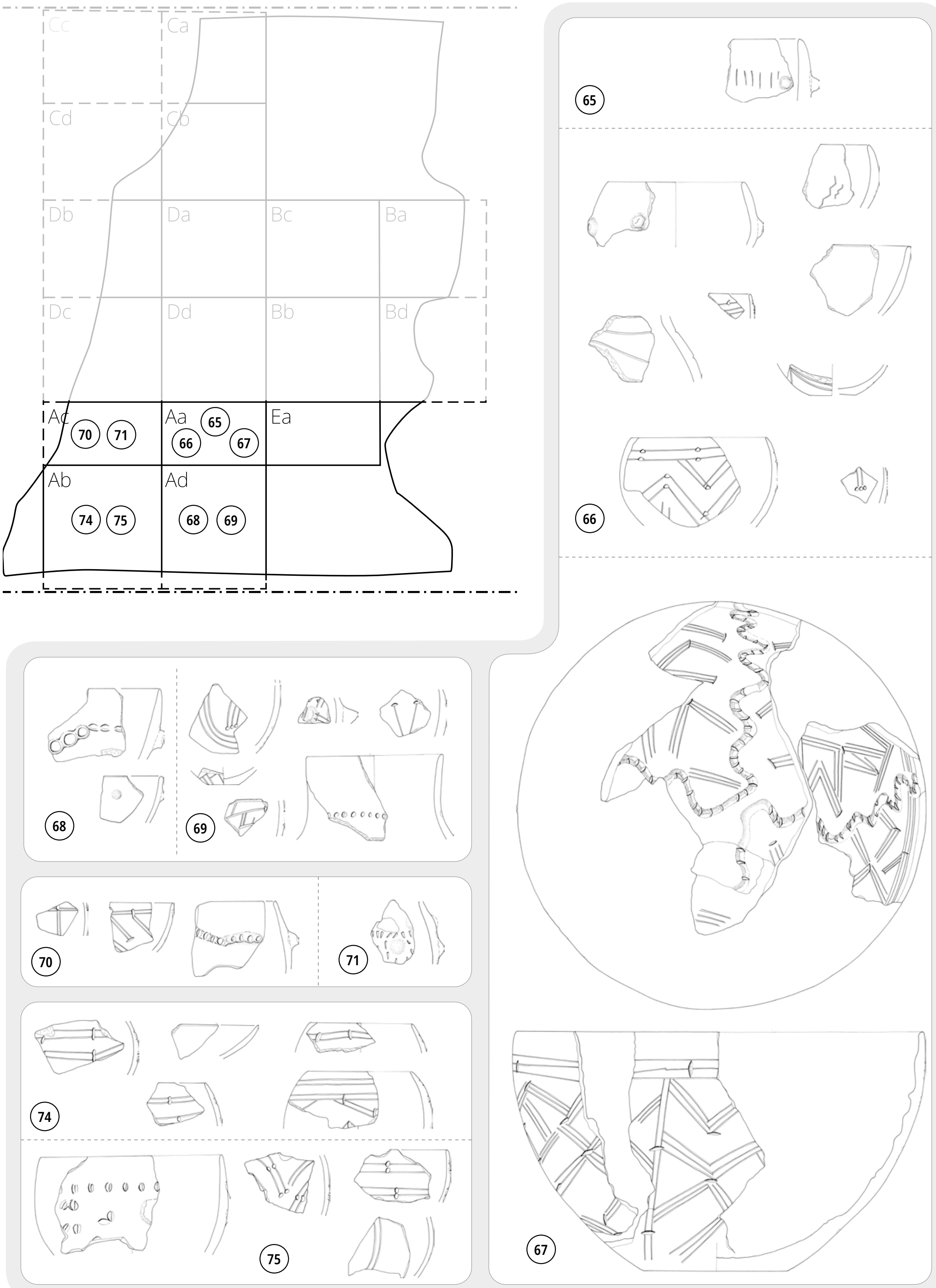

Figure 5.1.16. Ceramic finds in the eastern long pit of house 259 (trench 8) (continued).

The most numerous collection of ornamented ceramics from the excavation in 2014 was obtained from object H259/2 (Fig. 5.1.15-16), which was marked as B6 during the excavation. In the middle part of the western long pit of the house, three sections (QA, QB a QC) were explored initially, but after the discovery of the remarkable bowl with snake-like ornamentation in QAa, the excavation was extended to QD as well. In general, it can be said that a common, unifying attribute of their ornamented thin-walled pottery is the occurrence of circular (Pl. 5.1.33,7; 5.1.34,16), oval (Pl. 5.1.29,20; 5.1.33,15) or triangular (Pl. 5.1.29,2; 5.1.31,6; 5.1.34,1.13-14) impressions placed on or outside an incised line. The impressions occur independently, in pairs, or joined in groups of three. The variability of the ornamental motif, which forms a combination of incised lines terminated or interrupted by one or more impressions or short incisions, is observed in several ceramic shapes from this object.

The pottery from this object consists mainly of spherical vessels, in which a broader variety of incised ornamentation can be recognised. According to the preserved rims, a double line (Pl. 5.1.29,2.16; 5.1.32,7; 5.1.33,9.13.15, 5.1.34,17), more seldom a triple line (Pl. 5.1.29,8; 5.1.30,1; 5.1.34,16), and exceptionally a single line (Pl. 5.1.31,5) below the rim are a common element. The motif below it is predominantly formed by double lines that are rounded (Pl. 5.1.29, 1; 5.1.33, 15; 5.1.34, 9), bent (Pl. 5.1.29,2; 5.1.32,7.22; 5.1.34,10), oblique (Pl. 5.1.34,16), or horizontal (Pl. 5.1.29,17; 5.1.34,17). Some vessels show the same combination of incised lines and impressions. The object also contains fragments with incised ornamentation formed by interlocking arched lines in the form of a horizontal letter S (Pl. 5.1.29,20; 5.1.34,14). A similar ornamentation is also found on the fragments from QAb (Pl. 5.1.29,8), and QBc (Pl. 5.1.32,5). An exception is an ornamentation forming a bundle of three diagonal lines separated by three impressions and placed above the line below the rim (Pl. 5.1.34,6). Uniquely, a wavy line which occupies the fragment of a smaller globular vessel with a wide open mouth was found (Pl. 5.1.28,11).

The less numerous ceramic forms include hemispherical bowls. A double line under the rim is highlighted (Pl. 5.1.29,12; 5.1.32,2.5.20). Because the spherical vessels were more fragmented, we could determine the ornamental motif in only a few cases (Pl. 5.1.29,12). One of those represents multiple horizontal grooves evenly distributed over the body of the vessel (Pl. 5.1.32,15; 5.1.33,7). It should be noted that the object yielded several specimens without incised decoration (Pl. 5.1.28,16; 5.1.29,15; 5.1.33,10; 5.1.34,5.15), but in these cases, a hemispherical knob was applied under the rim of a vessel (Pl. 5.1.29,4). Two bowls with feet were also recognised. The first specimen is represented by the upper part of the body, with ornament, which consists of a circular double line with an incision under the rim, under which there is a rounded incised line (Pl. 5.1.33,16). The second specimen shows a bowl on a small, low foot (Pl. 5.1.32,12).

Thicker incised and grooved lines appear on the bulge of the lower belly of a vessel with neck (Pl. 5.1.28,14) and as an ornamental component covering the lower part of a very thick-walled vessel (Pl. 5.1.31,11).

In QD, a fragment of a vessel body found in the fourth spit is decorated with wider grooved lines delimited by a thicker groove and filled with short punctates. Three grooved lines run into each other, and at the point where the grooves join is an oval impression (Pl. 5.1.33,6).

In the evaluated inventory from object H259/2, a tall semi-spherical vessel or bowl from the third spit (QAa) was assigned to the exceptional finds. It is one of the most distinctive ceramic forms documented from the excavation of the houses in the different settlement areas at Vráble (Cheben and Furholt 2019). Because this find was so exceptional, the neighbouring quadrant (QD) was also excavated, enlarging the ceramic collection from object H259/2. The vessel in question is decorated on the outside and inside with three circumferential, incised lines under the rim and a motif which can be assigned to the Želiezovce group. The motif consists of three angled lines arranged in four stripes separated in the middle by a vertical double line. One of the most unique decorative elements is undoubtedly a three-dimensional application of long, curved, notched strips, probably representing two snakes (snake motif), on the inner side of the vessel (Pl. 5.1.30,2). The snake-like notched three-dimensional strips run from the one rim, through the base of the vessel, to the opposite rim. Due to the course of the three-dimensional decoration it is evident that they were placed almost symmetrically on the inside of the semi-spherical vessel and represent the natural movement of snakes in nature.

House 319

As part of the re-classification of the houses based on the magnetic plan (Chapter 2.1) and ^{14}C-dating, object 2 (B1, eastern long pit) of house H258 was redefined as object 1 (western long pit) of house H319. The three excavated quadrants of object 1 of house H319 yielded only a minimal number of decorated pottery sherds, which makes a comparison with the inventory derived from object 1 of house H258 rather difficult (Fig. 5.1.13). A fragment of a spherical vessel was found in QAb, probably with a line under the rim and double lines in the form of arches (Pl. 5.1.25,10). The finds consist of several small fragments with parts of preserved incised decoration, in one case double lines and notches.

Excavation area 10: House 262

In trench 10, the middle part of the western long pit and part of the central area of house H262 were uncovered. In this area, a minimum of two rows of postholes was assumed, which were even visible in the magnetic plan. The area of the long pit, object H262/1, was divided into twelve quadrants (QA-QL). The inner area of the house, in which four discolorations (marked B5-B8) and two postholes were distinguished, was divided into 15 roughly equal quadrants (QA-QO) in N-S orientation and then excavated. The four discolorations situated at the eastern edge of the long pit (QA) yielded a rim fragment of a spherical vessel and three sherds without decoration. The rim fragment was decorated with two incised lines.

The ceramic inventory from object H262/1 (Fig. 5.1.17) consists mainly of spherical vessels. Similar to the previous findings of this type of vessel, a line appears under the rim, under which there is an incised motif. It is formed by half arches in combination with vertical or diagonal double lines (Pl. 5.1.39,2.5.9.19; 5.1.40,10-11). There are also flexed double lines arranged horizontally (Pl. 5.1.39,10.13.16) or from top to base (Pl. 5.1.39,3). Similar motifs are also found on semi-spherical bowls (Pl. 5.1.39,12.14.17; 5.1.40,13; 5.1.40,1.3.7). There was also a bowl with a low hollow foot (Pl. 5.1.40,9). A triangular handle in the shape of an animal head (Pl. 5.1.39,6) and a handle with two knobs imitating (animal) horns (Pl. 5.1.40,8) were documented on an amphora-like vessel.

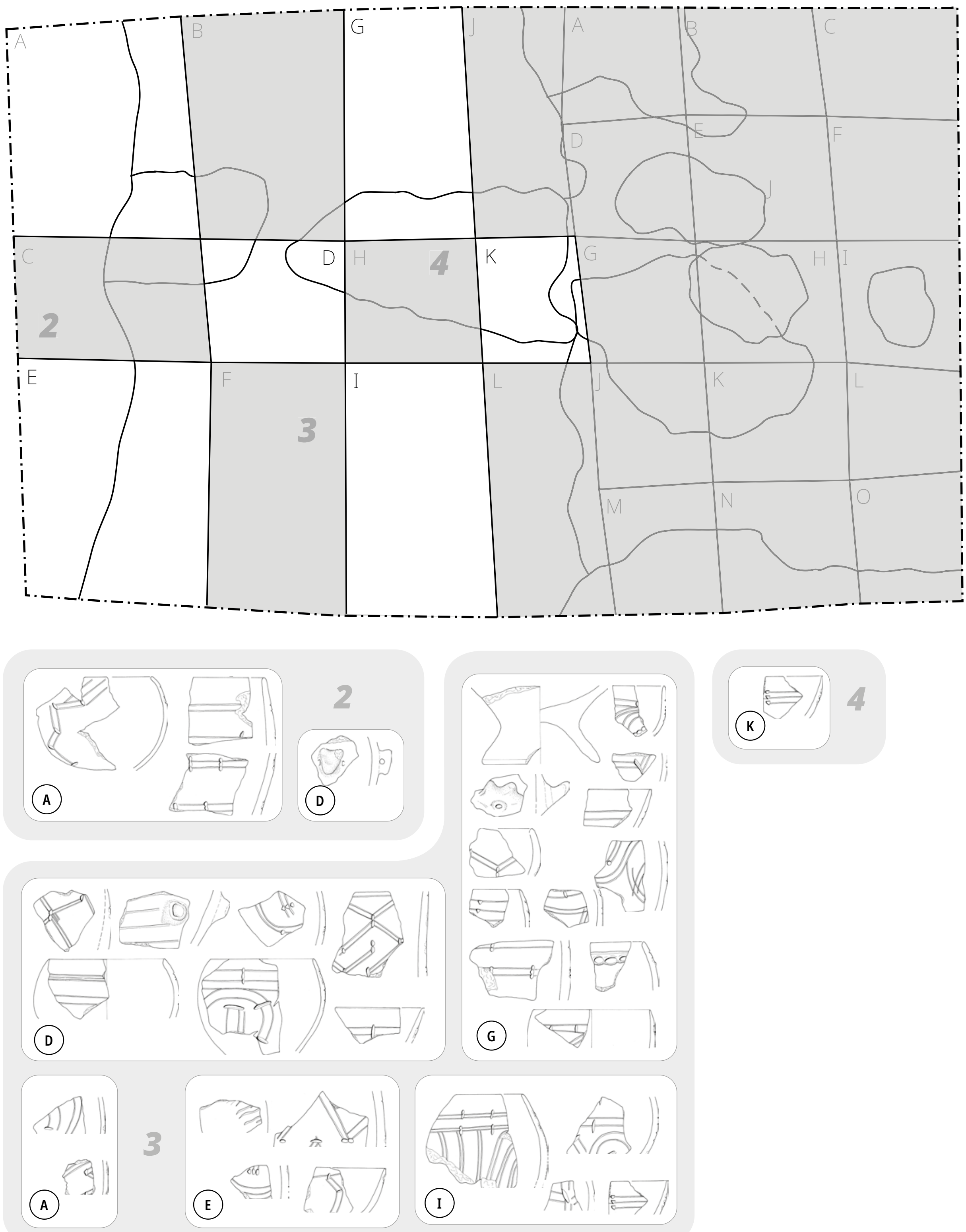

Figure 5.1.17. Ceramic finds in the western long pit of house 262 (trench 10).

Excavation areas 11-14: Houses 131-133, 126/127

House 131

Two long pits (objects H131/65 and H131/57) and 21 postholes were assigned to house H131, which was located in trenches 11 and 12. The house probably also includes object S11/7, which could form the continuation of the eastern long pit in the northern part. The majority of the pottery was obtained from object H131/65, which was completely excavated. During the excavation of the selected quadrants in object H131/57, two excavated objects – S12/57a and S12/57b – were recorded in the central and southern part of these. Along the eastern edge of the long pit of house H131, object S12/9 was recorded, which in its form reminded that of a long pit.

Several types of vessels represent the range of forms connected to house 131 (Fig. 5.1.18). A comparison with the total number of finds from this context showed that about a quarter of the material is constituted by decorated sherds. Spherical vessel forms are represented by fragments of a double-conically shaped pottery type (Pl. 5.1.41,4.12.14.20). This vessel type was not exhibiting incised decoration motifs. Further, this type of vessel also includes rims in a slight S-shape and exhibits a rudimentary form of a neck (Pl. 5.1.41,15-17). A bundle of flexed double lines in the shape of the letter S and a long incision appeared on an amphora-like vessel (Pl. 5.1.41,19). This type also includes a distinctively curved rim form (Pl. 5.1.41, 3) and a triangular handle (Pl. 5.1.41,5). The incised ornament, to the extent it can be defined on the basis of the fragmented state of preservation, forms bundles of double lines, through which a long incision leads (Pl. 5.1.41,2.15). More regularly appearing are multiple incised lines (Pl. 5.1.40,20; 5.1.41,6.8) and a wavy line (Pl. 5.1.40,17.24), also on the inside of a bowl (Pl. 5.1.40,18). Singularly appearing forms include the base of a cylindrical vessel with fragmented remains of an incised ornamentation (Pl. 5.1.41,11). In the second spit of Q4, which belongs the western long pit of house 131, a small fragment of a vessel with an ornamentation made in the style of the Bükk culture pottery was found.

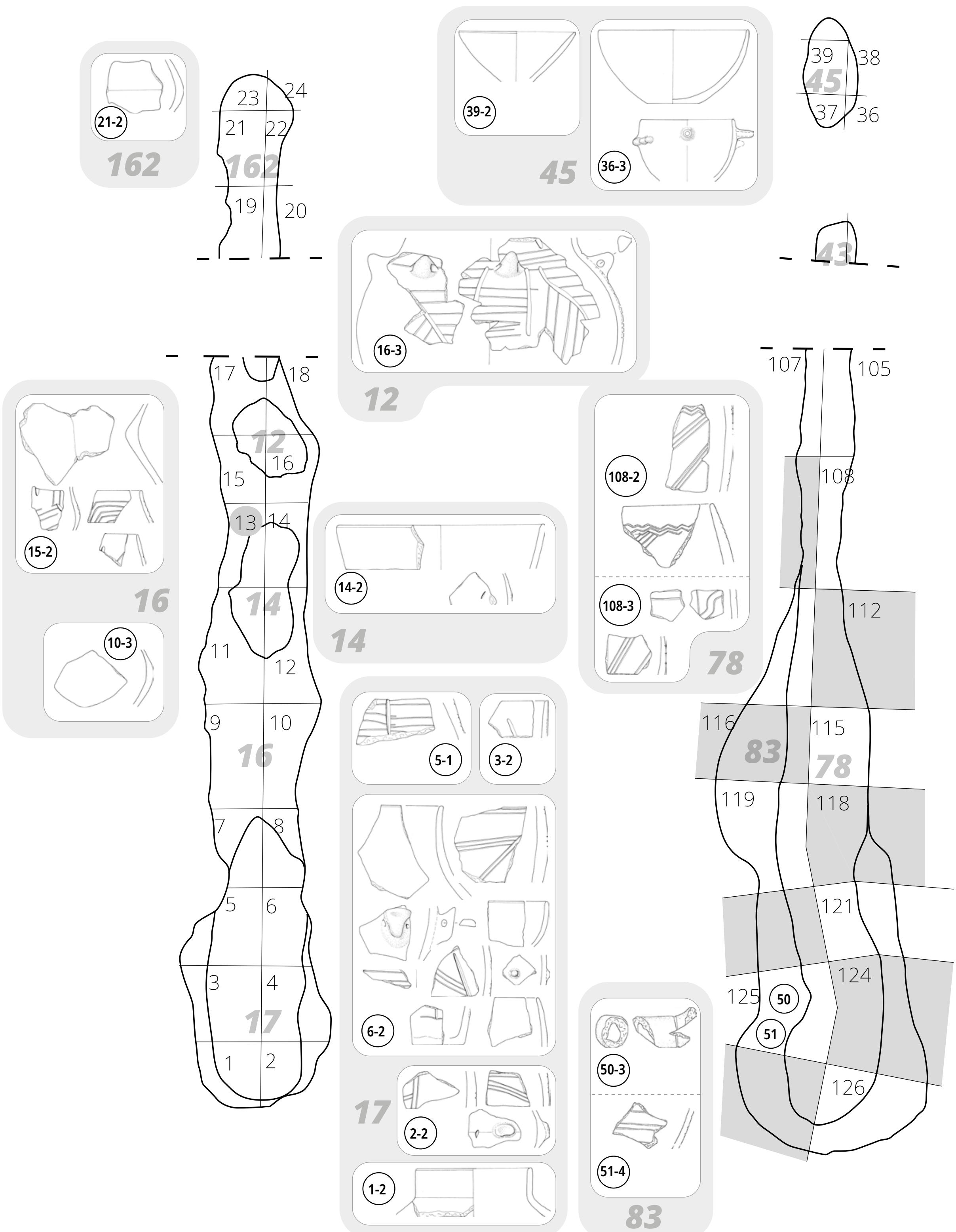

Figure 5.1.18. Ceramic finds in the long pits of house 131 (trenches 11-12).

From object S11/7 the most exceptional type was obtained – a spherical vessel with a tubular spout (Pl. 5.1.40,16) and three pointed knobs underneath the rim. The find was supplemented by a conical (Pl. 5.1.40,14) and semi-spherical (Pl. 5.1.40,15) bowl without decoration. All in all, the forms of pottery correspond with the exemplars from both long pits of house H131.

House 132

In the case of house H132, the situation during the fieldwork was more complicated, especially when determining the course of the western long pit. The stratigraphic situation indicates that the western long pit was formed by object H132/9 and object H132/14, which were heavily disturbed by objects S11/10, S11/11 and S11/12. In these objects, fragments of thin-walled vessels without decoration predominated. According to the location of object H132/25, it can be assumed that the southern corner of the house area is marked by object H132/9 (or S12/9). In the eastern long pit H132/25 the spacious object S11/24 was excavated, which cut into the former.

The ceramic inventory was obtained not only from the long pits, which were divided into quadrants and partly excavated, but also from the posthole H132/15 (Fig. 5.1.19). From these objects, we have a fragment of the upper part of a necked vessel, supplemented with a knob (Pl. 5.1.42,6). Three fragments of pottery exhibiting characteristics of the Bükk culture (Pl. 5.1.42,7.9-10) were found in the second spit of object H132/9, which otherwise did not include many finds. From object H132/25 (eastern long pit), which was disturbed in the northern part by object S11/24, fragments of decorated pottery were found in two excavated sections. On a spherical vessel with a double-conical form, the incised motifs consisted of bundles of diagonally and horizontally arranged lines, which were either interrupted or delimited by a long incision (Pl. 5.1.44,14). The fact that the long-pits of house H132 were still open during one of the later phases of inhabitation (see Chapter 4.1) on the settlement is also indicated by an S-shaped bowl without ornamentation (Pl. 5.1.44,9).

House 133

The ground plan of house H133, the northern part of which was not excavated, is delimited by the long pits (Fig. 5.1.20). On the eastern side of this area, object H133/26 was investigated, which was completed on the level of the fourth row of postholes during the excavations. The northern continuation of this object could not be documented and remained unclear even after the excavation of the section, where the continuation of the long pit had been expected. In object H133/26 three sections and the southern end of the long pit were excavated, where the stratigraphic relation to object H132/25 could be documented in a profile.

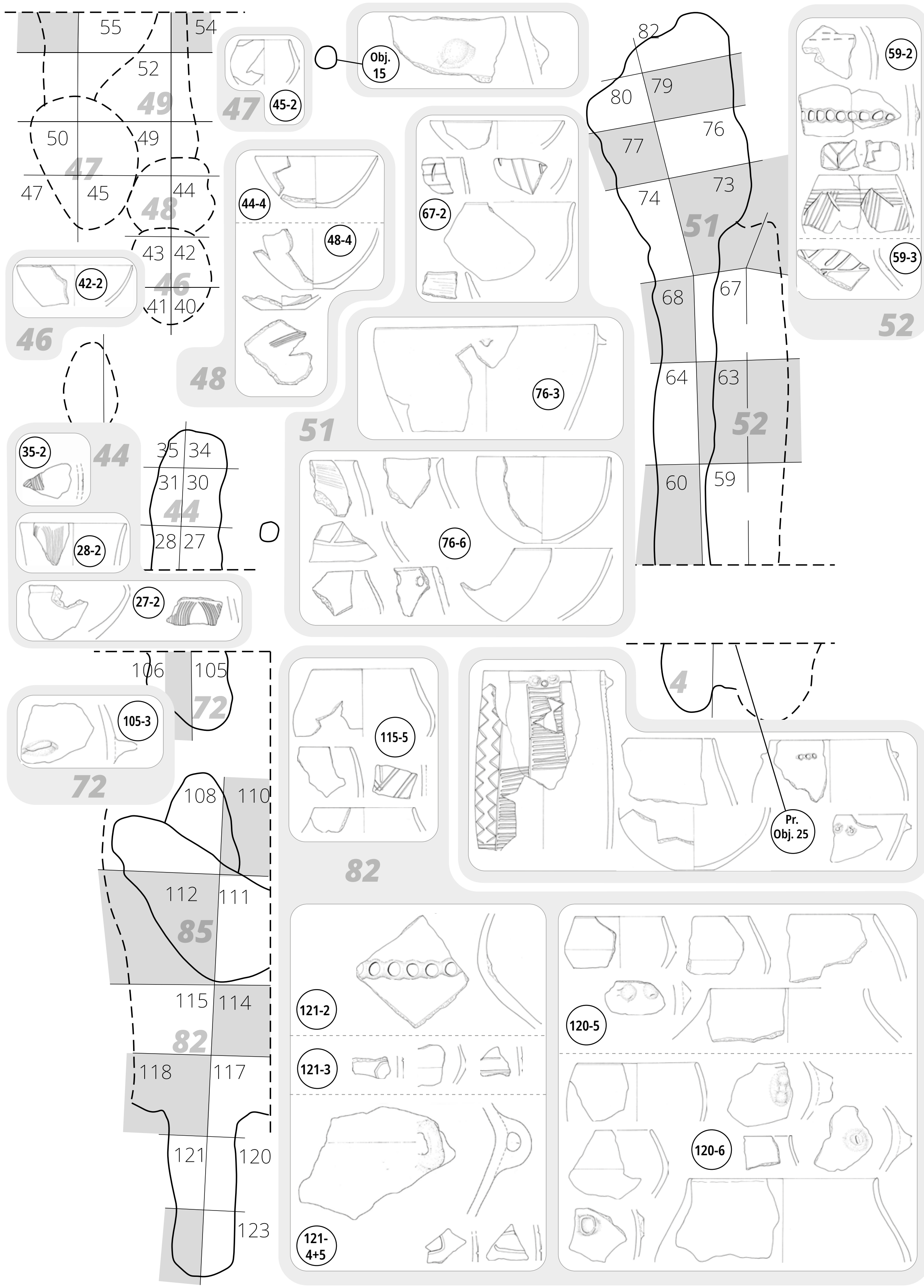

Figure 5.1.19. Ceramic finds in the long pits of house 132 (trenches 11-12).

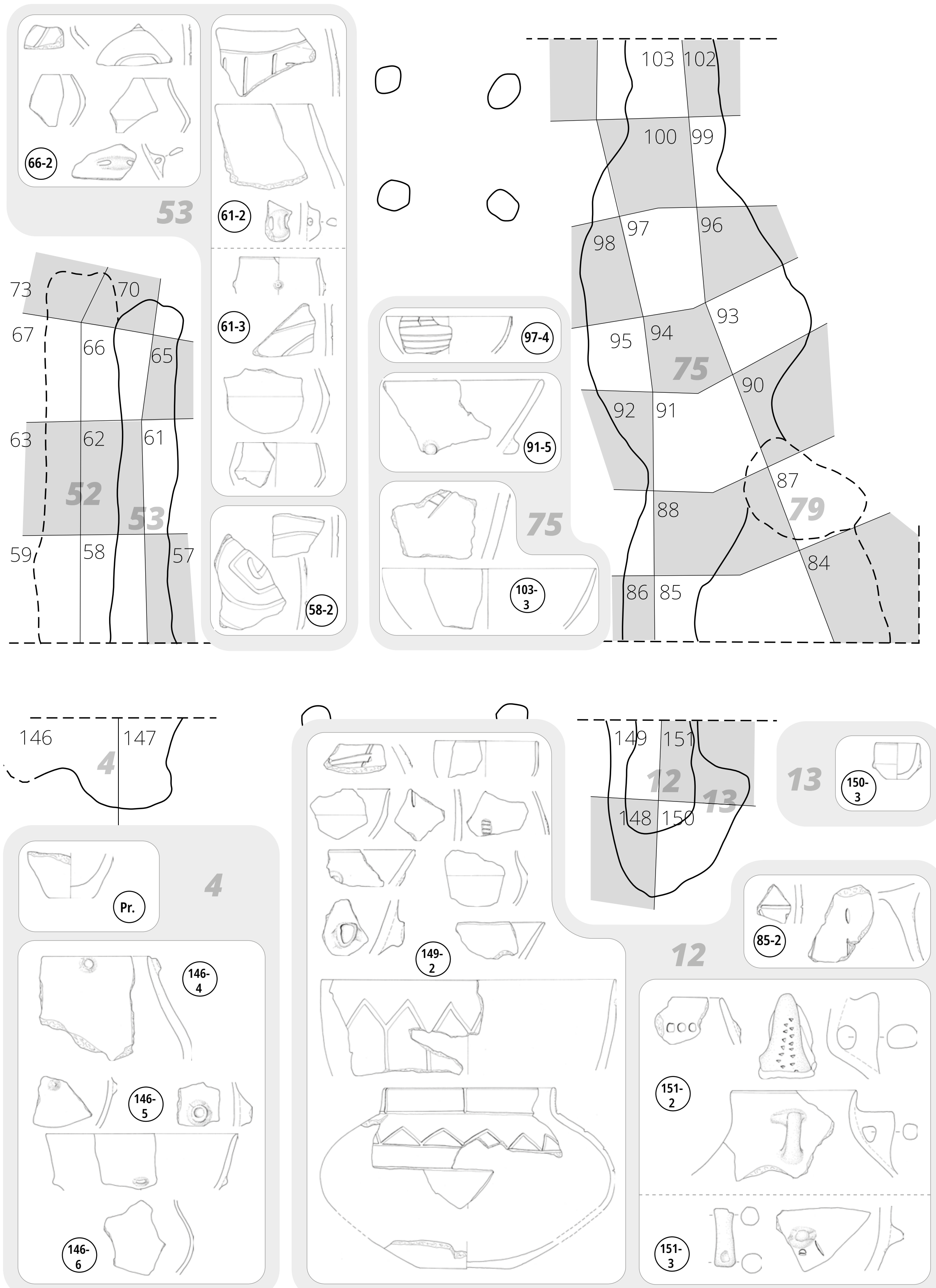

Figure 5.1.20. Ceramic finds in the long pits of house 133 (trenches 11 and 13).

Object H133/37 was in its central part disturbed by a larger oval pit (object S11/37a). From this pit, the most expressive ceramic form is the rim of a wide open bowl with a knob. This vessel can be assigned to the style typical for Lengyel contexts (Pl. 5.1.46,9). This classification is also supported by the different sorts of clay which were used. The clay used for the Lengyel-type vessel contained a higher amount of crushed stone. The pottery of the eastern long pit consists of finds from five quadrants. A characteristic attribute of this pottery is the presence of a large number of vessels without incisions. These are mainly spherical forms with narrower (Pl. 5.1.45,9.13-14; 5.1.46,17) or wider (Pl. 5.1.45,10) mouths and a more or less prominent double-conical body. This type also includes types with an s-shaped profile (Pl. 5.1.46,3). The bowls have a similar shape and form (Pl. 5.1.46,1.18) as spherical vessels. A semi-spherical bowl is also represented in the range of pottery (Pl. 5.1.46,7). Vessels with a double-conical profile were also found within the range of higher vessel shapes (Pl. 5.1.45,3.6.8.18). A change in the ornamentation, as far as its technical execution is concerned, is seen in the decline of the incised decorations and its replacement by knobs placed under the rim (Pl. 5.1.44,13; 5.1.45,2.18; 5.1.47,5) or on the maximum diameter of the belly (Pl. 5.1.45,6; 5.1.46,1; 5.1.47,3.4). An element that does not occur often is an ornamentation on the handle of a thick-walled vessel (Pl. 5.1.47,8).

The ceramic inventory of house H133 is enriched by the occurrence of rim fragments of three vessels. These vessels exhibit ornamentations that were done in two ways. The first ornamentation is a widely incised line in the shape of Gothic arches (Pl. 5.1.47,1) on a semi-spherical vessel. Similar ornamentations can be found on the cylindrically shaped neck and body, where circumferential lines and a row of triangles are located (Pl. 5.1.47,2). This style of decoration also includes fragments of vessels which are ornamented with wide, incised lines (Pl. 5.1.45,4.11-12) or spiral forms (Pl. 5.1.45,7.15). The second type of decoration was found on the neck of a vessel, under which, below incised lines and a line of knobs, is an ornamentation of vertical stripes filled with incised lines and hatched rectangles (Pl. 5.1.44,17).

House 126

In trench 14 objects were excavated that belong to house H126. From these objects, five excavated quadrants contained pottery of distinct shape and/or ornamentation (Fig. 5.1.21). A significant proportion of the fragments showed some traces of incised or sculpted decoration were found. Object H126/127 contained spherical vessels with a double-conical body (Pl. 5.1.49,6), but also with a more (Pl. 5.1.49,7) or less (Pl. 5.1.49,5) curved rim. In addition to a sherd with long, wide incised line which is crossing a double line (Pl. 5.1.49,2), a sherd from the lower portion of the vessel with incised, multiple wavy lines (Pl. 5.1.49,8) is worth mentioning. In object H126/127, the distinctive shapes include vessels with a neck. Ornamentation under the rim of this vessel type include double lines and incisions (Pl. 5.1.49,12.14-15.17). A semi-spherical bowl similar to the previously described ceramic displayed a knob (Pl. 5.1.49,16).

Excavation area 22: Houses 23 and 317

House 23

In the case of house H23, object H23/102 was explored in more detail. Here, a burial (G11/22) was found in the context of Q9 and Q11. Within the context of object H23/103, two sections were excavated which included finds of pottery (Fig. 5.1.22). With regard to the spherical vessels, variable motifs occur, which form an incised double line (Pl. 5.1.50,5.7.11.15; 5.1.51,9.19-21) and a triple line (Pl. 5.1.50,9; 5.1.52,12). The ornamentation is arranged in circumferential lines (Pl. 5.1.50,11.15.17; 5.1.51,21),

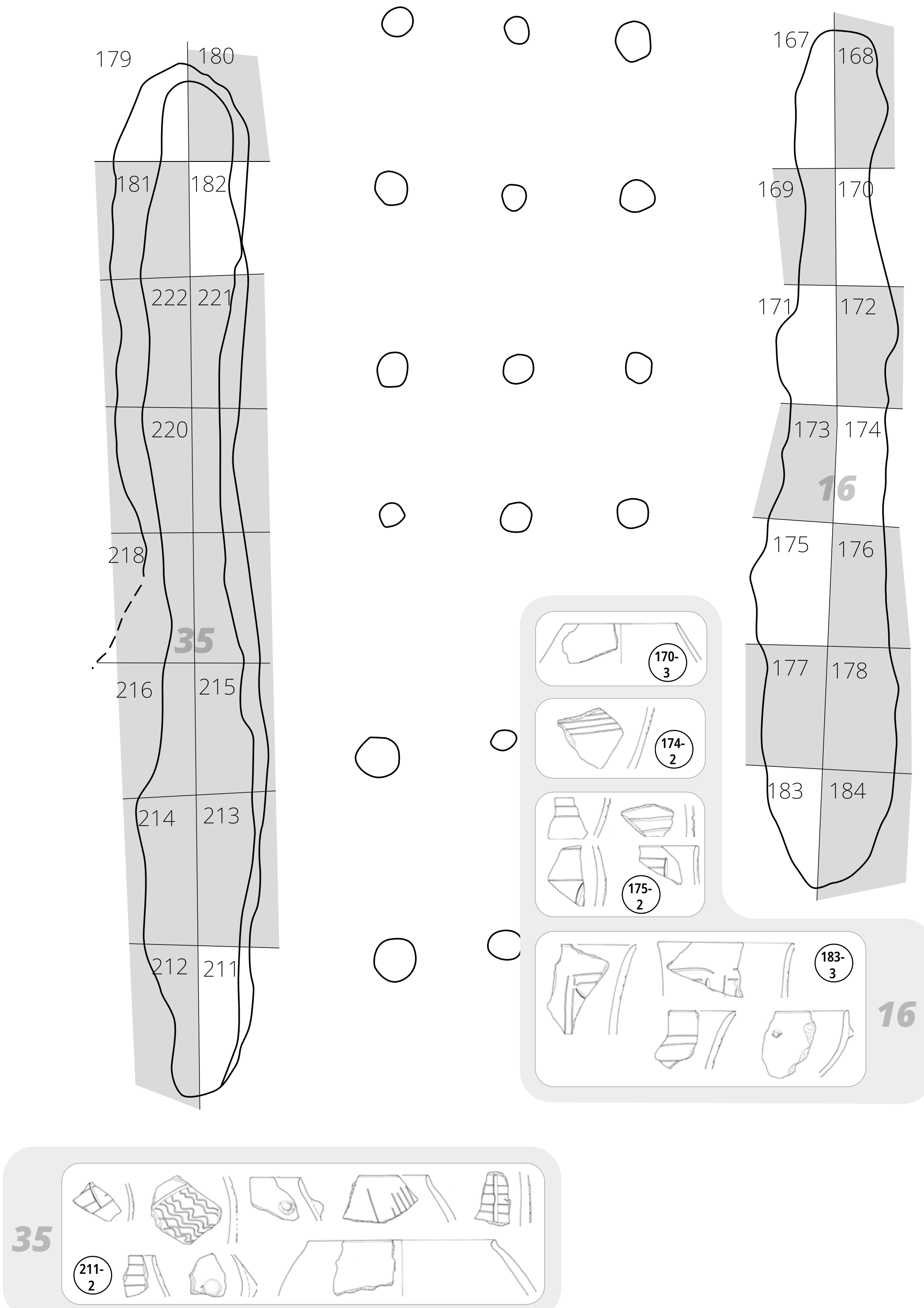

Figure 5.1.21. Ceramic finds in the long pits of house 126 (trench 14).

with short, curved bundles (Pl. 5.1.50,5; 5.1.51,9.12.20; 5.1.52,9) and arches (Pl. 5.1.50,6-7.13.16). The lines are either solid or interrupted by elongated incisions, and sporadically there is also an incision with a pair of impressions (Pl. 5.1.52,12). Fragments with a notch at the end of the incision line also occur (Pl. 5.1.50,10; 5.1.52,5). Bowl shapes are either without ornamentation (Pl. 5.1.50,12.22) or with ornamentation forming circular double lines interrupted by an incision (Pl. 5.1.50,8; 5.1.51,11.13). The occurrence of vessels with a neck or of amphora-like vessels in the inventories is documented by handles (Pl. 5.1.50,21; 5.1.52,6). There is one thick-walled spherical vessel with incised wide lines under the rim (Pl. 5.1.52,1), which is rather an exception for this vessel type. As a rule, these vessels have three-dimensional ornamentations in the form of impressed strips (Pl. 5.1.50,24; 5.1.51,7), knobs (Pl. 5.1.51,3.10; 5.1.52,3) or oval impressions (Pl. 5.1.51,4).

House 317

In the northern part of trench 22, the southern part of house H317 was uncovered. In both long pits, several quadrants were excavated; however, they were not very voluminous. Therefore, the ceramic inventory consists only of a small amount of material (Fig. 5.1.23). This is represented in object H137/100 by a semi-spherical bowl with horizontal circular double lines interrupted by short incisions (Pl. 5.1.52,13). Knobs occur on two fragments of a semi-spherical bowl (Pl. 5.1.52,15) and on the body of a probably spherical vessel (Pl. 5.1.52,14).

The pottery inventories from objects not part of long pits

We now describe the pottery inventories of those objects that were not directly part of the house-accompanying long-pits. In four excavation seasons, attention was primarily focused on the uncovering of houses and parts of houses. The sizes of the trenches were tailored to this purpose. As part of the research into the accompanying long pits of the individual houses, several superpositions were recorded. Independent objects that did not belong to houses were separated based on an evaluation during or after excavation. From a chronological point of view, these are either younger objects that damaged the house-accompanying long pits or older objects that were damaged by them. The excavations in 2016 and 2017, when the area around the houses was excavated, also identified individual settlement pits. Not all the excavated objects had a ceramic inventory rich in ornamentation. In some cases, the objects did not contain any finds or very fragmentary, and from a chronological point of view very atypical, sherd material.

The first group of pits consists of objects found in the area of the house-accompanying long pits. In cases where they have been damaged by a long pit, part of the ceramic inventory from the upper layers is missing. Objects outside the house were included in a second group. The following overview describes the vessel shapes and ornamental motifs that formed the inventory of these groups of objects. These are mainly settlement pits from which decorated sherds were extracted.

In trench 3, the lower part of object S3/30 was recorded in the eastern accompanying long pit of house H39, at a depth of 60 cm, in the fourth layer. The ceramic inventory of object S3/30 includes hemispherical forms with decoration formed by incised lines completed by impressions (Pl. 5.1.5,13.17.19). In one case, there is a double line on a hemispherical bowl, terminated by an elongated impression reminiscent of an incision (Pl. 5.1.6,6).

By removing the layers from QC object 1 of house H259 at the level of the fourth spit, outlines of a pit (marked B13-S8/30) were documented. The fill consisting of rim fragments and bodies of spherical vessels and hemispherical bowls. Less numerous were vessels with a neck (Pl. 5.1.36,2) and amphora-like vessels (Pl. 5.1.35,18;

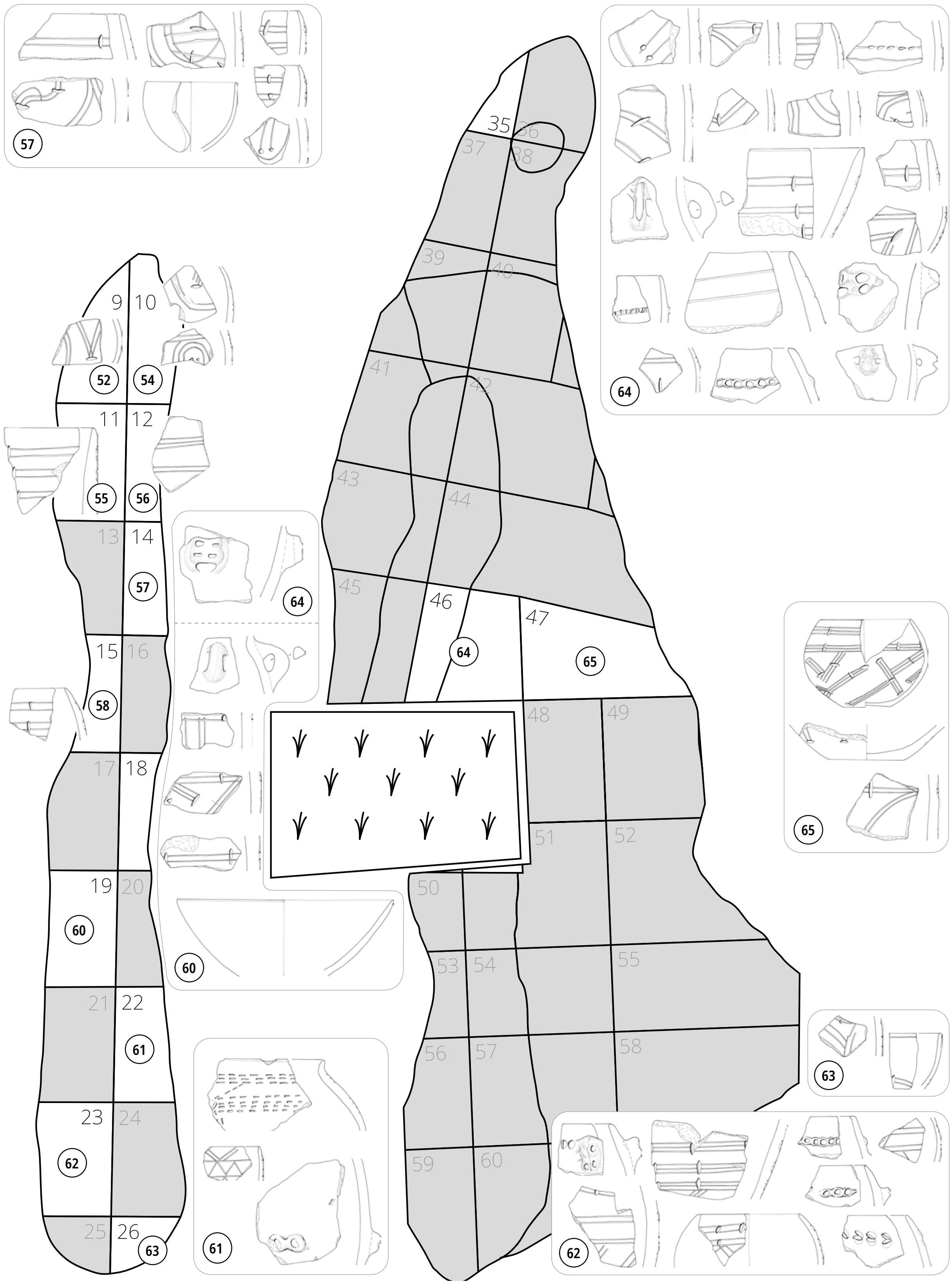

Figure 5.1.22. Ceramic finds in the long pits of house 23 (trench: 22). The square with grass symbols represent the block of topsoil left in place.

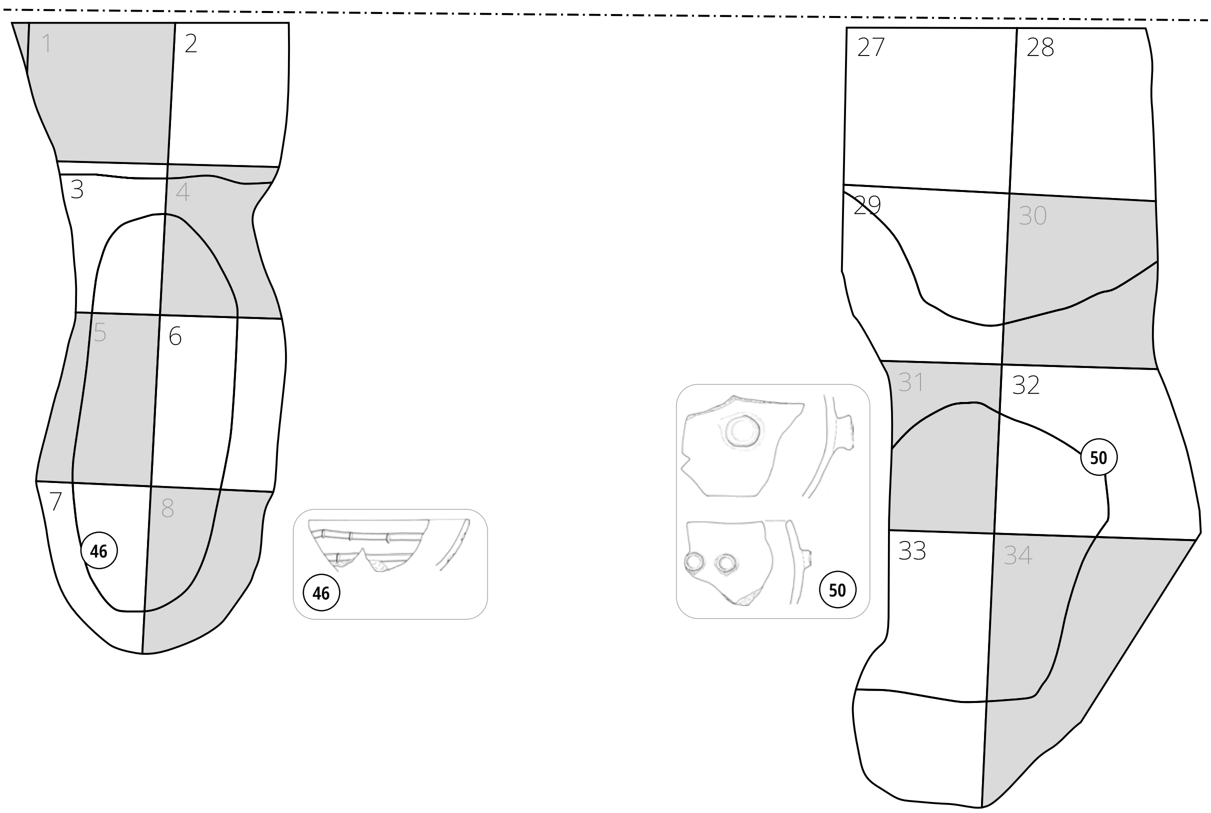

Figure 5.1.23. Ceramic finds in the long pits of house 317 (trench 22).

5.1.36,8). Due to the fragmentation of the ceramic material, it is only possible in exceptional cases to reconstruct the ornamental motif. The independent incised decoration consists mainly of double lines and triple lines arranged horizontally (Pl. 5.1.35,19; 5.1.36,13), diagonally (Pl. 5.1.35,16) or in arches (Pl. 5.1.35,17). In the analysed inventory, an independent incised line also occurred on a spherical vessel in the form of the horizontally letter S, which had been placed under a double line with triangular dimples (Pl. 5.1.36,14). A circulating zigzag line interrupted by oval dimples (Pl. 5.1.36,10) appeared on a larger, semi-spherical vessel. The incised lines are most often accompanied by round impressions, which usually interrupt the line. Triangular and oval impressions are also represented (Pl. 5.1.36,14). A single ornamental motif is found on a fragment of the body of a vessel made of horizontally and obliquely arranged double and triple lines with impressions and a horizontal row of impressions (Pl. 5.1.35,16). Functional applications include knobs (Pl. 5.1.36,1.7.11) and vertically pierced handles (Pl. 5.1.35,18; 5.1.36,8).

In both accompanying long pits of house H131, further settlement objects were preserved, but these offered only a small number of decorated fragments. In the southern end of the western long pit object H131/65, the lower part of the older pit S12/65a was recognised in the profile. The basal layer yielded only non-diagnostic ceramic fragments. Object H131/57, the eastern house-accompanying long pit, yielded two extensive objects with an oval outline – S12/57a and S12/57b – from the southern and middle parts. The fragment of a vessel body with horizontal double lines, which was found in the fourth spit, distinguishes itself from the non-diagnostic pottery.

Objects S11/10, S11/11 and S11/12 together form a complex which damaged the southern part of object H132/14 (the western accompanying long pit). The ceramic inventory included a semi-spherical bowl (Pl. 5.1.42,1) and spherical vessel with a double-conical body (Pl. 5.1.42,4), both without decoration. In object S11/12, a semi-spherical bowl without decoration (Pl. 5.1.42,5), a lower part of an amphora-like vessel (Pl. 5.1.42,2) and a bowl base with a bundle of incised lines on the inside

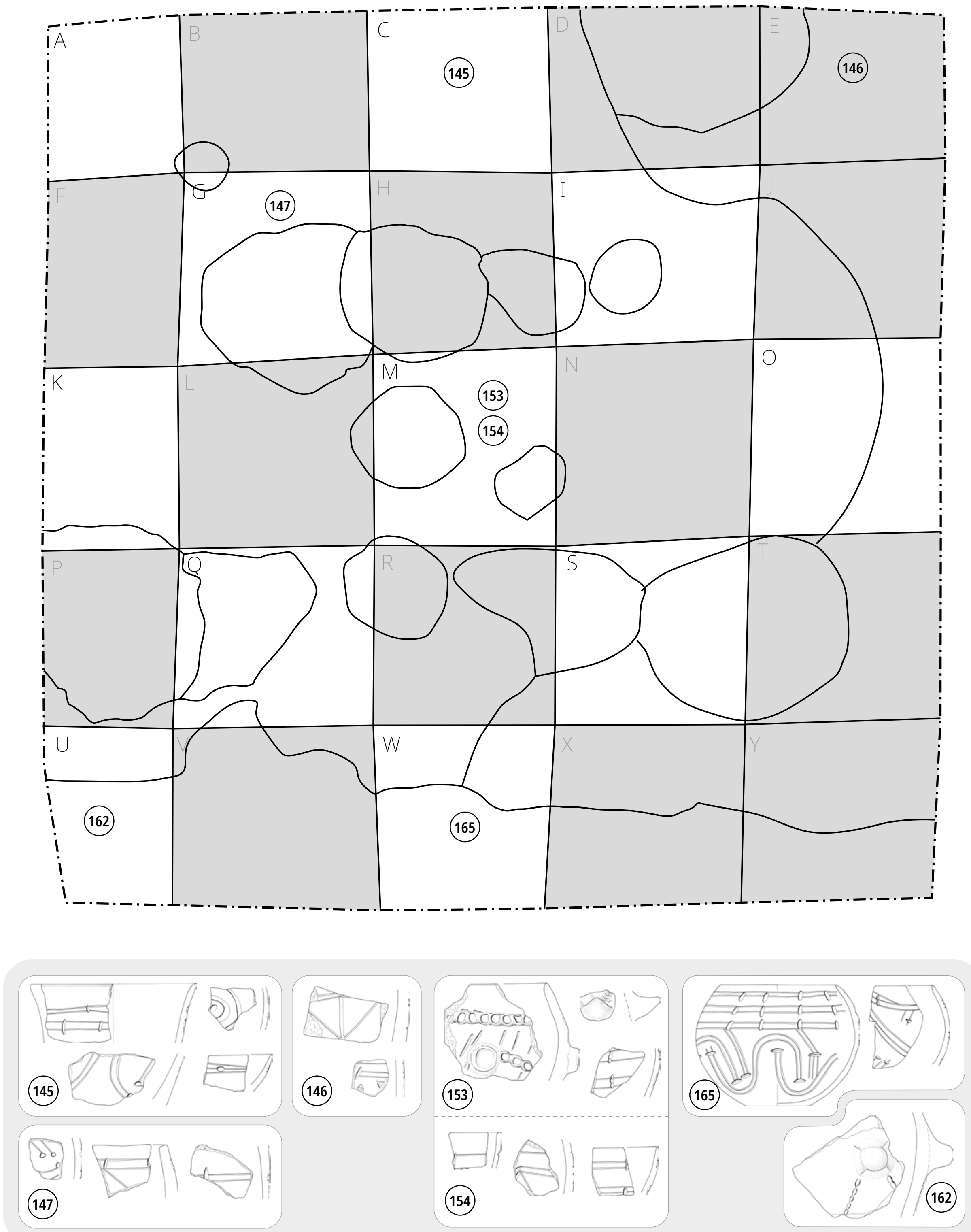

Figure 5.1.24. Ceramic finds in trench 9.

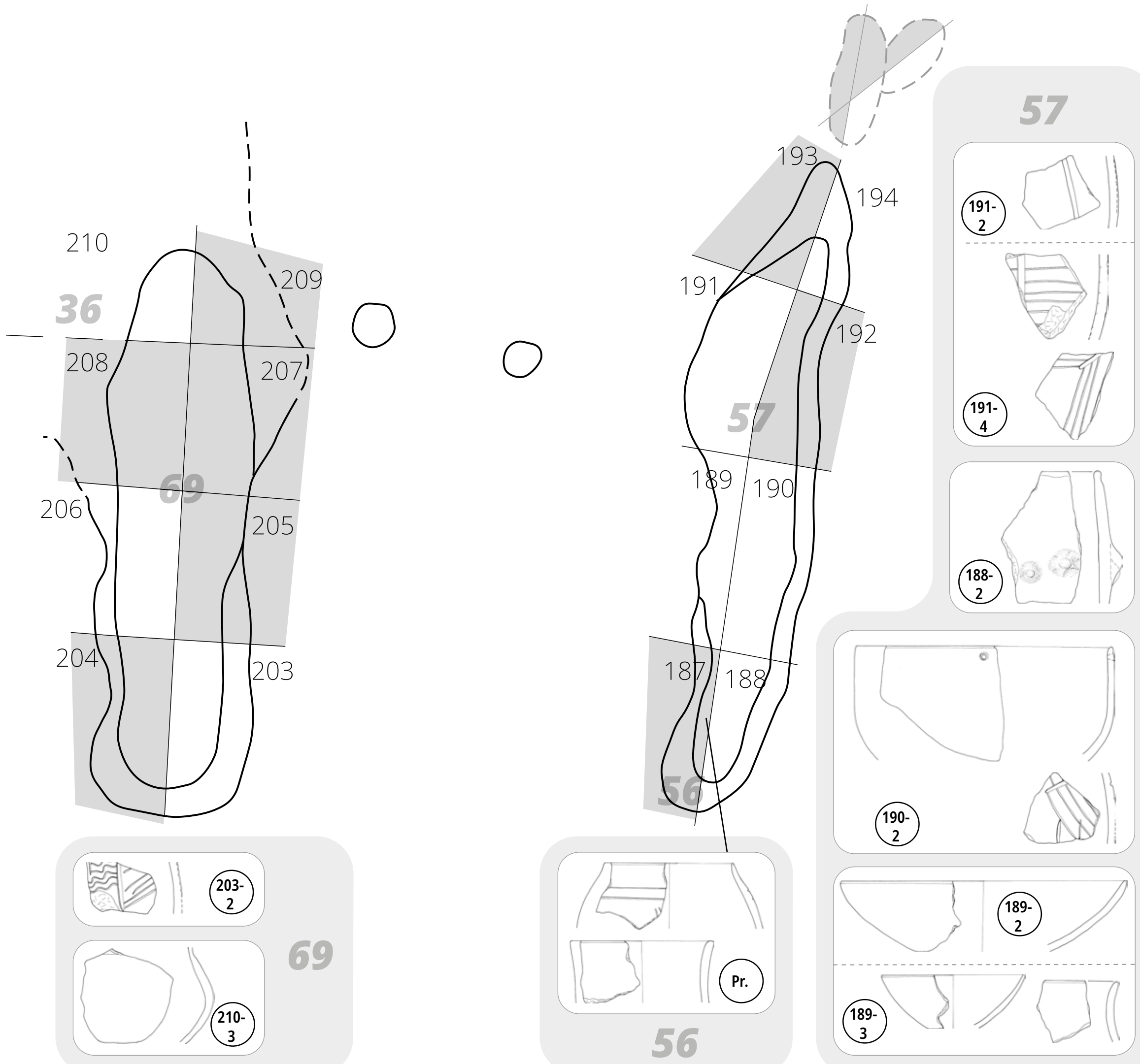

Figure 5.1.25. Ceramic finds from objects 157 and 145 in trench 14.

(Pl. 5.1.42,3) occurred in the fourth spit. The eastern accompanying long pit H132/25 was damaged by object S11/24. Ceramic material occurred mainly in spits 3 to 6. It contains hemispherical bowls without incisions (Pl. 5.1.43,17; 5.1.44,1), spherical vessels with slightly curved mouths (Pl. 5.1.43,15; 5.1.44,2-3) and a fragment of a vessel neck with a wider groove of an unidentifiable ornamentation (Pl. 5.1.44,4). A pointed knob was placed under the rim of a taller semi-spherical vessel (Pl. 5.1.43,16).

In trench 4, two postholes with ceramic material were recorded at the western edge of object H102/1. From object S4/25 comes a rim of a spherical vessel with two lines and an impression under the rim (Pl. 5.1.11, 1) as well as a rim of a spherical vessel with a pressed strip terminated by a circular knob (Pl. 5.1.11, 2). Posthole S4/25 yielded an S-shaped profiled rim of a vessel without decoration, probably a bowl (Pl. 5.1.11,3).

Trench 9 was placed where, according to geophysical measurements, an extensive settlement object, S9/1, was located. The explored area of 5 × 5 m was divided into quadrants measuring several metres, and the individual quadrants were gradually deepened in spits. Only two quadrants were left unexcavated but still only few materials were uncovered (Fig. 5.1.24). The occurrence of an oval impression placed on a double line or on its end appears on spherical vessels (Pl. 5.1.38,4.17-18), but also on necked vessels (Pl. 5.1.38,2) and semi-spherical bowls (Pl. 5.1.38,14). Also represented is an impression placed at the end of the line (Pl. 5.1.38,9) or several impressions connecting incised lines (Pl. 5.1.38,10). In layer 6 in QC was a fragment of a vessel with a broad groove forming a spiral (Pl. 5.1.38,17).

Trenches 11 to 14 were established to investigate the space between four houses, and several non-house-accompanying settlement objects were excavated. Only five of them have fragments of vessels with ornamental elements. The sherds from object S13/121 are distinctively ornamented (Pl. 5.1.48,4-8). Two pairs of objects situated in parallel and oriented approximately in N-S direction were also found in the researched area. Their shape is reminiscent of long pits placed alongside the houses. One of the pairs consisted of objects S12/9a and S13/113, and the other of objects S14/157 and S14/145 (Fig. 5.1.25). The ceramic findings from object S12/9a, which originated from the fifth and sixth layers, included undecorated fragments of spherical vessels with double conical bodies (Pl. 5.1.42,12.17; 5.1.43,1.5), but also a type of vessel with a distinctively profiled mouth (Pl. 5.1.42,13.19; 5.1.43,2-3). A double-conical body and amphora-like vessel are present, as well as a vessel with a neck (Pl. 5.1.43,7-8). These are ceramics characteristic for the end of phase III of the Želiezovce group. From the second object of this pair of objects come fragments with an incised line, found in the fourth spit (Pl. 5.1.48,1-3). In trench 14, semi-spherical bowls without incised decoration appeared (Pl. 5.1.48,13-15). The most distinctive form is a spherical vessel with a double-conical body (Pl. 5.1.48,19). The incised ornamentation consists of bundles of folded double lines and a long incision (Pl. 5.1.48,16.18). A double line under the rim was also applied to a spherical vessel with a slightly curved mouth (Pl. 5.1.48,10). In object S14/157, a sherd with wavy line appeared that is spread out between two incisions, which is among the less frequently found ornamental motifs in the settlement at Vráble (Pl. 5.1.48,20).

In trenches 21 and 23, two openings in the enclosure (entrance 1 and entrance 2) of the south-western neighbourhood were excavated. Next to the entrance situation, burials were uncovered, several of them containing complete or almost complete vessels. The enclosure fill only sporadically contained pottery material, predominantly fragments without decoration. A representative sample was obtained from objects S21/1 and S21/3 (Fig. 5.1.26): fragments of two hemispherical bowls without decoration (Pl. 5.1.49,24-25), five fragments with incised double lines with long incisions (Pl. 5.1.49,19-20.22-23; 5.1.50,3), a zoomorphic handle (Pl. 5.1.49,21) and pointed handles, probably from a barrow-shaped vessel (Pl. 5.1.50,2). Sherds with incised decoration were found in objects S21/2 (Pl. 5.1.50,1) and S23/209 (Pl. 5.1.52,16-20) and in burial G7/21 (Pl. 5.1.50,4).

The production of pottery in the settlement of Vráble

The ceramic data to be evaluated is, in general, based on fragmentary material. Fragments from different parts of the vessel body predominate. Fragmented or completely preserved rims and bases of vessels are represented to a lesser extent. In general, the level of fragmentation was very high. Accordingly, the possibility of a reconstruction of not only the shape of vessels, but also their ornamentation, was possible to only a limited degree. Occasionally, larger parts of vessels appeared, but only rarely did the upper part of the vessel profile exhibit a full composition of incised or three-dimensional ornamentation. This statement is valid for all kinds of thin-walled and thick-walled pottery from the examined objects.

The unifying characteristic of the pottery production at Vráble is the clay from which the vessels were made. In addition, the vessel shapes and the overall decoration element composition represents what is well-known for the regional pottery groups younger LBK and Želiezovce. However, as can be seen from the description of similarities and differences in the characteristics of individual subassemblages

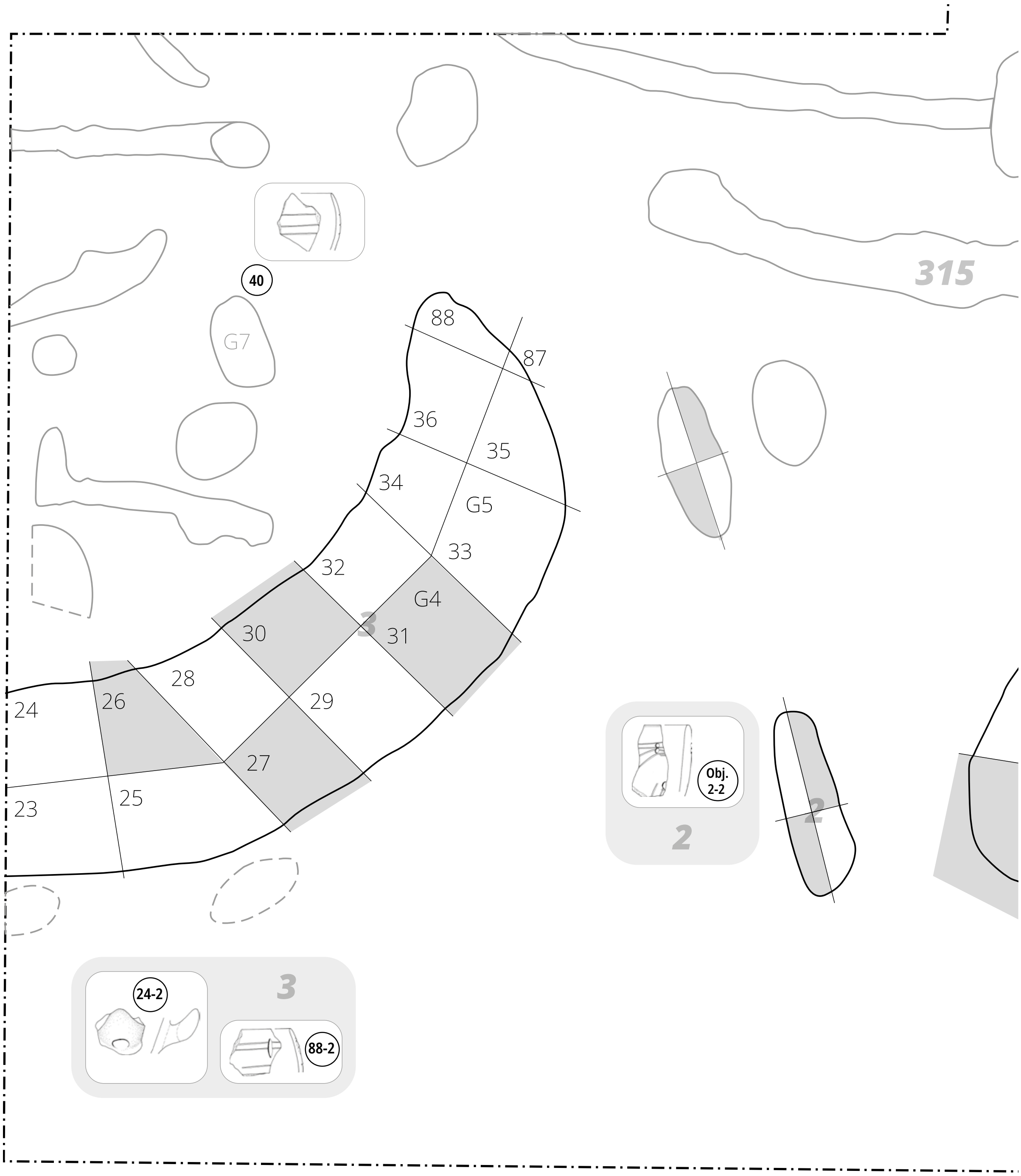

Figure 5.1.26. Ceramic finds from trench 21.

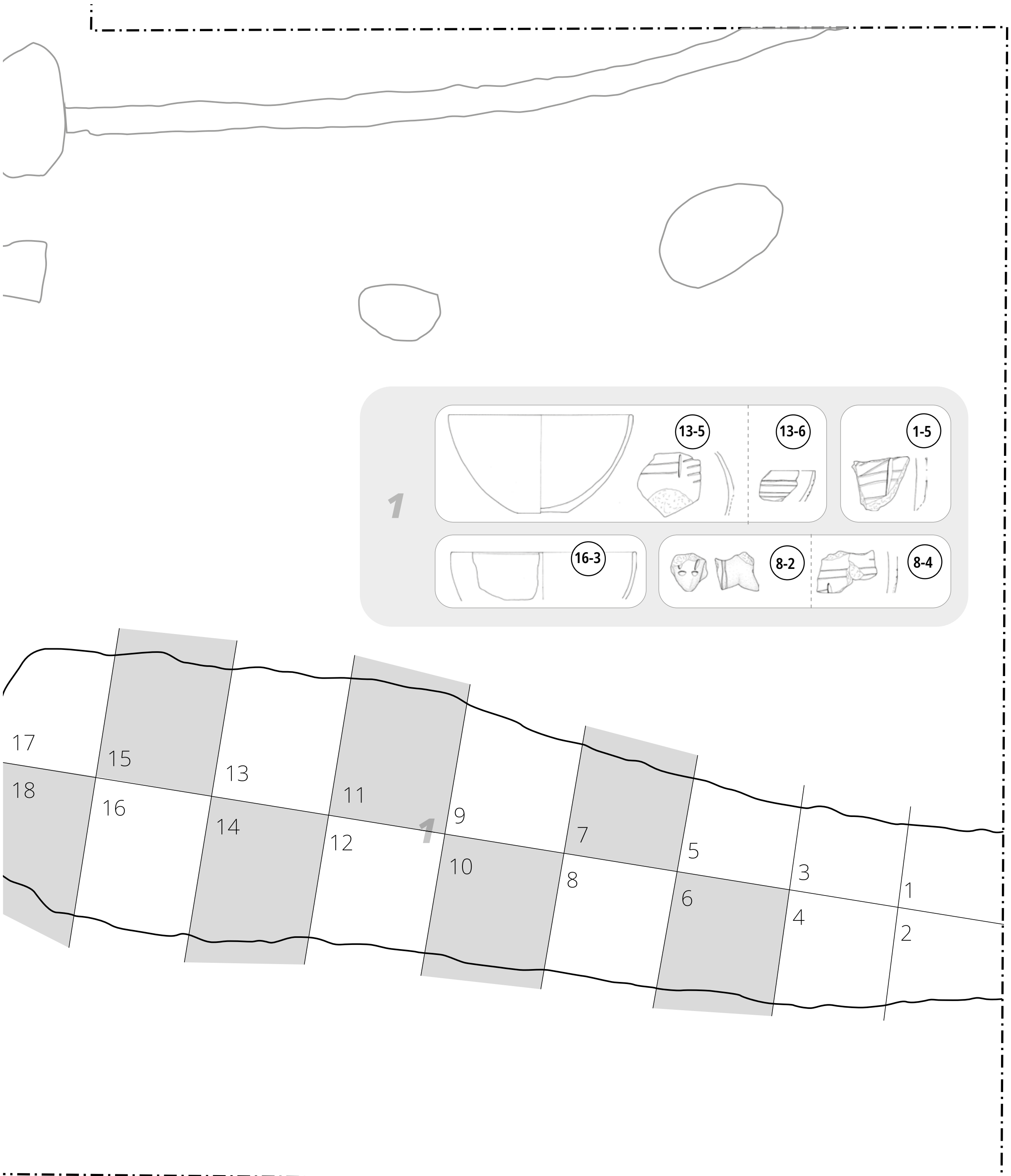

Figure 5.1.26. Ceramic finds from trench 21 (continued).

relating to individual houses (see above), at least three separate circuits of pottery production can be considered in the settlements of the younger LBK and Želiezovce group at Vráble. Each neighbourhood seems to have had its own pottery production. This difference concerns decorative elements rather than the vessel shape. As the statistical analyses in chapter 4.1 indicates, we can even go one step further to state that at least pottery decoration preferences were yard-specific rather than being connected to the neighbourhood or settlement community.

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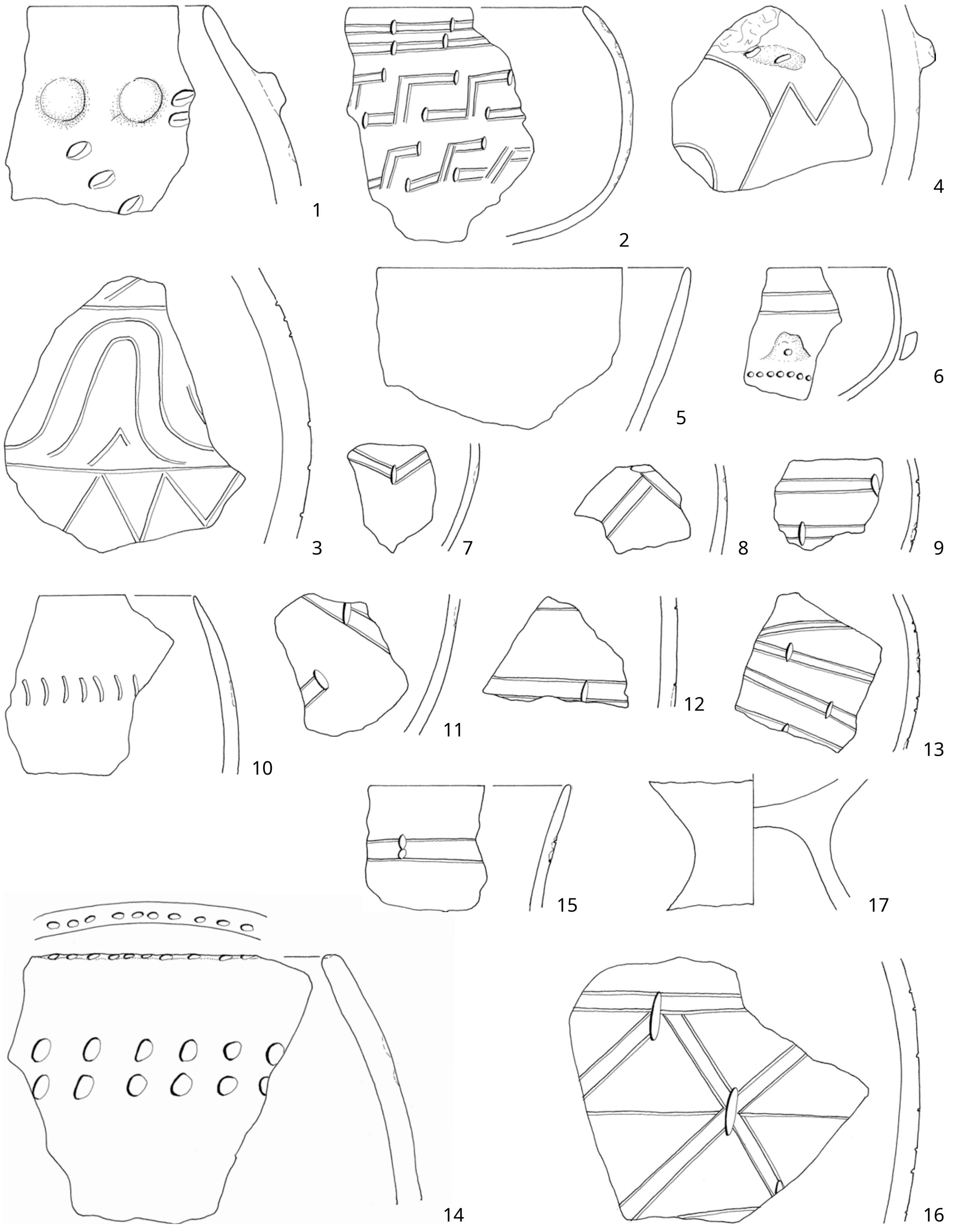


Plate 5.1.1. Selected ceramic finds. 1-16: trench 3. 1-16: object 1 (house 39, western long pit). Scale 1:2 (drawings: E. Bakytová).

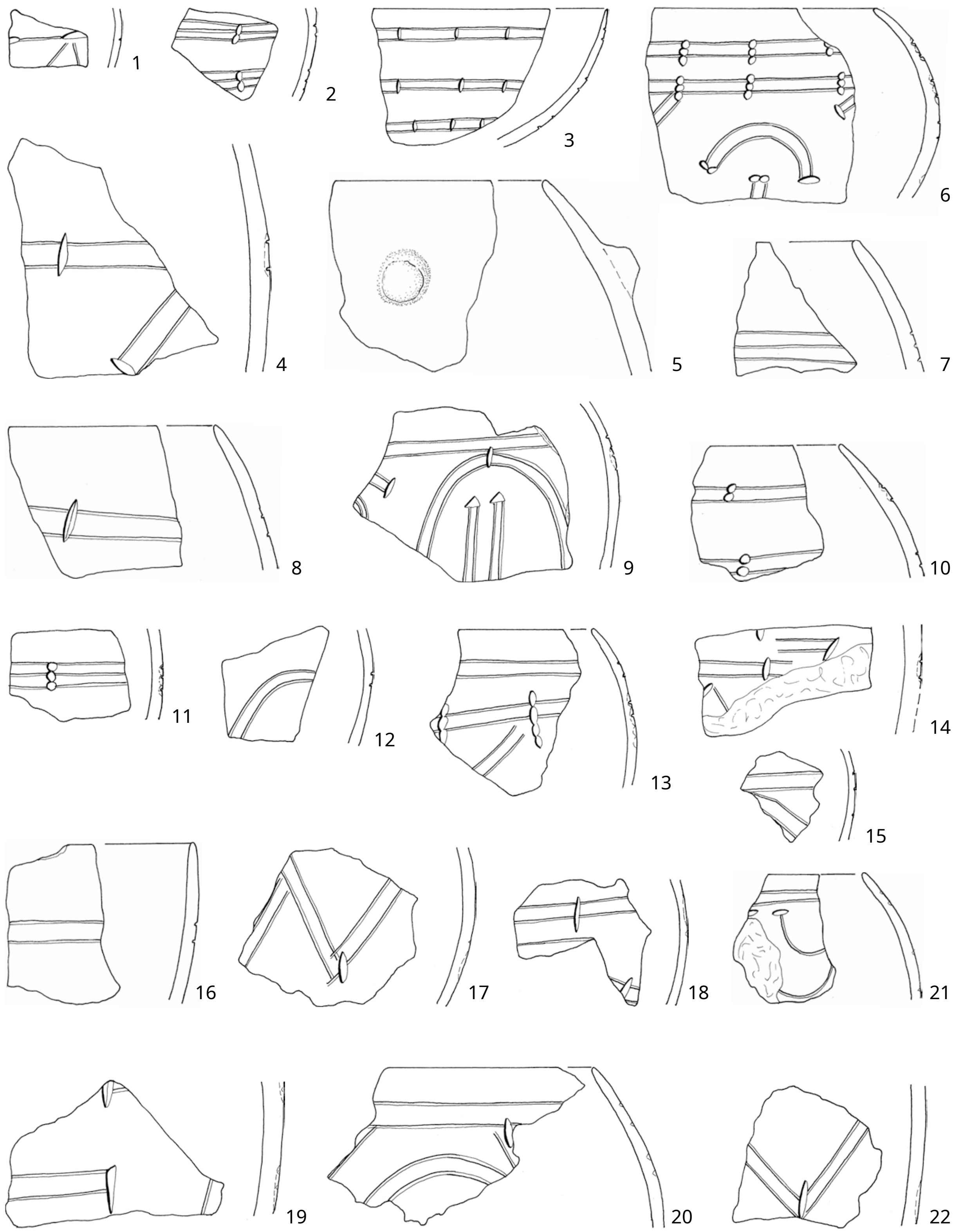


Plate 5.1.2. Selected ceramic finds. 1-22: trench 2. 1-22: object 1 (house 39, western long pit). Scale 1:2 (drawings: E. Bakytová).

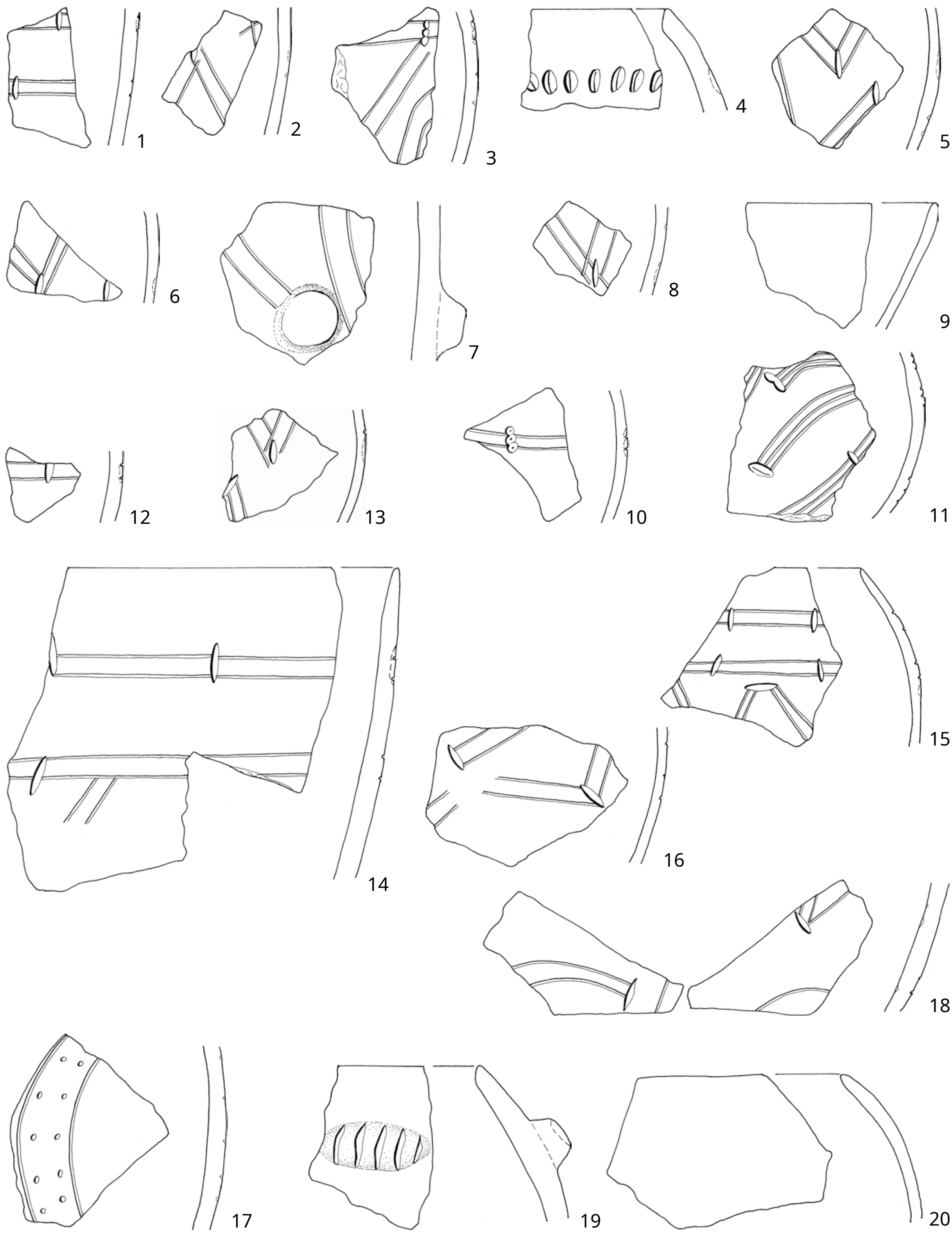


Plate 5.1.3. Selected ceramic finds. 1-20: trench 2. 1-20: object 1 (house 39, western long pit). Scale 1:2 (drawings: E. Bakytová).

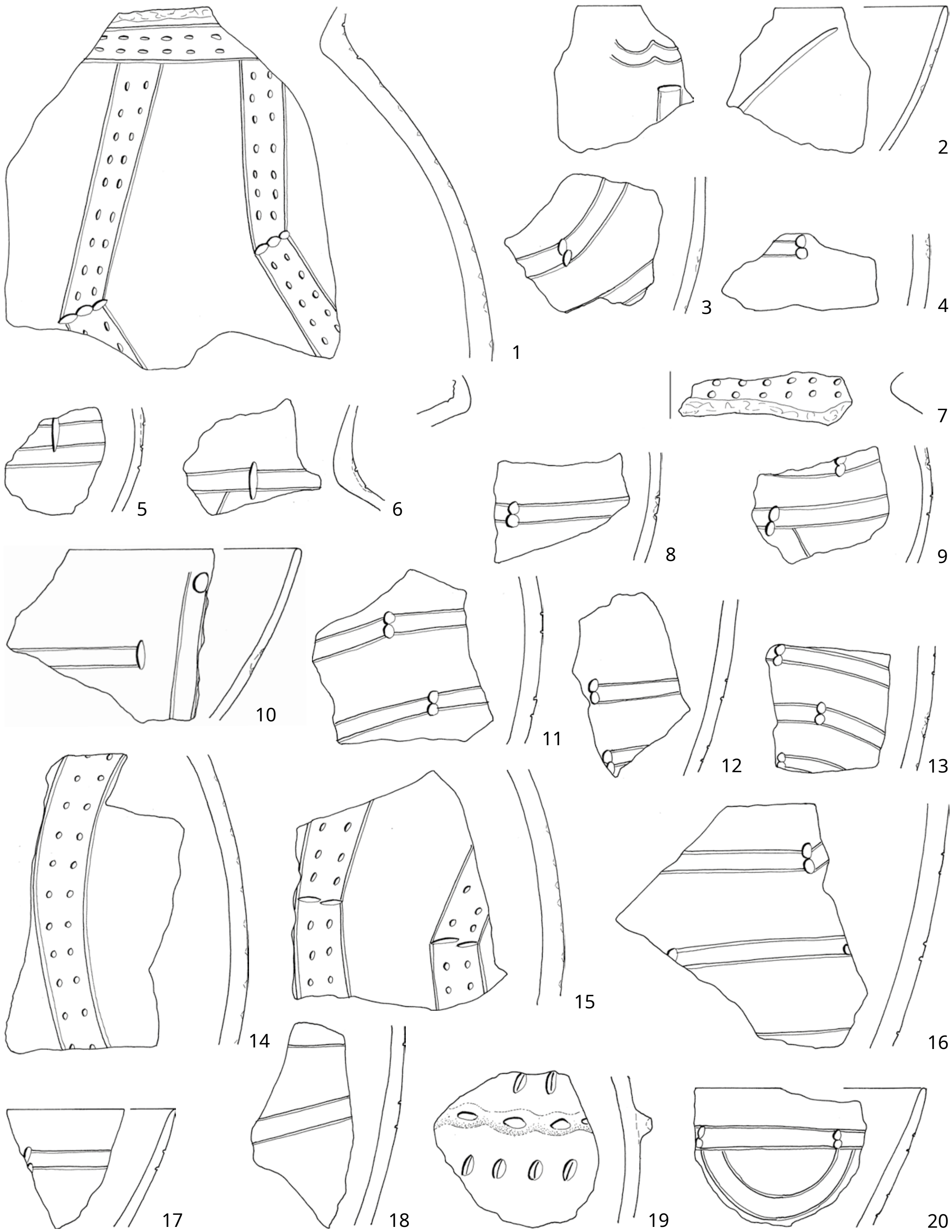


Plate 5.1.4. Selected ceramic finds. 1-20: trench 3. 1-20: object 2 (house 39, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

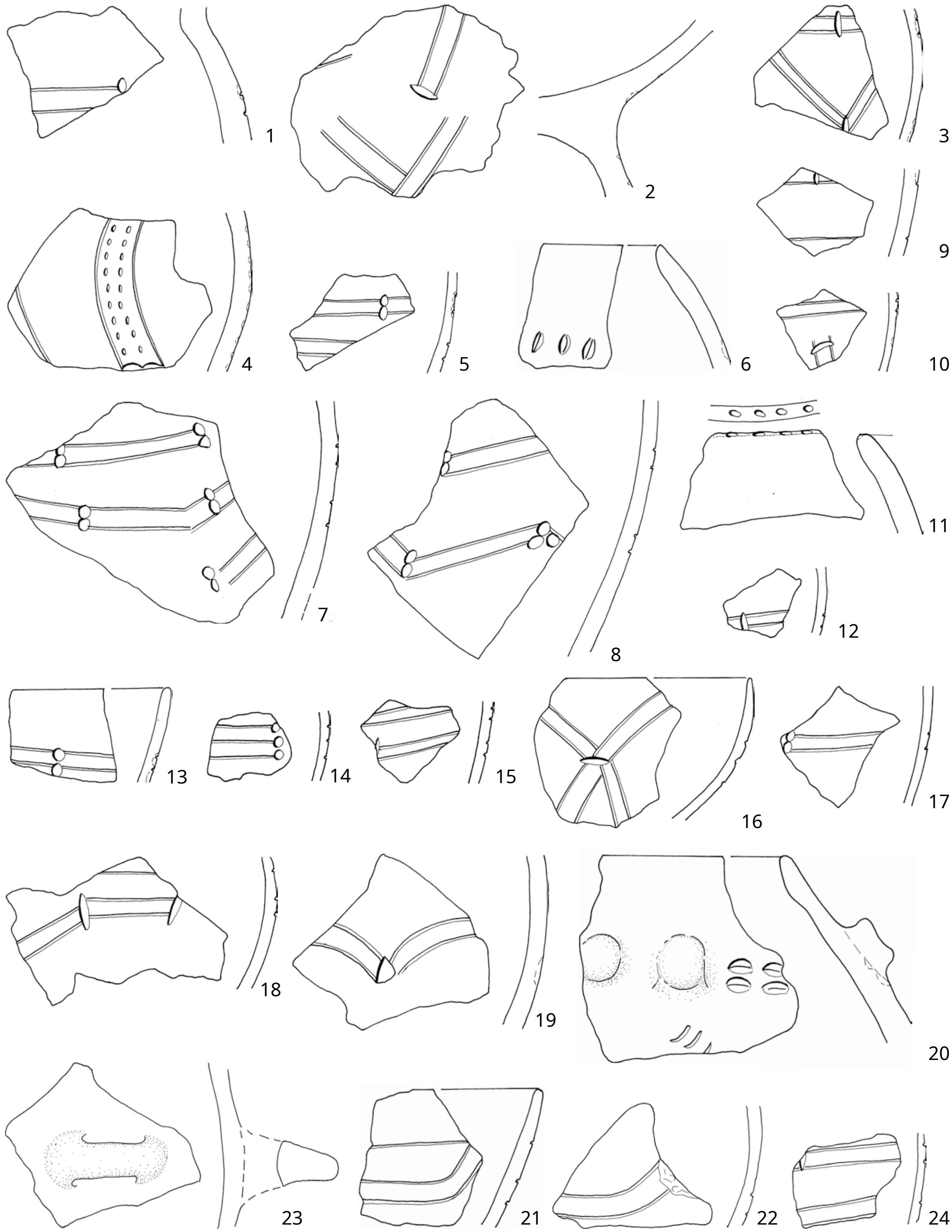


Plate 5.1.5. Selected ceramic finds. 1-24: trench 3. 1-24: object 2 (house 39, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

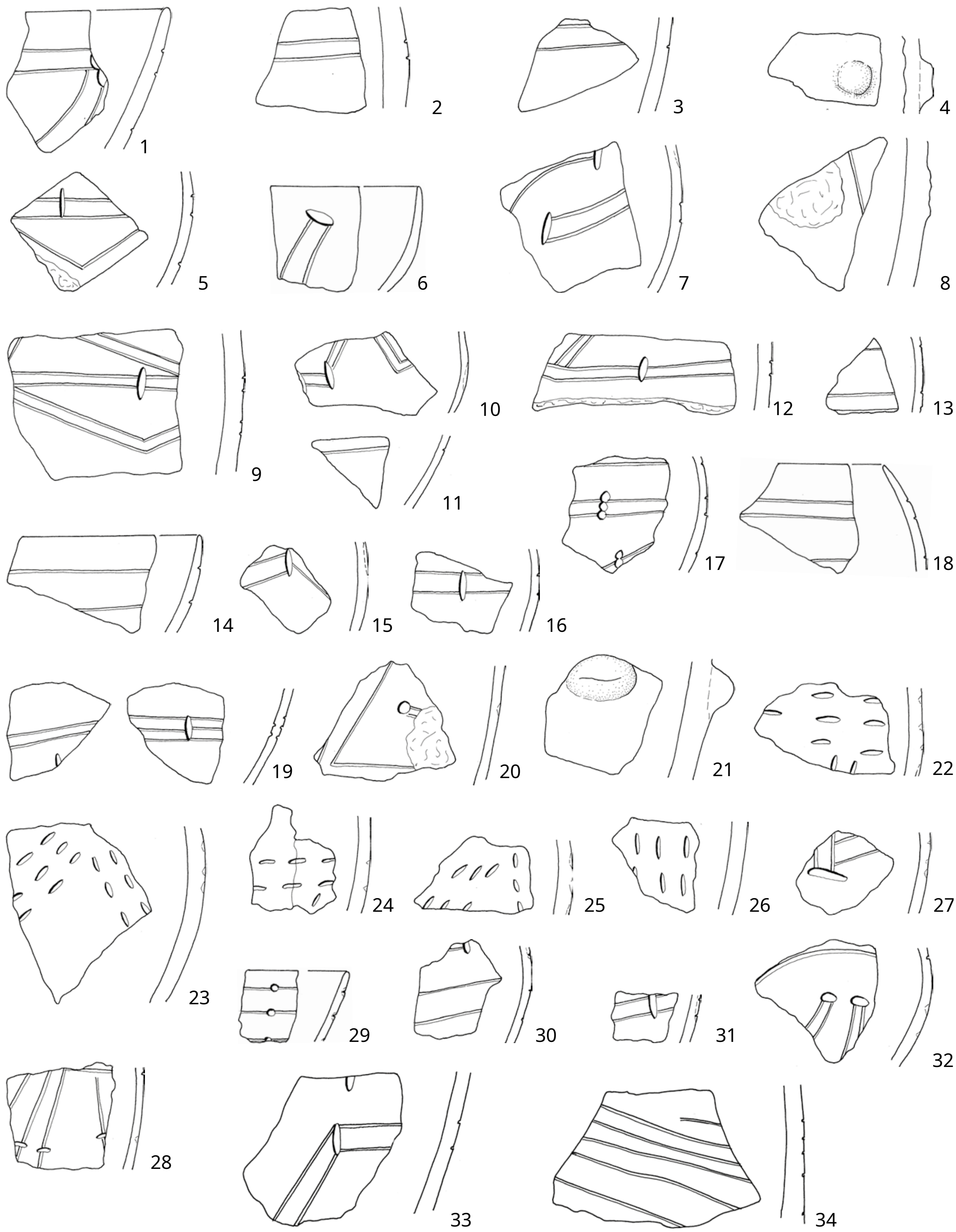


Plate 5.1.6. Selected ceramic finds. 1-8: trench 3; 9-33: trench 2. 1-8: object 2 (house 39, eastern long pit); 9-33: object 2 (house 39, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

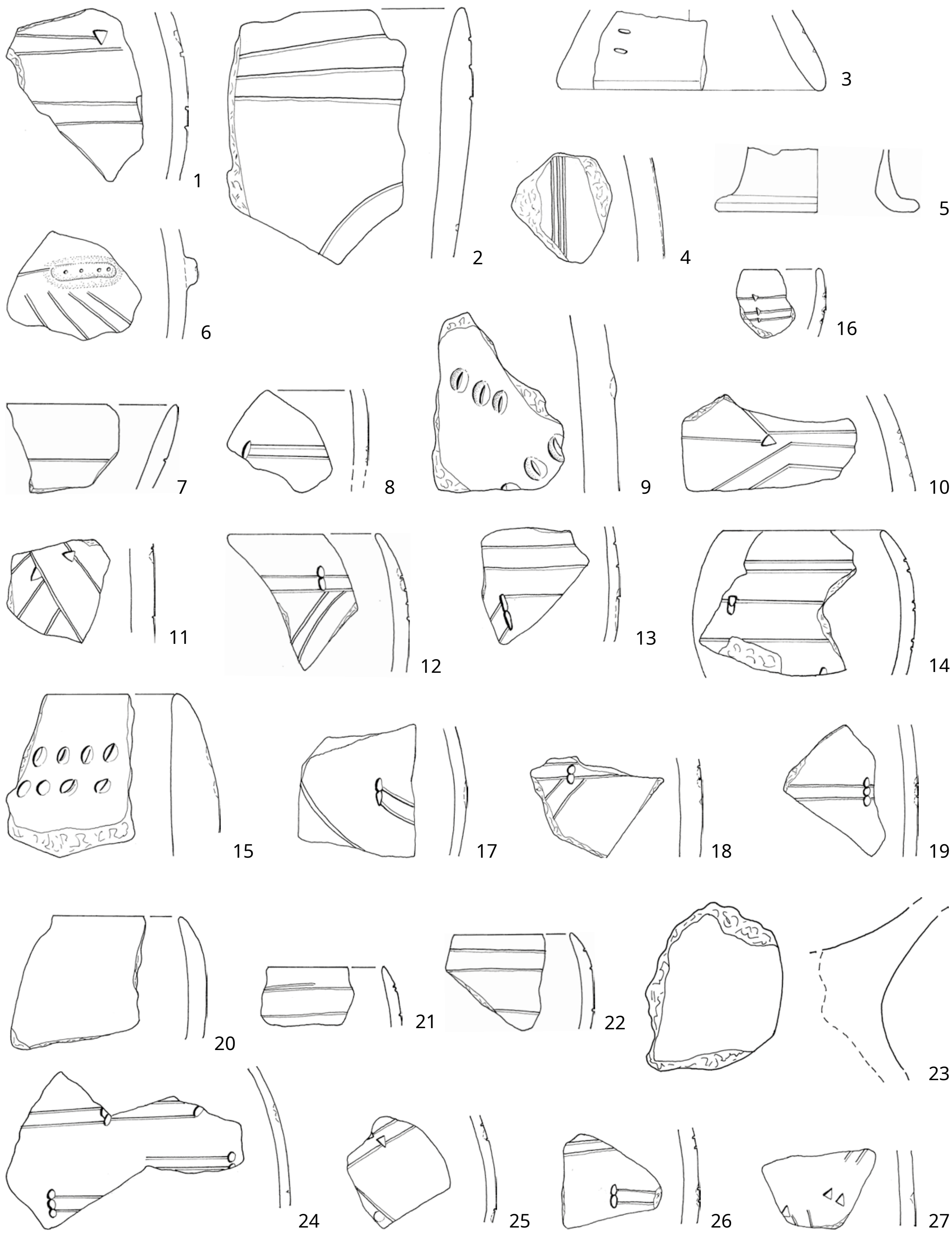


Plate 5.1.7. Selected ceramic finds. 1-27: trench 4. 1-27: object 1 (house 102, western long pit). 1-13, 20-27: spit 1; 14-15, 18-19: spit 2. Scale 1:2 (drawings: E. Bakytová).

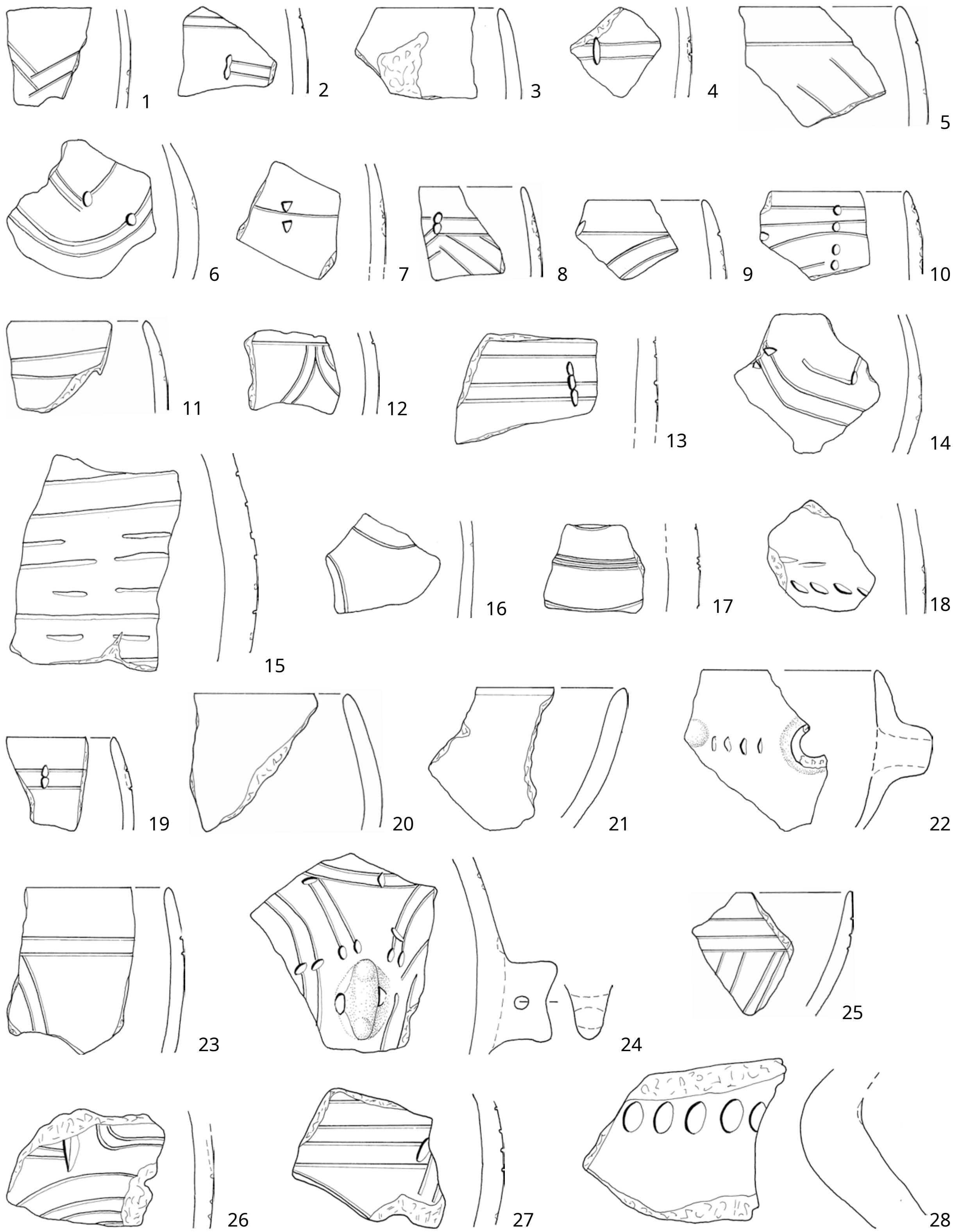


Plate 5.1.8. Selected ceramic finds. 1-28: trench 4. 1-28: object 1 (house 102, western long pit). 1-2, 5-8, 16-23: spit 1; 4, 10-14: spit 2; 23-28: spit 3. Scale 1:2 (drawings: E. Bakytová).

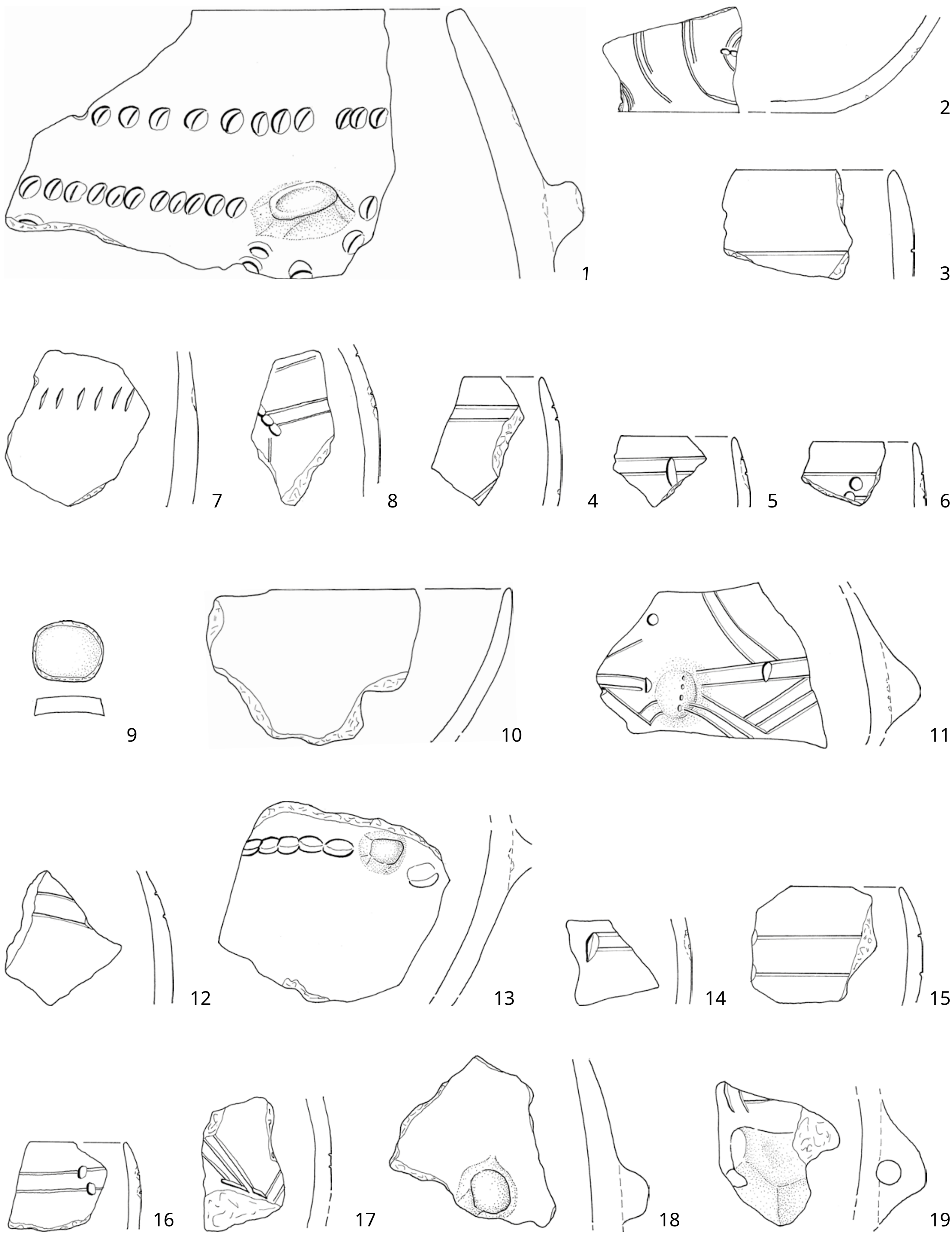


Plate 5.1.9. Selected ceramic finds. 1-29: trench 4. 1-29: object 1 (house 102, western long pit). 3-6: spit 2; 1-2, 7-8: spit 3; 9-19: spit 4; 15: spit 5. Scale 1:2 (drawings: E. Bakytová).

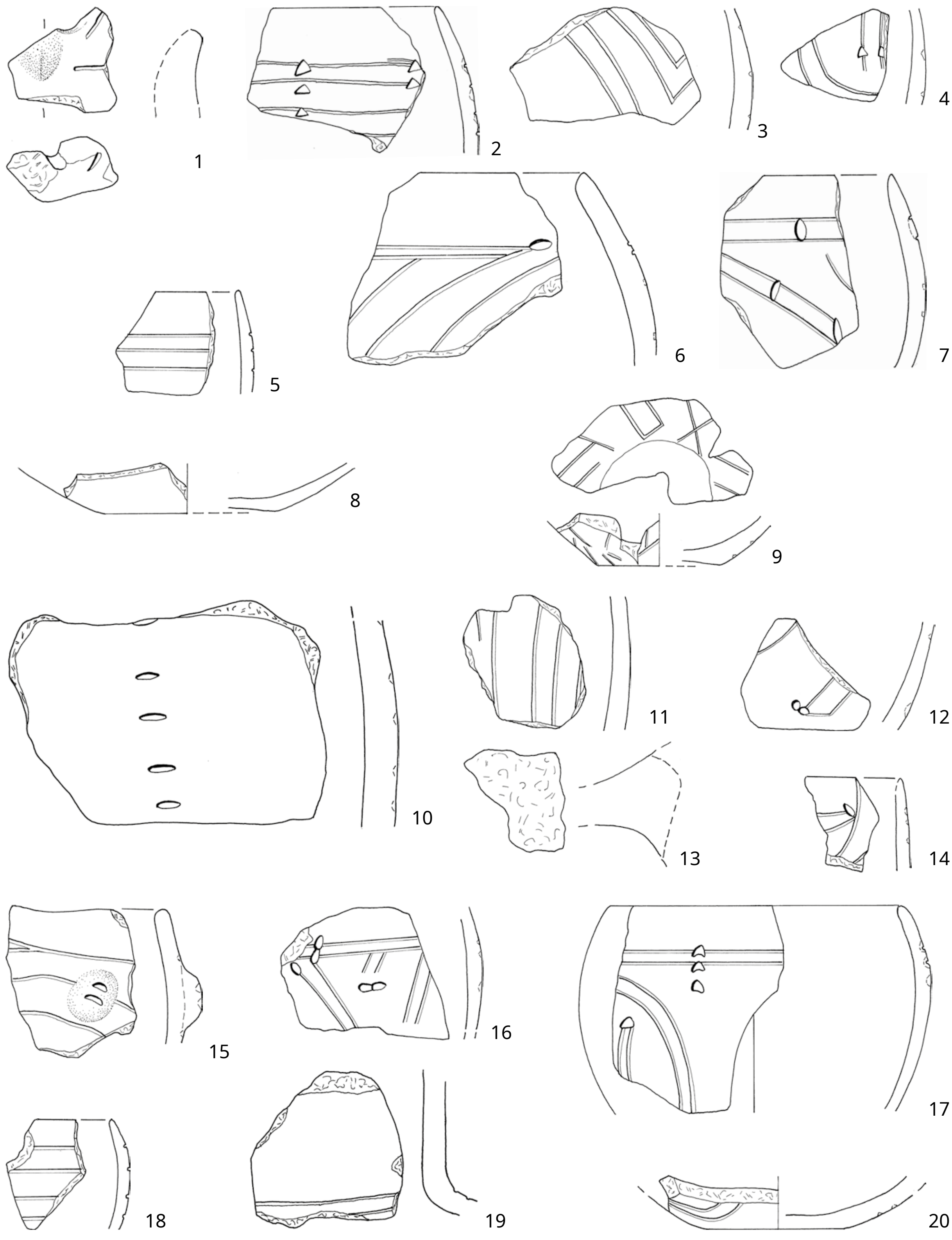


Plate 5.1.10. Selected ceramic finds. 1-20: trench 4. 1-20: object 1 (house 102, western long pit). 9-14: spit 1; 15-16: spit 2; 1-8, 17-20: spit 4. Scale 1:2 (drawings: E. Bakytová)."

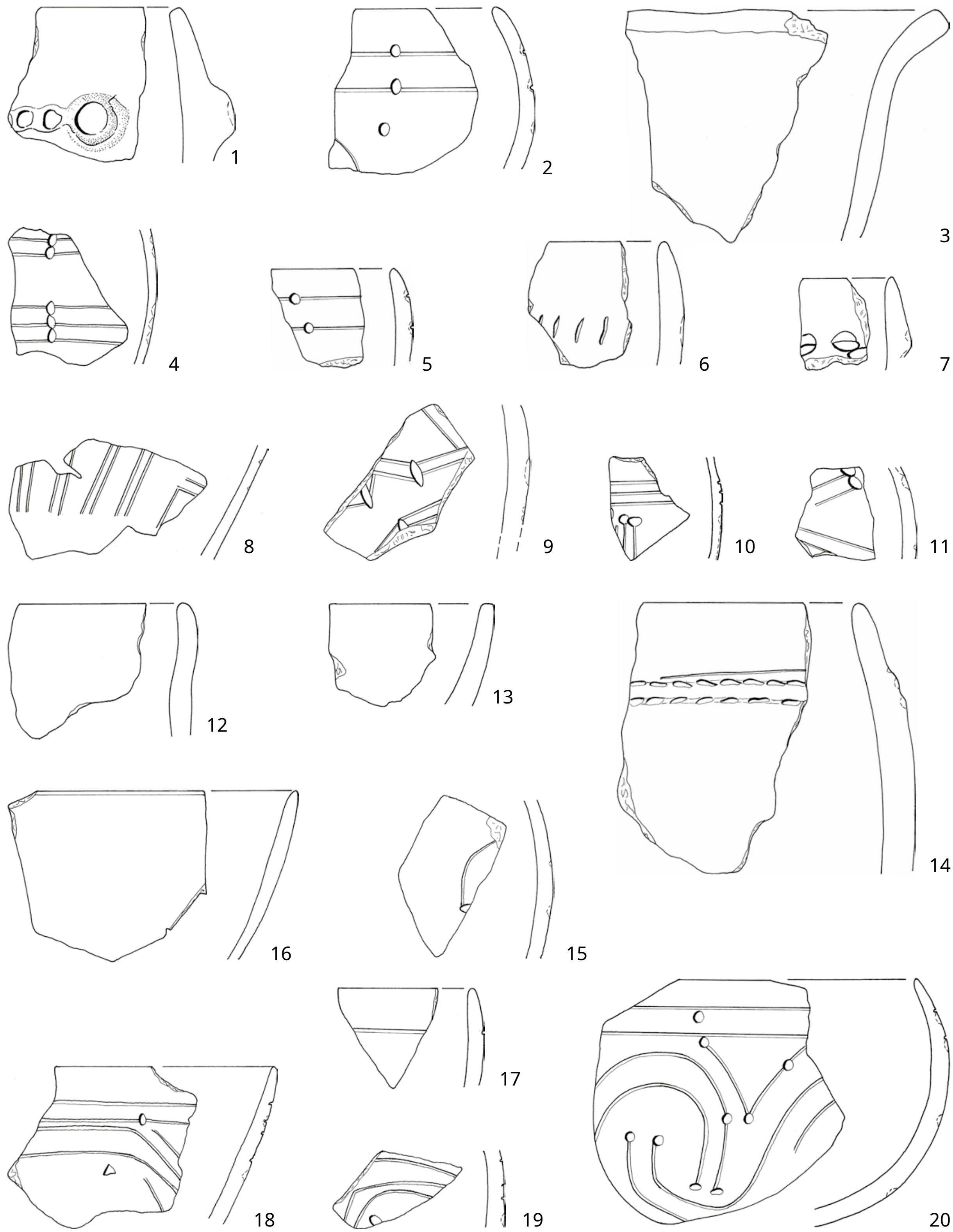


Plate 5.1.11. Selected ceramic finds. 1-20: trench 4. 1-11: object 1 (house 102, western long pit); 12-20: object 2 (house 102, eastern long pit). 4-7, 12-20: spit 1; 9-11: spit 3. Scale 1:2 (drawings: E. Bakytová).

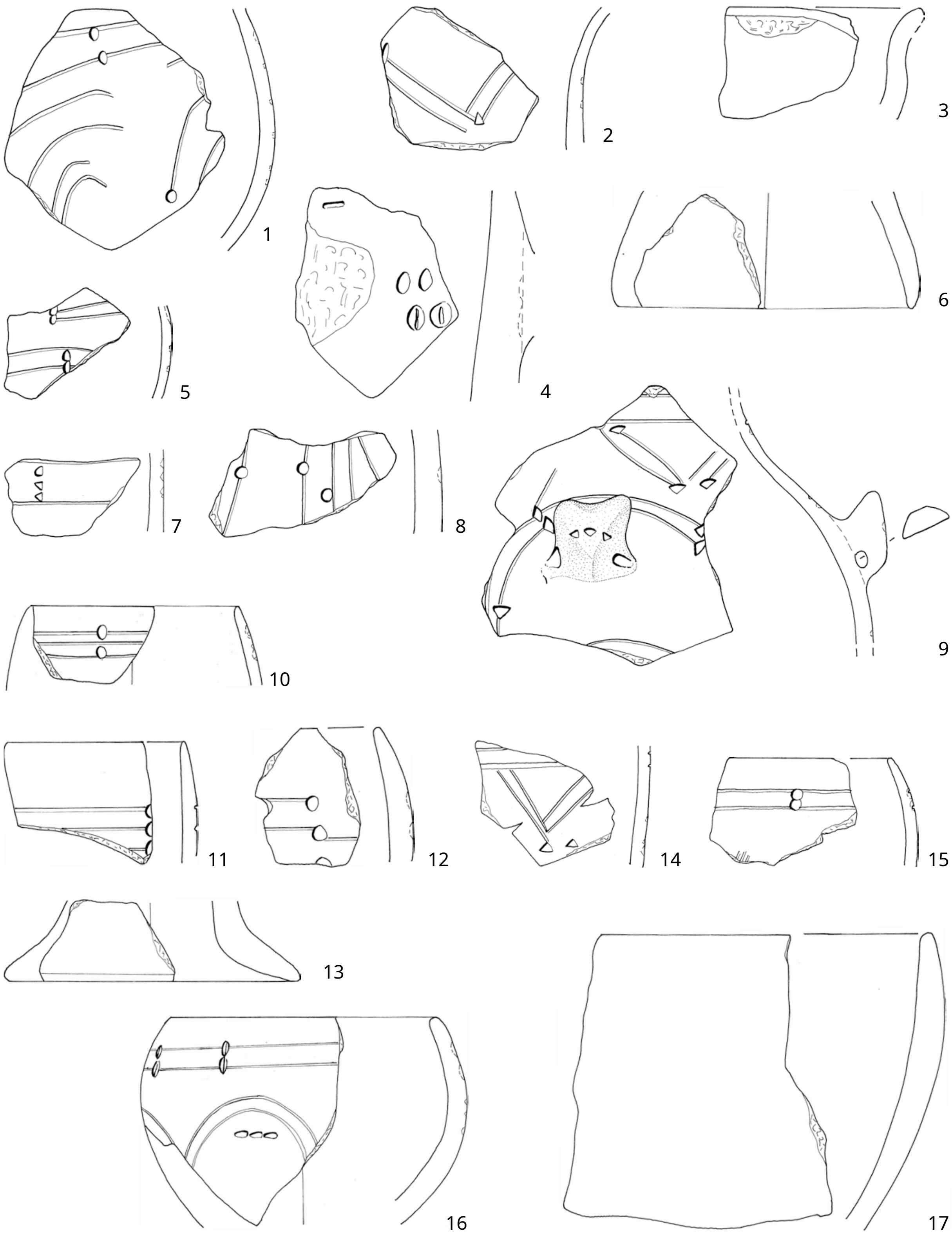


Plate 5.1.12. Selected ceramic finds. 1-17: trench 4. 1-17: object 2 (house 102, eastern long pit). 1-9: spit 1; 10-13: spit 2; 16-17: spit 3. Scale 1:2 (drawings: E. Bakytová).

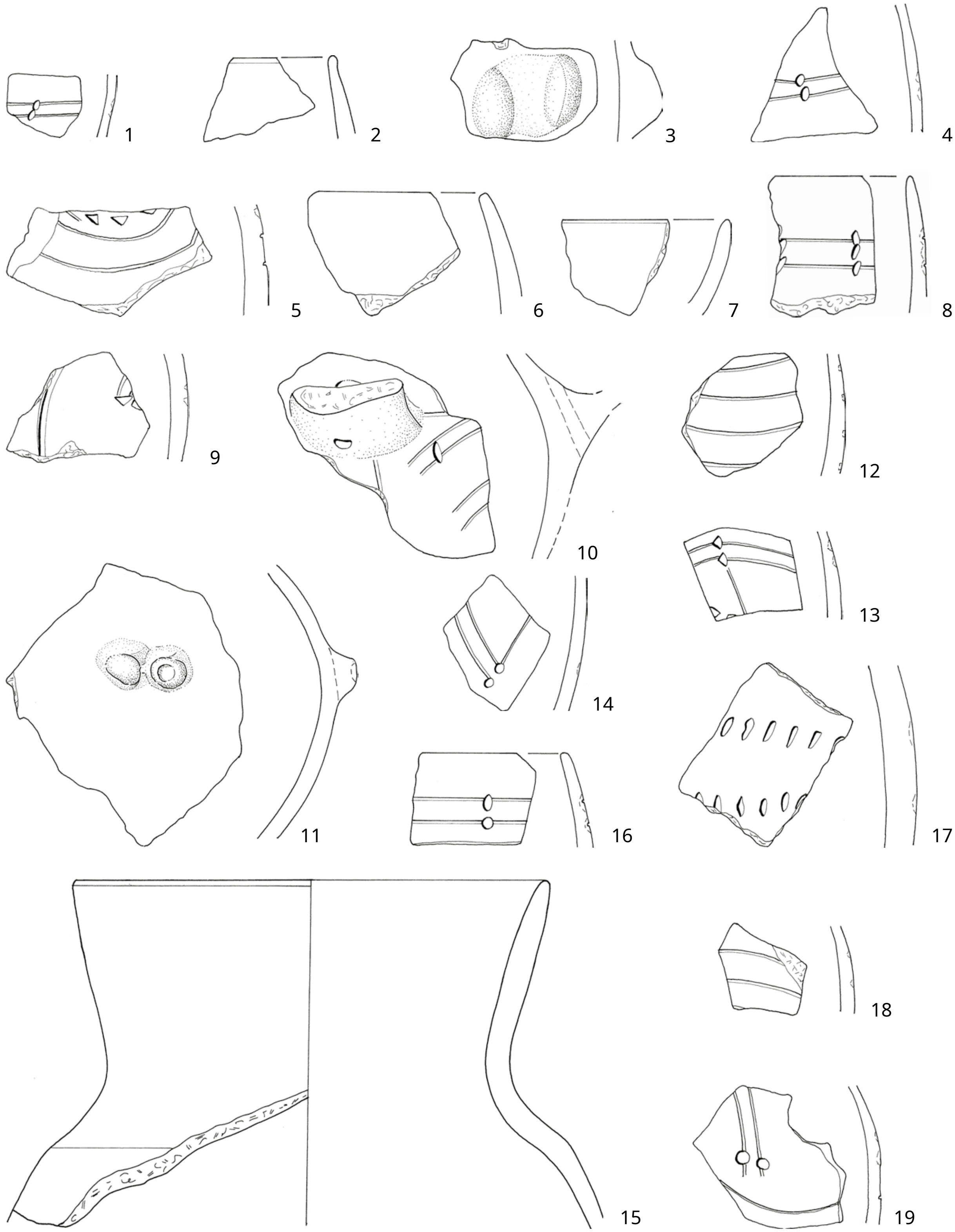


Plate 5.1.13. Selected ceramic finds. 1-19: trench 4. 1-19: object 2 (house 102, eastern long pit). 1-11, 16-17, 19: spit 1; 12-14, 16: spit 2; 15: spit 3. Scale 1:2 (drawings: E. Bakytová).

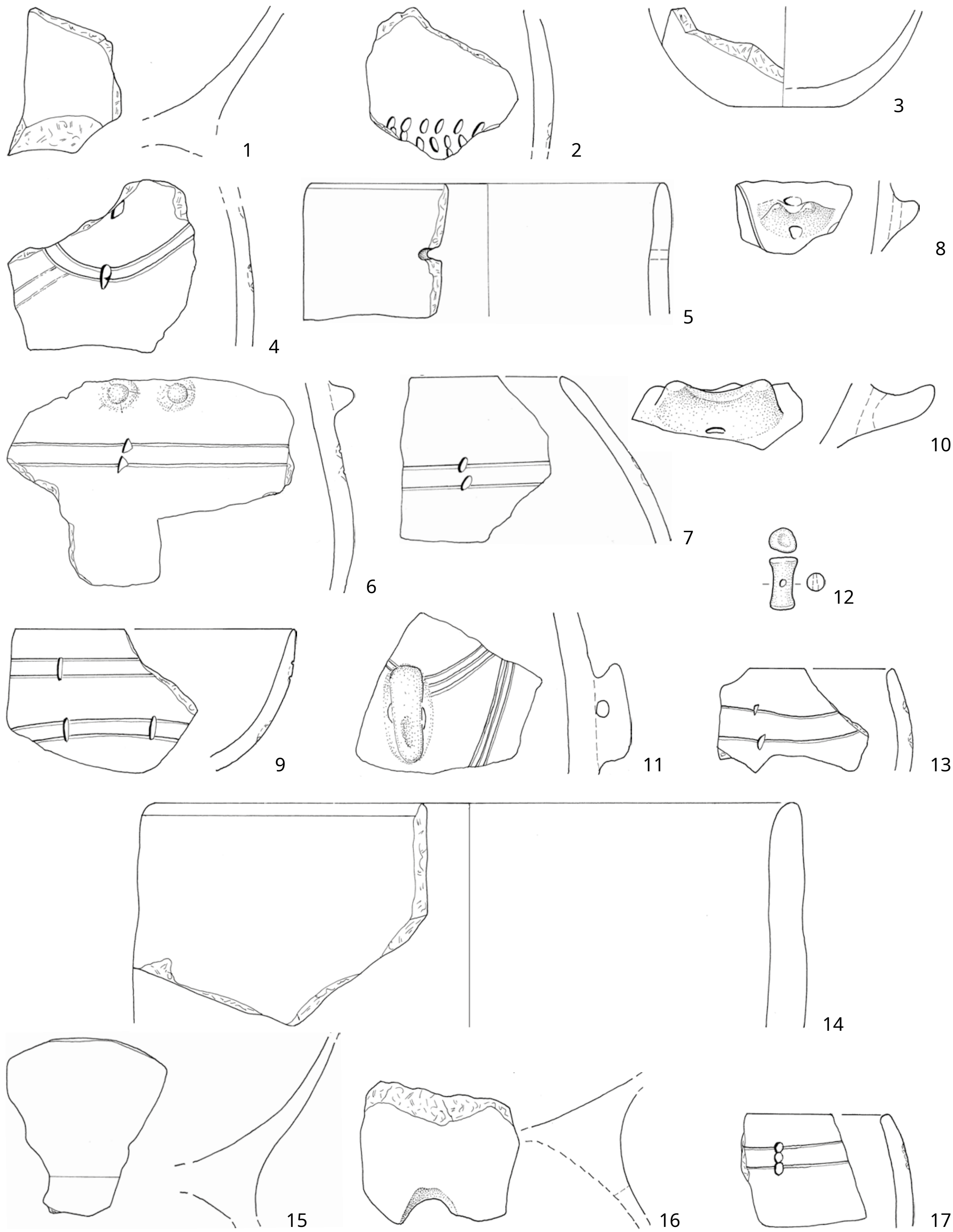


Plate 5.1.14. Selected ceramic finds. 1-17: trench 5. 1-17: object 2 (house 102, eastern long pit). 1-12: spit 1; 13-15, 17: spit 2. Scale 1:2 (drawings: E. Bakytová).

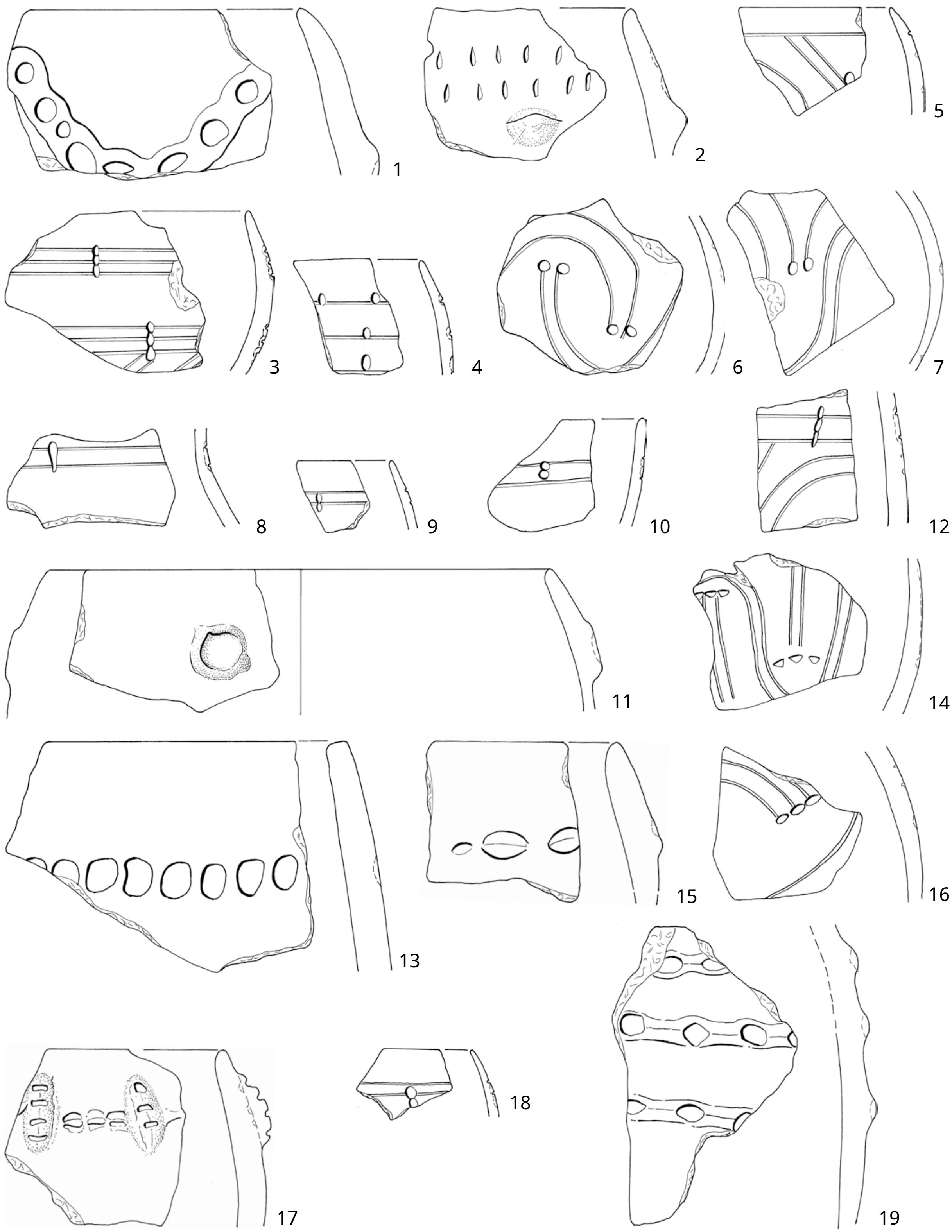


Plate 5.1.15. Selected ceramic finds. 1-19: trench 5. 1-13: object 2 (house 102, eastern long pit); 14-19: object 1 (house 102, western long pit). 2-3, 14-15, 17-19: spit 1; 1, 4-11, 16: spit 2; 12-13: spit 3. Scale 1:2 (drawings: E. Bakytová).

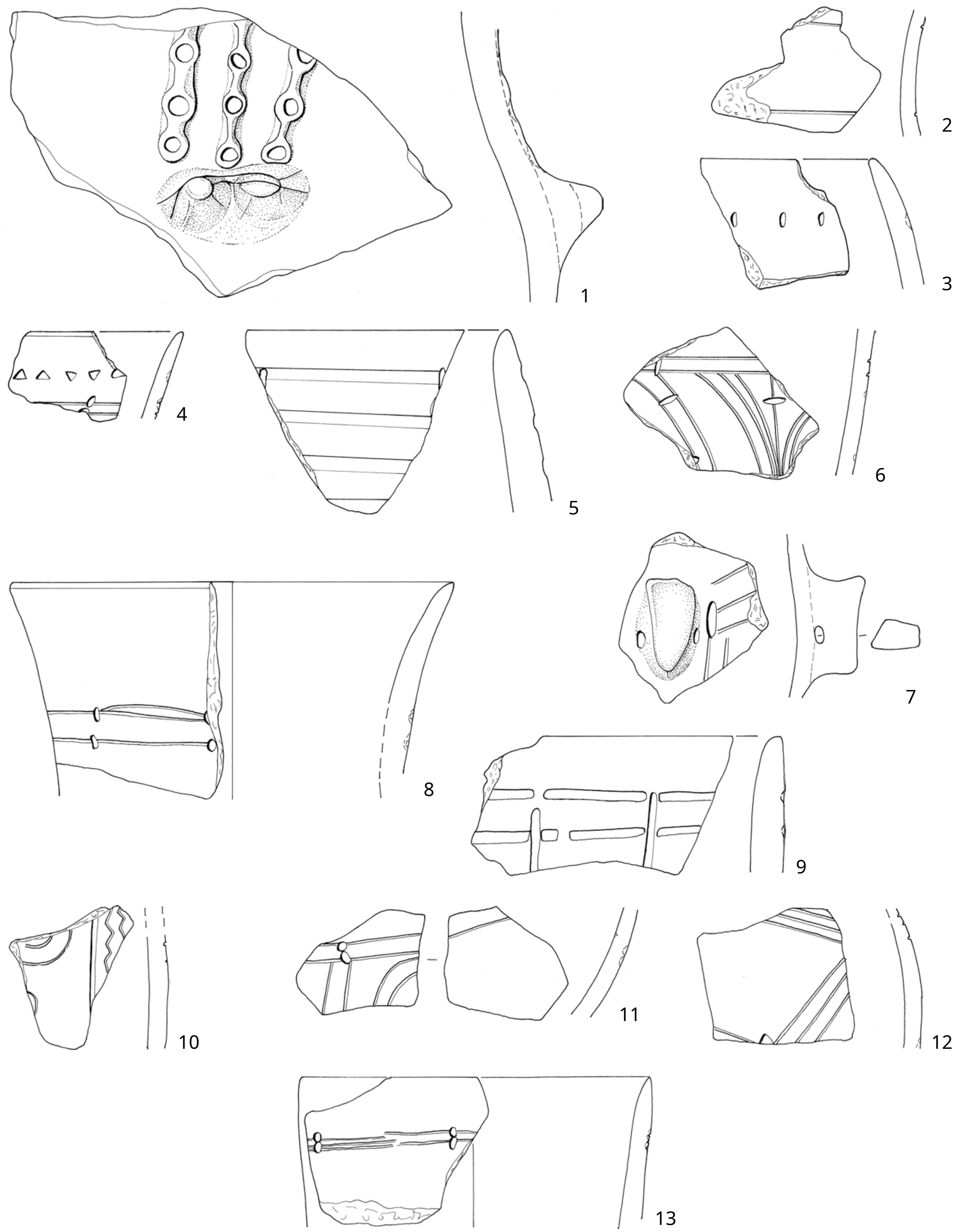


Plate 5.1.16. Selected ceramic finds. 1-13: trench 5. 5-11: object 1 (house 102, western long pit); 2-4, 12-13: object 2 (house 102, eastern long pit). 1, 4-11: spit 1; 12-13: spit 2. Scale 1:2 (drawings: E. Bakytová).

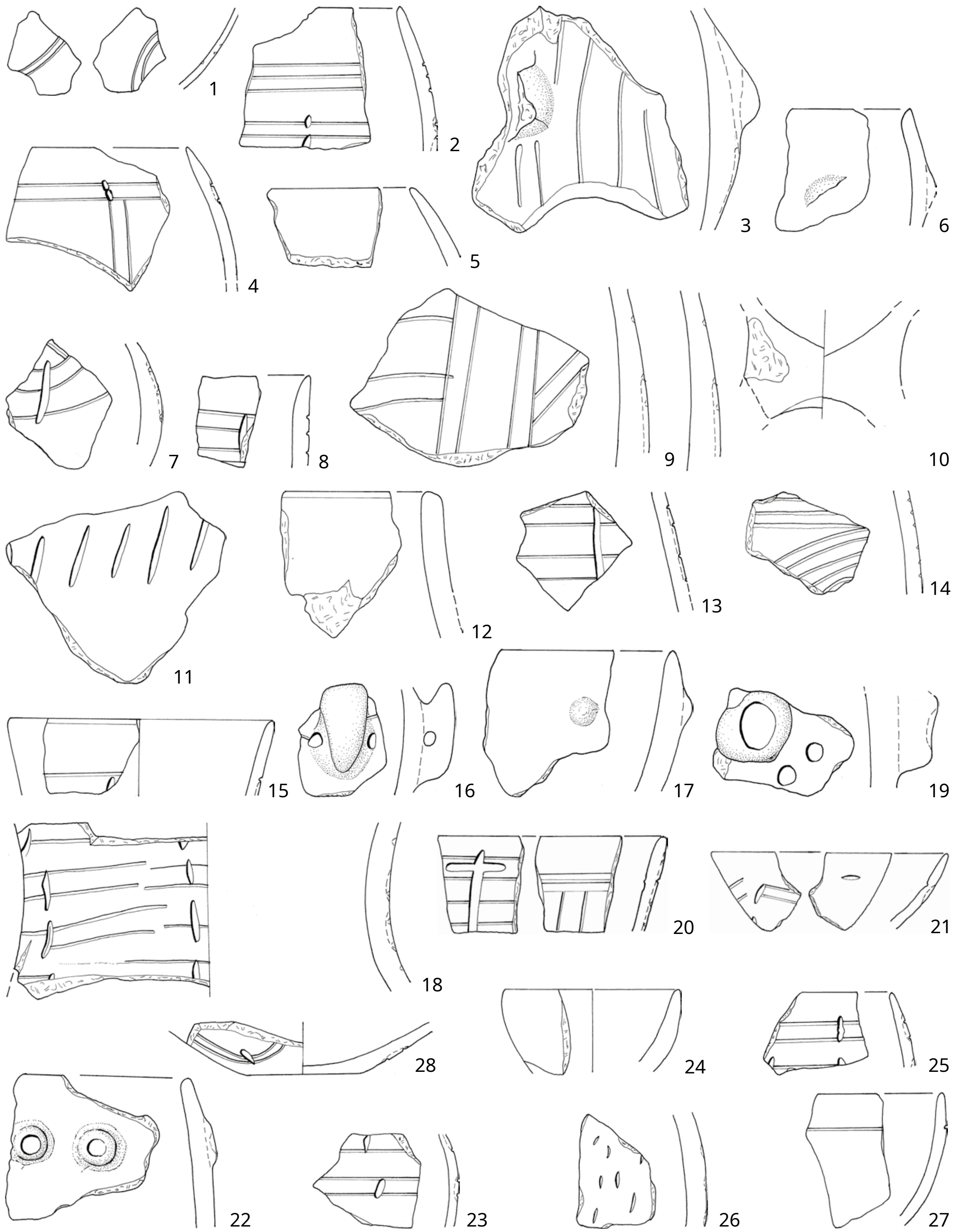


Plate 5.1.17. Selected ceramic finds. 1-27: trench 6. 1-27: object 1 (house 102-103, western long pit). 2-18, 23-27: spit 1; 10-22: spit 2. Scale 1:2 (drawings: E. Bakytová).

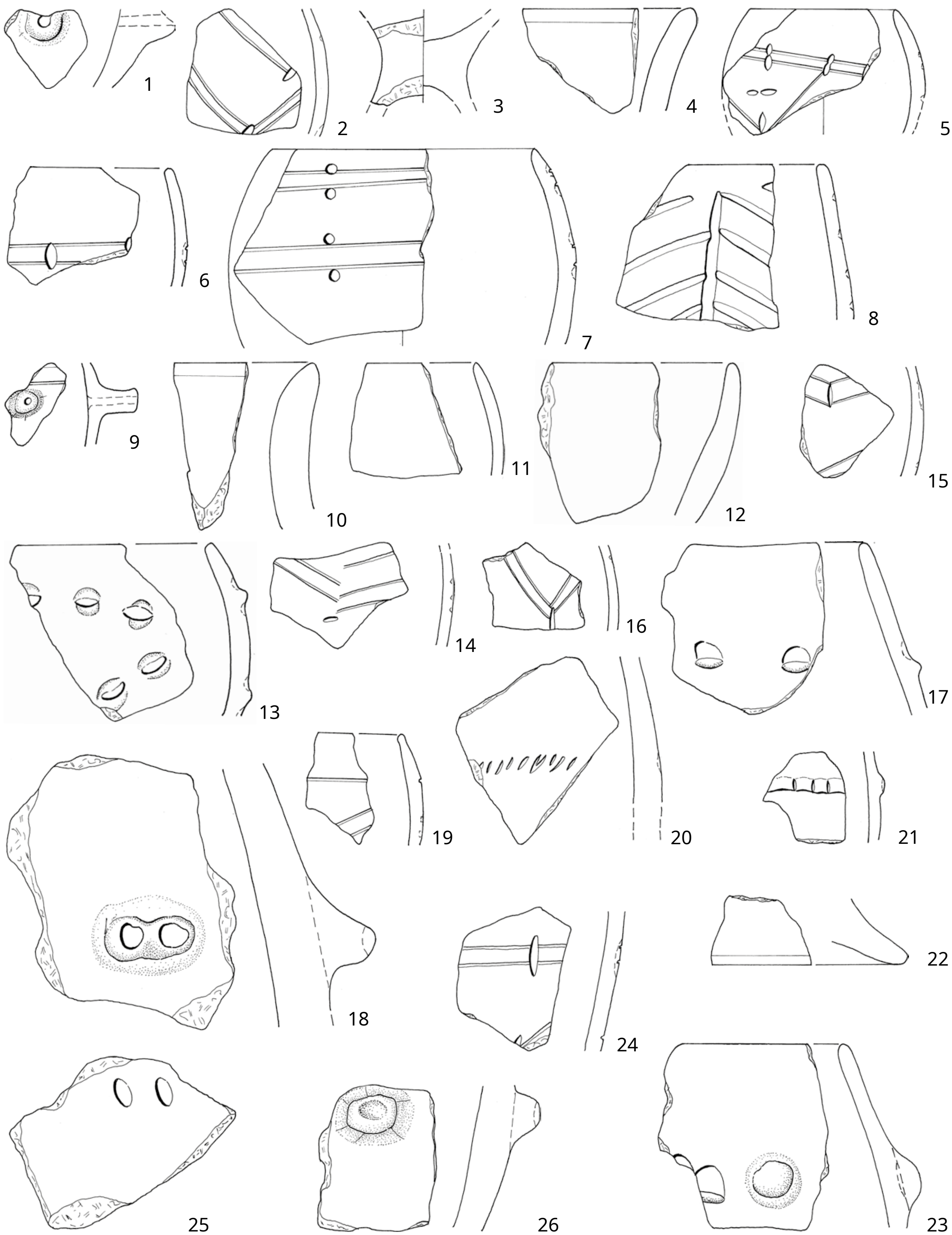


Plate 5.1.18. Selected ceramic finds. 1-28: trench 6. 1-28: object 1 (house 102-103, western long pit). 1-22: spit 1; 23-26: spit 2. Scale 1:2 (drawings: E. Bakytová).

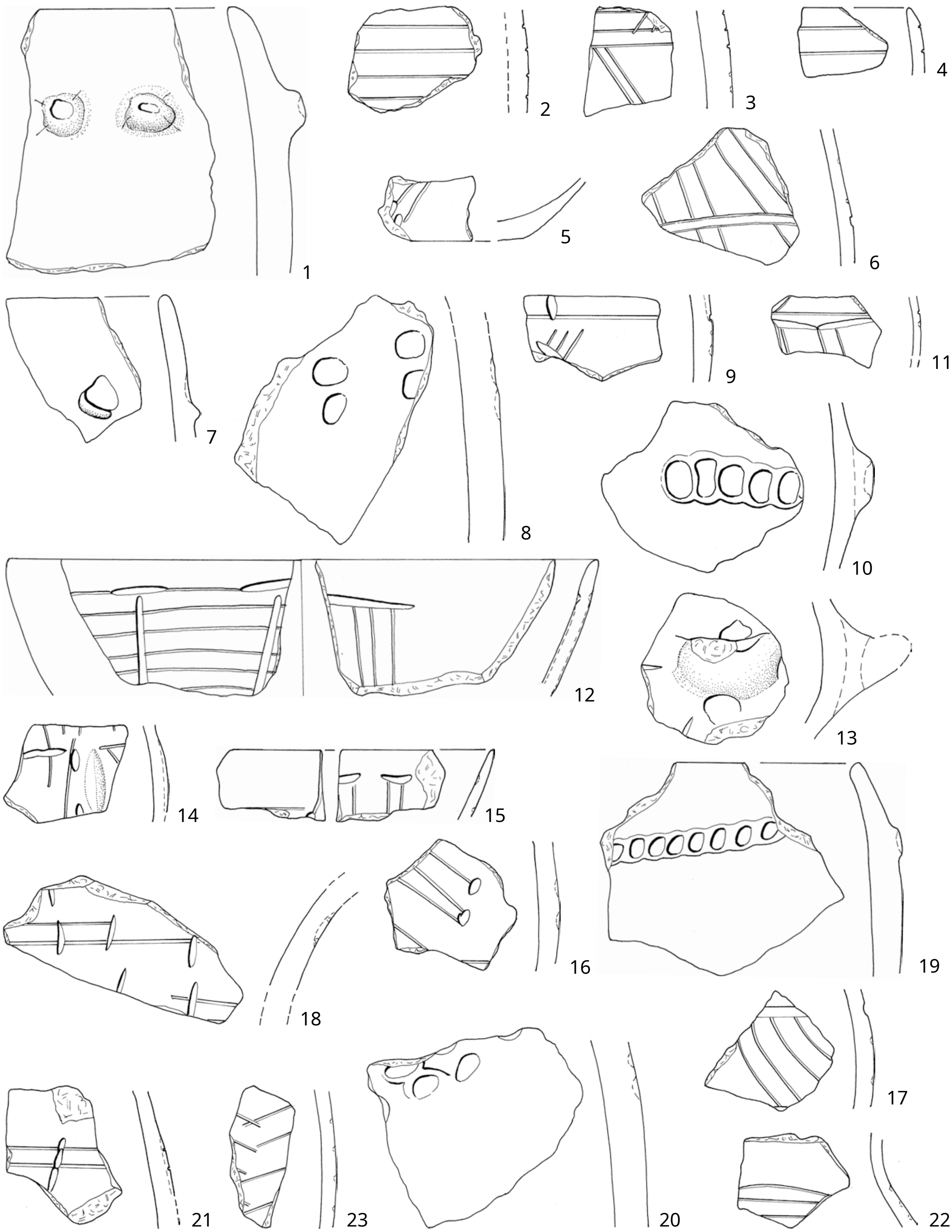


Plate 5.1.19. Selected ceramic finds. 1-23: trench 6. 1-19: object 1 (house 102-103, western long pit). 20-23: object 2 (house 102-103, eastern long pit). 20-23: spit 1; 1-9. 13-18: spit 2; 10-12, 19: spit 3. Scale 1:2 (drawings: E. Bakytová).

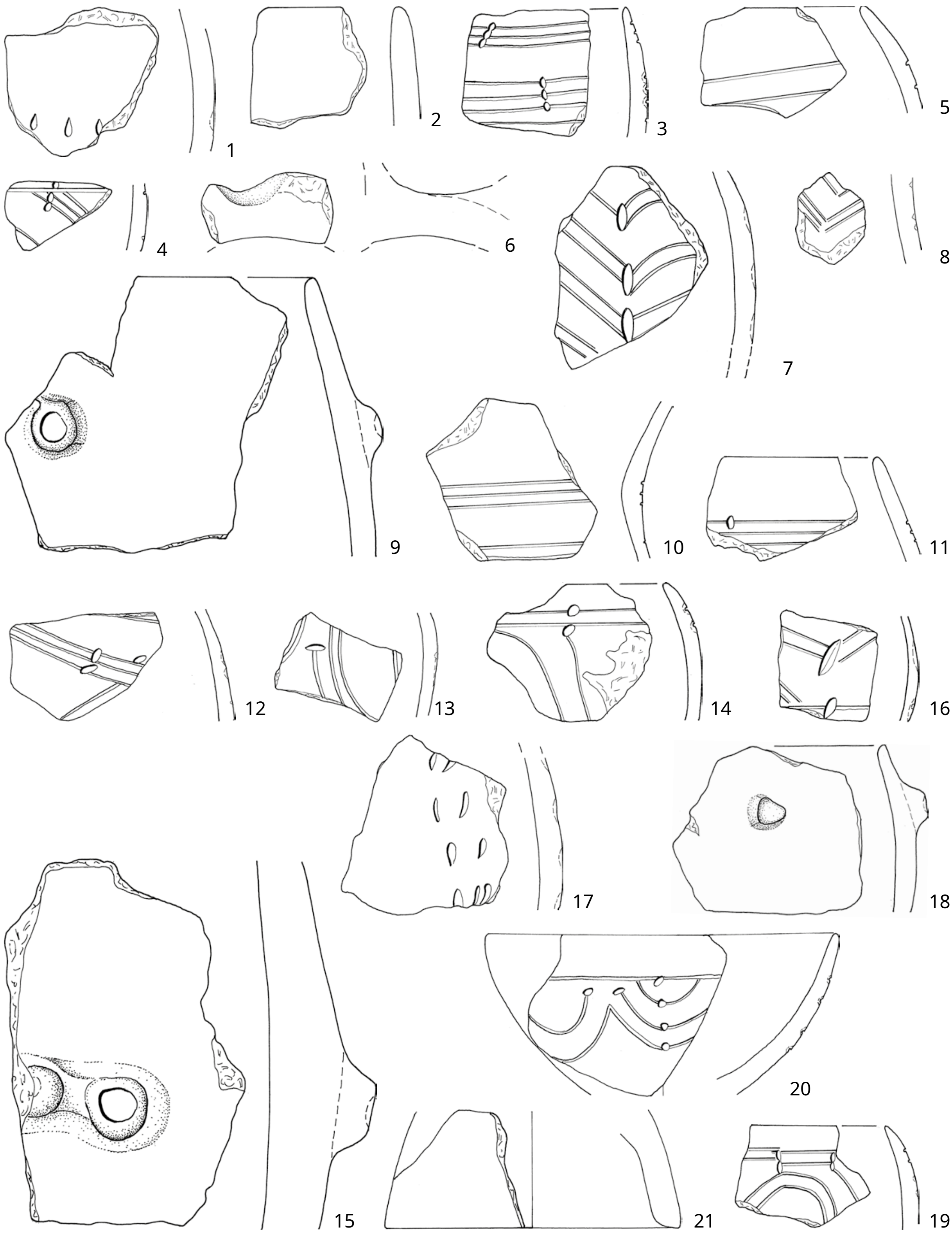


Plate 5.1.20. Selected ceramic finds. 1-21: trench 6. 1-21: object 2 (house 102-103, eastern long pit). 1-20: spit 1; 21: spit 2. Scale 1:2 (drawings: E. Bakytová).

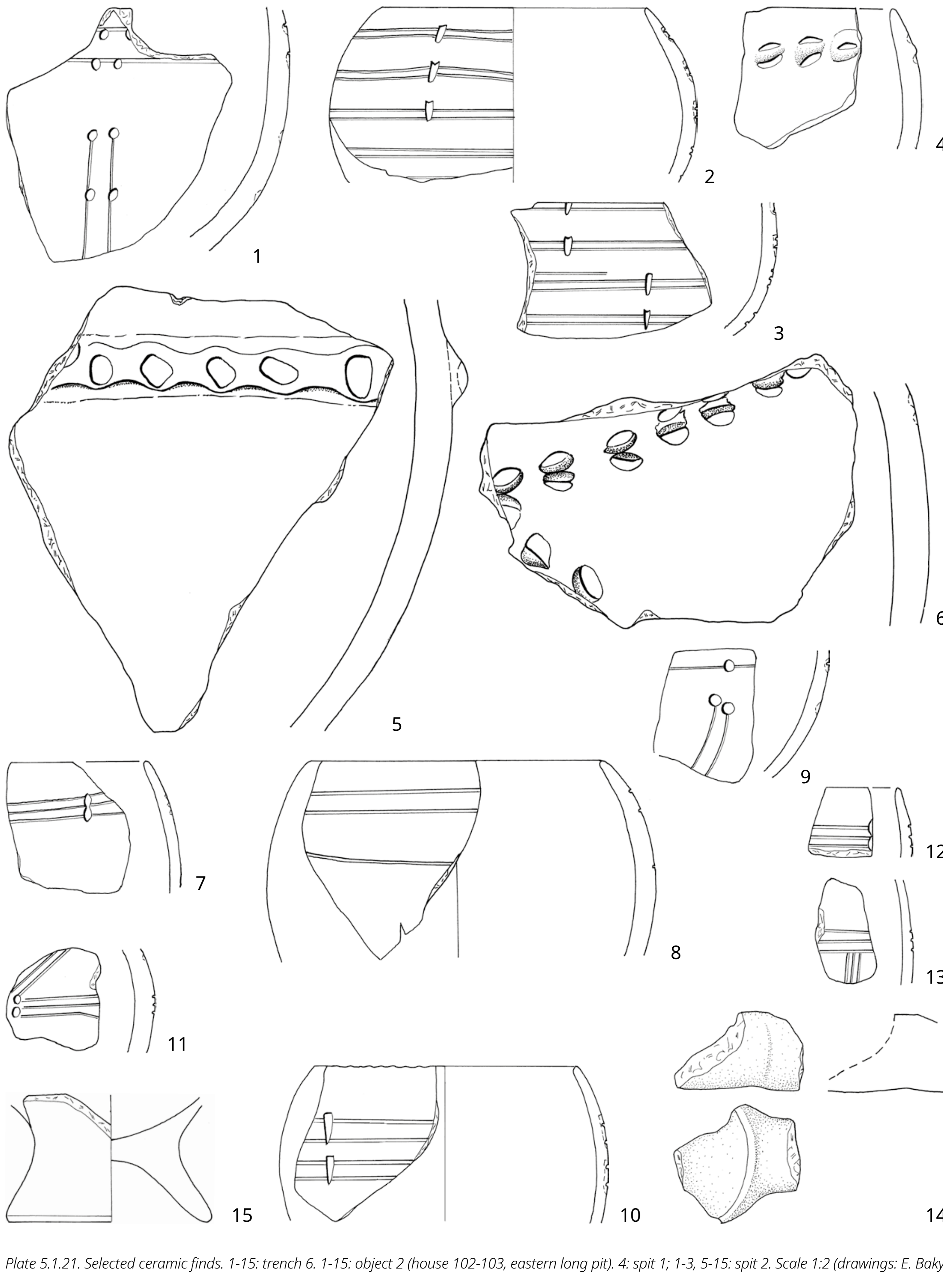


Plate 5.1.21. Selected ceramic finds. 1-15: trench 6. 1-15: object 2 (house 102-103, eastern long pit). 4: spit 1; 1-3, 5-15: spit 2. Scale 1:2 (drawings: E. Bakytová).

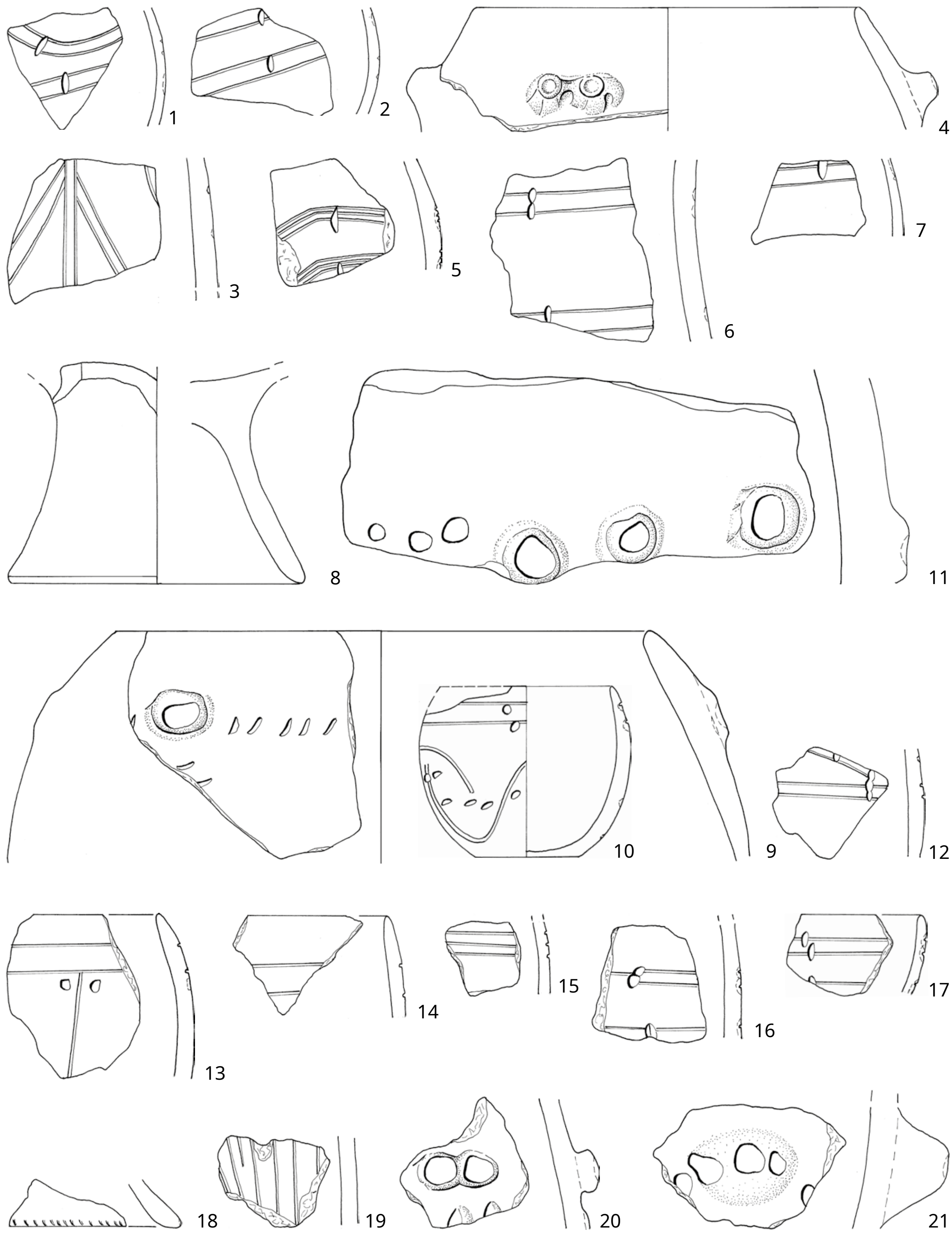


Plate 5.1.22. Selected ceramic finds. 1-21: trench 6. 1-21: object 2 (house 102-103, eastern long pit). 10-11: spit 1; 1-4, 6-7, 12: spit 2; 5, 8: spit 3. Scale 1:2 (drawings: E. Bakytová).

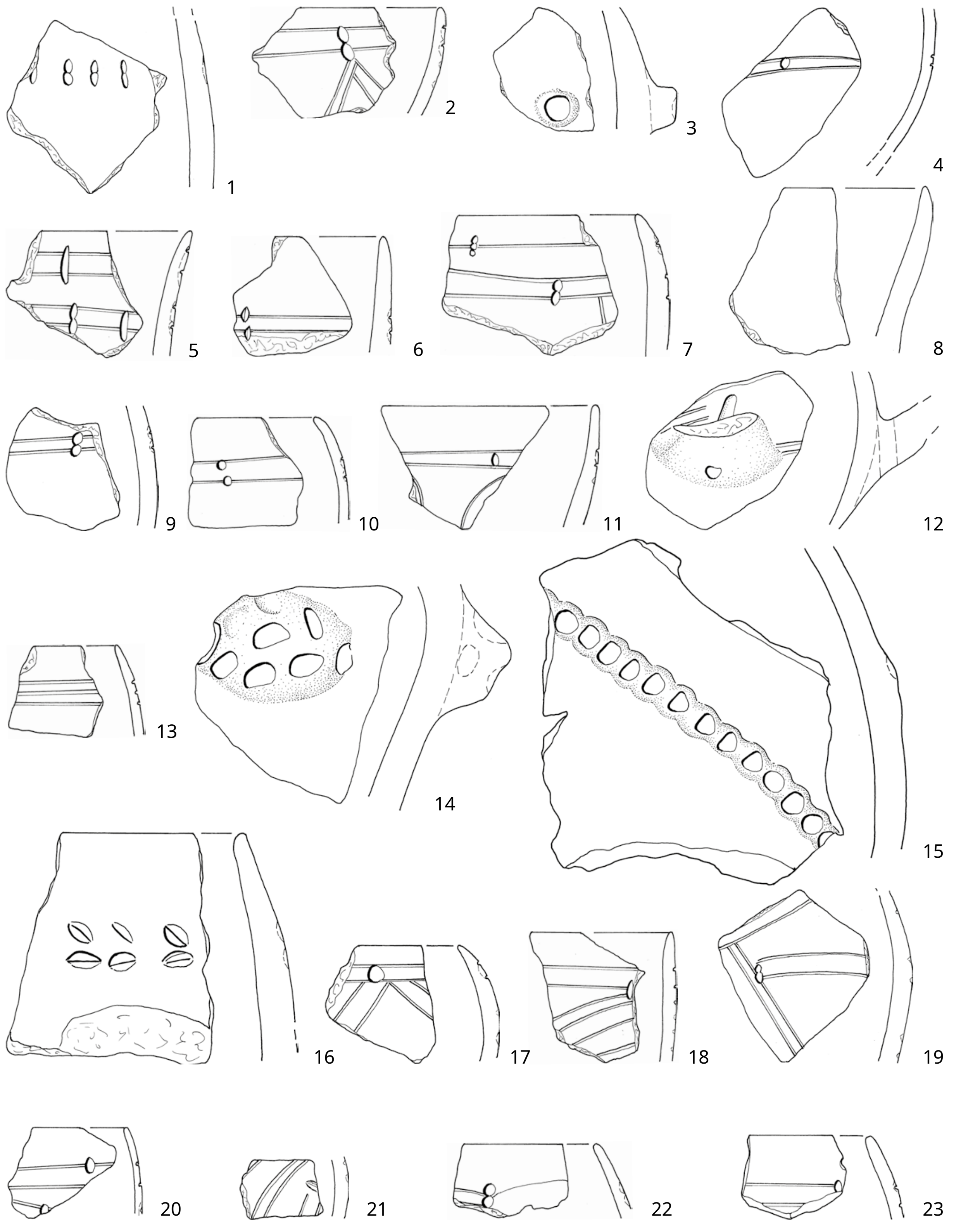


Plate 5.1.23. Selected ceramic finds. 1-23: trench 7. 1-23: object 1 (house 244, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

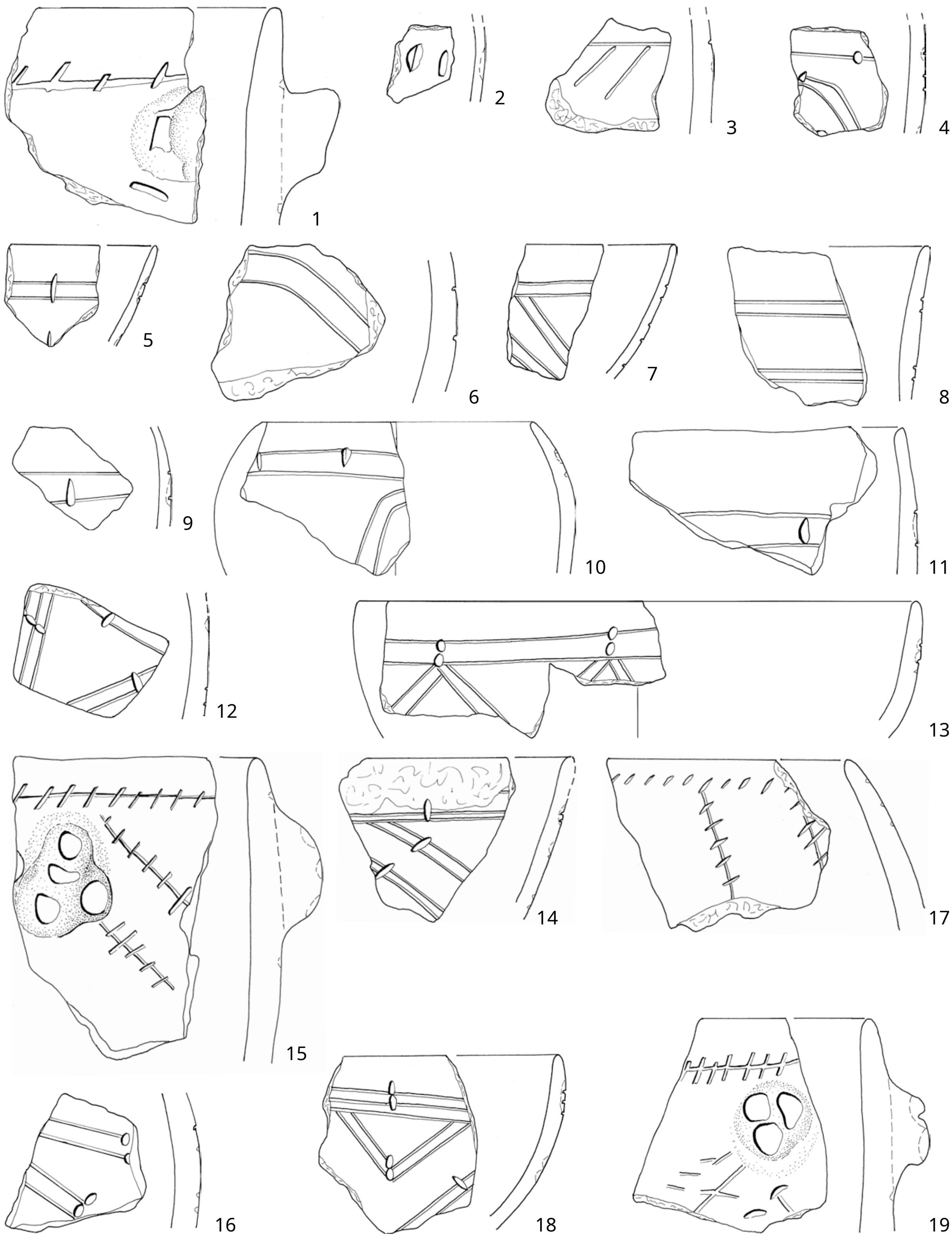


Plate 5.1.24. Selected ceramic finds. 1-8: trench 7; 9-19: trench 8. 1-8: object 1 (house 244, eastern long pit); 9-18: object 2 (house 245, eastern long pit); 19: object 1 (house 245, western long pit). Scale 1:2 (drawings: E. Bakytová).

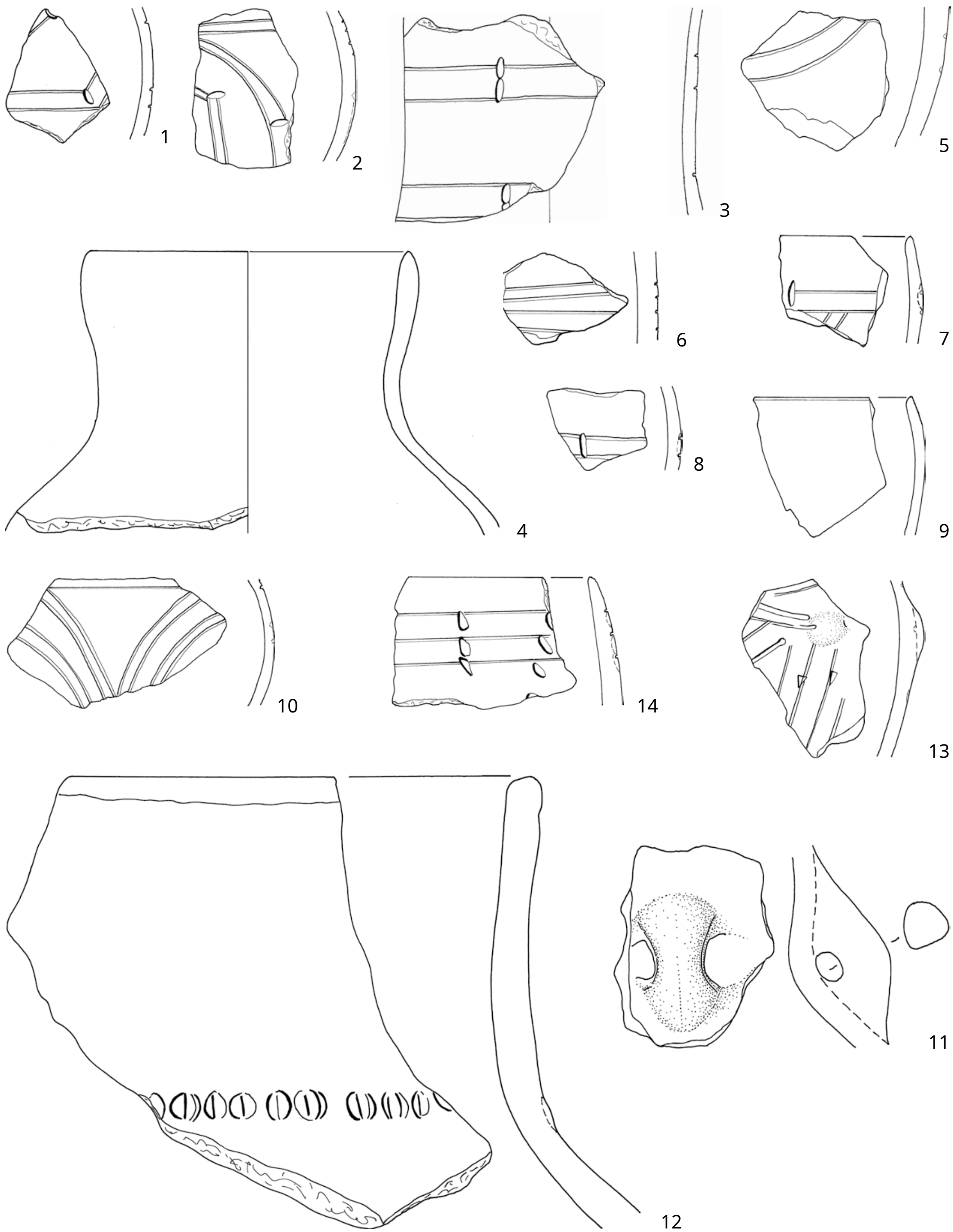


Plate 5.1.25. Selected ceramic finds. 1-14: trench 8. 1-3: object 1 (house 245, western long pit); 5-9: object 133 (house 245, posthole); 10-11: object 1 (house 319, western long pit); 12-14: object 1 (house 258, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

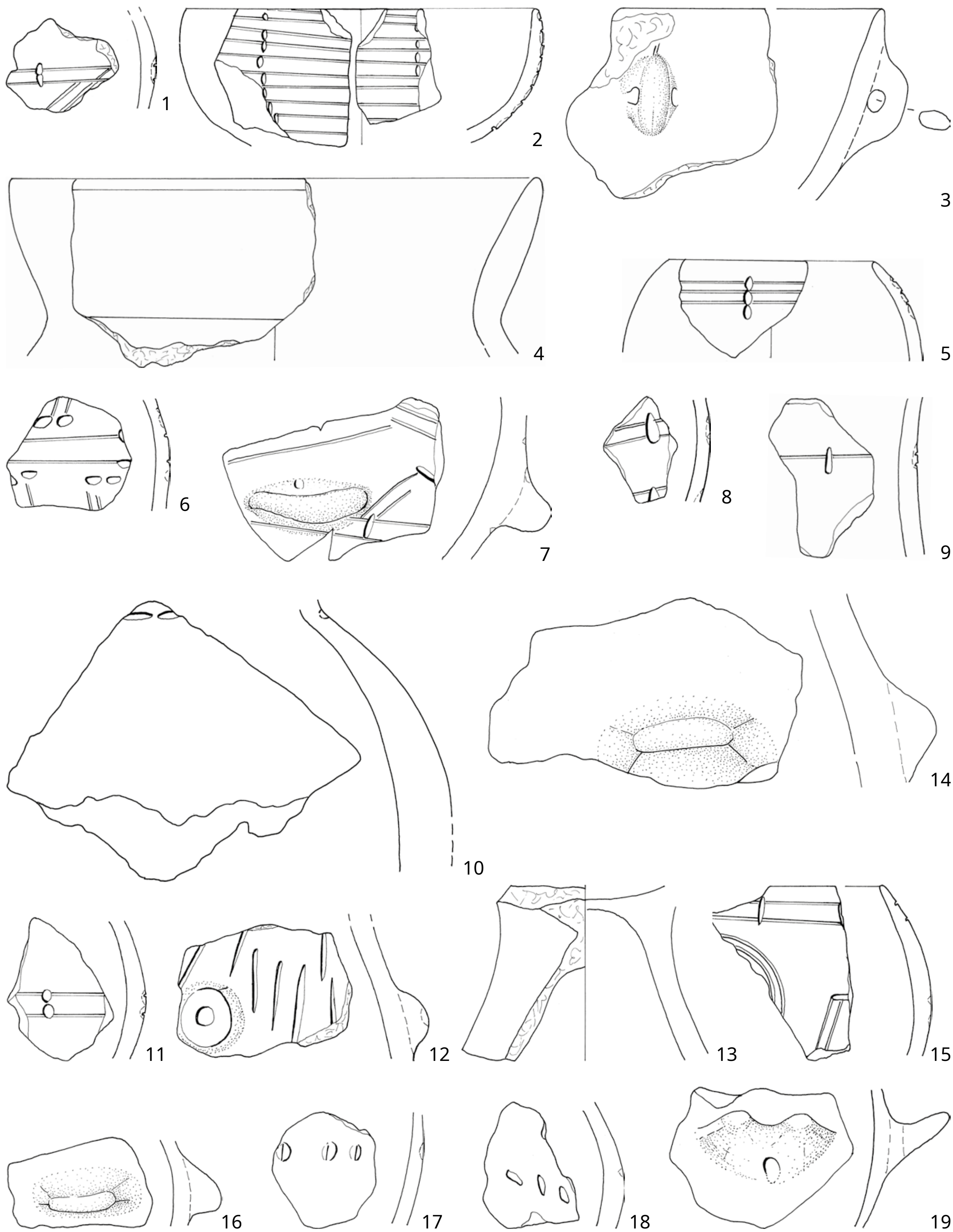


Plate 5.1.26. Selected ceramic finds. 1-19: trench 8. 1-19: object 1 (house 258, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

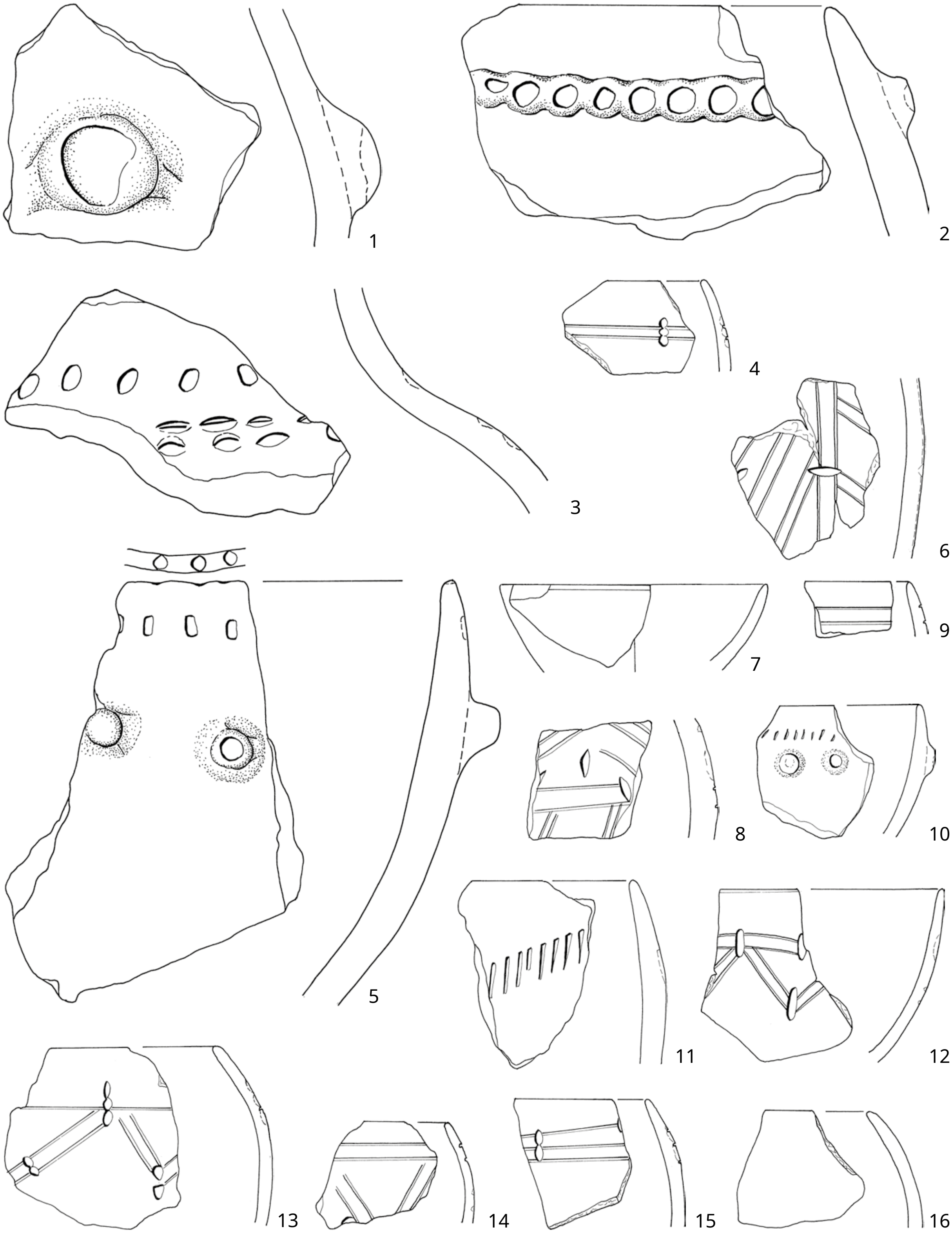


Plate 5.1.27. Selected ceramic finds. 1-16: trench 8. 1-16: object 1 (house 258, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

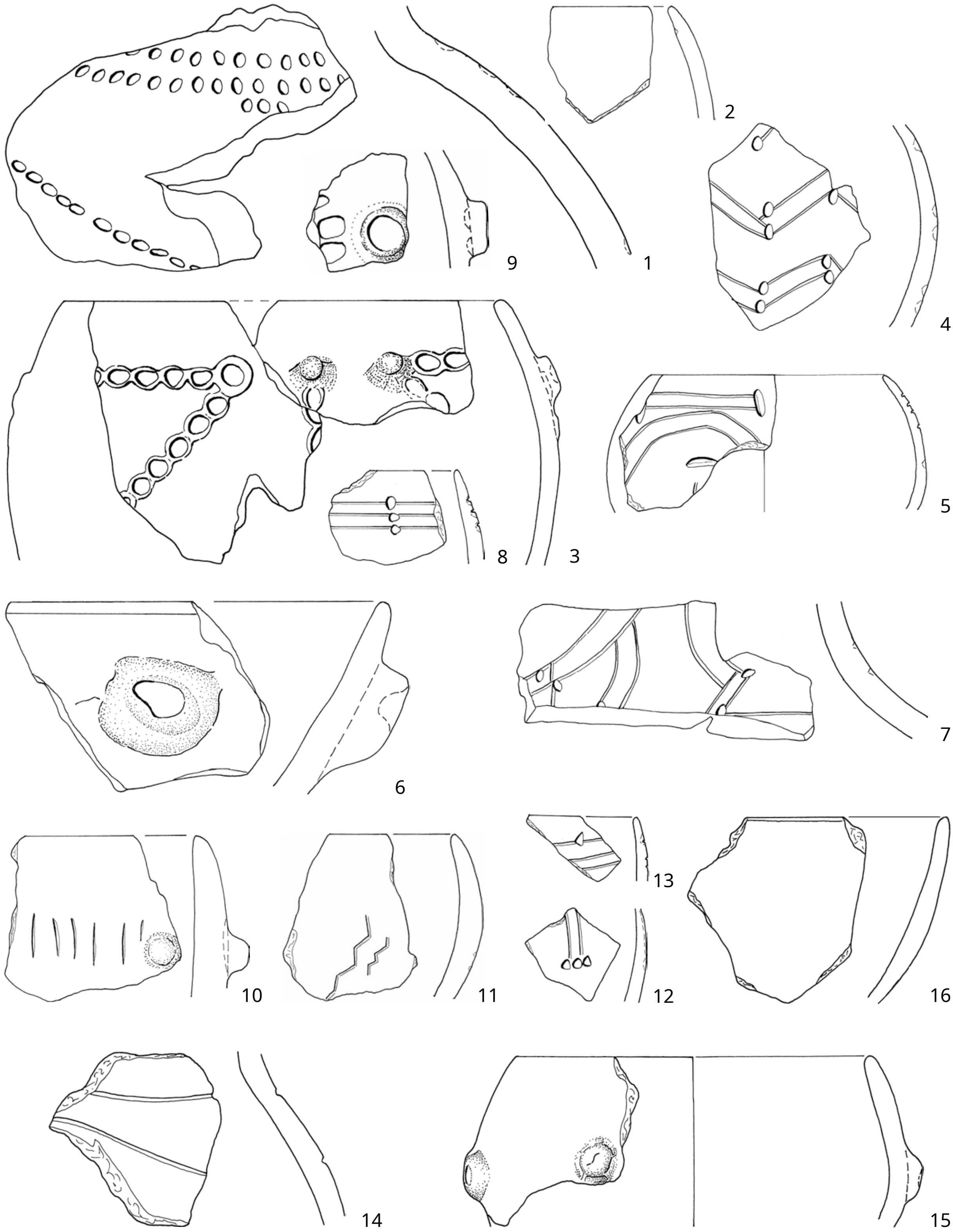


Plate 5.1.28. Selected ceramic finds. 1-16: trench 8. 1-9: object 1 (house 258, eastern long pit); 10-16: object 2 (house 259, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

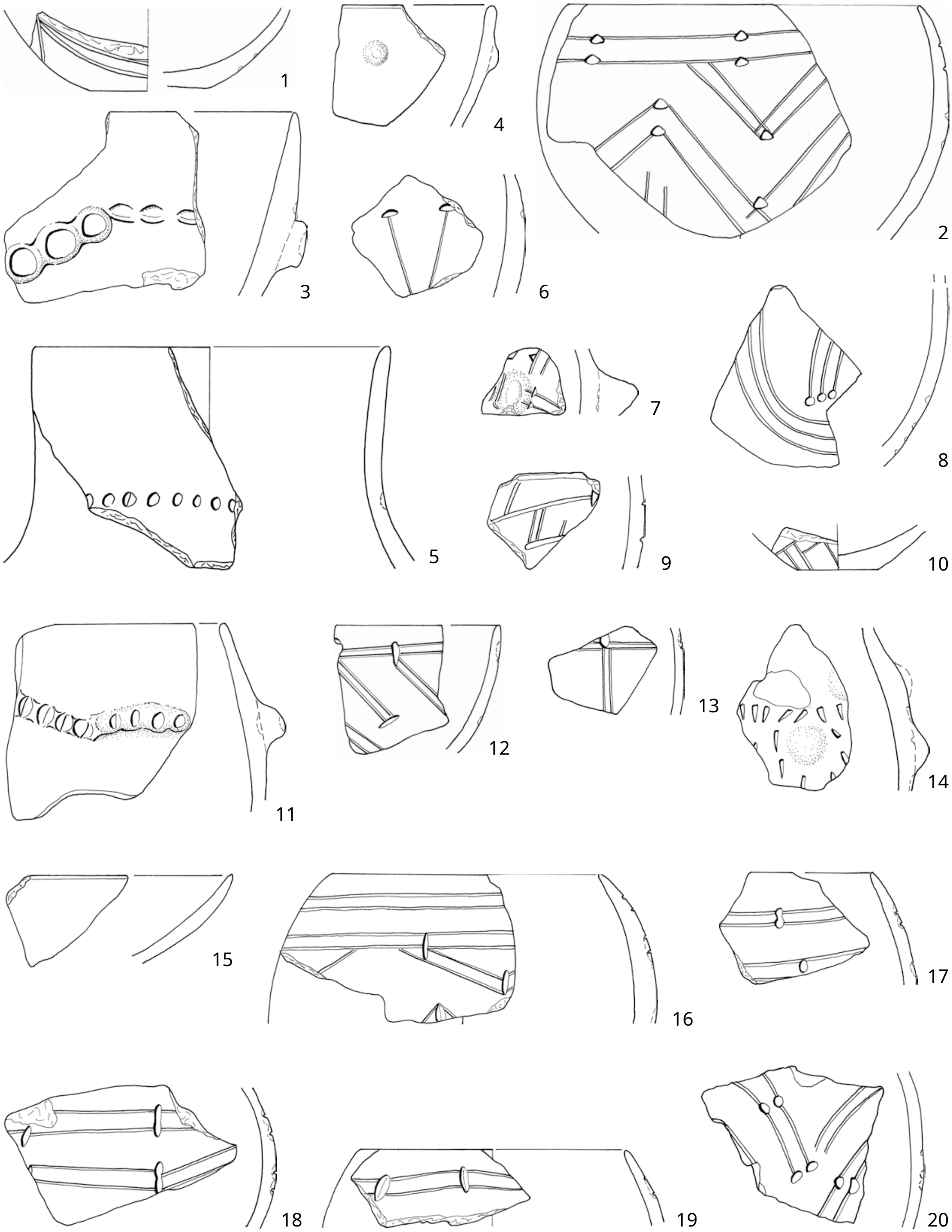
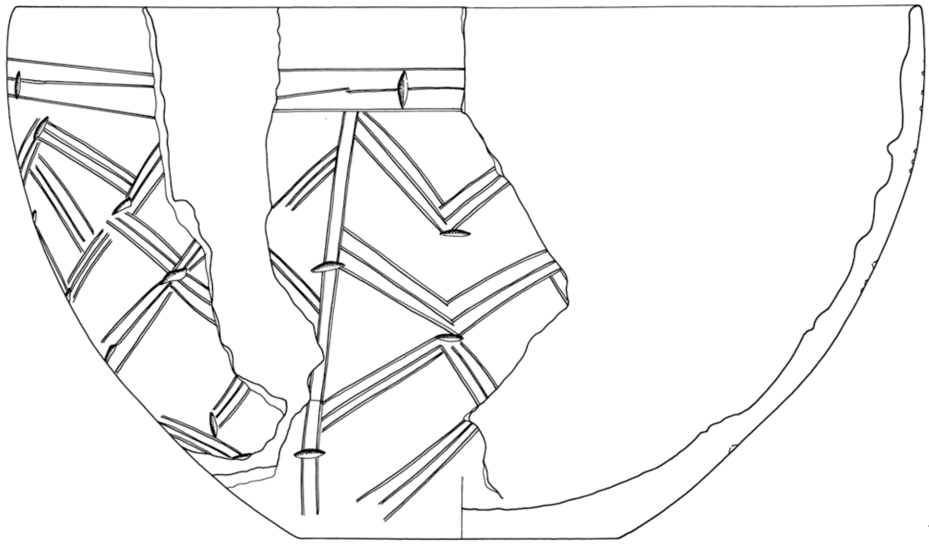


Plate 5.1.29. Selected ceramic finds. 1-20: trench 8. 1-20: object 2 (house 259, eastern long pit). Scale 1:2 (drawings: E. Bakytová).



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2

Plate 5.1.30. Selected ceramic finds. 1-2: trench 8. 1-2: object 2 (house 259, eastern long pit). Scale 1:3 (drawings: E. Bakytová).

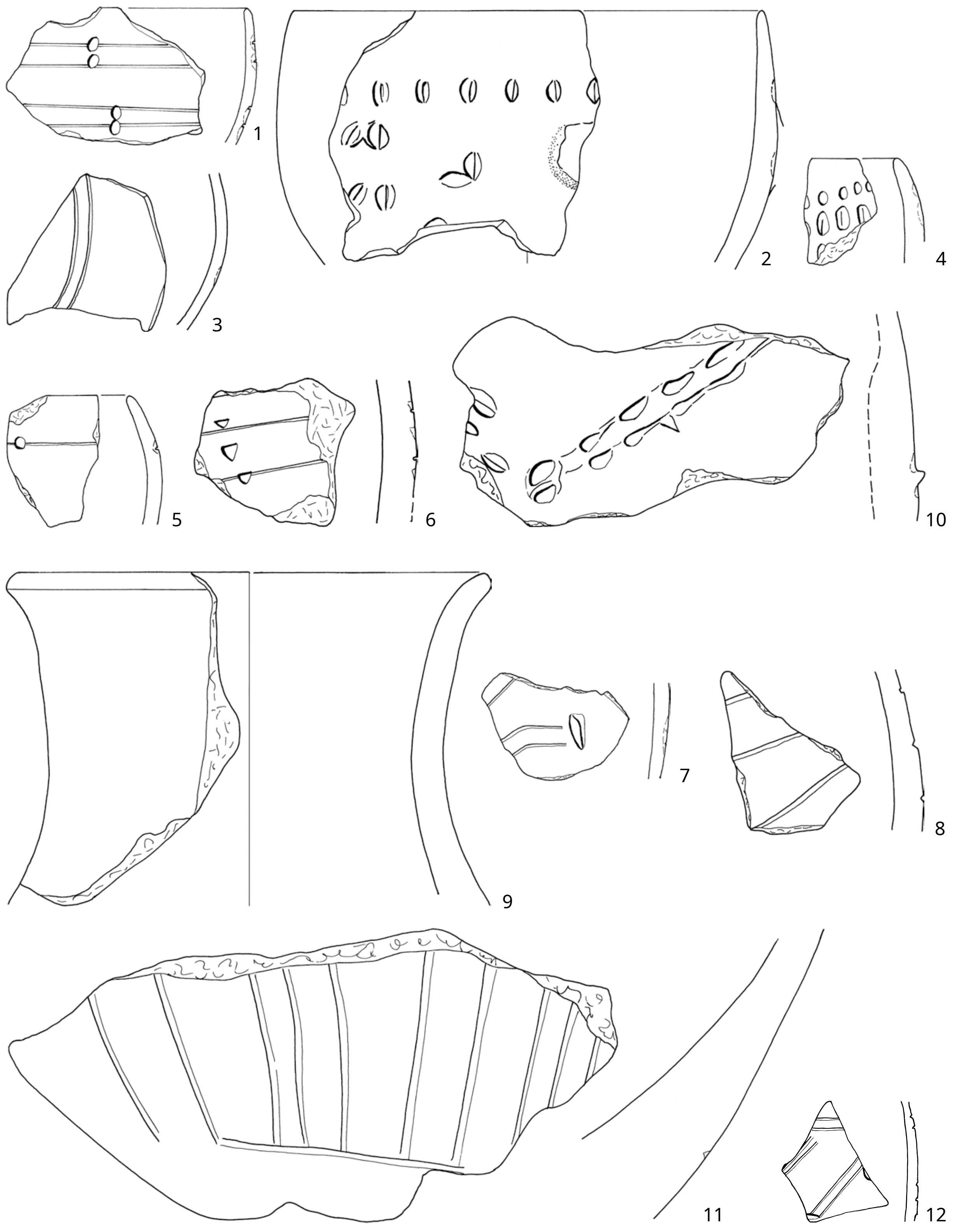

Plate 5.1.31. Selected ceramic finds. 1-12: trench 8. 1-2: object 2 (house 259, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

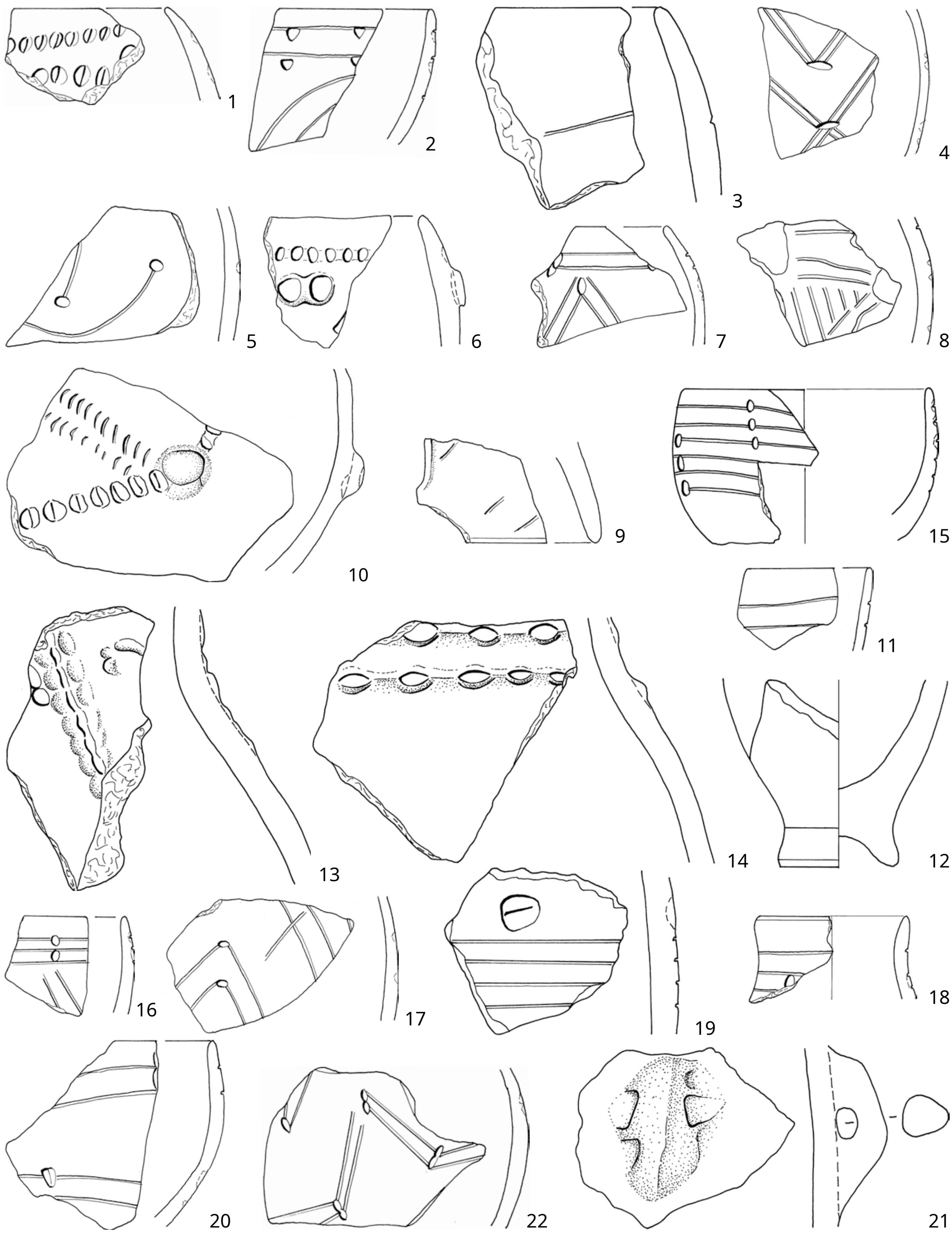

Plate 5.1.32. Selected ceramic finds. 1-22: trench 8. 1-22: object 2 (house 259, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

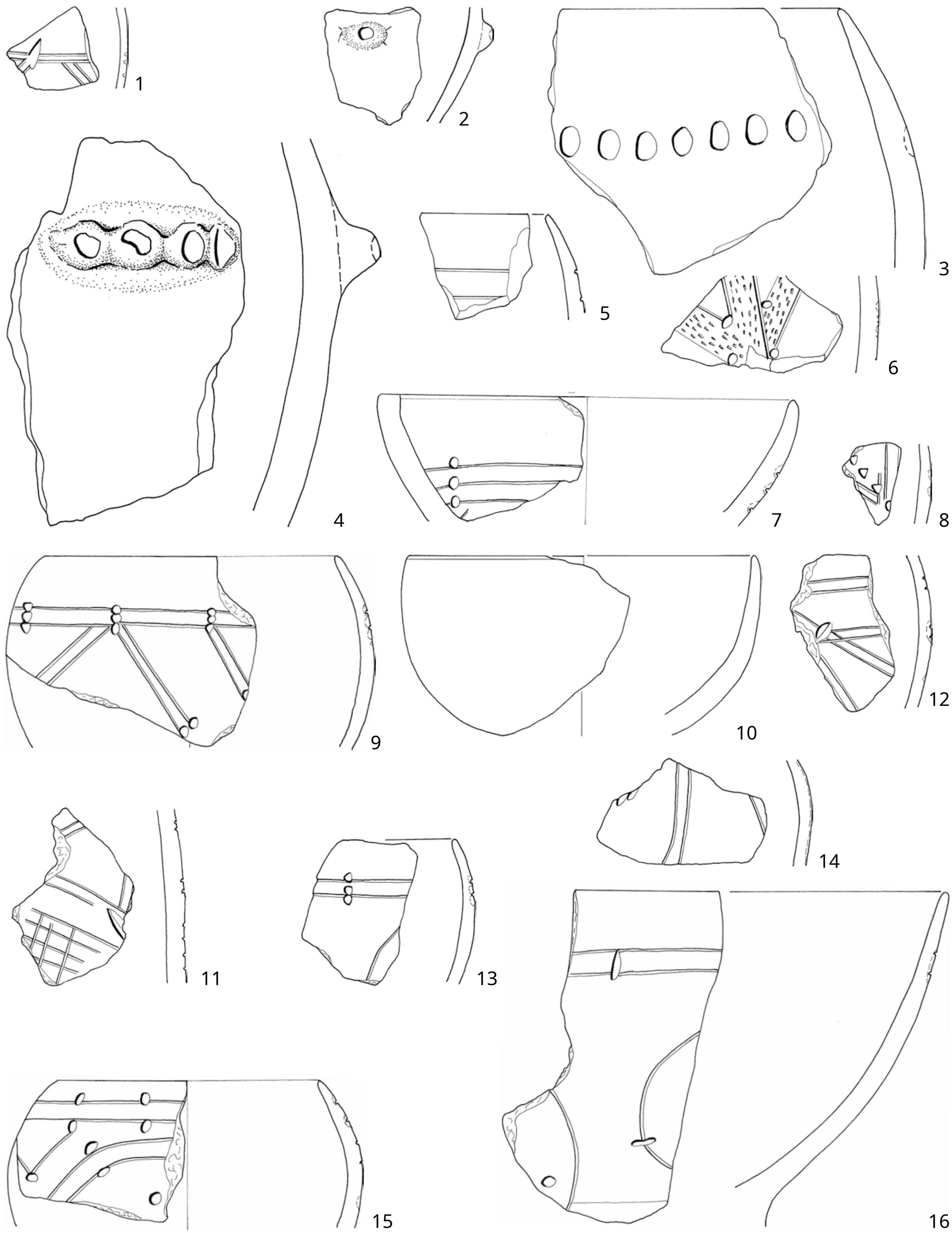

Plate 5.1.33. Selected ceramic finds. 1-16: trench 8. 1-16: object 2 (house 259, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

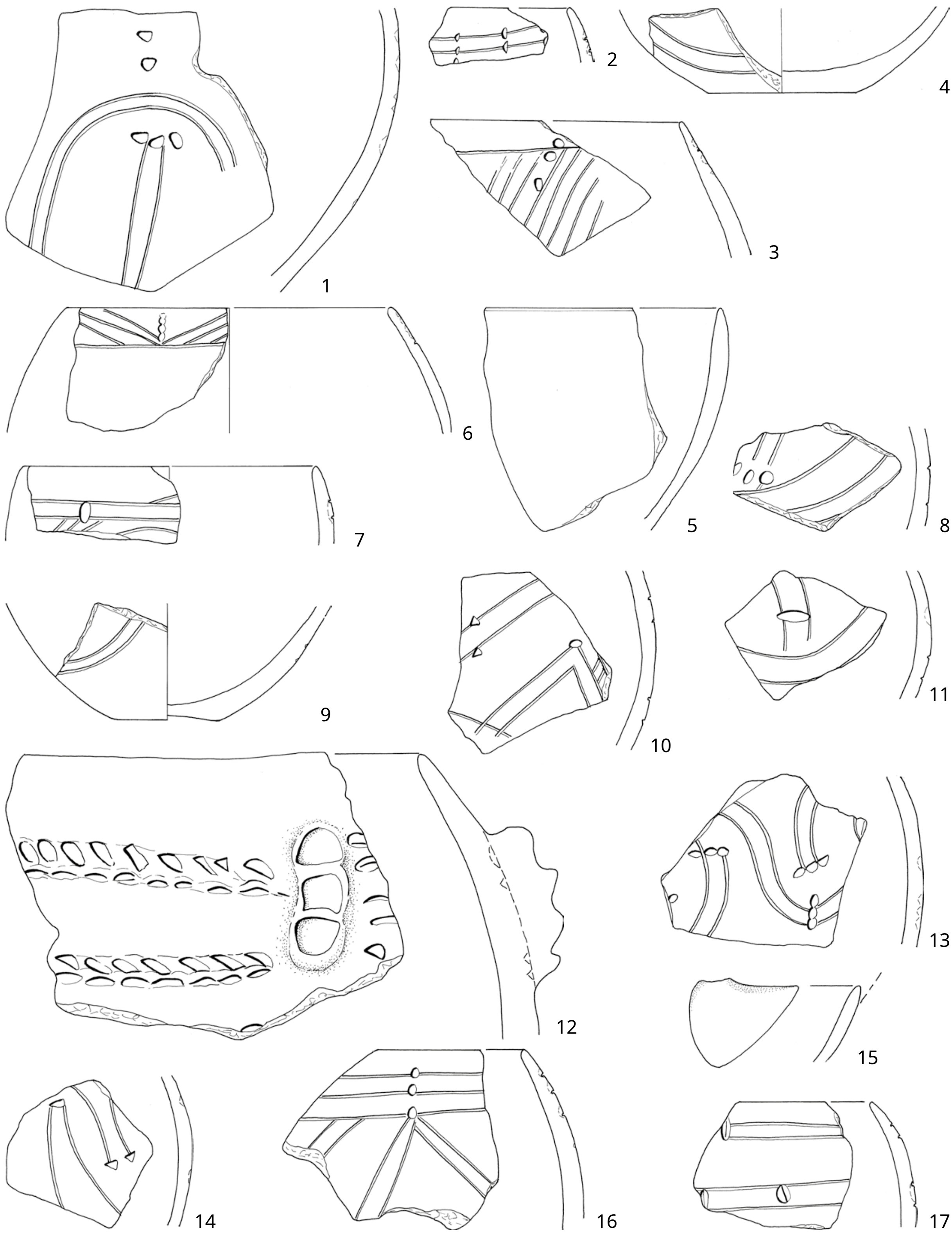

Plate 5.1.34. Selected ceramic finds. 1-17: trench 8. 1-17: object 2 (house 259, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

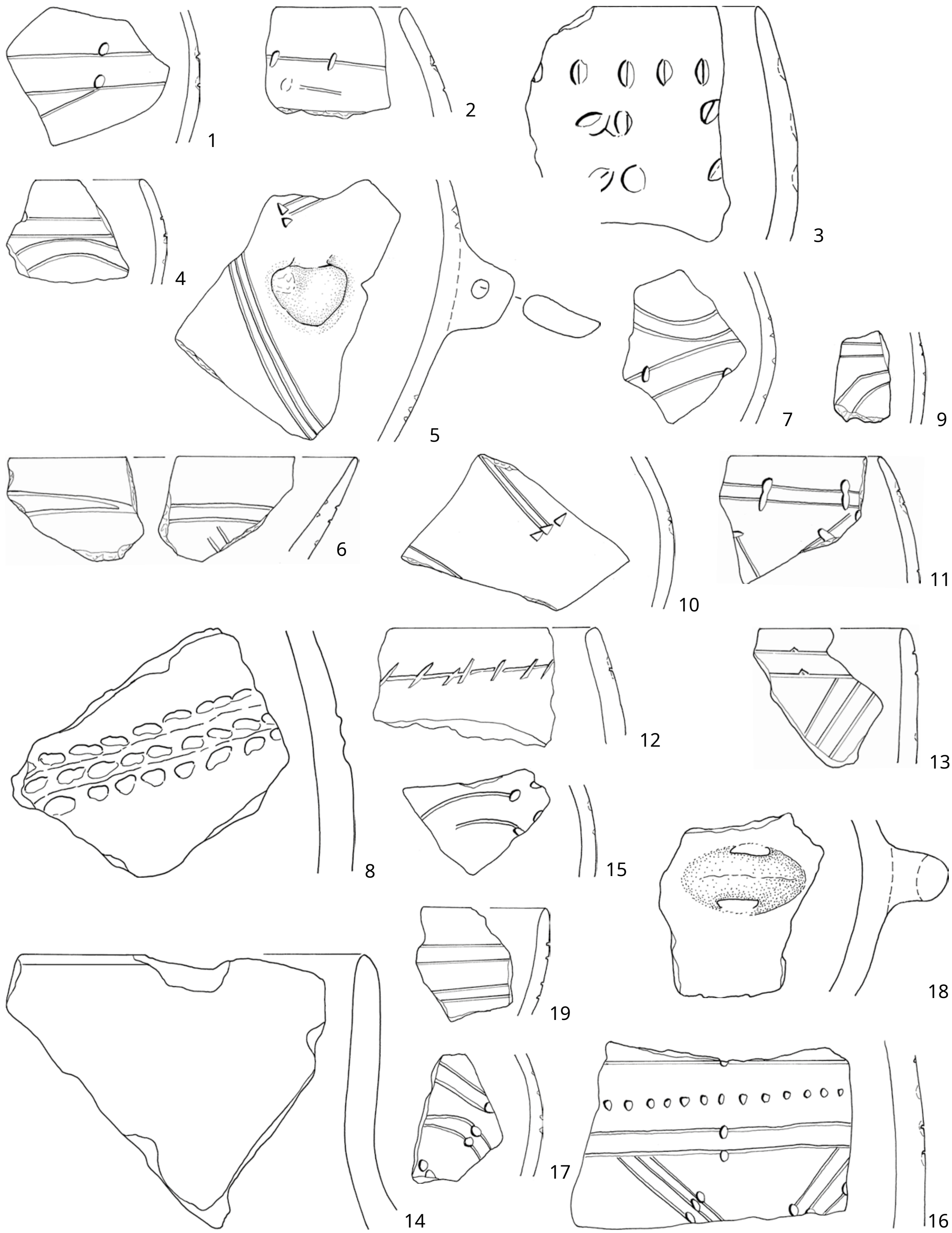

Plate 5.1.35. Selected ceramic finds. 1-19: trench 8. 1-3: object 2 (house 259, eastern long pit); 4-13: object 1 (house 259, western long pit); 14-19: object 13 (house 259, pit). Scale 1:2 (drawings: E. Bakytová).

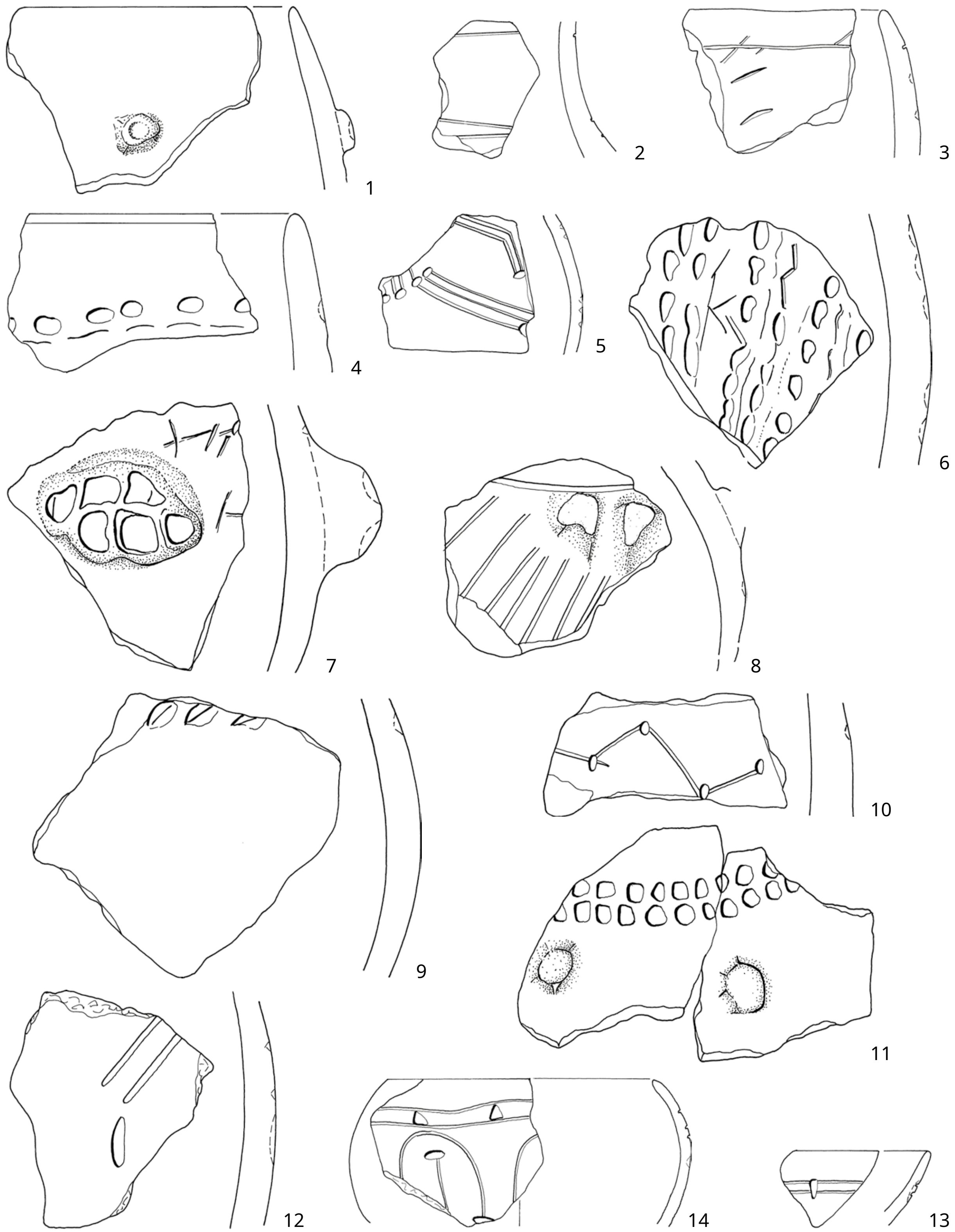

Plate 5.1.36. Selected ceramic finds. 1-14: trench 8. 1-14: object 13 (house 259, pit). Scale 1:2 (drawings: E. Bakytová).

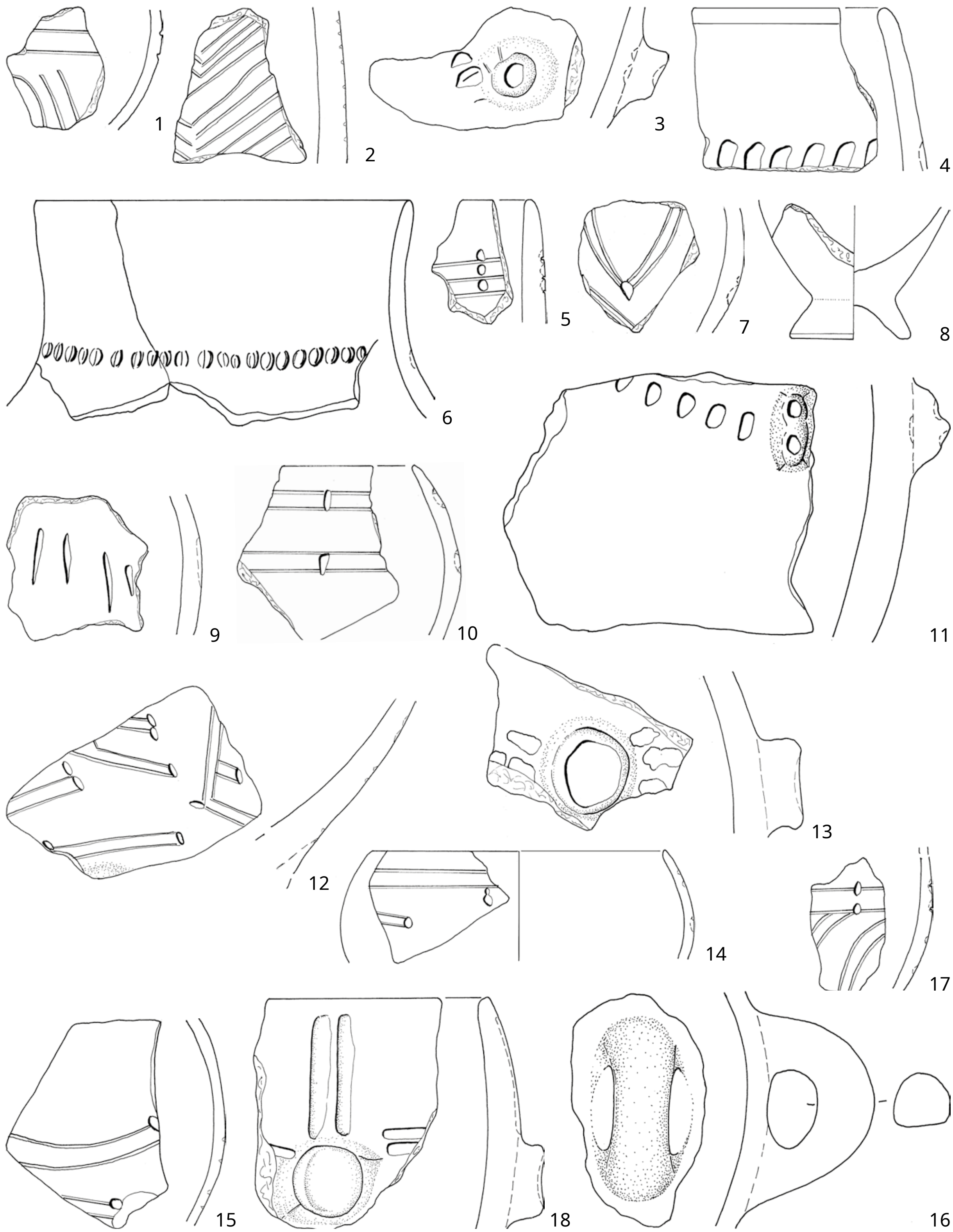

Plate 5.1.37. Selected ceramic finds. 1-18: trench 8. 1: house 245; 2-4: house 258; 5-12: pit, objects 145, 148-152 (house 258); 13-16: house 259. Scale 1:2 (drawings: E. Bakytová).

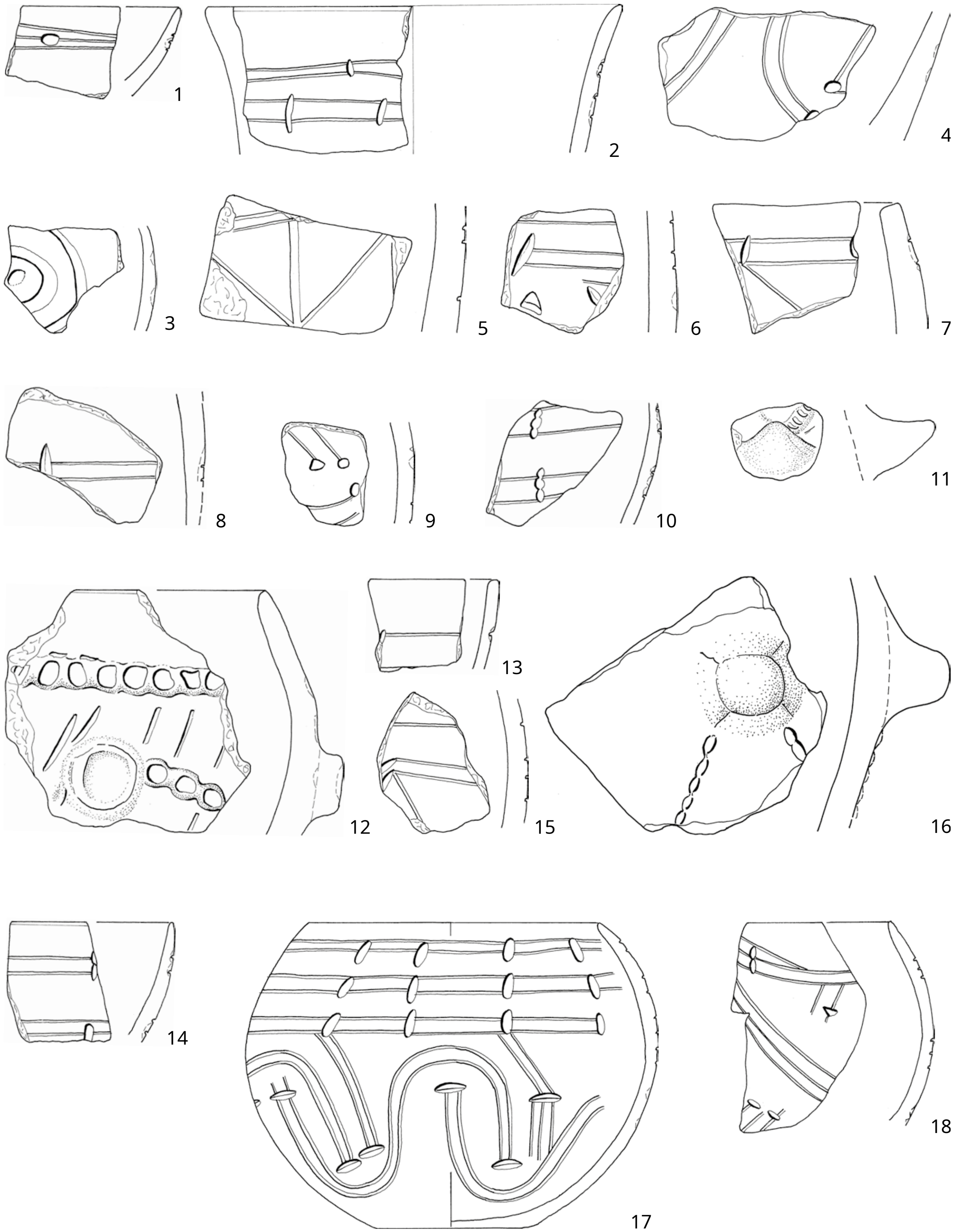

Plate 5.1.38. Selected ceramic finds. 1-18: trench 9. 1-18: object 1 (near house 262). Scale 1:2 (drawings: E. Bakytová).

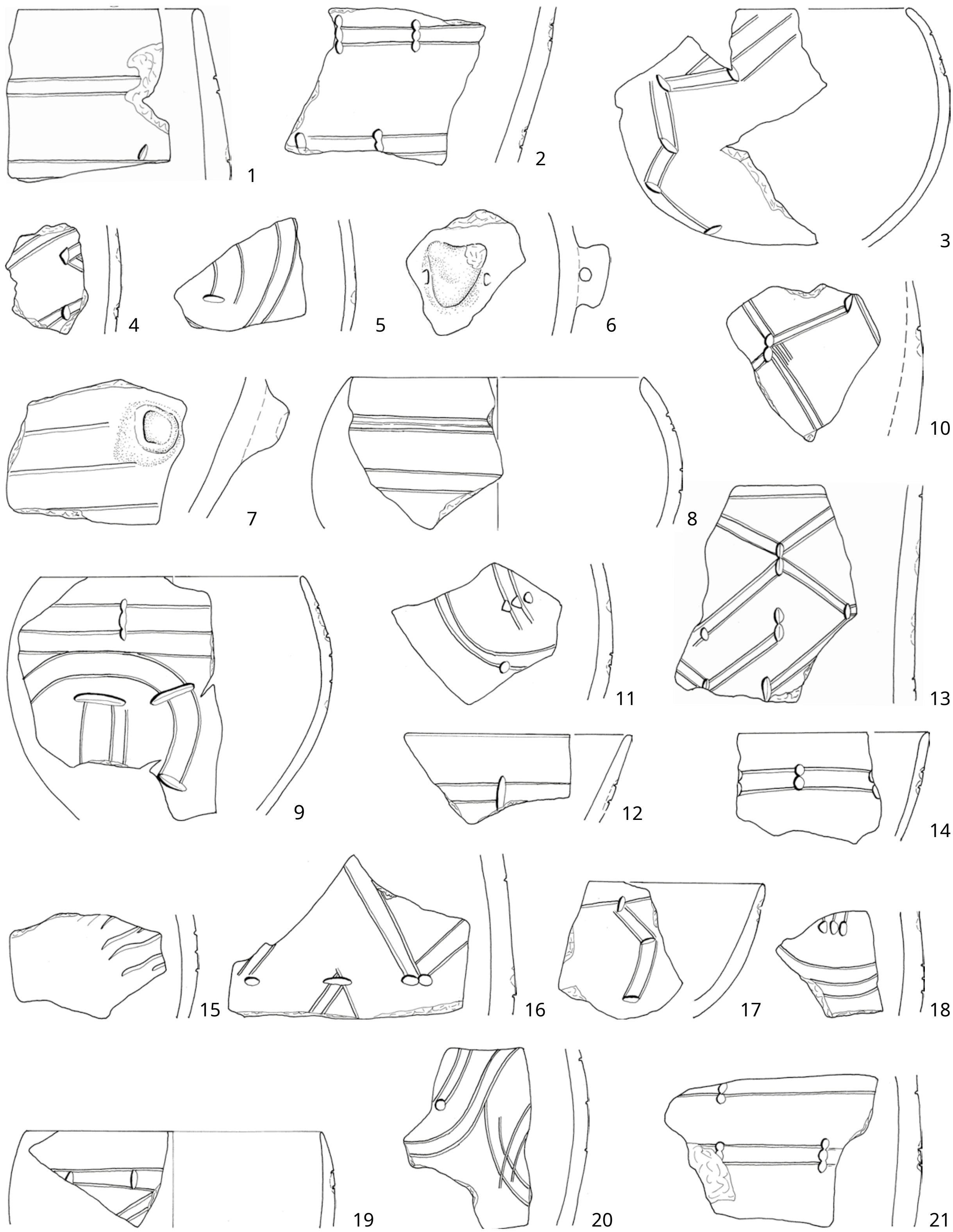

Plate 5.1.39. Selected ceramic finds. 1-21: trench 10. 1-21: object 1 (house 262, eastern long pit). Scale 1:2 (drawings: E. Bakytová).

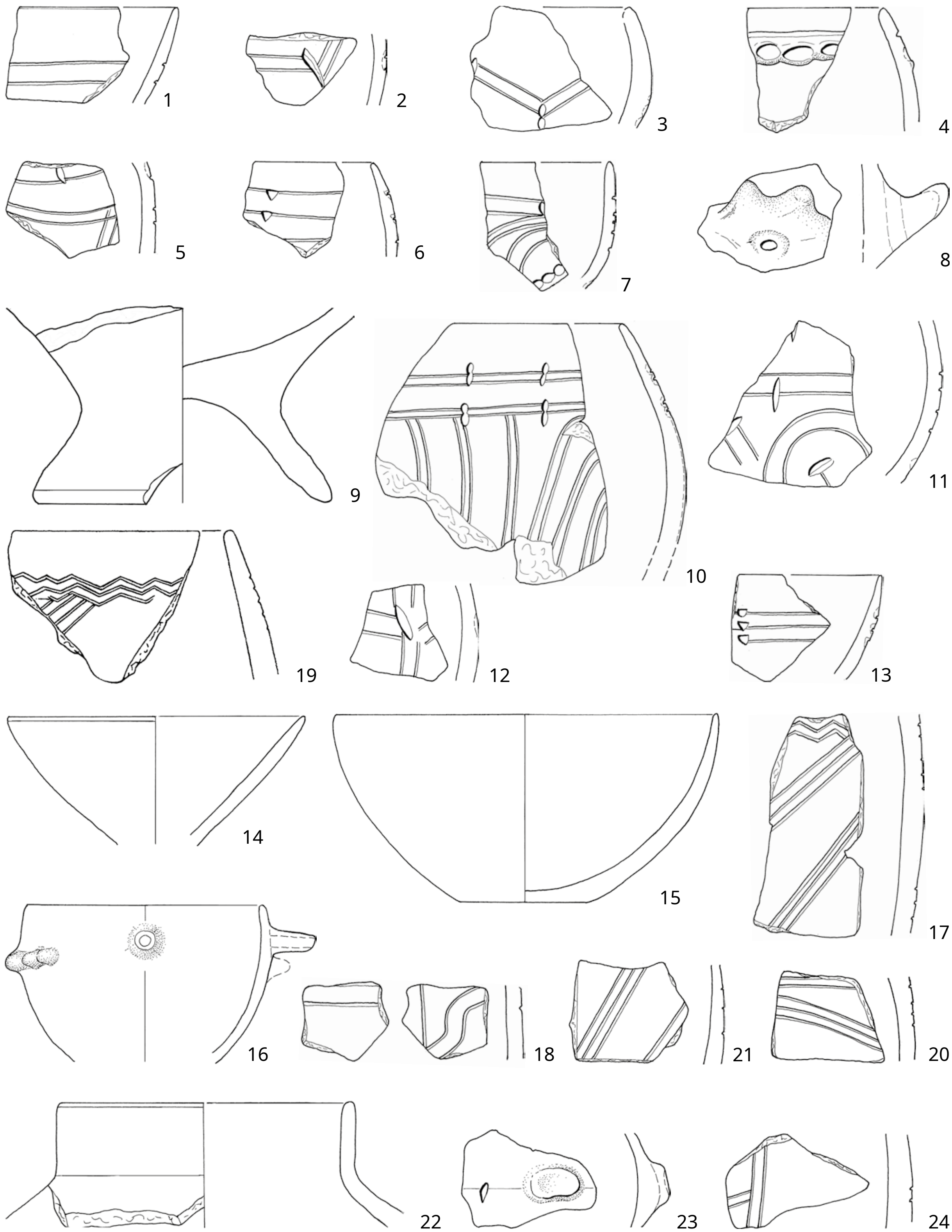

Plate 5.1.40. Selected ceramic finds. 1-13: trench 10; 14-16: trench 11; 17, 18, 21-25: trench 12. 1-13: object 1 (house 262, eastern long pit); 14-16: object 7 (house 131); 17-18, 21: object 57 (house 131, eastern long pit); 22-25: object 65 (house 131, western long pit). 17, 22-25: spit 2; 14-16, 18, 21: spit 3. Scale 1:2 (drawings: E. Bakytová).

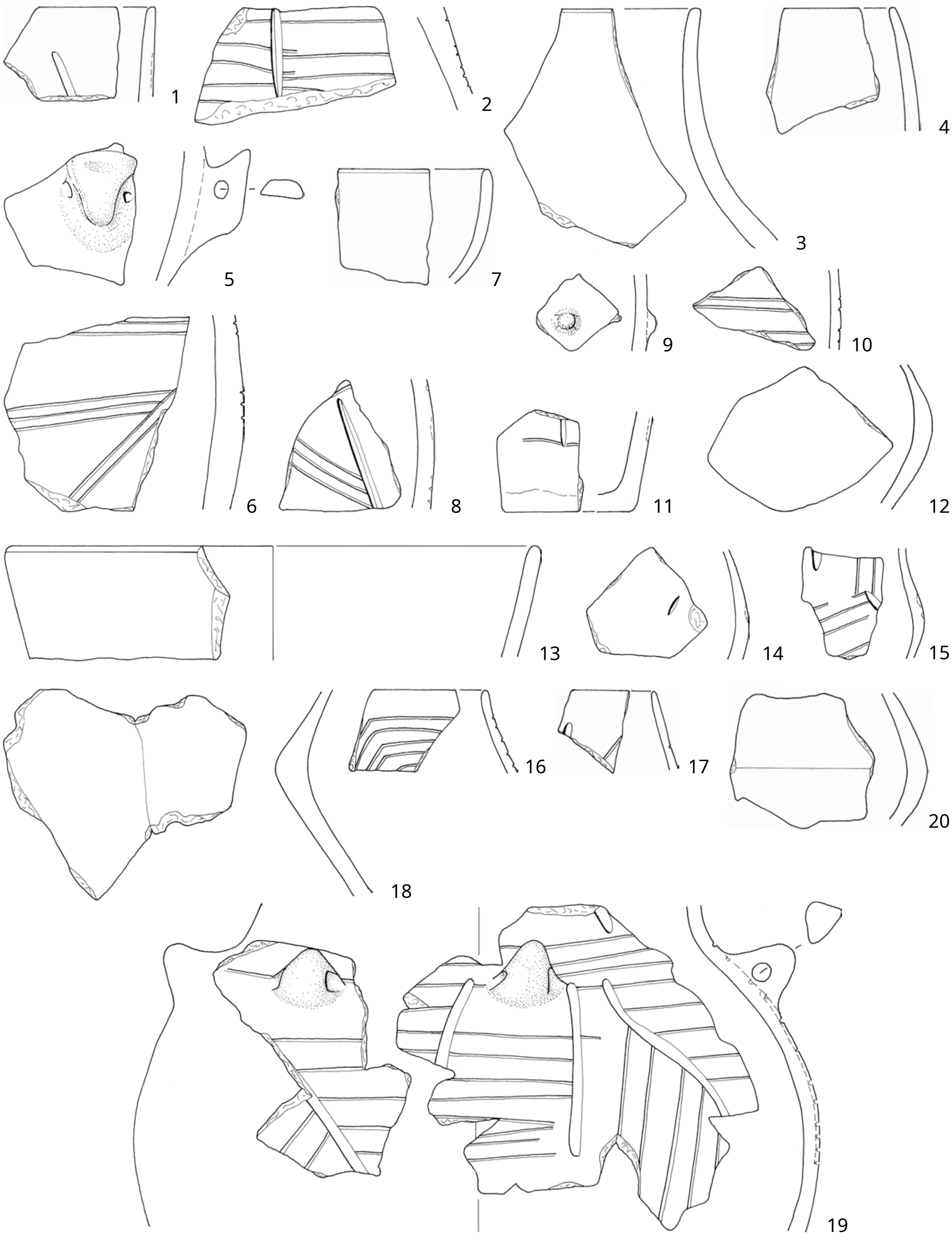

Plate 5.1.41. Selected ceramic finds. 1-19: trench 12; 12, 14, 19, 20: trench 11. 1-9: object 65 (house 131, western long pit); 12, 14, 19, 20: object 1 (house 131, western long pit). 1-19: spit 1; 3-11, 13, 15, 18, 20: spit 2; 12, 14, 19: spit 3. Scale 1:2 (drawings: E. Bakytová).

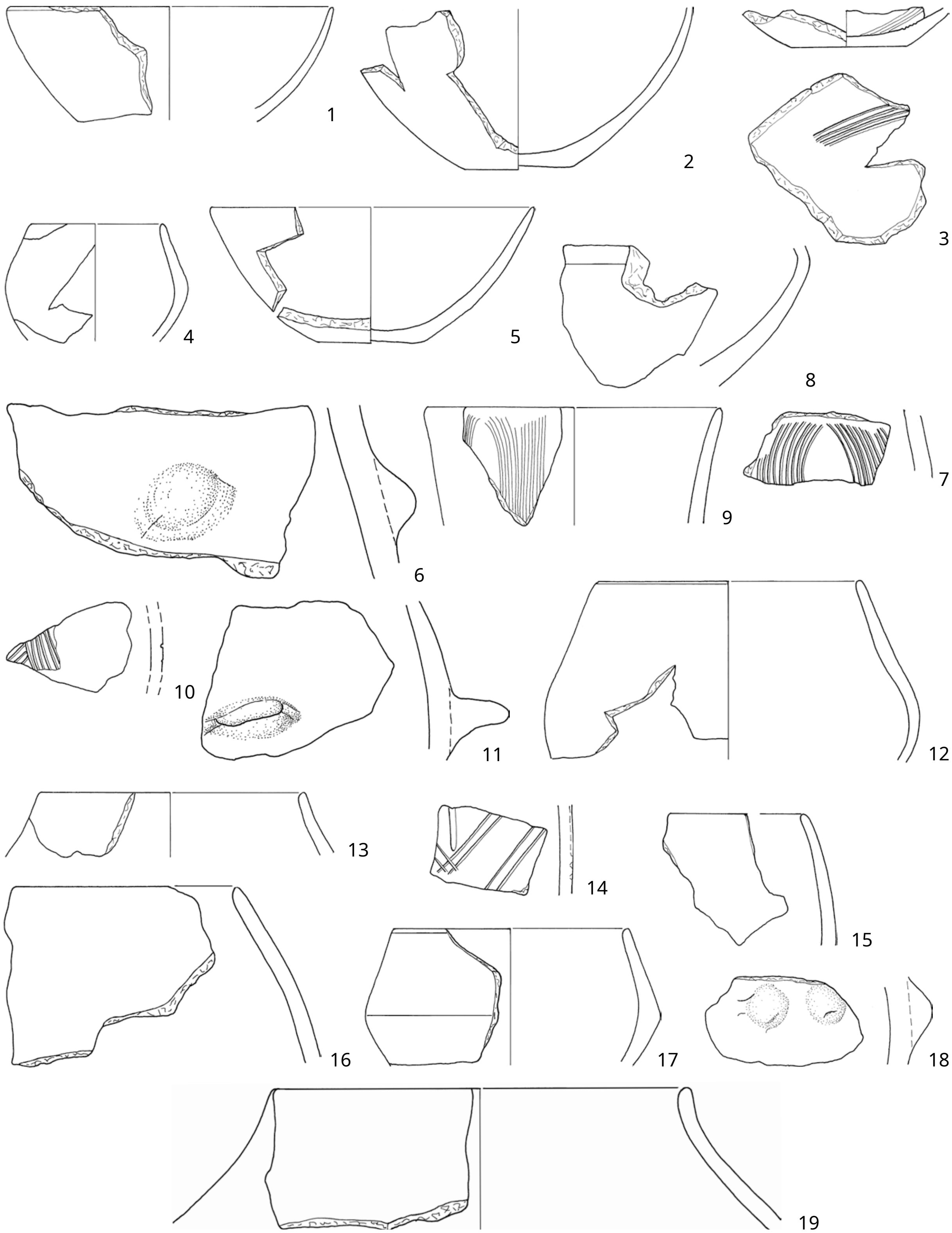

Plate 5.1.42. Selected ceramic finds. 1-10: trench 11; 11-19: trench 12. 1: object 10 (house 132, western pit); 2-3, 5: object 12 (house 132, western pit); 4: object 11 (house 132, western long pit); 6: object 15 (house 132, western long pit); 7-19: object 9 (house 132, western long pit). 1, 4, 7-10: spit 2; 11: spit 3; 2-3, 5: spit 4; 12-19: spit 5. Scale 1:2 (drawings: E. Bakytová).

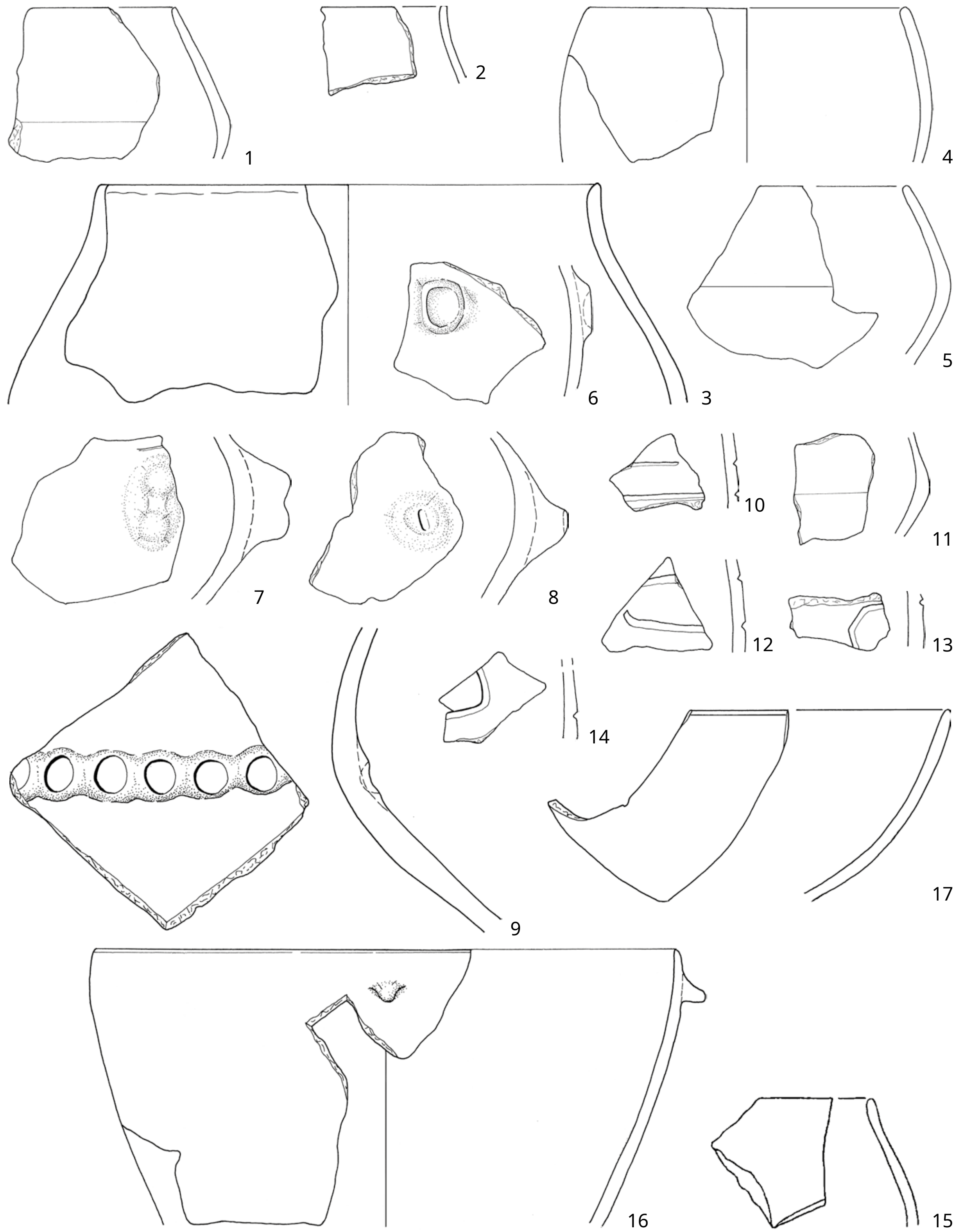

Plate 5.1.43. Selected ceramic finds. 1-14: trench 12; 16-17: trench 11. 1-14: object 9 (house 132, western long pit); 16-17: object 24 (house 132, eastern long pit). 9-14: spit 2; 16: spit 3; 1: spit 5; 2-8, 17: spit 6. Scale 1:2 (drawings: E. Bakytová).

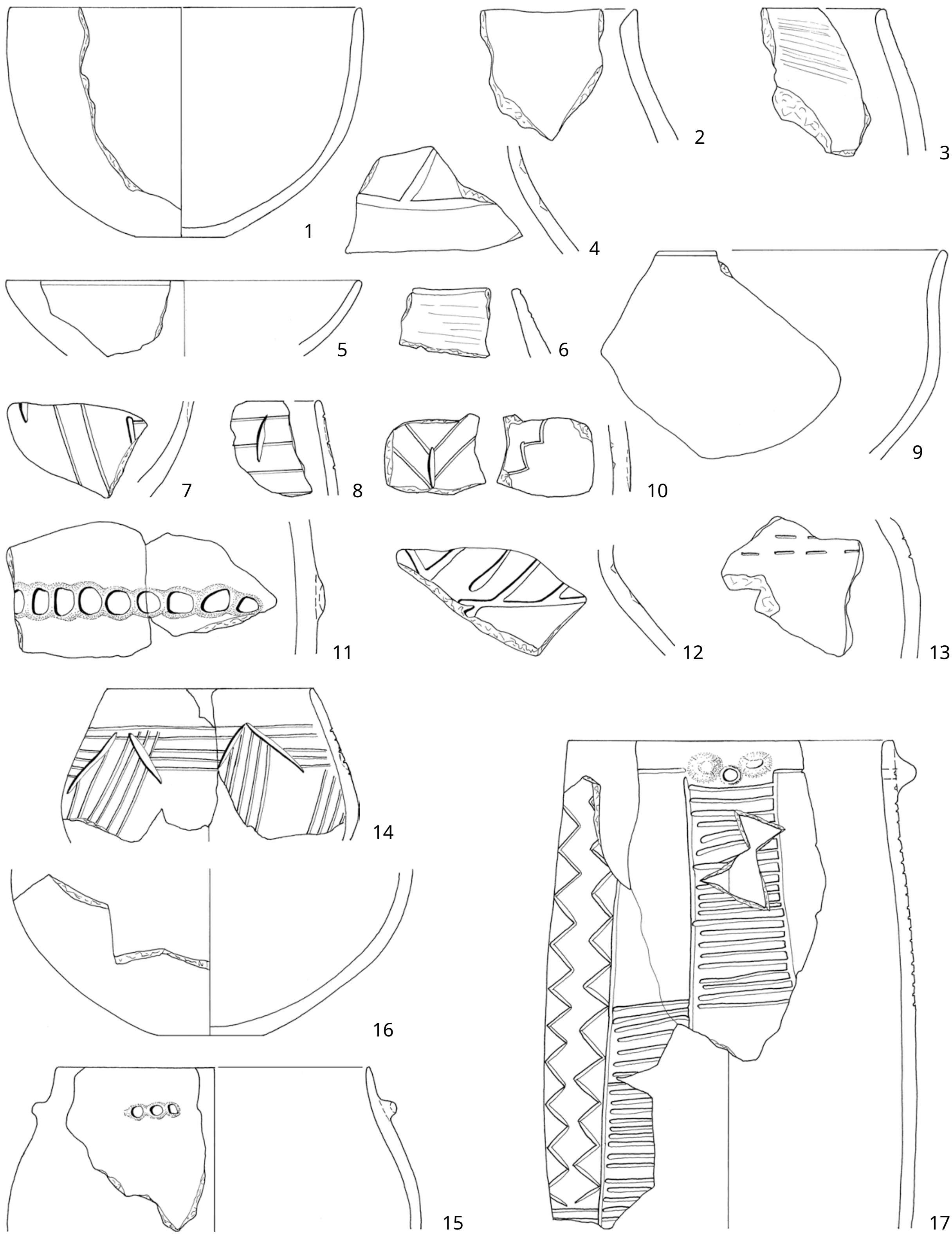

Plate 5.1.44. Selected ceramic finds. 1-14: trench 11; 15-17: trench 13. 1-17: object 24 (house 132, eastern long pit); 5-11, 13-14: spit 2; 12: spit 3; 2-4: spit 5; 1: spit 6. Scale 1:2 (drawings: E. Bakytová).

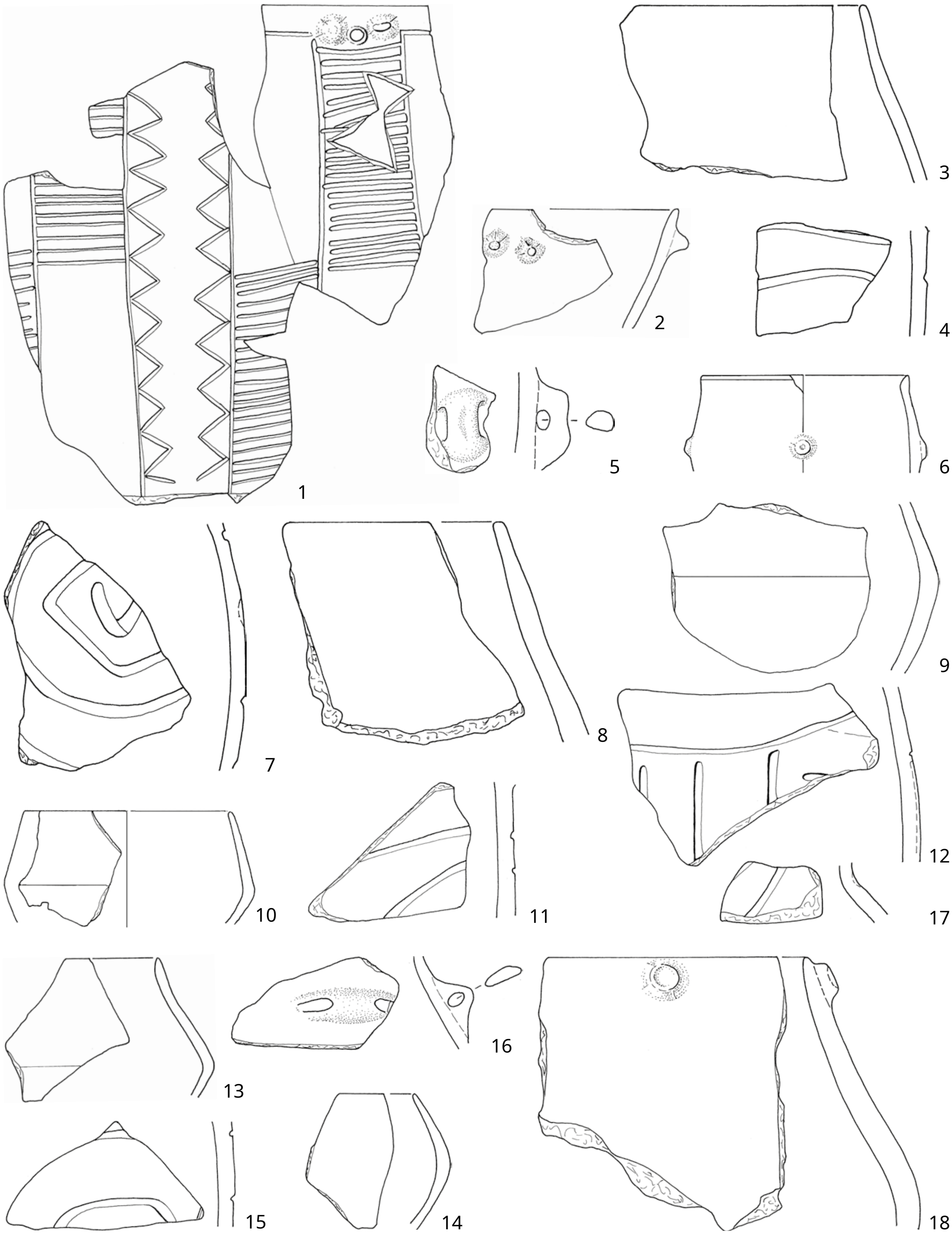

Plate 5.1.45. Selected ceramic finds. 1-3, 18: trench 13; 4-17: trench 11. 1-3: object 24 (house 132, eastern long pit); 4-18: object 26 (house 133, western long pit). 4-5, 7-8, 12-17: spit 2; 6, 9-11: spit 3; 18: spit 4. Scale 1:2 (drawings: E. Bakytová).

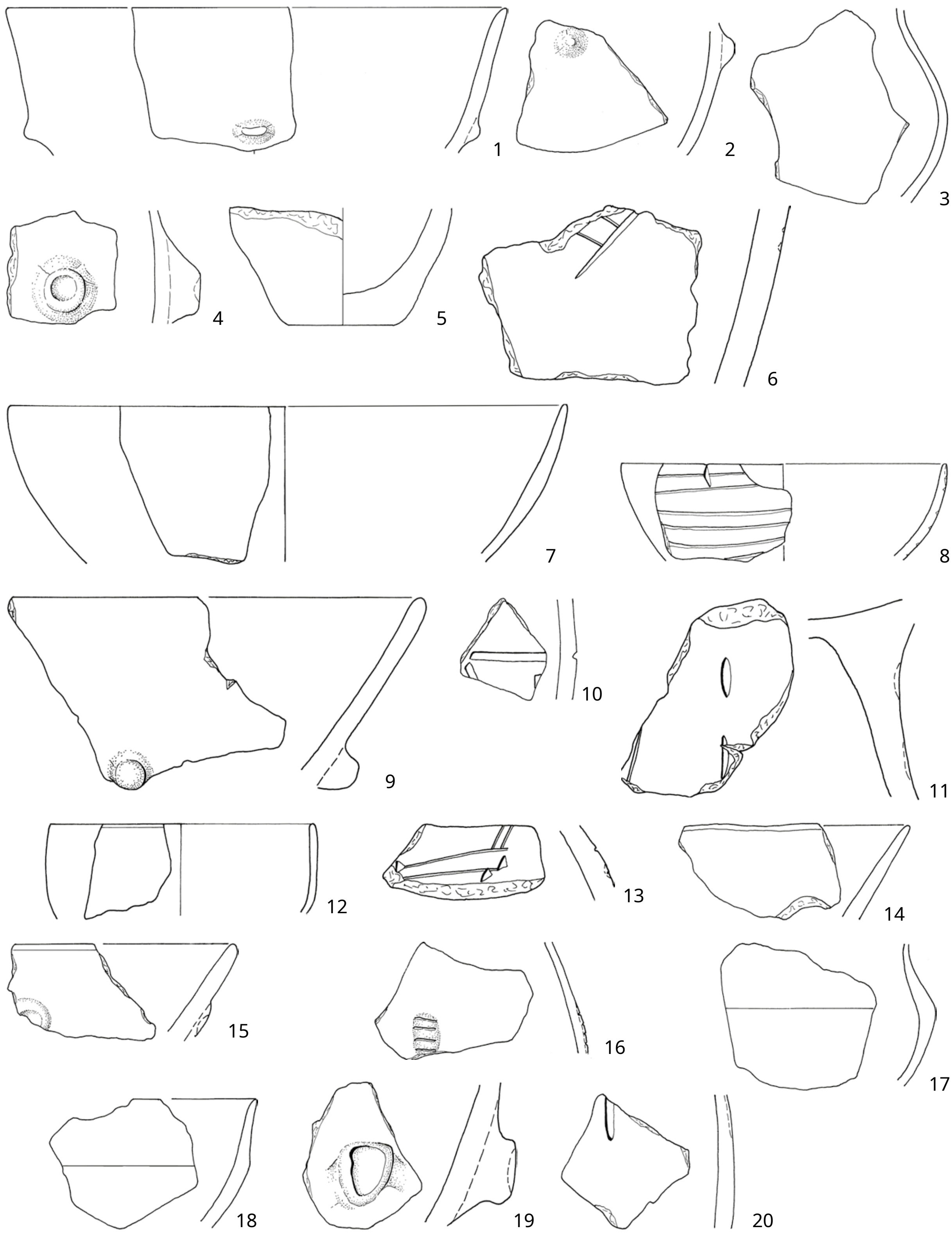

Plate 5.1.46. Selected ceramic finds. 1-5, 12-20: trench 13; 3-11: trench 11. 1-5: object 26 (house 133, western long pit); 6-20: object 37 (house 133, eastern long pit). 10-11, 12-20: spit 2; 6-7: spit 3; 8: spit 4; 1-2, 4: spit 5; 3: spit 6. Scale 1:2 (drawings: E. Bakytová).

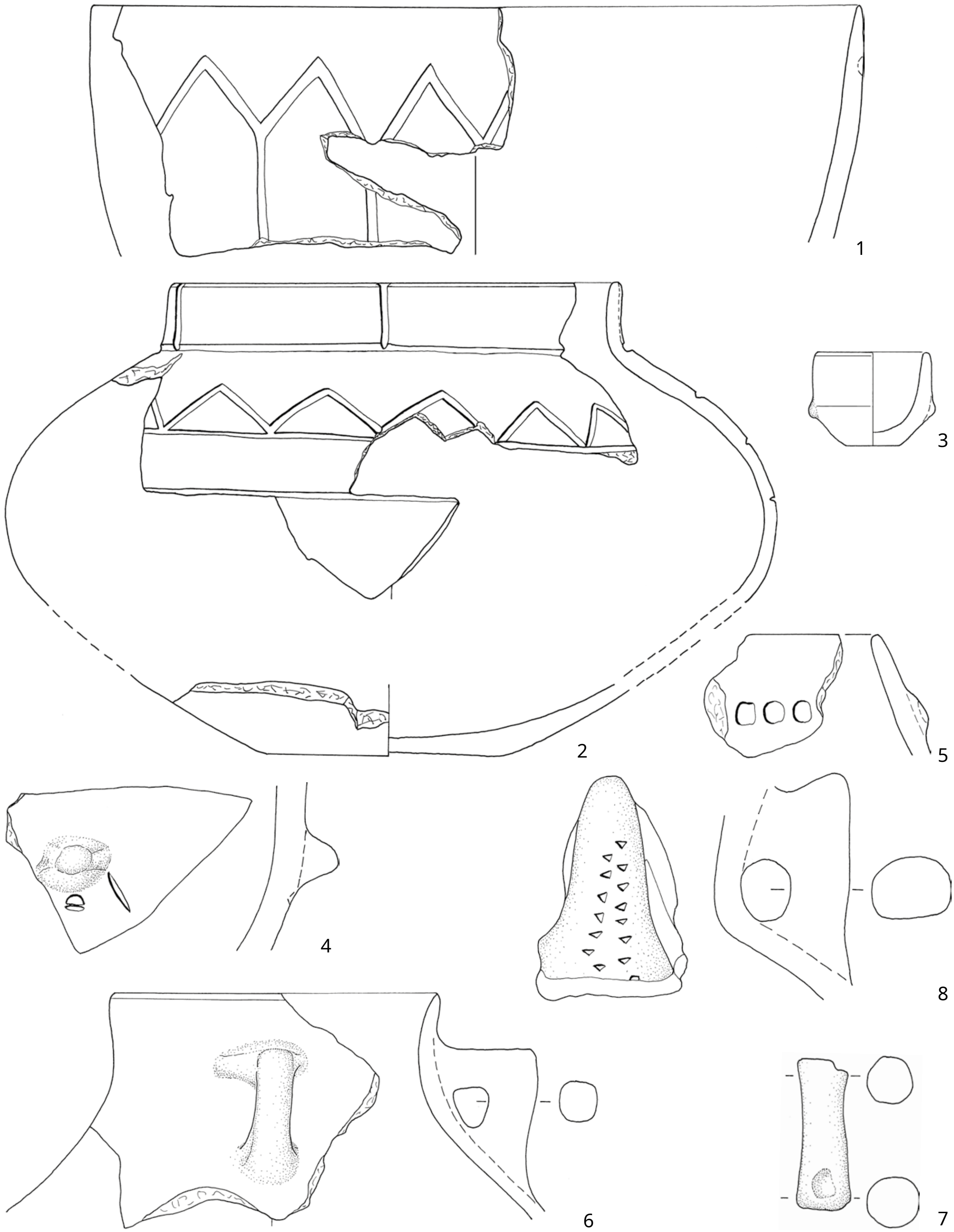

Plate 5.1.47. Selected ceramic finds. 1-8: trench 13. 1-8: object 37 (house 133, eastern long pit). 1-2, 5-6, 8: spit 2; 3, 4, 7: spit 3. Scale 1:2 (drawings: E. Bakytová).

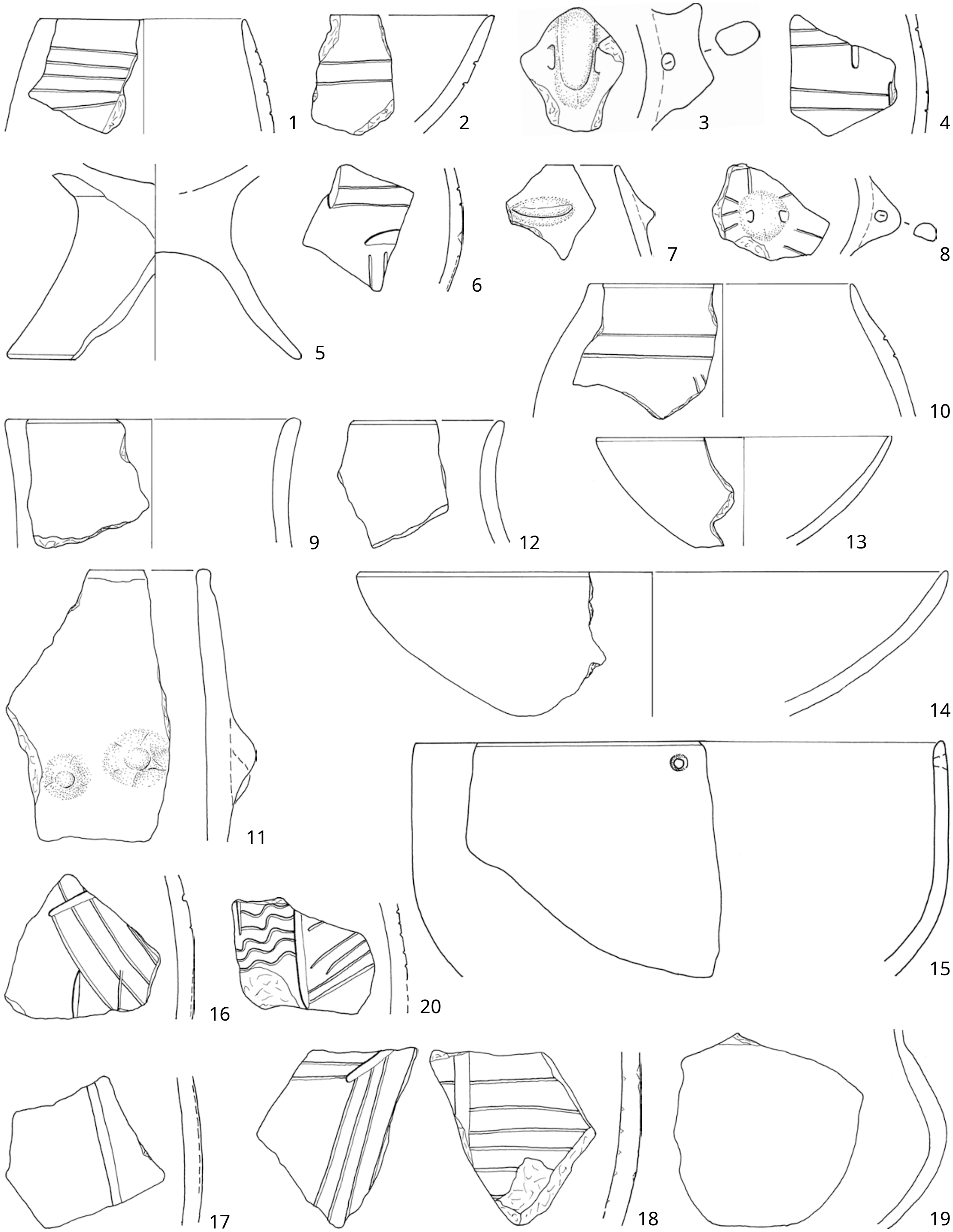

Plate 5.1.48. Selected ceramic finds. 1-8: trench 13; 9-19: trench 14. 1-3: object 113 (house 132, pit); 4-8: object 121 (pit); 9-18: object 144 (house 126, eastern long pit); 19: object 157 (house 126, western long pit). 1, 3, 11, 13-17: spit 2; 3-4, 7, 12, 19: spit 3; 8, 18: spit 4. Scale 1:2 (drawings: E. Bakytová).

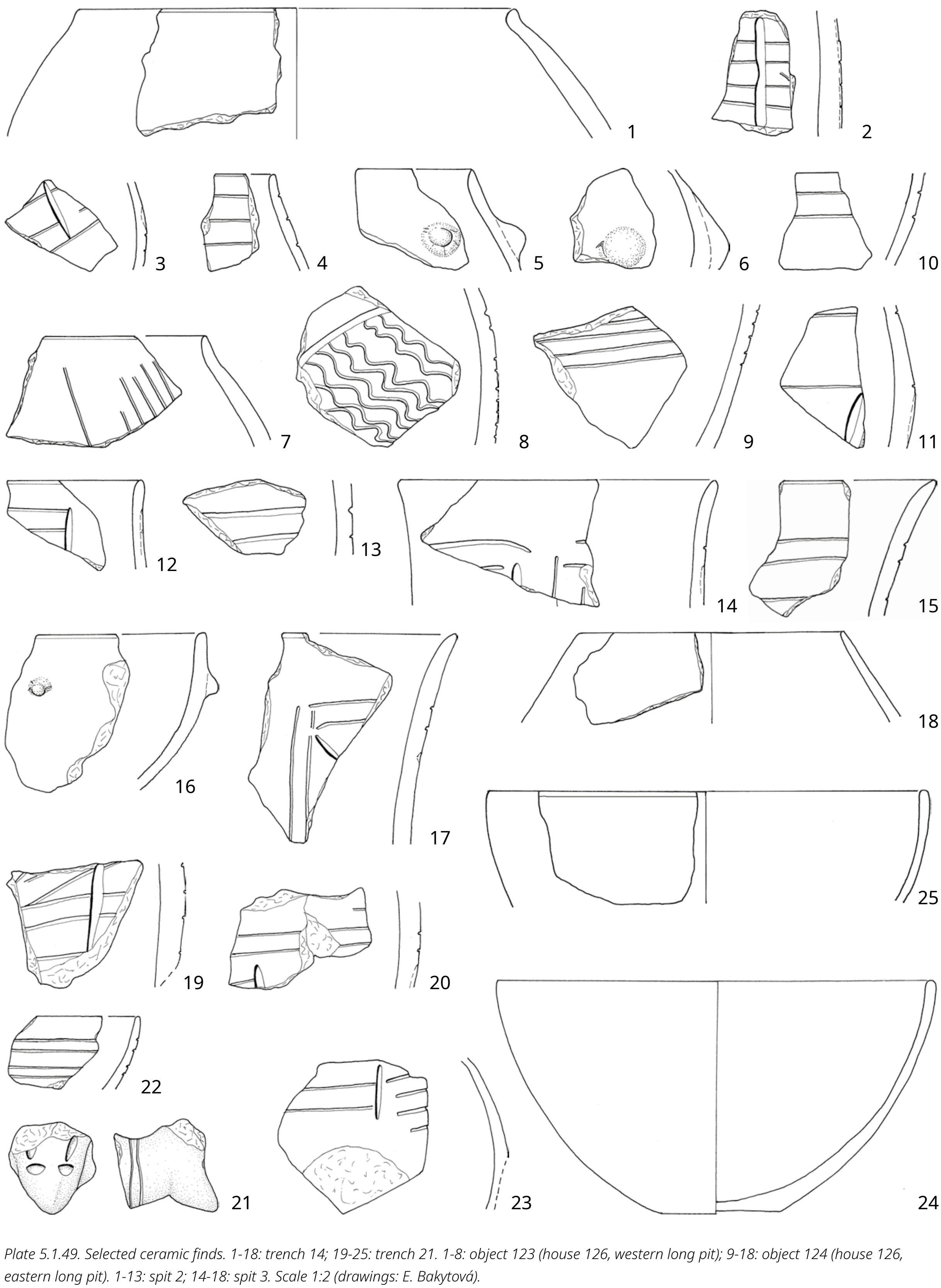

Plate 5.1.49. Selected ceramic finds. 1-18: trench 14; 19-25: trench 21. 1-8: object 123 (house 126, western long pit); 9-18: object 124 (house 126, eastern long pit). 1-13: spit 2; 14-18: spit 3. Scale 1:2 (drawings: E. Bakytová).

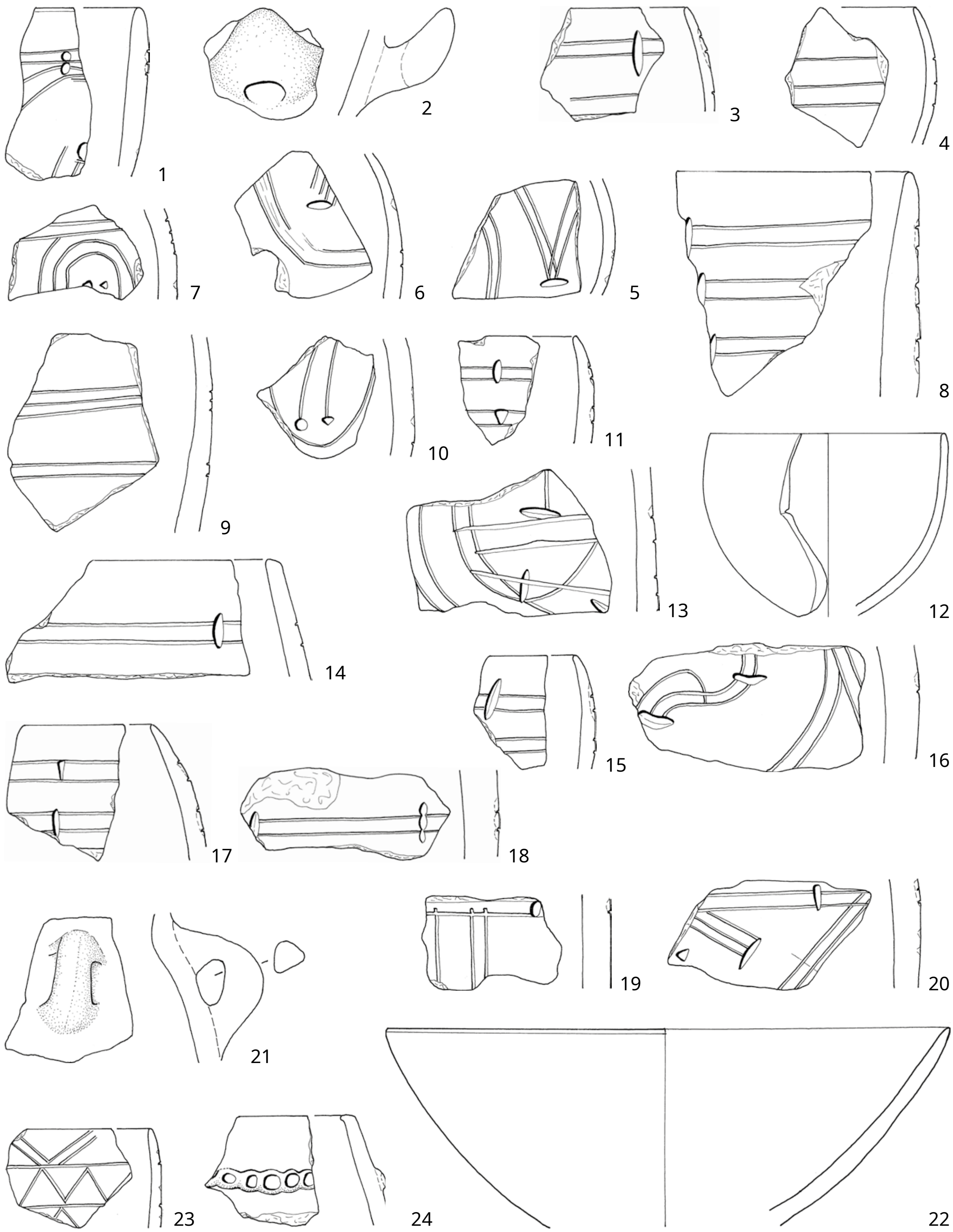

Plate 5.1.50. Selected ceramic finds. 1-4: trench 21; 5-24: trench 22. 1-24: house 23. Scale 1:2 (drawings: E. Bakytová).

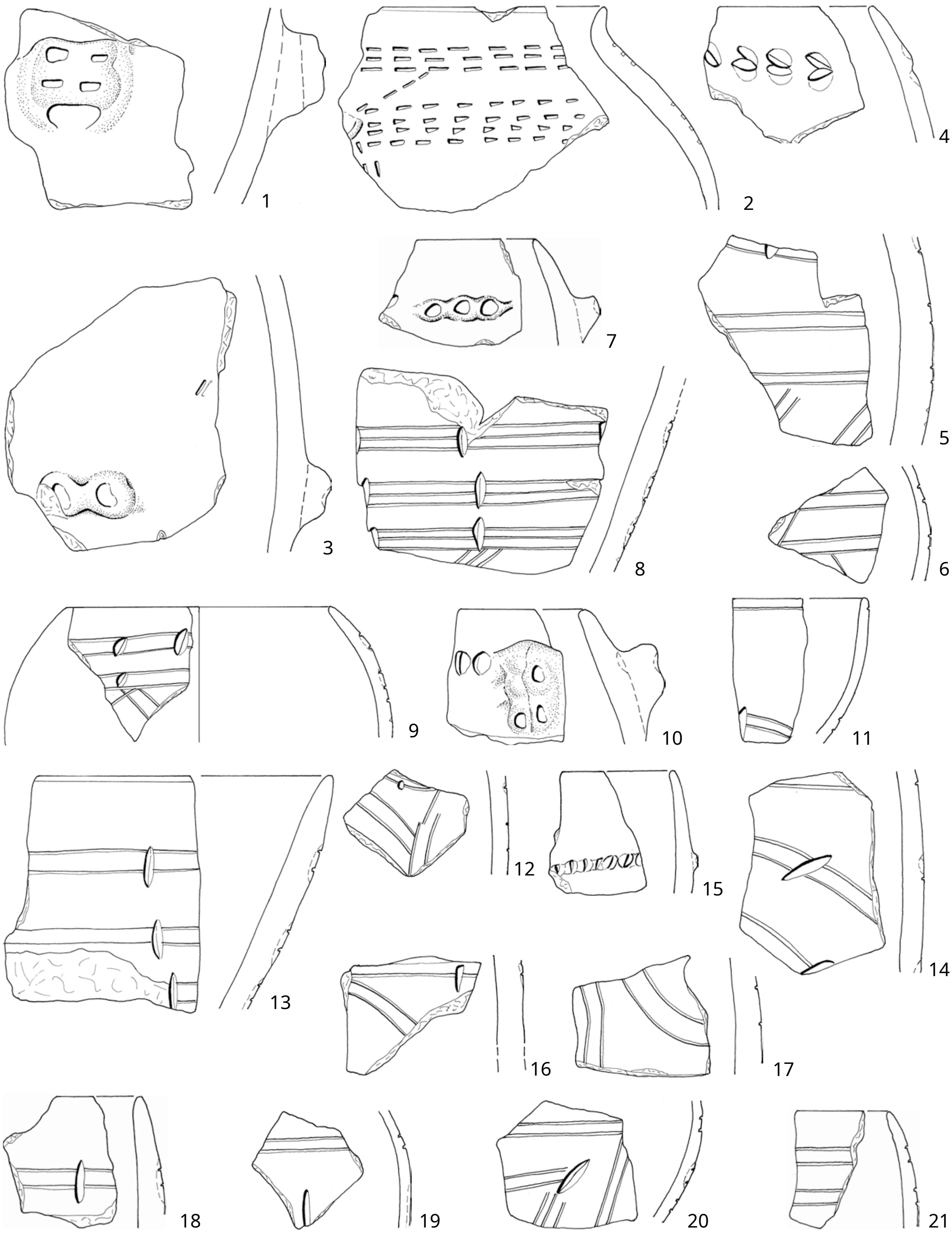

Plate 5.1.51. Selected ceramic finds. 1-21: trench 22. 1-21: house 23. Scale 1:2 (drawings: E. Bakytová).

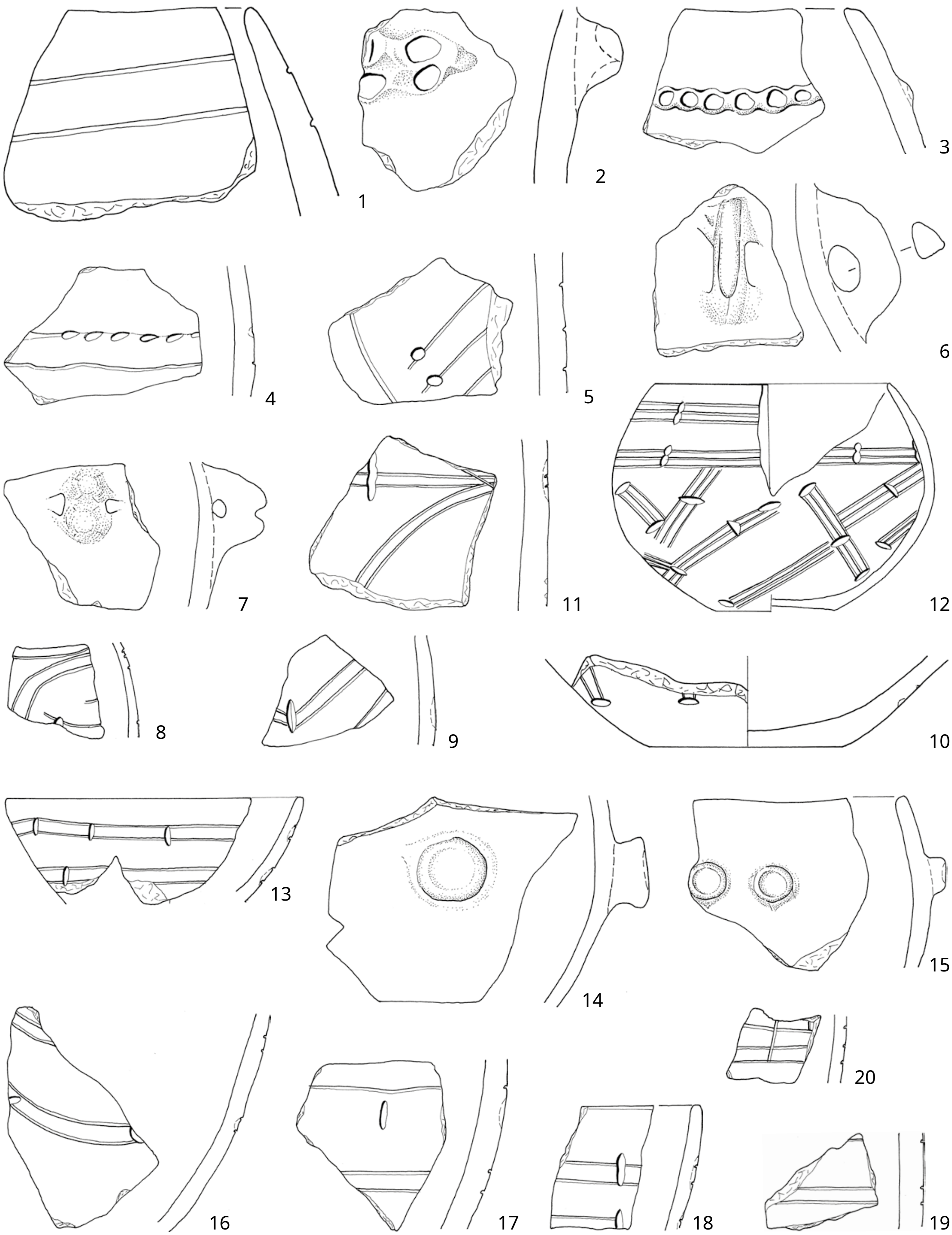

Plate 5.1.52. Selected ceramic finds. 1-15: trench 22; 16-20: trench 23. 1-12: house 23; 13-15: house 317. Scale 1:2 (drawings: E. Bakytová).

5.2. The lithic material from the LBK and Želiezovce settlement site of Vráble

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Abstract

This chapter presents the lithic material from Vráble, consisting of chipped and ground stone tools and debitage. The analysis of the chipped stones shows that different varieties of raw materials, and types of tools were commonly used within the settlement. The use of chipped stones as grave goods is only documented in two case in Vráble, although it must be kept in mind that the number of graves is rather low. From a technical point of view, indirect percussion techniques are traceable within the material record. Further, the existence of core fragments can be linked to the production of chipped stone tools within the settlement.

Ground stone tools in Vráble appear only in small numbers and rather low variation. Despite this limitations, variations in the distribution of the number and types of ground stone tool artefacts are traceable with regard to the different houses and neighbourhoods. This characteristic points towards a possible economic differentiation within the settlement of Vráble, which is also traceable in other find categories, such as animal bones and botanical remains.

Keywords: LBK, lithics, chipped stone tools, groundstone tools, use wear

History and dating of the site

During the archaeological works in 2012-2014, 2016 and 2017, several ground plans of long houses and accompanying long pits from the younger LBK and Želiezovce group have been excavated (Chapter 3.1). So far, fifteen long houses have been examined on the area in question. In addition, a part of the enclosure around the south-western neighbourhood was uncovered. Several burials were found in the settlement and close to the enclosure gates, partly accompanied by stone tools.

Altogether, 359 pieces of chipped stone were found in features attributed to the LBK. From features classified as belonging to the Želiezovce group, only 89 chipped stones were obtained.

Methododological approach

In respect to the methodological approach towards the analysis of the lithic industry, we relied on the works by A. Dzieduszycka-Machnikowa and J. Lech (1976), who use traditional typological-morphological analysis. Other authors, *e.g.* M. Oliva (1998, 2001) or I. Mateiciucová (2002) apply a dynamic-technological approach. Basically, it is a *chaîn operatoire* following the process from obtaining a raw material, to preparation of cores, production of the preforms and final, retouched tools. Both systems are – on the one hand – complemented and, on the other hand, reduced by omitting uninformative records, so that the classification system is adapted as much as possible to the needs of working with collections of Neolithic chipped stone industry. A. Dzieduszycka-Machnikowa and J. Lech elaborated a classification system for the description of the lithic industry based on the finds from the Neolithic workshops at the site of Sąspów. The principle of this method is based on identification and comparing the whole processed collection as well as its individual parts. Thereby, they divided the lithic finds into four basic groups/categories: 1 prepared-core forms and cores, 2 blades and their fragments, 3 flakes and waste, 4 tools. In this work, the classification system is slightly altered. The category of flakes and waste is divided into two separate groups, since the final products – with the exception of blades – are considered to be flakes. This is documented by numerous finds of tools in the collections of Neolithic chipped stone industry made on flakes.

The chipped stone material from the younger LBK

Raw materials

The set of chipped stone industry from the excavated areas contains a wide and varied range of raw materials (Fig. 5.2.1). The most frequent raw material on the site is local limnosilicite. In the inventory, it is represented by as many as 130 exemplars (39 %). The second well represented raw material is obsidian (103 pieces). Together with obsidian, Volhynian flint arrived to the site from eastern Slovakia (1 piece). Other imported raw materials identified in the assemblage include Kraków-Częstochowa Jurassic silicite (30 pieces), Szentgál radiolarite (31 pieces) and Tevel flint (28 pieces). In the collection, there were four pieces of radiolarite whose origin can be sought in the klippen belt. The assemblage contained a new, previously undescribed type of a raw material identified as a siliceous substance of volcanic origin (9 pieces). So far, it has not been identified in any collection obtained at Neolithic or Eneolithic settlements or in collections with Paleolithic industry. It is a silicite raw material whose primary sources are situated in the area of the neovolcanites of Central Slovakia, where it is bound to rhyolite bodies. In rhyolite, it creates several centimetres thick layers which can be a few metres long. During an intense survey, one of the authors (M. Ch.) identified one of the primary sources of this raw material near the town of Hliník nad Hronom. In 20 cases, it was not possible to identify the raw material, since the artefacts were damaged by fire. Three artefacts in the collection were patinated.

From the preservation of the original surface we can assume that raw materials such as Kraków-Częstochowa Jurassic silicite, Szentgál radiolarite, Tevel flint

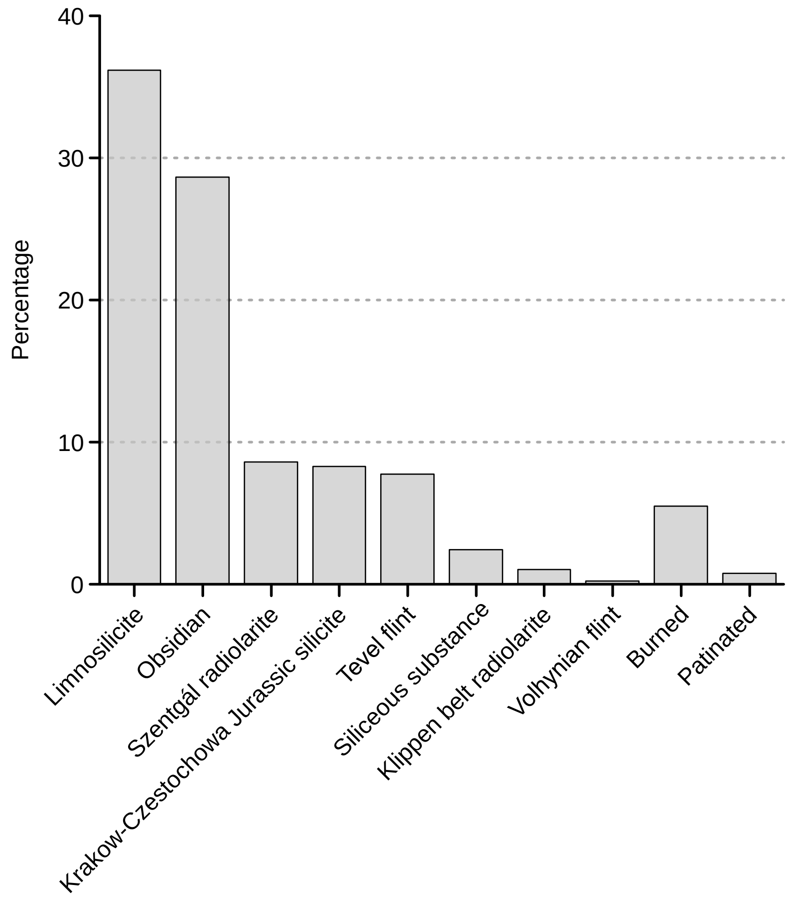


Fig. 5.2.1. Raw material types represented in features attributed to the LBK in Vráble (identified pieces, n = 359).

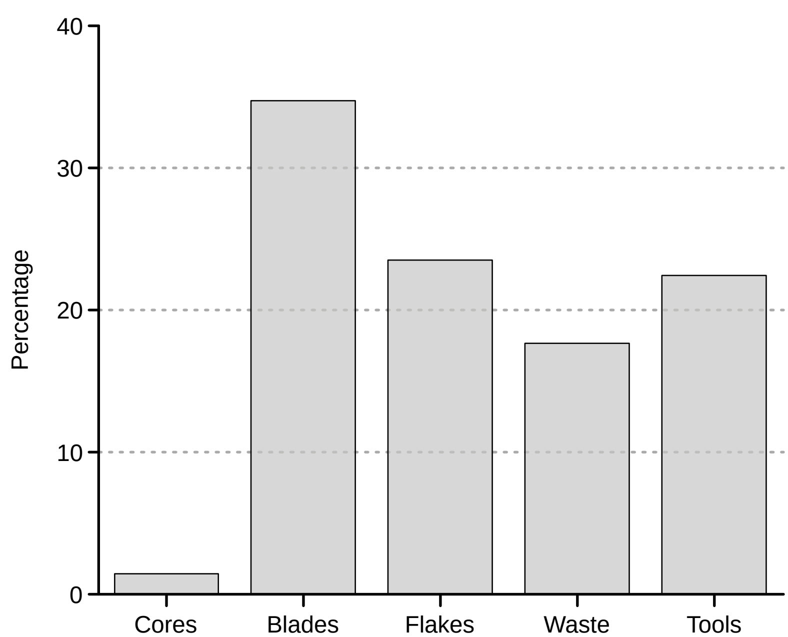


Fig. 5.2.2. The different technological categories from features attributed to the LBK in Vráble (n = 463).

	LS	KCJS	Ra-Szentgál	OBS	RA	Tevel flint	Siliceous substance	Volhynian flint	Patinated	Burned	Total
Cores	6			1							7
Blades and their fragments	34	18	12	59	3	16	7	1	1	10	161
Flakes	58	9	6	21	1	10	2		1	1	109
Waste	32	3	13	22		2			1	9	82
Tools	27	12	9	29	2	10	5	1	1	8	104
Total	157	42	40	132	6	38	14	2	4	28	463

Table 5.2.1. Cross-tabulation of raw materials and artefact groups from features attributed to the LBK.

and obsidian were transported to the settlement unprocessed or processed only very roughly. The original cobble surface detected on limnosilicites suggests that secondary sources from the gravel of the Hron river were used. However, limnosilicite could also have been obtained from the Volková strata complex coming to the surface between the villages of Tajná and Nevidzany (10 km from Vráble).

The chipped stone industry studied represents the elements of all stages of the production process, starting with preform blades and flakes, secondary blades and bladelets from the core edge (subcrest) to final blades, bladelets and flakes (Fig. 5.2.2). The collection contains large numbers of blades and flakes from the reparation phase of the production sequence. They are represented by rejuvenating pieces from the reduced or striking platforms of the core. In addition, waste and final tools appear. The most numerous group are blades and their fragments. They are followed by flakes. The tool category makes up almost a fifth of the whole chipped stone industry collection analysed.

Cores

Seven artefacts in total were classified in the group of cores (Table 5.2.1). Two pieces from limnosilicite with traces of manipulation occurred in the collection. One piece was used as a knapper.

Most cores – with the exception of an obsidian one – were made of limnosilicite (5 pieces). One artefact was a fragment of a single-platform core (Pl. 5.2.6,3) with the striking platform modified by repeated striking. The core edge was not modified. Negatives suggests that flakes were reduced from it. Two prismatic double-platform cores (*e.g.* Pl. 5.2.6,2) had their platforms modified by reduction of a series of flakes. On one of them, modification of the core edge by removal of overhanging material was detected. Both cores were from the advanced phase of reduction. Both cores were discarded after knapping accidents took place during reduction. The negatives on the reduced surface of cores point to reduction of flakes and blades. The striking surfaces of two single-platform cores (*e.g.* Pl. 5.2.6,4) of pyramidal shape were treated by multiple striking. Core edges of both individuals were modified by removal of overhang. Both cores were from an advanced stage of reduction. The reason for their rejection was impossible to determine. From one core only flakes were won, from the other both flakes and blades. A single-platform obsidian core of pyramidal shape (Pl. 5.2.2,1) had a striking platform modified by several strokes. Modification of the core edge was not detected. Based on the negatives captured on the reduction surface of the core, we can conclude that only bladelets and flakes were obtained from the core during its advanced phase of reduction. At this stage of the core, it was no longer possible to remove blade blanks.

	Blades	%	Bladelets	%
Complete	12	11%	7	26%
Proximal	9	9%	1	4%
Proximal-mesial	27	25%	6	22%
Mesial	38	36%	10	37%
Mesial-distal	11	10%	1	4%
Distal	9	9%	2	7%
Total	106	100%	27	100%

Table 5.2.2. Number and percentages of blades, bladelets and their fragments in features attributed to the LBK.

Blades and their fragments

161 artefacts were classified as blades and their fragments (Table 5.2.1). 12 pieces of complete blades occurred in the assemblage (Pl. 5.2.7,1-4). Only 7 complete bladelets have been preserved. A considerable part of the blades was in a fragmentary state (Table 5.2.2). Among them dominated mainly fragments of the mesial part of blades (38 exemplars) and bladelets (10 exemplars). Other blade fragments were determined proximal (9), proximal-mesial (27), mesial-distal (11), and distal (11). The bladelets have a similar trend. Six pieces were detected from the proximal-mesial, one piece from the mesial-distal and proximal and two pieces from the distal parts.

Eight blades and three bladelets appeared from the core preparation phase (Pl. 5.2.7,5; 5.2.7,7 and 5.2.10,11). They suggest that the raw materials were brought to the site in an unprocessed or only partially prepared condition and were there made into pre-core forms and cores. This idea is reinforced by the presence of four crested blades and one crested bladelet (Pl. 5.2.3,9; 5.2.7,6; 5.2.7,8 and 5.2.10,11). Reduction of the cores at the site, in addition to blank processing, is also evidenced by reparation flakes, which were struck to repair of the cores if a technological error occurred. Ten reparation blades and one reparation bladelet were identified. In two cases, a blade modifying the striking surface of the core was identified (Pl. 5.2.7,10 and 5.2.8,1). Types of butts, such as plain, dihedral and faceted, were identified on the blade preforms. As for the bladelet preforms, only plain butts were identified. A lip was observed only on three pieces. On final bladelets, faceted (4), linear (2), dihedral (2), plain (4) and punctiform (1) butts occured. A lip was recognized on one plain butt. As for blades, faceted (25) and plain (12) butts prevailed. In six cases, the butts were linear; dihedral, punctiform and secondarily retouched butt occurred once each. A wing-shaped faceted butt was identified on one blade. A lip was observable on 13 butts only – either faceted (7 exemplars) or plain (5 exemplars). On two artefacts, the detected butt was bipoled. On reparation blades, faceted (3 exemplars, two butts with a lip) and plain (3 exemplars, one butt with a lip) butts were predominant. On two exemplars, the butts were dihedral and linear with bipoled edges.

In twelve blades, a modification of the angle between the platform and exploited surface by means of dorsal preparation was documented. Modification of the core edge by removing overhang was documented in 26 cases. From the preserved traces on blade preforms, it can be said that they were struck indirectly, using a punch (3) and directly, using a soft organic percussor (2). As for reduction of blades and bladelets from single-platform cores (two blades were reduced from a double-platform core), the technique of indirect reduction with use of a punch was most frequent (12 exemplars). For eight pieces, that can only be assumed. In ten cases, the reduction was achieved using direct soft percussion; direct strokes with a soft anorganic hammer was identified on twelve exemplars. Five blades were struck either by direct soft percussion or by indirect blow. On two obsidian pieces, it was not possible to identify the technological choice. The use of a direct impact with a soft organic (3 pieces) and inorganic (3 pieces) markers was recognized for removing the reparation blades. The three blades extracted to repair the core were removed by an indirect blow using an intermediate implement.

Flakes

The group of flakes consisted of 109 pieces (Table 5.2.1). The set included eight pieces of original cortex, one with a plain butt, one wing-shaped, one dihedral and one plain butt with cortex. The most numerous group is the unspecific flakes (55 pieces); there is also one massive flake. Several types of butts were identified on the flakes. Plain butt dominates (15 pieces) followed by faceted one (12 pieces). Two bipoled edges were detected on two plain butt and one faceted butt. Linear and dihedral butts were determined on three pieces. Two butts were secondarily retouched. Lips were observable on seven – mainly faceted and dihedral – butts. Modification of the angle between the platform and the exploited surface using dorsal preparation was detected on eight flakes. On three pieces, a modification of the core edge by the removal of overhang was detected.

45 flakes from the reparation phase of the core were discovered. In two cases, massive reparation flakes with punctiform and plain butts (with lips) were detected. Two percussion points as punctiform butts were observable on one massive flake which was not separated from the core by the first one. The second one was situated next to it and separated it. It might suggest a lack of skill of the flintknapper. Thirteen flakes rejuvenating the striking surface of the core – tablets – were detected in the assemblage. Among the butts identified on the tablets, four plain (one butt edge was bipoled) and one faceted, one punctiform, one linear, one dihedral and one secondarily retouched butts occurred. Lips were observed on two plain butts. Four butts were typologically undeterminable.

30 pieces from the assemblage were identified as flakes rejuvenating the exploitation surface of the core and three flakes came from the core edge (part of a platform and part of the exploited core surface). Among the reparation flakes, plain butts (13 exemplars) were predominant, on four of them, lips were detected. One edge of a plain butt was bipoled. Faceted butts were identified on four exemplars. Presence of lips was detected on three exemplars. From other butt types, one punctiform, one linear and one secondarily retouched butts occcured. One reparation flake rejuvenating the exploited core surface was interesting. Another flake had two such points on his butt. The first strike was an unsuccessful attempt to knap the intended flake, and only the second strike, placed next to the first, managed to remove the flake. Such unsuccessful knapping attempts can be attributed to the inexperience of the knapper.

An indirect percussion technique was used to remove the preparatory flakes by using an intermediary piece (3 pieces). The technique of reduction by means of indirect strokes using a punch (18 pieces) dominates among the flakes. Exploitation by direct strikes using a soft organic hammer was applied on five flakes. Two artefacts were reduced either indirectly using a punch or by means of direct striking with a soft organic hammer. In one case, a direct blow with a hard hammer occurred and five flakes were struck using a direct blow with a soft inorganic implement. For reduction of rejuvenating flakes, direct strikes using a soft anorganic hammer (8 pieces) and direct stroke using a hard anorganic hammer were observed most frequently. In one case, it was impossible to say whether direct striking using a soft or hard anorganic hammer was used. Indirect reduction using a punch was documented on eight pieces from the rejuvenation phase. A direct blow with a soft organic hammer appeared in eight cases.

Waste

From the whole lithic assemblage obtained from the settlement, 88 pieces were identified as waste (Table 5.2.1). Mainly microflakes (so-called splinters), fragments of blades and flakes as well as fragments of tools are represented.

Tools

The assemblage of tools contains 104 exemplars (22 % of the whole collection). Besides retouched artefacts, pieces with traces of wear (so-called use-wear retouch) and pieces with sickle-gloss were classified as tools (Table 5.2.3; Fig. 5.2.3). Mainly blades, bladelets and their fragments (58 pieces) were used for production of tools. In 26 cases, flakes were used. Besides blade, bladelet and preform flakes, in 16 cases pieces from the preparation or rejuvenation phase were used.

The most frequent tools are retouched blades, bladelets and their fragments (21 pieces). Blades and bladelets with lateral, bilateral retouch or straight and oblique retouch on the distal end were the most numerous in the assemblage (Pl. 5.2.7,6; 5.2.7,10 and 5.2.8,3-4). In rare cases, convex or concave retouch was detected. Eight pieces had modified mesial platforms and either their lateral edges or end distal platforms were trimmed (Pl. 5.2.7,3 and 5.2.8.5-6). Trapezes did not occur in the assemblage. In one case, a subcrest blade with a notch situated in its distal part was detected (Pl. 5.2.7,9).

Apart from retouched blades, also a relatively high number of retouched flakes (8 pieces) were detected. Most often, lateral and terminal distal (oblique, concave and convex) retouch occurred (Pl. 5.2.8,7-8 and 5.2.8,10).

The group of end-scrapers is represented by 16 artefacts. Blades as well as flakes were used for their production. Blade end-scrapers prevail with 8 pieces (Pl. 5.2.8,9 and 5.2.8,11-12). A tall blade end-scraper was identified in one case (Pl. 5.2.7,7). The mesial part of a blade was used for the production of a bilateral end-scraper (Pl. 5.2.8,13).

The re-use of artefacts with a different primary function (most often blades with sickle-gloss) which ceased to fulfil their original function due to blunted edges as end-scrapers as well as other tools (see drills, fragments of tools) is a frequent phenomenon. Such a secondary use of artefacts might suggest economic use of raw material. One such end-scraper was identified (Pl. 5.2.9,1).

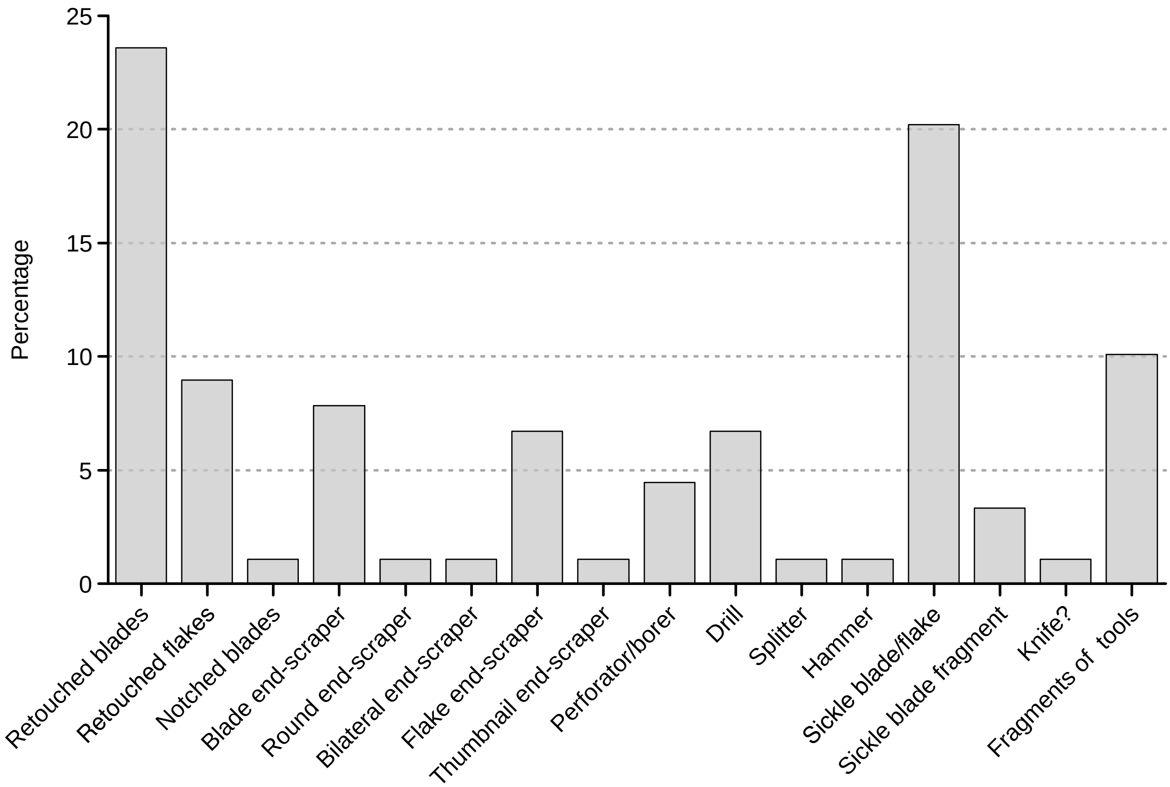
Two end-scrapers were bilaterally retouched (Pl. 5.2.9,2-3). Six flake end-scrapers were discovered (Pl. 5.2.9,4-7; 5.2.9,9 and 5.2.14,5). One rounded end-scraper (Pl. 5.2.9,8) and one thumbnail end-scraper (Pl. 5.2.9,10) were made from preform flakes.

Tools for treatment and processing of organic materials, such as drills and perforators, were also identified. The group of drills contains 6 specimens. Thin pieces with slightly offset or non-offset basal parts occurred (Pl. 5.2.9,11-12) as well as an untypical drill with irregular edges in the basal part (Pl. 5.2.9,13). This group is complemented by a massive drill with removed basal part. In one case, a sickle blade was re-used as a fine drill with offset basal part (Pl. 5.2.9,14). One bilaterally retouched blade can be identified as an unfinished drill. Only four artefacts in the collection were identified as perforators and borers. Three of them were thin, without offset basal part (Pl. 5.2.9,15-16) and one had an untypical shape.

One blade with removed distal part and with traces of wear on the lateral edge could be interpreted as knife (Pl. 5.2.10,1).

One tool made from the mesial part of a bladelet was identified as splitter.

In the lithic assemblage, nine damaged (broken) tools were identified. Fragments of end-scrapers were detected most frequently (4 pieces) (Pl. 5.214,1). One fragment of a thumbnail end-scraper showed sickle-gloss on its edge (Pl. 5.2.10,2). Three fragments of retouched tools and one fragment of a thin drill (Pl. 5.2.10,3) without offset basal part made from a sickle blade were also identified in the assemblage. A fragment of a slim piercing tool with broken point and basal part was found as well.



	LS	KCJS	Ra-Szentgál	OBS	RA	Tevel flint	Siliceous substance	Patinated	Burned	Total
Retouched blades		1	3	13	1		2		1	21
Retouched flakes	5			2		1				8
Notched blades							1			1
Blade end-scraper	1	1	1			3		1		7
Round end-scraper		1								1
Bilateral end-scraper						1				1
Flake end-scraper	4	2								6
Thumbnail end-scraper	1									1
Perforator/borer	3	1								4
Drill		2	1	2					1	6
Splitter				1						1
Hammer	1									1
Sickle blade/flake	7	3	1			4	2		1	18
Sickle blade fragment									3	3
Knife?					1					1
Fragments of tools	4		1	2		1			1	9
Total	26	11	7	20	2	10	5	1	7	89

Artefacts with sickle-gloss make up a large group within the group of tools. Not only blades and their fragments were used as sickle tools, but also flakes. Four pieces with sickle-gloss were classified as flakes (Pl. 5.2.10,4-6 and 5.2.10,9). Two of them had straight distal retouch (Pl. 5.2.10,4 and 5.2.10,6). As many as 14 pieces with sickle-gloss were made from blades and their fragments (Pl. 5.2.10,7-8; 5.2.10,10-12 and 5.2.11,1-7). In most cases, the mesial part was used (6 pieces) (Pl. 5.2.10,7; 5.2.10,11-12 and 5.2.11,1-3). Two complete blades were also used as sickles (Pl. 5.2.11,5 and 5.2.11,7). One of them was modified by means of oblique distal end retouch (Pl. 5.2.11,5). Several sickle blades were retouched – either straight-transverse or oblique – on their distal or proximal end (Pl. 5.2.11,1-7). Final retouch was carried out on purpose, to reinforce the edge and facilitate mounting and fixing of organic handles. Also their lateral edges were often modified by retouch (denticulation also occurs). One segment with straight distal denticulated retouch and oblique proximal retouch was discovered.

Three burned fragments of blades with sickle-gloss were also identified. Modification of the lateral or distal part by means of retouch was identifiable on them.

Nine blades, four bladelets and two tablets with traces of wear (so-called use-wear retouch) on lateral edges were also classified as tools.

The chipped stone material from the Želiezovce group

Raw materials

The composition of chipped stone raw materials from the Želiezovce group is more or less similar to that of the LBK. Limnosilicite and Kraków-Częstochowa Jurassic silicite dominate. Other silicites such as obsidian, Szentgál radiolarite and Tevel flint are considerably rarer than in LBK features. The local limnosilicite makes up nearly one half of the raw material in the whole assemblage (Fig. 5.2.4; Table 5.2.4). The second most frequent material is the Kraków-Częstochowa Jurassic silicite which was imported from Southern Poland. Obsidian is another imported raw material from Eastern Slovakia (ten pieces). Radiolarite, whose origin is probably in the klippen belt, the siliceous substance of volcanic origin and Szentgál radiolarite are represented by one piece each. It was not possible to identify the raw material of twelve pieces, since they had been damaged by fire. One piece was patinated.

Based on the preservation of the original surface, we can state that raw materials such as obsidian and Krakow-Czestochowa Jurassic silicite were transported to the settlement unprocessed or processed only roughly. On one limnosilicite piece the original cobble surface was preserved. We can assume that a secondary source situated in the gravel of the Hron river was used. However, limnosilicite could also have been obtained from the Volková strata complex coming to the surface between the villages of Tajná and Nevidzany (10 km from Vráble).

The chipped stone material represents all phases of the production process (Fig. 5.2.5). Blade and flake preforms as well as secondary blades and bladelets from core edges (subcrest) and final preforms occur. The inventory also contains pieces from the rejuvenation of mostly the striking and exploited surface of cores. Waste as well as final tools are also represented. The most numerous category consists of blades and their fragments. In terms of number, it is followed by flakes. The group of tools is rather well represented for such a small assemblage.

Fig. 5.2.2 (above left). The different tool categories from features attributed to the LBK in Vráble (n = 89).

Table 5.2.3 (below left). Cross-tabulation of raw materials and tools from features attributed to the LBK.

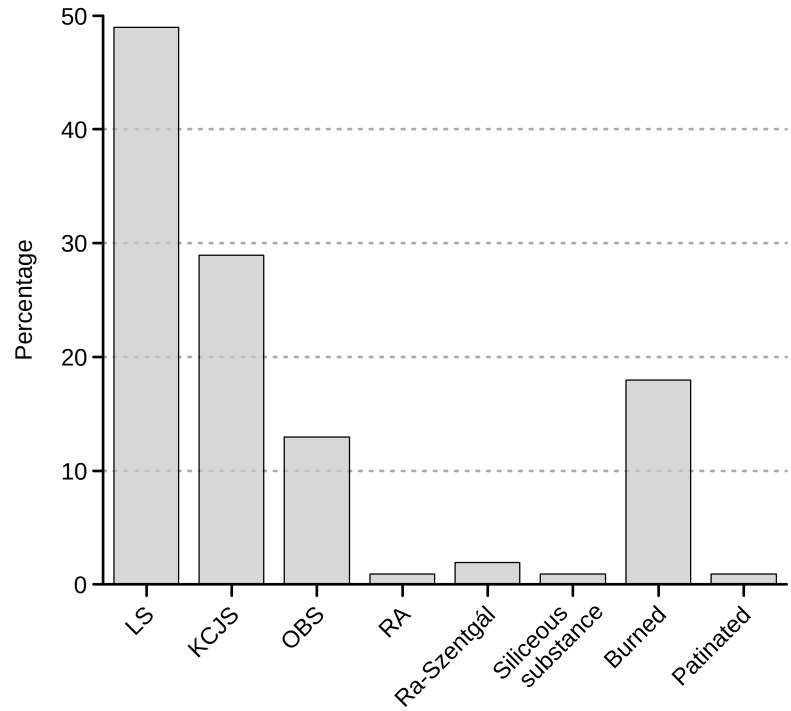


Fig. 5.2.4. Raw material types represented in features attributed to the Želiezovce group in Vráble (n = 114).

	LS	KCJS	OBS	RA	Ra-Szentgál	Siliceous substance	Patinated	Burned	Total
Prepared-core forms and cores	4		1						5
Blades and their fragments	13	14	8	1	1		1	5	43
Flakes	18	5	1					2	26
Waste	3	1				1		5	10
Tools	11	9	3		1			6	30
Total	49	29	13	1	2	1	1	18	114

Table 5.2.4. Cross-tabulation of raw materials and artefact groups from features attributed to the Želiezovce group.

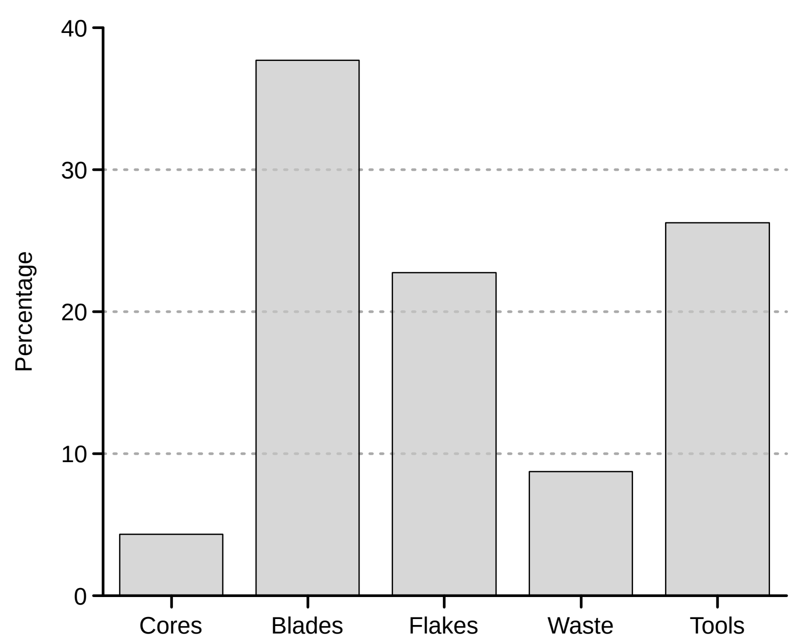


Fig. 5.2.5. The different technological categories from features attributed to the Želiezovce group in Vráble.

	Blades	%	Bladelets	%
Complete	8	25%	4	44.5%
Proximal	3	10%	0	0%
Proximal-mesial	7	22%	1	11%
Mesial	11	34%	0	0%
Mesial-distal	2	6%	4	44.5%
Distal	1	3%	0	0%
Total	32	100%	9	100%

Table 5.2.5. Number and percentages of blades, bladelets and their fragments in features attributed to the Želiezovce group in Vráble.

Cores

Five artefacts were classified as prepared-core forms and cores. In one case, a slightly burned piece of a limnosilicite with traces of manipulation was broken into seven pieces which we were able to refit.

The assemblage contains three cores of limnosilicite and one of obsidian. In one case, a massive rejuvenating flake (Pl. 5.2.12,2) with a plain butt was used as a core. It was reduced by a direct stroke using a hard anorganic hammer. The conical single-platform core was used for the exploitation of flakes. The platform did not need to be trimmed since its ventral side was used. From another double-platform prismatic core (Pl. 5.2.12,1) only flakes were reduced. Both platforms were modified by the reduction of one flake. The core edge was modified by means of dorsal preparation. The third core was of pyramidal shape with one platform modified by several percussions. Only flakes were reduced from it. The core edge was modified by removal of overhang. For both cores, it was impossible to determine the reason for abandonment.

The platform of the obsidian conical core was modified by multiple striking. Modification of the core edge was not detected. The core was in the exploitation phase. The reason for its abandonment was impossible to identify. From the negatives on the exploited surface, it can be said that blades and bladelets were reduced from this core.

Blades and their fragments

43 artefacts were classified as blades and fragments of blades (Table 5.2.5). Eight complete blades were identified. In one case, the complete blade with the core plunging *(outrepassé)* was preserved. Four complete bladelets were counted. A considerable part of the blades is in a fragmentary state: mesial (11 pieces) and proximal-mesial (7 pieces) parts prevail. Furthermore, three proximal, two mesial-distal and one distal part were identified. Among the bladelets, mesial-distal parts dominate (4 pieces). One proximal-mesial part of a bladelet was also identified.

From the preparation phase of the core, only one piece of the mesial part of a blade occurred. Preparation of cores and their exploitation in the area of the settlement is – besides a subcrest bladelet – documented by numerous final blades and bladelets. However, not a single rejuvenation piece was found, which is probably caused by the limited number of features attributed to the Želiezovce group. Faceted, plain and dihedral butts were detected on final blades, each occurring four times, with the exception of the faceted butt occurring five times. A lip was detected on two faceted butts. They also occurred on all dihedral butts, two of which were bipoled. A dihedral faceted butt occured on one piece. The butts on two pieces were modified by secondary retouch. Two faceted and two linear butts were detected on bladelets. In one case, a plain butt occured.

Modification of the angle between the striking and exploitation surfaces of the core by dorsal preparation was detected on one blade. Modification of the core edge between the platform and the exploited surface by removing overhang from the edge was found on twelve pieces. Final flakes were reduced from single-platform cores mainly indirectly using a punch (10 pieces). Direct striking using a soft organic hammer was applied in one case. The technique of direct striking using an anorganic hammer to obtain blades is almost absent and only assumed in one case. Nevertheless, we cannot say the same with regard to the reduction of bladelets. In three cases, direct striking with a soft anorganic hammer was detected. On two bladelets, indirect percussion with a punch is only assumed.

Flakes

26 pieces were classified as flakes. As for blades, the assemblage contains only one flake with preserved original surface (cortex) on which a plain butt was identified. Its edge was damaged due to direct reduction using a hard anorganic hammer. Two faceted butts as well as one plain (with a lip), one dihedral and one linear (with a lip) were identified on flakes. Modification by dorsal preparation of the angle between the platform and the exploited surface of the core was not documented on flakes. Most numerous are rejuvenating flakes with plain, linear or punctiform butts. Two rejuvenating flakes still show the striking surface and part of the reduced surface (Pl. 5.2.13,3). Flakes from the rejuvenation of the reduction surface included 11 pieces. Plain butts dominate on those flakes (7 pieces). A lip was found on one of them. Five edges of plain butts were identified as bipoled. Two pieces have dihedral butts, one has a punctiform butt. The butt of one rejuvenating flake shows five percussion points (ringcrack) from an unsuccessful attempt to reduce a flake.

In most cases, soft reduction methods were used to obtain flakes. On three pieces, indirect percussion with a punch was recorded. Another piece was reduced by a direct percussion with a soft organic hammer. On another flake, the application of this technique is only assumed. Unlike flakes, rejuvenating flakes were reduced using a considerably more aggressive process. Reduction by means of direct stroke by a hard (3 pieces) and soft (4 pieces) anorganic hammer dominate. Indirect reduction by a punch and direct stroke with a soft organic hammer were detected on one piece each.

Waste

Ten pieces were identified as waste. Mainly miniature flakes (so-called splinters), fragments of blades and flakes as well as fragments of tools are represented.

Tools

30 artefacts were classified as tools. They represent almost a quarter of the complete collection. Besides retouched artefacts, tools include pieces with traces of wear (so-called use-wear retouch) as well as artefacts with sickle-gloss. Most tools were made from blade (19 pieces) and bladelet (2 pieces) preforms. Five tools were made from flakes, three of which were rejuvenating flakes.

With eight pieces, retouched blades, bladelets and their fragments were the most numerous group among the tools (Table 5.2.6). The assemblage contains two blades with retouched edges. One was laterally (Pl. 5.2.13,2) and the other bilaterally (Pl. 5.2.13,1) retouched. One blade shows sickle-gloss on both edges; ventrally, it was secondarily laterally retouched (Pl. 5.2.14,2). Another two pieces were modified by distal end curved and hollow retouch (Pl. 5.2.8,2 and 5.2.13,4). One proximal blade fragment with distal end oblique retouch (Pl. 5.2.13,6) and one mesial part with

	LS	KCJS	OBS	Burned	Total
Retouched blade/bladelet	3	4	2		9
Retouched flake		1			1
Blade end-scraper		2			2
Drill	1				1
Perforator/borer				1	1
Burin spall with retouch	1				1
Sickle blade/flake	4	2		5	11
Fragment of a percussor	1				1
Total	10	9	2	6	27

Table 5.2.6. Cross-tabulation of raw materials and tools from features attributed to the Želiezovce group in Vráble.

punctiform proximal end and arcuate distal retouch was identified. One mesial part of a blade with lateral hollow and angular retouch on both its end (proximal and distal) was detected. A ventral notch occurs on the lateral side of the obsidian bladelet (Pl. 5.2.13,7).

The inventory also contains one flake with lateral retouch. The group of end-scrapers is represented by two blade end-scrapers (Pl. 5.2.13,8 and 5.2.13,10); in one instance the proximal end was retouched, probably to facilitate the attachment of a handle. Evidence of production and use of burins at the settlement is provided by a burin spall with straight distal end retouch (Pl. 5.2.13,5). The group of tools also includes drills and perforators/borers to process organic materials. There is one slim perforator without offset basal part (Pl. 5.2.13,9) and one slim drill with slightly offset basal part (Pl. 5.2.13,11). One fragment of a percussor was also identified.

Artefacts with sickle-gloss are quite numerous. Six sickle blades with no further modification were counted. Three blades with traces of wear on the lateral edges were also included in the group of tools.

Evaluation

So far, 448 pieces of chipped stone were obtained from settlement features in Vráble. Most of them come from features attributed to the LBK (359 pieces). Only 89 pieces come from features associated with the Želiezovce group.

The assemblage of chipped stone contains a wide range of raw materials of either local or supraregional origin. The local raw limnosilicite dominates in the LBK as well as in the Želiezovce group material. The nearest primary sources are located in the Žiarska kotlina basin (*e.g.* Lutila, Slaská), only 70 km from Vráble. Secondary sources are found in the gravel of the Hron river. The nearest occurrence of this raw material, however, is located between the villages of Tajná and Nevidzany, where it is associated with the Volková strata complex dated to the Pliocene, Dacian (Priechodská and Harčár 1988, 36-40). In terms of other raw materials, there are remarkable differences between LBK and Želiezovce. The nearest primary sources of the obsidian are associated with the volcanic mountain ranges in southeastern Slovakia and northeastern Hungary, is significantly more frequent in features associated with the LBK than in those of the Želiezovce group. Volhynian flint probably arrived at the site together with obsidian, as it is found only in the inventory of the LBK. The situation is similar with the Szentgál radiolarite from the Bakony Mountains. While in the assemblage of the Želiezovce group it is represented by only a few pieces, it was one of the main raw materials in the LBK. In contrast, the proportion of Kraków-Częstochowa Jurassic silicite imported from the territory of Southern Poland (Kraków-Częstochowa hills) is almost identical in both groups. Raw materials from Slovakia, such as radiolarite and siliceous rock of volcanic origin, are represented by several pieces. The primary sources of Slovakian radiolarite are to be located in the klippen belt. Siliceous rock is associated with rhyolites in the territory of neovolcanites in central Slovakia, mainly in the Žiarska kotlina basin.

The main categories of artefacts are almost identical in both assemblages of the LBK and the Želiezovce group. Also when comparing types and shapes of cores and their modifications (platform, core edge, etc.), no significant differences between both groups can be observed.

Blades and their fragments prevail in both groups. In the LBK as well as in the Želiezovce group, proximal-mesial and mesial parts of blades dominate. In contrast, the mesial parts of bladelets are absent in the Želiezovce group, while they are most frequent in the LBK. Among blades, final pieces dominate. When we compare the modification of the angle between the platform and surface exploited by dorsal preparation as well as the modification of the core in both groups, we do not find differences. Removal of overhang was the predominant technique of modification. Reduction of final pieces was done mainly from single-platform cores by means of indirect strokes with a punch or direct strokes with soft organic hammer.

No significant differences are observable in the category of tools. The only difference is in the number – a noticeably higher number of artefacts interpreted as tools was detected in the assemblage from the LBK. However, this is also caused by the fact that this collection contained a considerably higher number of chipped stone artefacts. Almost identical types of tools are represented in both assemblages. Retouched pieces (blades, flakes) and artefacts with sickle-gloss are the most frequent. Furthermore, various types of end-scrapers, drills, perforators or borers, percussors, etc. occurred.

From the analysis of the chipped stone industry, it can be said that both LBK and Želiezovce group communities probably consisted of users.

Analysis of the chipped lithic material from burial contexts

Several burials as well as human skeletons deposited in settlement features were discovered in Vráble (Chapter 3.2). Of the burials with chipped stones as grave goods, two burials dated to the end of the Želiezovce group merit special attention.

G7/S21

Two pieces of chipped stone tools were found with the male individual, aged 30-44 years. One blade (36.07 mm long) was located under the right scapula (Fig. 3.2.10) and a second blade (70.41 mm long) was placed in the area of the rib cage (Fig. 3.2.11). The latter was made of limnosilicite, the other was patinated, thus, it was impossible to determine the raw material. This artefact is the mesial part of a blade with sickle-gloss (Pl. 5.2.15,1). The second artefact was identified as a crest blade (Pl. 5.2.15,2) with linear butt. On the edge of the sickle blade, traces of wear are visible.

From the technological point of view, the blades were probably reduced from single-platform cores. The reduction method could be identified on the crest blade only. It was reduced by direct stroke with a soft anorganic percussor.

G8/S21

One piece of chipped stone was found with the male individual, aged 20-30 years. The blade (98.48 mm long) was situated near the spine (Fig. 3.2.13). The complete blade with a plain butt and an indistinct lip was made of limnosilicite (Pl. 5.2.15,3). None of the edges bore traces of wear. The blade was reduced indirectly from a single-platform core using a punch. It is interesting that the longest blade discovered in Vráble so far was found in a burial.

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Ground stone items

Excavation season	Neighbourhood	Weight (g)	Excavated material total (m^3)
2013	SE	3,898	17.7
2016	SE	5,592	73.2
2014	N	10,438	20.4
2017	SW	1,823	10.44
2012	SW	0	9.6

Table 5.2.7. Weight of ground stone artefacts found during the different excavation campaigns.

The spectrum of ground stone tools within the different excavation areas of Vráble ‚Veľke Lehemby'/‚Farske' reflects, on the one hand, the expected range of typical tools within LBK contexts and, on the other hand, some items of exceptional interest. In the following, the different objects falling in these two categories will be presented and set in the wider context of the LBK phenomenon. After a brief discussion of the spatial distribution and composition of the ground stone artefacts, a description of the most important individual finds, as well as a brief discussion of the results in the light of the wider framework of LBK contexts, will follow.

The spatial distribution and composition of ground stone artefacts at Vráble

All in all, 41 finds of ground stone were discovered during the excavations between 2012 and 2017. This overall number shows some interesting differentiation between the neighbourhoods in terms of the total weight and composition of the finds (Table 5.2.7). The ground stone artefacts mainly comprise the lower part of querns – the part known as the grinding slab or lower stone (n = 27) – although four handstones were also discovered. Furthermore, four rubbing stones were found, as well as one whetstone. One of the most iconic tools of the LBK, the adze blade, is represented by four, mostly fragmented, exemplars at Vráble.

The south-eastern settlement area

In the course of the excavations in 2013 and 2016, six trenches were opened in the area of the south-eastern settlement area. The trenches cut six different houses of this neighbourhood (house 102; 131; 132; 133; 126 and 127). The distribution of ground stone tools within these different houses is marked by sharp differences. Three of the houses included in the excavations revealed only one or two ground stone artefacts, in almost all cases (n = 3) classified as fragments of grinding stones (for example Pl. 5.2.16,7). One ground stone item found in house 126 could not be identified due to the poor condition of the artefact. Nevertheless, it is clear that the find constitutes a fragment of either a grinding stone or a whetstone. All the finds are characterised by a high degree of use, which led to strong abrasion of the surfaces of the stones. A higher number of ground stone artefacts was recovered from the area of house 133 (n = 4; weight: 1,655 g). Also, in this case all the artefacts constitute potential fragments of grinding stones, which are marked by a high degree of damage and strongly used surfaces. The second highest number of finds derives from house 132, which is outstanding in terms of the diversity of finds. Here, two of the finds can be defined as potential fragments of grinding stones or grinders, because the flatness of the surfaces may also have been caused by natural processes. Another find can be defined as a clear fragment of a grinding stone due to its very flat surface. Another, rather small, artefact exhibits several grinding or rubbing surfaces of *c.* 1 cm^2. The most impressive within the context of this house is a fragment of an adze. House 131 was excavated in 2016. In contrast to the other houses described above, this house was excavated in its entirety. It yielded 9 finds that are tentatively or securely classified as ground stone artefacts. Among these are 7 finds (weight: 2,104 g) that potentially constitute fragments of grinding stones. As it is the case with the other finds described, these fragments are partly very small and in general exhibit heavily worn surfaces. Due to the smoothness of these partly concave surfaces, these finds are nevertheless included in the list of ground stone artefacts. Lastly, one almost complete miniature adze head, as well as a fragment of another adze blade, are also among the material from this house (see description and figures below).

One more interesting find was recovered from the south-eastern settlement area. This was a polishing stone (Pl. 5.2.16,6) found in the potential sunken dwelling.

The northern settlement area

During the excavation of 2014, five houses of the northern neighbourhood of Vráble were partly excavated, resulting in a smaller number of ground stone artefacts (n = 9) compared with the south-eastern area. Only 2 finds can be assigned to house 244, namely, a fragment of a grinding stone and a ground stone. Both artefacts were in a well preserved state and can be assigned to their function with certainty. The second house (house 259), whose long pits were partly excavated in the same year, yielded 7 finds. In contrast to the diversity of the finds from the other houses, only fragments from the upper and lower parts of grinding stones were found here. Yet, these artefacts are preserved in a more complete state than the other finds already presented and have a combined weight of 6,486 g. Among these artefacts, find no. 8073 constitutes an outstanding example. This large portion of a grinding stone is well preserved, so that the concave form deriving from the intensive use of this tool is clearly visible. From the same trench, but without a clear context, comes another example of a well-preserved grinding stone (find no. 9010). It derives from the proximity of house 262 and has a weight of 3,600 g.

The south-western settlement area

The last of the three settlement areas, the south-western neighbourhood, was the aim of targeted excavations both in 2012 and in 2017. The results from the two trenches excavated here stand in stark contrast to the results obtained from the other settlement areas. Although the area excavated equals that of the northern settlement area, the number of ground stone artefacts is much lower. In 2012 no ground stone artefacts were discovered, although two fragments of adze heads were registered during the fieldwalking undertaken prior the excavation. Due to the unclear context of these finds, they are excluded from the further descriptions and analyses. Within Trench 22, two houses (house 317 and house 23) were partly excavated in 2017, yielding only four potential ground stone tools, with a combined weight of 1,823 g. All the finds constitute possible fragments of grinding stones and originate from house 317.

The tools: Adze blades

Being one of the most regularly occurring ground stone tools within the different areas and phases of the LBK complex and the subsequent Middle Neolithic phases in central Europe, adzes play a special role within assemblage of ground stone artefacts (Ramminger 2007, 157). At Vráble, five exemplars of this tool type were documented, comprising a complete miniature adze as well as several fragments. The complete miniature exemplar of an adze (house 131, south-eastern neighbourhood) was made of actinolithic shale and exhibits the typical asymmetrical form of the cutting edge and a tall profile (Pl. 5.2.16,1). It was all-over polished. The lower end of the adze shows signs of damage. The length, width and height of this object are 59.1 × 13.5 × 14 mm, respectively. The item, and especially its cutting edge of sharp and symmetrical form, is in very good condition, possibly indication a rather low intensity of use.

One exemplar was interpreted as a small chisel; actinolithic shale was used for its production. It is typical for its gray-green coloring, the texture is foliaceous and the rock is fine-grained. It is a metamorphic rock formed by low to medium temperature and low-pressure metamorphosis of ultrabasic rocks (basalts, andesites and gabras).

Further exemplar is a large fragment of an adze blade from house 132 (Pl. 5.2.16,2), also in the south-eastern settlement area. It was made of tremolite shale and contained amphibole and garnet. This exemplar showed signs of what we presume is heavier use. Especially the cutting edge is not entirely symmetrical and shows more pronounced signs of use than the miniature example from house 131. The lower end of the find is missing; thus, no length reconstruction is possible. But we can tell that it has the same tall shape and small size as the one from house 131. What remains of the find from house 132 measures 64 × 16 × 17 mm.

Typological analyses of adzes are commonly based on measurement indices and therefore stand in sharp contrast to the often decoration-based typological analyses and derived chronologies of LBK pottery. This is due to the rather uniform and technology-driven form of the adze blades, which show little differentiation over the course of the Early and Middle Neolithic (Ramminger 2007, 172-176; compare Ramminger 2009, 81).

Another fragment of an axe blade that allows a reconstruction of the type is a flat axe blade (Pl. 5.2.16,3), which was also found in the context of house 131, in the south-eastern settlement area. The height of this exemplar measures 12 mm. Only a part of the cutting edge and the upper part of this axe blade are preserved, thus no reconstruction of the width and length of this find can be offered.

Another two artefacts identified as polished lithic industry were only fragmentarily preserved. The first example was interpreted as a small chisel made of actinolithic shale typical for its grey-green colouring, foliaceous texture and the fine-grained rock. It is a metamorphic rock formed by low to medium temperature and low-pressure metamorphosis of ultrabasic rocks (basalts, andesites and gabras).

The second artefact, probably a flat axe, was made of tremolite shale (it contained amphibole and garnet). The material is also a metamorphic rock, formed in low-temperature and low-pressure arising from the transformation of ultrabasic rocks. The rock is fine-grained and has a grey-green colour.

Green schists of various types were most commonly used rock for the production of polished lithic industry in the Neolithic and Eneolithic. The closest occurrence of green schists from the surveyed site was linked to the Little Carpathians on the Pezinok-Pernec formation, the eastern edge of the Bohemian Massive and in the Spišsko-gemerské rudohorie (Méres et al. 2001, 376).

Special types

Three of the stone items found at Vráble can be assigned to special types and be classified as non-utilitarian. One of them is a bead made from green serpentinite (Pl. 5.2.16,5), which was found in the western long pit of house 132, in the south-eastern settlement area. The bead is of disc-shaped form and measures 7 mm in diameter and 3 mm thick. The bead represents a final product with a carefully polished surface. The striking feature of the bead is the large diameter (3 mm) of the aperture in comparison to the overall size. The origin of this piece is probably on the territory of Austria. Serpentinite beads with a disc-shaped form also appear in on other LBK and Želiezovce Group settlement in southwest Slovakia. Two stone pearls appeared in the settlement of the early LBK in Bíňa (Pavúk 1980, Fig. 16). Other serpentinite pearls come from the Želiezovce Group settlement in Bajč Medzi kanálmi. A large collection of this kind of inventory was captured as an addition in a skeleton grave (Cheben 2000, 72).

The second find of a special type, which we present here in brief, is a potential tool made of hematite, measuring 2.5 × 1.1 mm (Pl. 5.2.16,4). This find also originates from the south-eastern neighbourhood of the settlement. It was found in the western long pit of house 102. The lower part of one face of the artefact has been artificially flattened and exhibits a sharp angle to the overall symmetrical vertical axis of the tool. The perforation is located at the upper part of the item and was created by the sand-glass shaping technique (that is, perforated from both faces). The entire surface of the item is heavily worn and polished. Numerous grooves and scratches can be seen on almost all surfaces; they are oriented in the same direction. This artefact is a whetstone used for final sharpening of polished objects, *e.g.* blades of flat axes and adzes. The perforation suggests that it was worn around the neck or hung on the belt. It is the second find of this type detected in Neolithic assemblages of Slovakia. The first such find was discovered in the settlement of Hurbanovo-Bohatá (Březinová and Pažinová 2011, 273).

A further example was made of hematite. It was a whetstone used for the final sharpening of smoothed artifacts (blades of flat axes and hoof-shaped wedges). Its shape is irregular. Numerous grooves/scratches can be seen on almost all surfaces; they are oriented in the same direction. The artifact was drilled, which can suggest that it was worn around the neck or hung on the belt. It is the second find of this type detected in the assemblages of Neolithic lithic industry. The first such find was discovered in the assemblage of lithic industry from the Neolithic settlement in Hurbanovo-Bohatá (Březinová and Pažinová 2011).

Discussion

The ground stone items show some interesting patterns of distribution and composition. With regard to the spatial distribution within the different neighbourhoods and houses, a clear imbalance is observable with regard to the south-western settlement area. Here, the low density and uniformity of the ground stone artefacts is striking; only fragments of grinding stones were found in this area. In contrast, the south-eastern settlement area stands out due to the comparatively high number of finds and their variability, comprising grinding stones, sharpening stones and adze blades. In this area, house 131 is special because of its high number of finds and the presence of a miniature adze blade of remarkably good preservation. As already mentioned, the fact that this house was excavated more extensively than the other houses discussed in this chapter means that the sample sizes are not comparable. This house also contained an obsidian core in one of the postholes, thus strengthening the argument of a potentially special role of this house, connected to specific courses of action and social implications.

The two outstanding finds from Vráble, the stone bead and the stone pendant, are interesting items in themselves. The bead could, through the use of serpentinite, possibly represent an imitation of jade beads and is reminiscent in its morphology of the limestone beads. Like green stone beads, these limestone beads are known from LBK cemeteries, although they appear in small numbers (Nieszery 1995, 160). The hematite artefact may have been used as a polishing or colouring tool, as indicated by the flat and sharply angled surface on one side of the find. An interpretation as a colouring tool, accords with the appearance of such items in LBK cemeteries and with the strong importance of colour in LBK communities in general (Nieszery 1995, 161-162).

The unequal distribution of finds among the different neighbourhoods raises questions concerning possible social and economic reasons. Because we can also see economic differentiation in the distribution of wheat types (see Chapter 5.5) and animal bone assemblages (see Chapter 5.4), it can be argued that we can trace economic differentiation of the different settlement areas. This partly accords with results from other LBK sites.

Altogether the density of ground stone artefacts is low at Vráble, including that of adze blades. Within the LBK distribution, both high and low densities of adze blades are known. A sample of 28 LBK settlements yielded an average number of 2.3 adzes per house (Ramminger 2009, 87-90). The author of this study suggests differences in the supply with raw material as one of the possible reasons for deviations from this mean. Case studies support this argument for central Germany, where the number of amphibolite adzes per settlement decreases significantly according to the distance from the raw material source (Nowak 2008). Regional studies at Weisweiler 107/108 also indicate differences in the quantity and density of adze blades within contemporaneous settlements. In this case, the author assumes that an economic specialisation is behind this distribution pattern. While the biggest settlements contained the lowest density of adze heads, the smaller settlement sites contained higher densities. This pattern may be explained by two aspects: 1) the smaller settlements may have been in greater need of a higher number of tools because networks of exchange and sharing were not as developed as they would have been in bigger settlements, and 2) the higher degree of specialisation in bigger settlements resulted in a lower number of adze heads (Nockemann 2017, 263-266).

Altogether, several factors may be responsible for the stone artefact distribution patterns at Vráble. With regard to all of them, we have to keep in mind that the number of houses excavated is rather low and that in most cases only a small part of each house was excavated. Several aspects of the site of Vráble point towards the occurrence of processes of economic and social differentiation, and the ground stone tools may be part of this. The low density of finds especially in one of the neighbourhoods may then very well be interpreted as another marker of a certain degree of specialisation. Similarly, to the interpretation made by Nockemann (2017), we can see a high degree of communality and sharing practices within Vráble. Therefore, the distribution and the rare occurrence of ground stone artefacts may be connected both to factors of differentiation and specialisation, and to factors of communal strategies and cooperation.

M.W., K.Sz.

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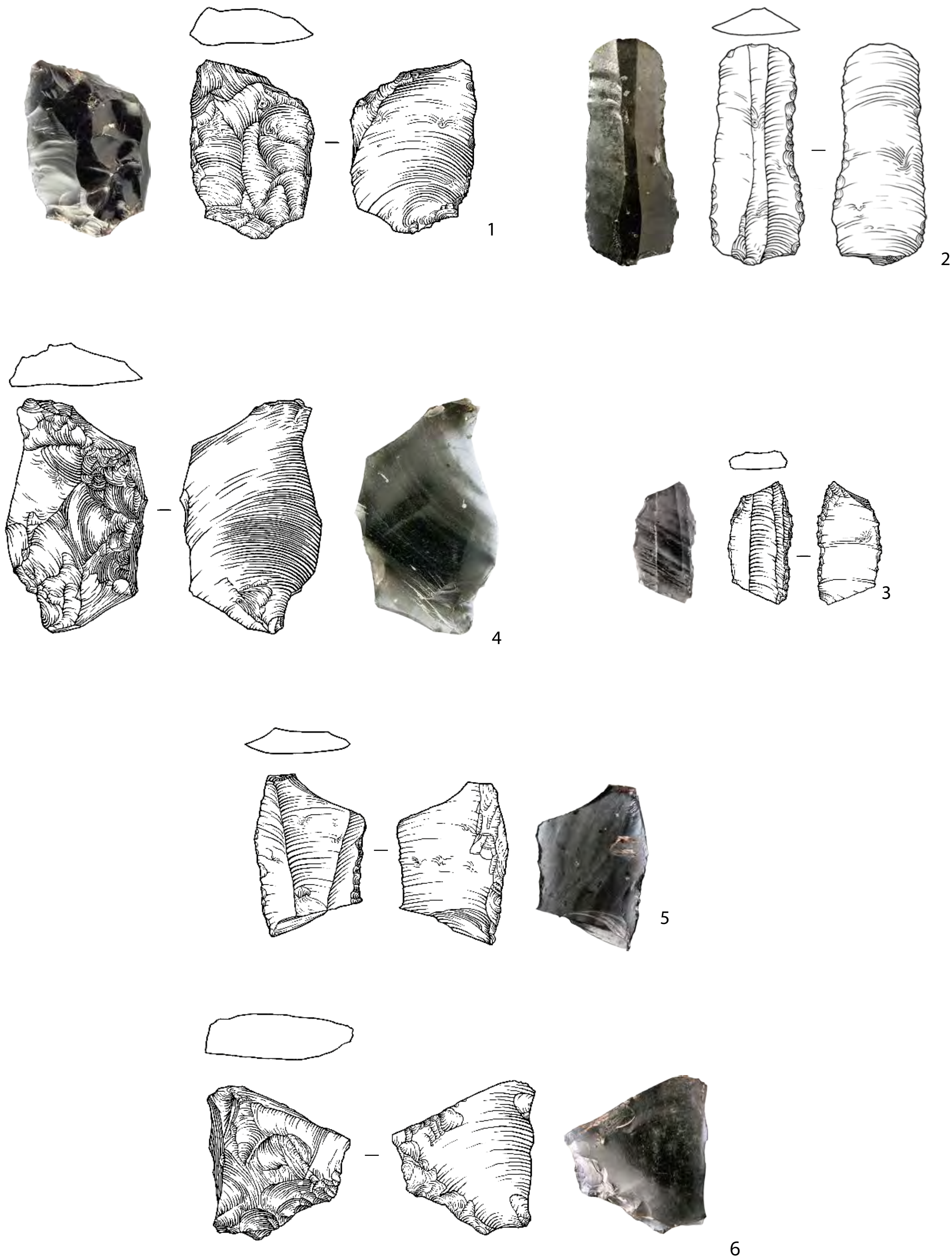

Plate 5.2.1 Tools made of obsidian: 1,4,5,6: flake; 2-3: blade. 1,2,3: trench 11; 4,5,6: trench 12. 1: object 24 (house 132, eastern long pit); 2: object 9 (house 132, western long pit); 3: object 26 (house 133, western long pit); 4,5: object 65 (house 131, western long pit); 6: cleaning planum 1. Scale 1:1 (drawings: K. Winter; photos: S. Jagiolla).

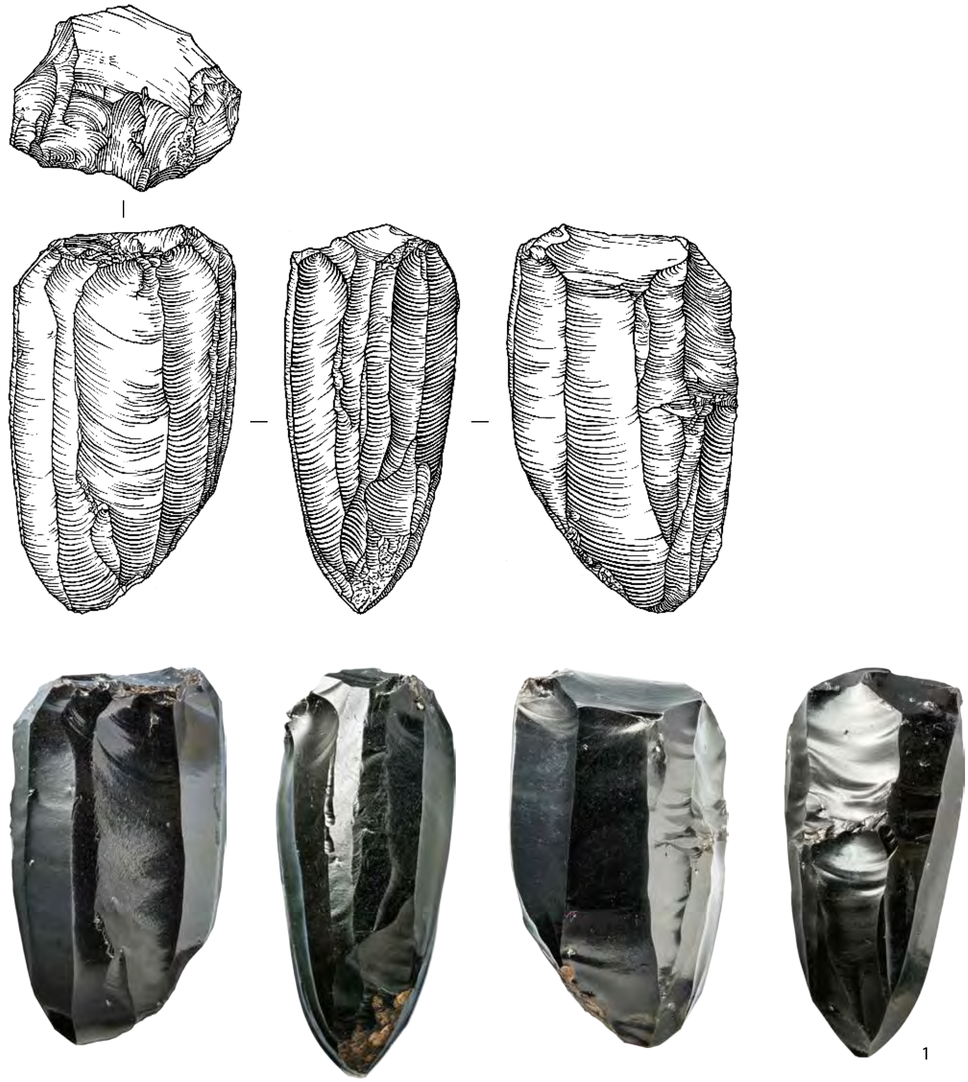

Plate 5.2.2. Obsidian core. 1: trench 12. 1: object 106 (house 131, posthole). Scale 1:1 (drawings: K. Winter; photos: S. Jagiolla).

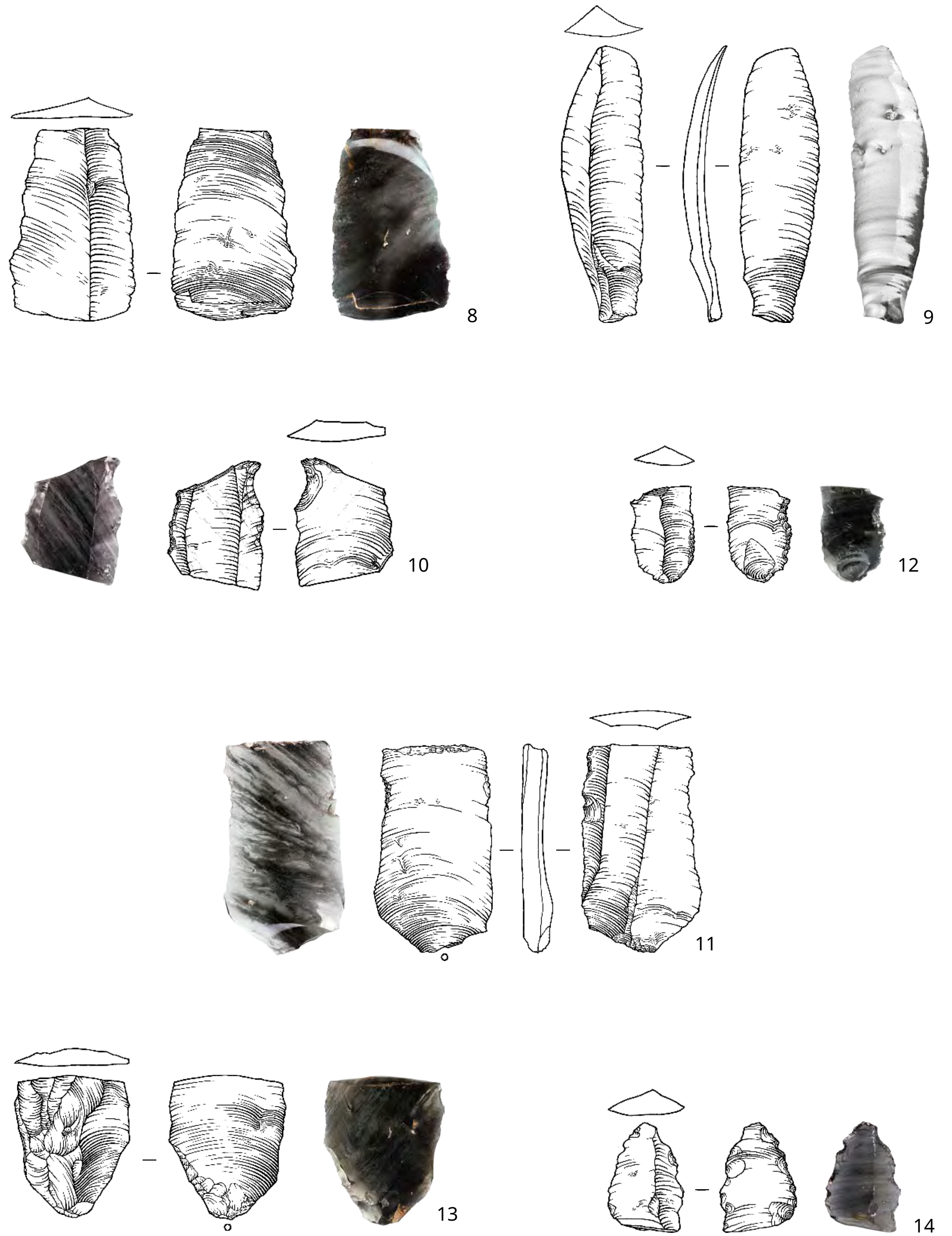

Plate 5.2.3. Tools made of obsidian: 8,9,11,12,13,14: blades; 10: flake. 8,9,10,11: trench 12; 12: trench 13; 13,14: trench 14. 8,9,10,11: object 57 (house 131, eastern long pit); 12: object 37 (house 133, eastern long pit); 13: object 157 (house 126, western long pit); 14: 123 (house 126, eastern long pit). Scale 1:1 (drawings: K. Winter; photos: S. Jagiolla).

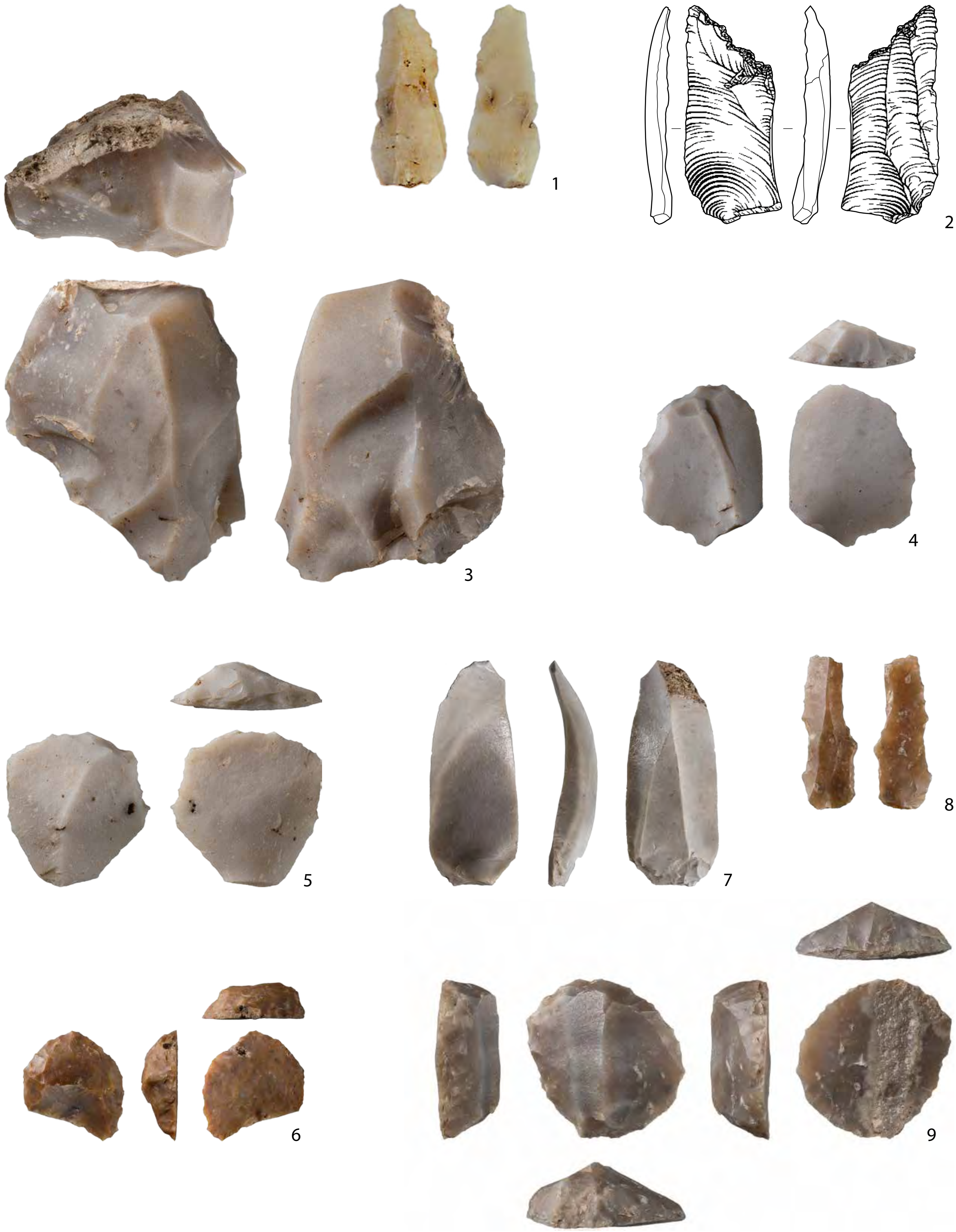

Plate 5.2.4. Tools made of radiolarites and limnosilicit. 1,2,7-8: blade; 3: core; 4-6,9: scraper. 1: trench 3; 2: trench 4; 3-6: trench 11; 7-9: trench 12. 1: object 2 (house 39, eastern long pit); 2: object 1 (house 102, western long pit); 3,4: object 24 (house 132, eastern long pit); 5,6: object 26 (house 133, western long pit); 7-9: object 65 (house 131, western long pit). Scale 1:1 (drawings: K. Winter; photos: A. Heitmann).

Plate 5.2.5. Tools made of radiolarites, obsidian and limnosilicit. 1,3: 2: scraper; drill; 4,5,6,7,8,9,10,11,12: blade. 1-7: trench 12; 8-9: trench 13; 10-11: trench 14; 12: trench 22. 1: loose find; 2-3: object 65 (house 131, western long pit); 4: object 9 (house 132, western long pit); 5: object 106 (house 131, posthole); 6,7: object 57 (house 131, eastern long pit); 8: loose find; 9: object 24 (house 132, eastern long pit); 10: object 135 (house 126, posthole); 11: object 157 (house 126, western long pit); 12: object 102 (house 23, western long pit). Scale 1:1 (photos: A. Heitmann).

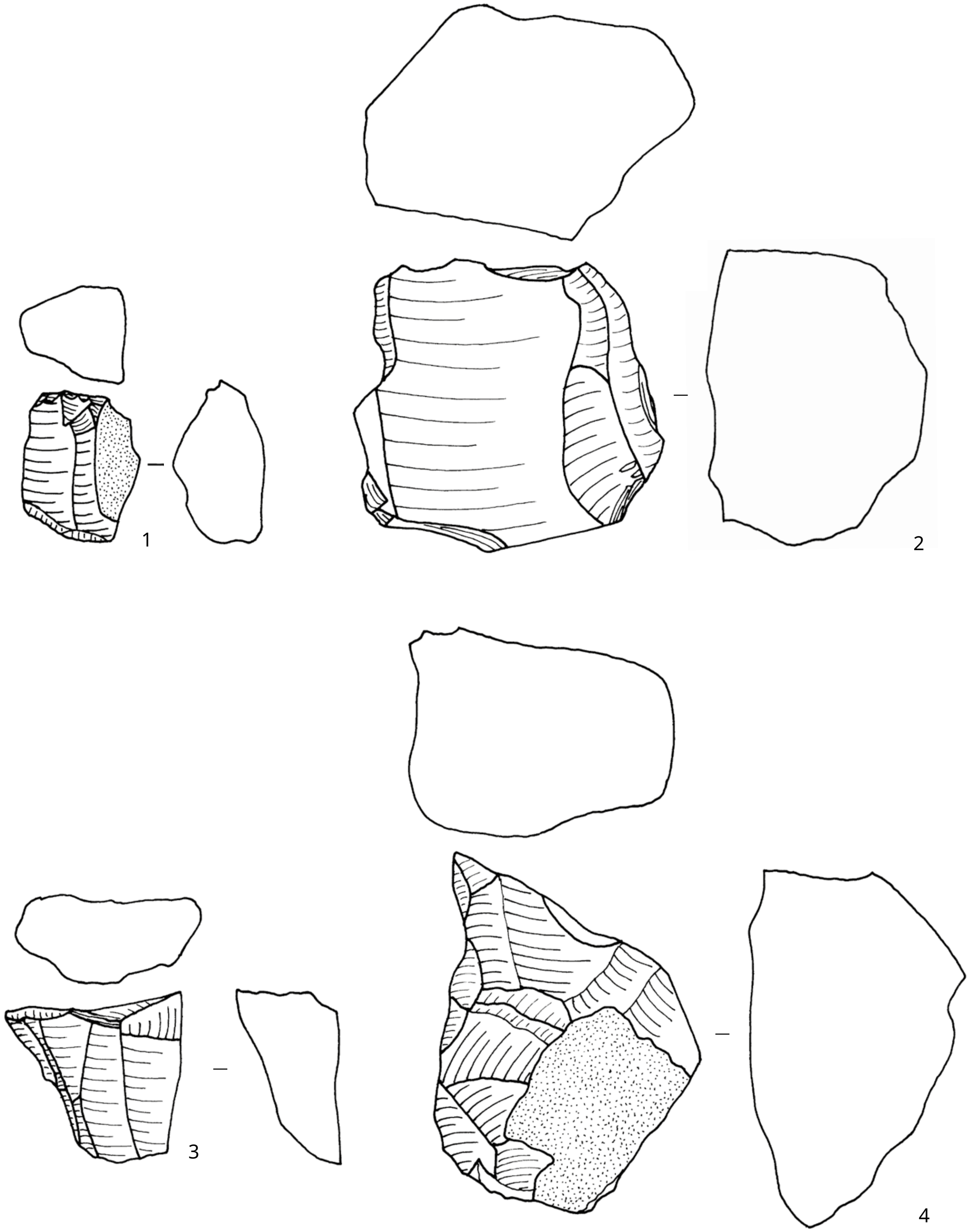

Plate 5.2.6. Chipped stone tools: 1-4: cores. 1: trench 9; 2: trench 22; 3: trench 3; 4: trench 11. 1: object 1; 2: object 100; 3: object 1 (house 102, western long pit); 4: object 25. Scale 1:1 (drawings: E. Bakytová).

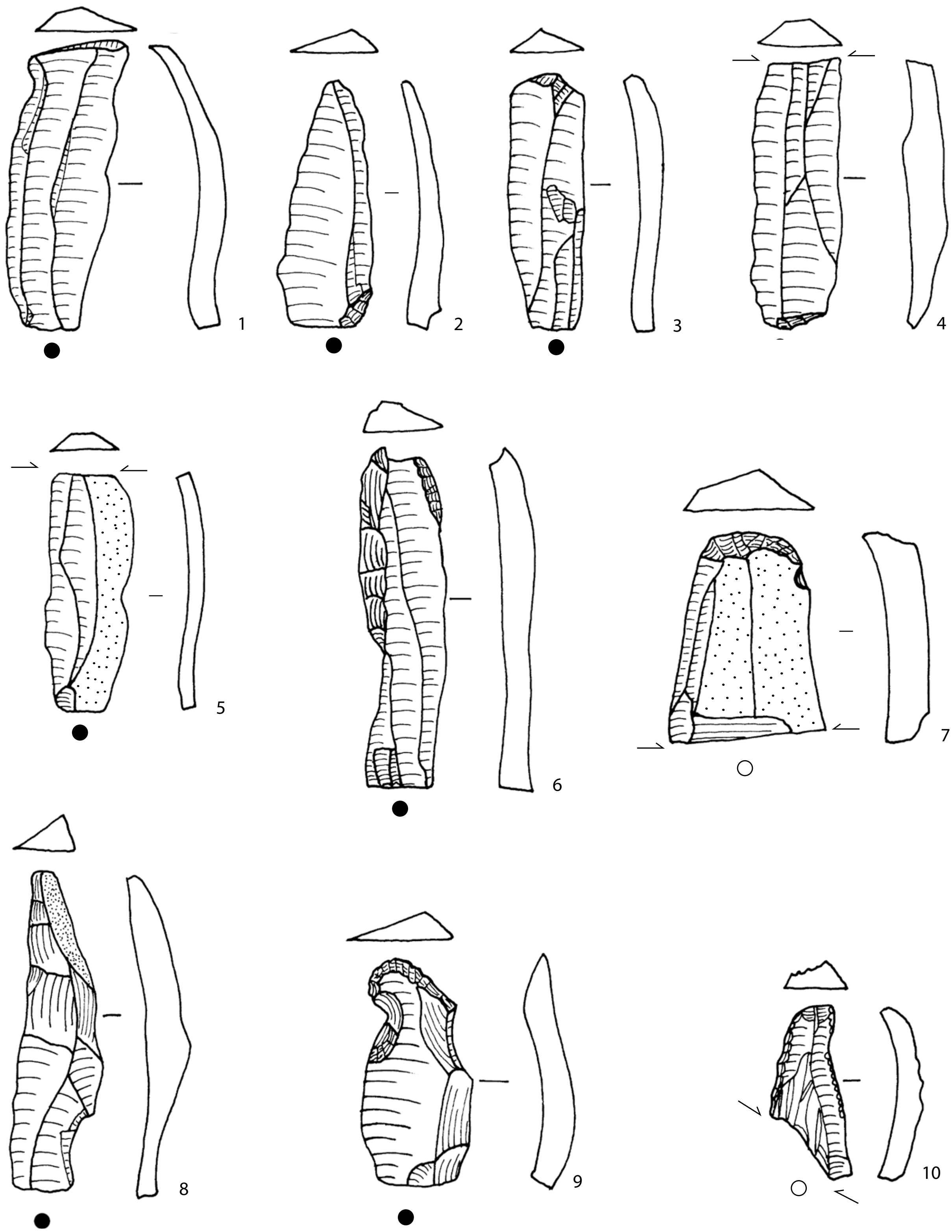

Plate 5.2.7. Chipped stone artefacts: 1-2,4: complete blade; 3: retouched blade/reparation blade (from the striking surface of the core); 5: preparation blade; 6: subcrest blade/retouched blade; 7: preparation blade/tall blade end-scraper; 8: subcrest blade; 9: subcrest blade/subcrest blade with a notch; 10: retouched blade/reparation blade (from the striking surface of the core). 1,5-6: trench 4; 2: trench 5; 3,7,9: trench 13; 4,8,10: trench 7. 1,2,6: object 2 (house 102, eastern long pit); 3,9: object 37 (house 133, eastern long pit); 4,8,10: object 1 (house 244, eastern long pit); 5: object 1 (house 102, western long pit); 7: object 25/26 (house 133, western long pit). Scale 1:1 (drawings: E. Bakytová).

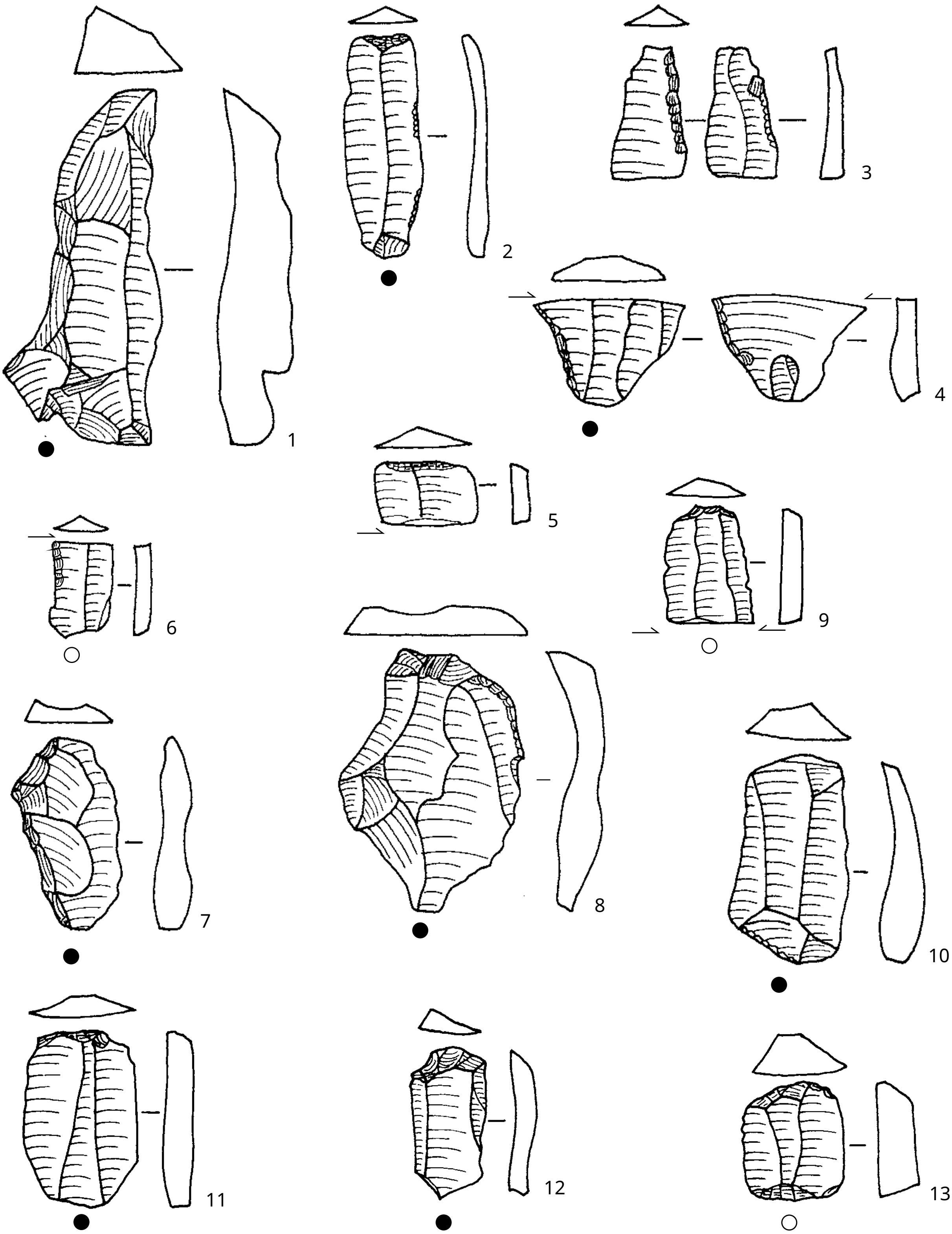

Plate 5.2.8. Chipped stone artefacts: 1: reparation blade (from the striking surface of the core); 2: retouched blade with its fragment; 3-4: retouched blade; 5-6: retouched mesial part of the blade; 7-8,10: retouched flake; 11-12: blade end-scrpaer; 13: bilateral end-scraper. 1,3,4,9: trench 13; 2: trench 8; 5,8: trench 4; 6,13: trench 12; 7: trench 7; 10-11: trench 14; 12: trench 22. 1,3,4: object 25/26 (house 133, western long pit); 2: object 1 (house 259, western long pit); 5,8: object 2 (house 102, eastern long pit); 6,13: object 65 (house 131, western long pint); 7: object 1 (house 244, eastern long pit); 9: object 37 (house 133, eastern long pit); 10,11: object 123 (house 126, western long pit); 12: object 103 (house 23, eastern long pit). Scale 1:1 (drawings: E. Bakytová).

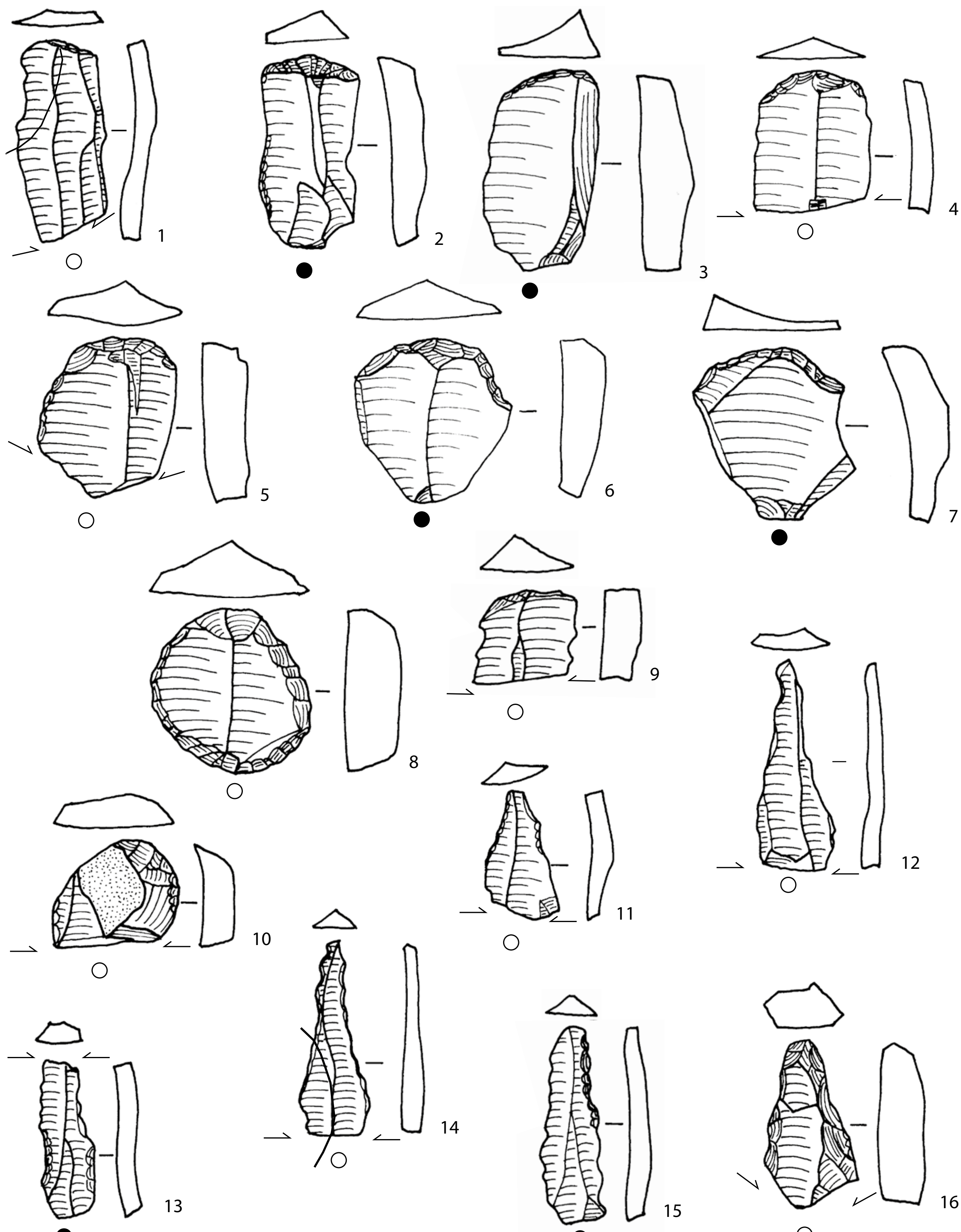

Plate 5.2.9. Chipped stone artefacts: 1: blade end-scraper with sickle-gloss; 2-3: bilateral retouched end-scraper; 5-7,9: flake end-scraper; 8: rounded end-scraper; 10: thumbnail end-scraper; 11-14: drill; 15-16: perforator. 1,8,11,12,13,15: trench 12; 2: trench 4; 3,4: trench 5; 5,6: trench 11; 7,16: trench 13; 9,14: trench 22; 10: trench 14. 1,11: object 57 (house 131, eastern long pit); 2,3,4: object 2 (house 102, eastern long pit); 5: object 25 (house 133, western long pit); 6: object 26 (house 133, western long pit); 7: 25/26 (house 133, western long pit); 8,12,13,15: object 65 (house 131, western long pit); 9: object 102 (house 23, western long pit); 10: object 144 (house 127, eastern long pit); 14: object 103 (house 23, eastern long pit). Scale 1:1 (drawings: E. Bakytová).

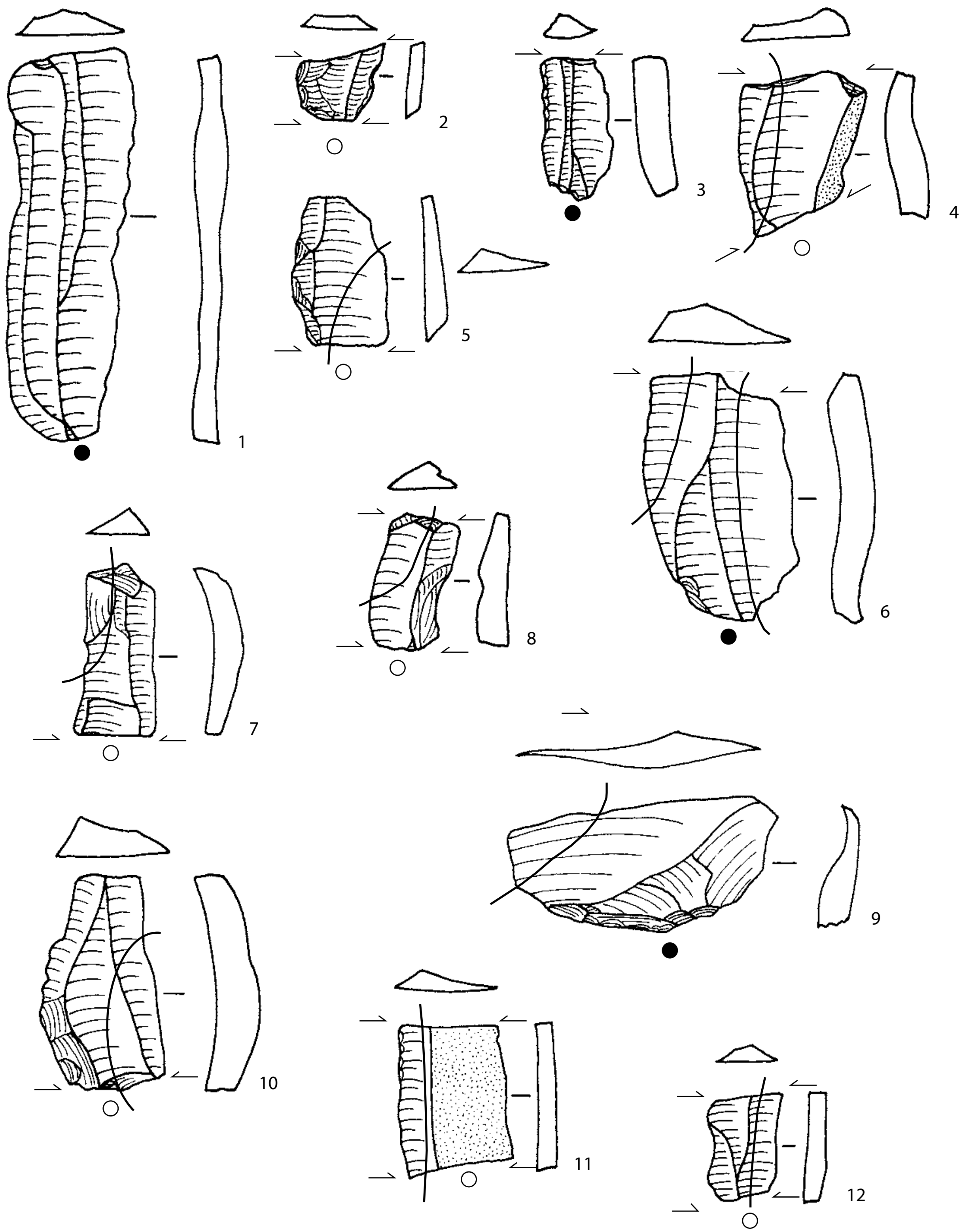

Plate 5.2.10. Chipped stone artefacts: 1: knife; 2-3: damaged (broken tools); 4-6,9: flakes with sickle-gloss; 7-8,10,12: blades with sickle-gloss; 11: blade with sickle-gloss/preparation blade. 1,9,10: trench 13; 2,3,4,6: trench 12; 5,11,12: trench 22; 7: trench 4; 8: trench 9. 1,9: object 37 (house 133, eastern long pit), 2,3,4,6: object 57 (house 131, eastern long pit); 5: object 100 (house 317, western long pit); 7: object 1 (house 102, western long pit); 8: object 1 (miscellaneous pit); 10: object 25/26 (house 133, western long pit); 11: object 102 (house 23, western long pit); 12: object 101 (house 317, eastern long pit). Scale 1:1 (drawings: E. Bakytová).

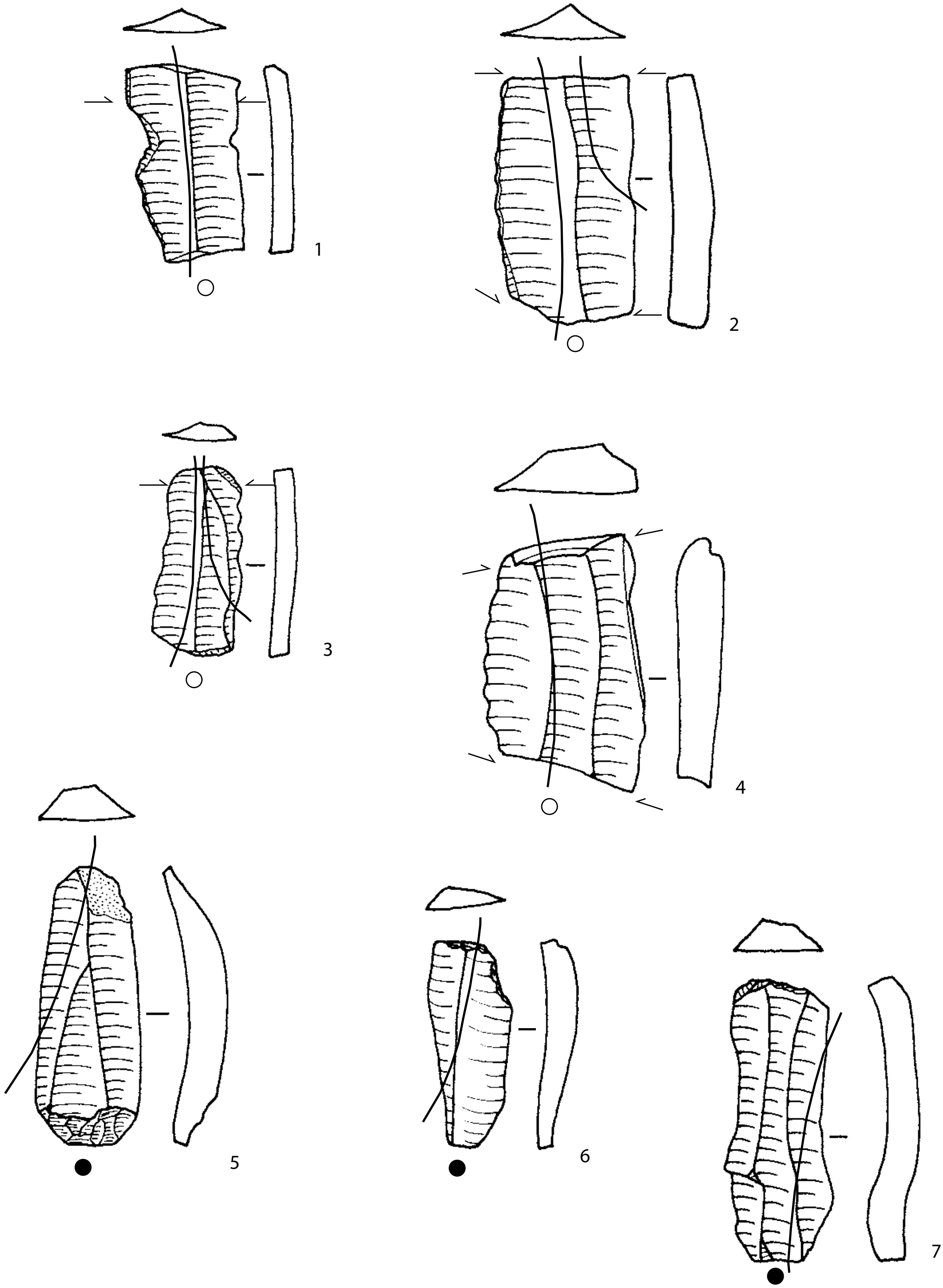

Plate 5.2.11. Chipped stone tools: 1-7: blades with sickle-gloss: 1,3: trench 14; 2,7: trench 13; 4: trench 11; 5, 6: trench 12. 1: object 144 (house 126, eastern long pit); 2: surface find; 3: object 135 (house 126, posthole); 4: object 25 (house 133, western long pit); 5: object 65 (house 131, western long pit); 6: object 9/57 (house 131/132, eastern long pit/western long pit); 7: object 25/26 (house 133, western long pit). Scale 1:1 (drawings: E. Bakytová).

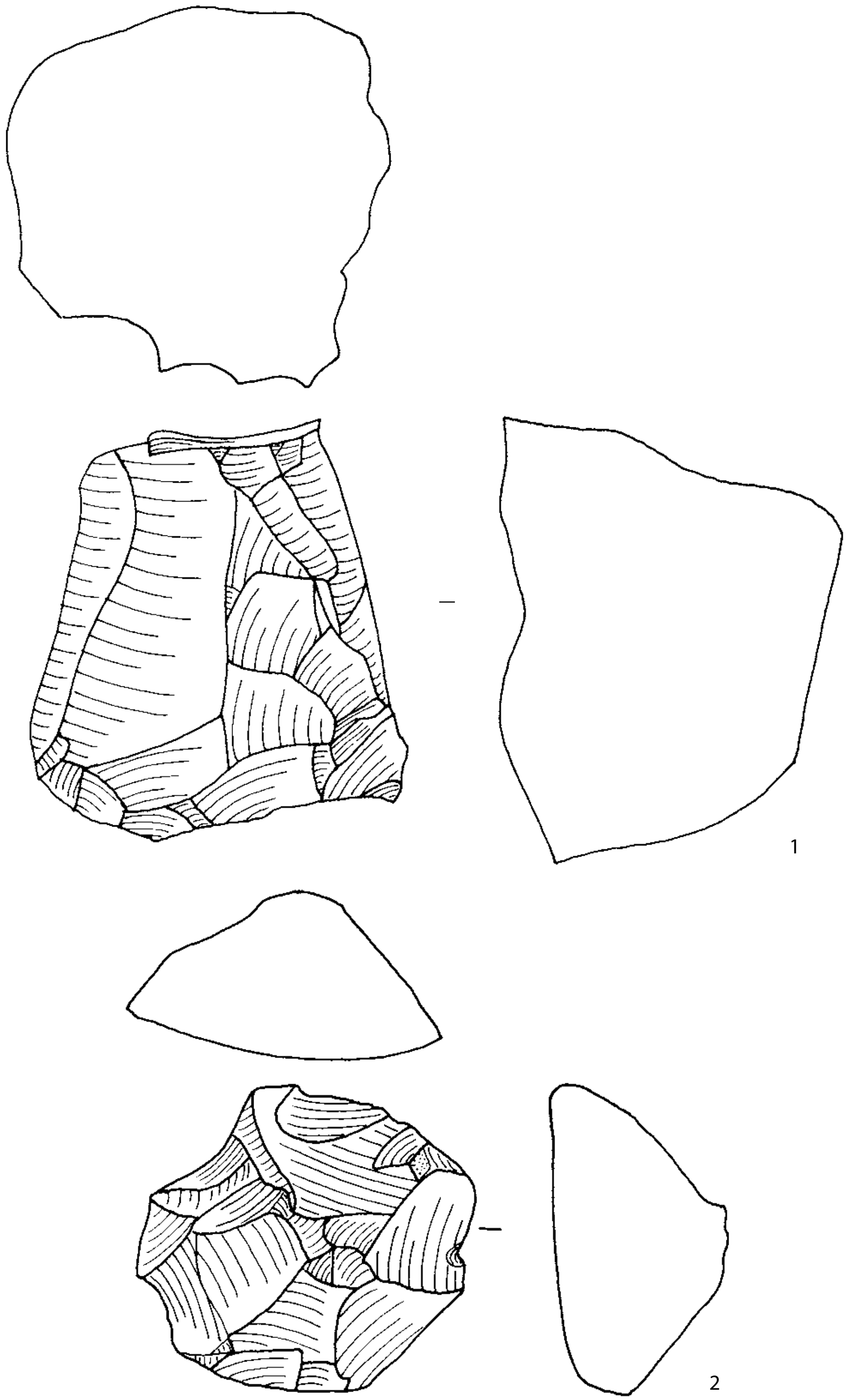

Plate 5.2.12. Chipped stone tools: 1-2: cores. 1-2: trench 6. 1-2: object 2 (house 103, eastern long pit). Scale 1:1 (drawings: E. Bakytová).

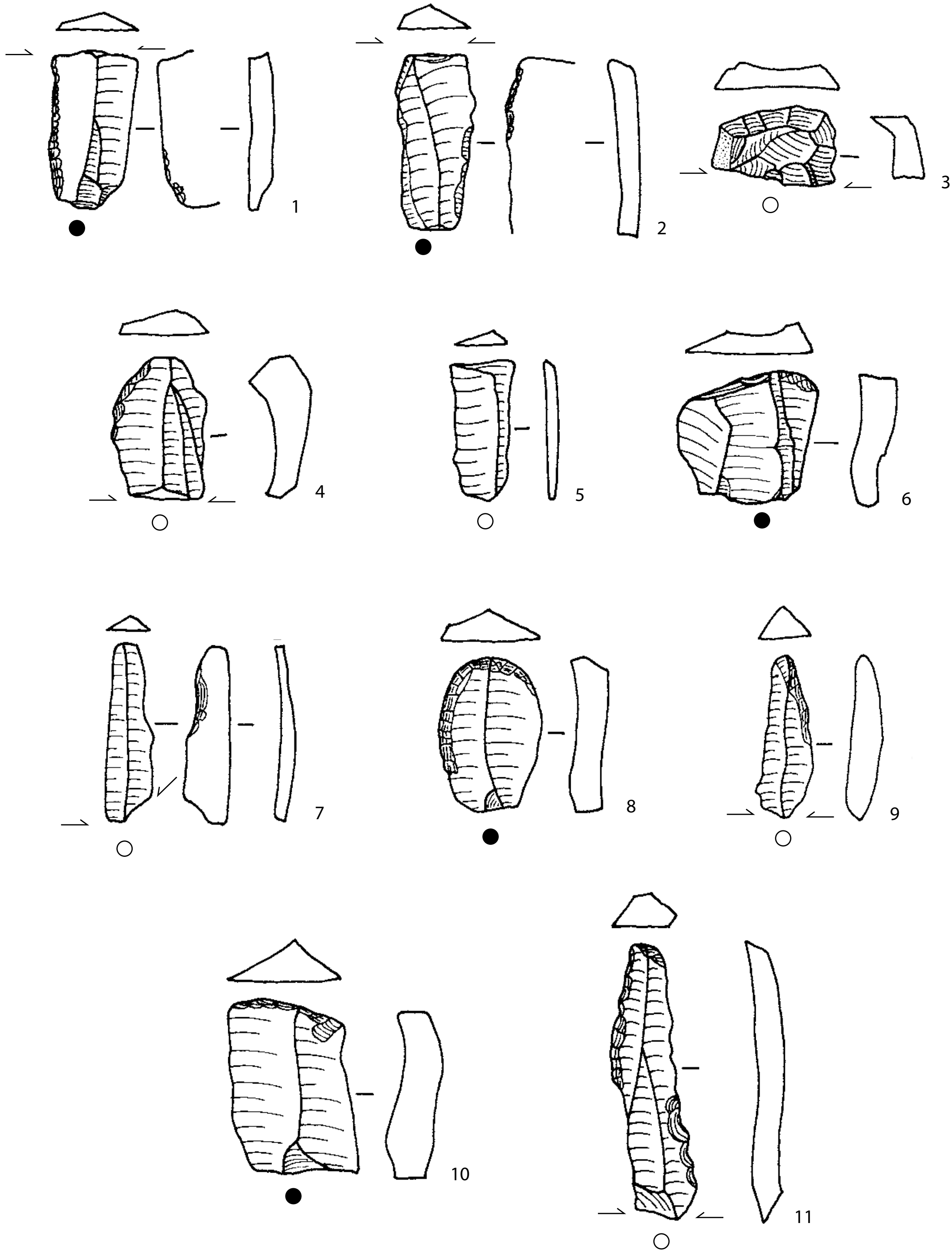

Plate 5.2.13. Chipped stone artefacts: 1-2: blades with retouched edges; 3: rejuvenating flake-tablet; 4,6: retouched blade with its fragments; 5: burin spill; 7: bladelet with notch; 8,10: blade end-scraper; 9: perforator; 11: drill. 1-2,5,11: trench 8; 3-4: trench 10; 6-10: trench 6. 1-2: object 6 (house 259, eastern long pit); 3-4: object 1 (house 262, western long pit); 5,11: object 8 (house 259, western long pit); 6-8,10: object 1(house 103, western long pit); 9: object 2 (house 103, eastern long pit). Scale 1:1 (drawings: E. Bakytová).

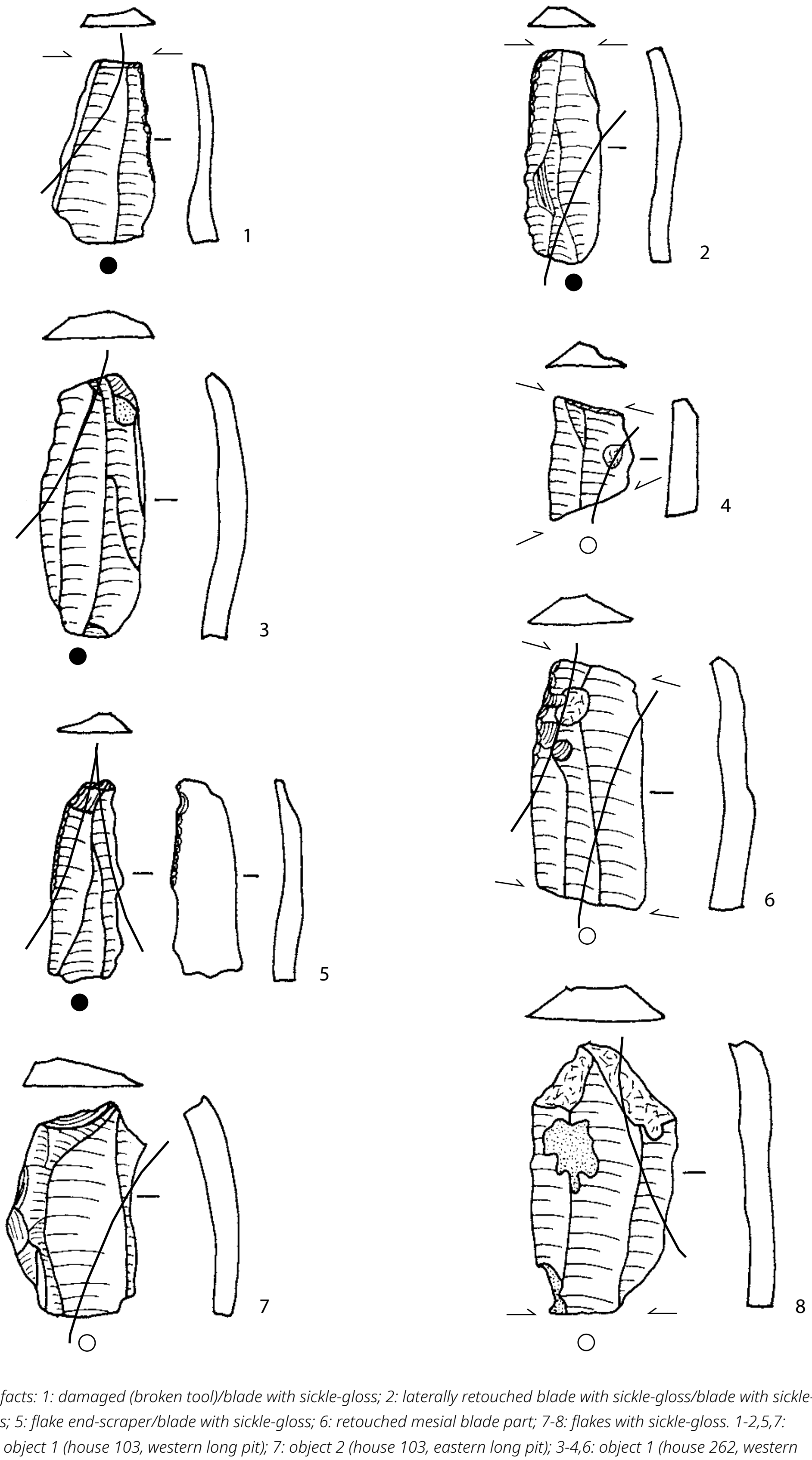

Plate 5.2.14. Chipped stone artefacts: 1: damaged (broken tool)/blade with sickle-gloss; 2: laterally retouched blade with sickle-gloss/blade with sickle-gloss; 3-4: blade with sickle-gloss; 5: flake end-scraper/blade with sickle-gloss; 6: retouched mesial blade part; 7-8: flakes with sickle-gloss. 1-2,5,7: trench 6; 3-4,6: trench 10. 1-2,5: object 1 (house 103, western long pit); 7: object 2 (house 103, eastern long pit); 3-4,6: object 1 (house 262, western long pit). Scale 1:1 (drawings: E. Bakytová).

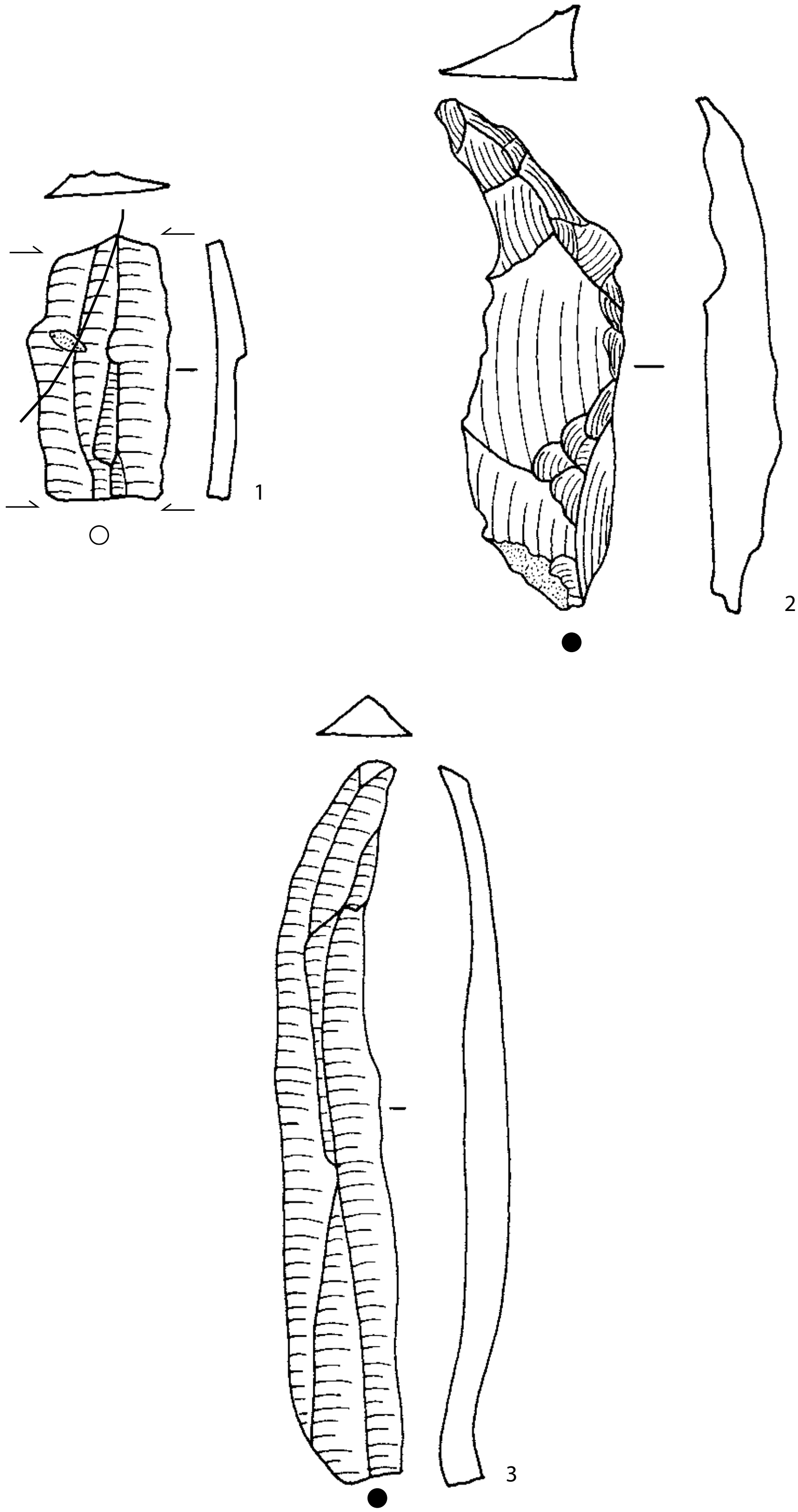

Plate 5.2.15. Chipped stone artefacts: 1: mesial portion of a blade with sickle-gloss; 2: crest blade; 3: blade. 1-3: trench 21. 1-2: grave 7; 3: grave 8. Scale 1:1 (drawings: E. Bakytová).

Plate 5.2.16. Ground stone tools: 1: miniature high adze blade; 2: fragment of a tall adze blade; 3: fragment of a flat axe blade; 4: pendant made from a potential polishing or colouring tool; 5: bead; 6: polishing stone; 7: fragment of the lower part of a grinding stone. 1,3,5: trench 12; 2,6: trench 13; 4: trench 3; 7: trench 14. 1: object 57 (house 131, eastern long pit); 2: object 24 (house 132, eastern long pit); 3: object 57 (house 131, eastern long pit); 4: object 1 (house 102, western long pit); 5: object 9 (house 132, western long pit); 6: object 122 (sunken dwelling?); 7: object 157 (house 126, western long pit). 1,2,3,6: scale 1:2; 4: scale 1:1; 5: scale 2:1; 7: scale: 1:4 (photos: A. Heitmann).

5.3. The bone artefacts from the LBK and Želiezovce settlement site of Vráble

Rebekka Eckelmann

Abstract

The spectrum of bone tools discovered at Vráble (Nitriansky kraj, Slovakia), despite being rather limited, is in many aspects comparable to the spectrums found in other LBK contexts. The assemblage is comprised of tools made predominantly from cattle ribs, such as spatulas, adzes and spoons, with the adze being of special interest because its main distribution is in the western LBK area. The bone tools were probably produced directly on-site. Some of the objects are indicative of high quality production and were re-worked, thus indicating their value to the community. A number of pendants and a possible figurine fragment further highlight the social aspects represented by these artefacts.

Keywords: Handicraft, symbolic meanings, bone production, cattle bones, worked bone

Introduction

A small number of bone artefacts was recovered during the excavations at the LBK and Želiezovce settlement site of Vráble. Although bone artefacts are among the most frequently encountered find categories, for a long time they played only a minor role in archaeological research. The number of publications on this subject as well as analyses of production processes and used materials only increased in recent years. Similarly, typological investigations gained in importance. Due to their small number and fragmentary preservation, the larger significance of the finds from Vráble is difficult to gauge. Accordingly, this chapter will be focused on presenting the bone artefacts found at the site and offer interpretations as to their use where it is possible.

For the purpose of this article bone artefacts are defined as all finds that consist of intentionally modified bones. The modification served the further use of the object in its new form, which is why changes to the bones caused by the processes of dissection and slaughter are not included. It is irrelevant whether the artefact was ever used in its intended form. In addition to use as a tool, a purely ornamental or representative application is also possible. Accordingly, the characteristics of a bone artefact are visible changes of the original bone, for example in the form of traces of usage, smoothing or grinding marks, working edges and carving marks.

Research history of LBK bone tools

The first archaeological report that included bone artefacts from the LBK was already published at the beginning of the 20th century, however, this remained an exception within a larger archaeological research landscape in which bone artefacts and their analysis were mostly ignored for the following decades (cf. Hüser 2005). The reasons for this are most likely their relative rarity and often poor preservation. For a long time, very little interpretative value was attributed to them compared with stone and ceramic finds. Following pioneering work in Russia, it was only from the mid-1960s onwards that Central European archaeological research also began to increasingly deal with bone artefacts, which included, among other things, analysis of traces of usage and comparative experimental studies (cf. Fehlmann 2008).

However, it took another 20 years for the first essay specifically concerned with LBK bone tools to be published by J. Rulf (1984). By the year 2000, more than a thousand bone artefacts from the LBK had been published, and this number has only increased since then (cf. Hüser 2002). In recent decades, attempts have been made to produce a typochronology of LBK bone artefacts. Still, according to the current state of research, this typochronology is only useful for rough chronological classifications in supra-regional areas (Sidéra 2013; Fehlmann 2008).

From the area of modern Slovakia LBK bone objects are for example known from Bíňa, Milanovce, Hurbanovo, Nitra and Štúrovo with the latter probably falling into the same period as Vráble, as well as from Bajč, which dates to the Prelengyel horizon (chronologically directly following the Želiezovce group). The most common type of finds are points, especially metapodial points as well as rib and shoulder blade tools; and, to a lesser extent, fishhooks (Pavúk 1980; 1966; 1994; Cheben 2000; Vlačiky 2011).

The overall small number of recovered bone artefacts has resulted in their relevance to the everyday life of prehistoric cultures often being strongly underestimated. Only comparisons with sites that have an exceptionally good preservation of organic materials, such as the alpine lakeside settlements, where large quantities of bone objects were found demonstrate that objects and implements made of bone and antler most likely played a much greater role in prehistoric societies than is generally assumed (cf. Hüser 2005). In addition, it is often difficult to identify fragmentarily preserved bone artefacts, especially in bone inventories that are poorly preserved, which often leads to them being grouped in and quantified with the zooarchaeological assemblage.

Overview of the bone tool finds

In contrast to France, where relatively uniform terms for bone objects where established in the 1970s, German and English language research communities use a large number of different systems for categorising bone artefacts, which are based on form, function or source material. Additionally, different terms for certain forms are used depending on the author (*e.g.* Haack 2002; Fritsch 1998; Fehlmann 2008). Since there are only 16 bone objects from Vráble in total, for which in several cases an exact determination of the skeletal element and hence taxon from which they originate is no longer possible, the present analysis is based on the scheme devised by D. Fehlmann (2008) based on the bone artefacts from Asparn-Schletz (Austria), which represents a combination of skeletal element and form. At the same time, other common designations are included to facilitate comparison with other works. As far as possible, the original material; greatest length, width and thickness; shape of the working end; state of preservation; traces of manufacture and use; and possible functional interpretation were recorded for each object. The measurements were taken using hand-held callipers, the anatomical determination was made with the help of the zoological collection of the Christian-Albrechts-Universität zu Kiel, and the analysis of traces of usage via a binocular microscope with a 40× magnification.

With regard to the general preservation of the artefacts, it should be noted that for none of the objects all fragments were recovered. In addition, the state of preservation of the finds varies greatly, resulting in some objects being very fragile and/or retaining only remnants of the original surface, while others are in good condition.

Artefacts from ribs

Most of the objects whose anatomical unit of origin could be determined were made from large mammal ribs, corresponding to other LBK sites most likely stemming from domestic cattle (see Sidéra 2001). With the exception of one artefact, which is probably a semi-finished product, the seven identified rib artefacts were split longitudinally, and the exposed cancellous bone was ground over at least rudimentarily.

In general, two groups of rib artefacts can be distinguished: rib scrapers and rib spatulas. Both have at least one working edge transverse to the rib length; they differ in that the spatulas consist of a longitudinally bisected rib whereas the scrapers consist of the full rib (cf. Fehlmann 2008). At least two objects at Vráble are categorised as rib spatulas. For others, this affiliation is considered to be likely. Rib spatulas are present in the entire area of the LBK and vary mostly in width and the shape of the working edge. A particularly large number was found at Bad Nauheim-Nieder-Mörlen (Germany) as well as at Vedrovice (Czech Republic); other exemplary sites include Asparn-Schletz and Rosenheim (France) (Hüser 2005; Berkovec *et al.* 2004; Fehlmann 2008; Haack 2002).

1 Rib spatula (Pl. 5.3.1,1)

Find no. S60090

Max. length	112.3 mm
Max. width	29.5 mm
Max. thickness	3.1 mm

A rib spatula made of a split large mammal rib, the surface of which is partially decomposed and whose lateral natural rib edges are still visible. The working edge is rectangular with rounded corners. It is clearly visible and shows signs of use, indicating that the appliance has been used for scraping or scratching. The working edge has probably been reworked or resharpened at least once.

Altogether, this is a typical example of a rib spatula, or broad spatula according to A. Hüser, as found at Bad Nauheim-Nieder-Mörlen (cf. Hüser 2005, Pl. 7, 96.105).

2 Rib spatula (Pl. 5.3.1,2)

Find no. S40064

Max. length	92.6 mm
Max. width	17.5 mm
Max. thickness	2.9 mm

In contrast to no. 1, described above, this object was very carefully smoothed all over. The longitudinal edges and the potential working edge were rounded almost completely and form a continuous smooth edge. Accordingly, the shape of the working edge is round or semi-circular.

In general, no further traces of usage could be found on the object that would indicate the preferred use of one working edge or a general use for scraping or scratching, which is often assumed for rib spatulas.

The shape of the object largely corresponds to what is known from rib spatulas with round working edges from Ansparn-Schletz and Hilzingen (Germany) (cf. Fehlmann 2011, Pl. 21; Fritsch 1998, Pl. 11, 20). However, the complete absence of traces of usage, as well as the very careful workmanship on this object is extremely unusual. If it was actually a spatula, it was probably never used for anything that would have put pressure on the edges, as they show no abrasion or work polish. It is therefore either a very new piece, was used in an unusual way or had a representative function.

3 Rib spatula

Find no. EF110263

At the time of analysis, the object was only available as a photograph, without scale and with an obvious crust of adhering soil. It was nevertheless possible to establish that the object most probably also represents a rib spatula, with slightly converging edges and a rectangular working edge with rounded corners. The side edges as well as the surface are smoothed. This form is known from Bad Nauheim-Nieder-Mörlen (see Hüser 2005, Pl. 6, 84.92), among other sites.

4 Bone stick/rib spatula (Pl. 5.3.1,3)

Find no. F80376	
Max. length	37.8 mm
Max. width	13.8 mm
Max. thickness	6.4 mm

This small object is one of the more elaborately crafted pieces among the find material. It is very carefully smoothed on both sides, which is why the cancellous bone is hardly visible on the inside. The lateral rib edges are rounded, and it is not entirely clear whether the short, rectangular end with rounded corners is a working edge. The slightly varying shape of the traces of usage present at this end – which could possibly indicate that the piece was resmoothed shortly before its disposal – as well as the slightly asymmetrical shape of this edge make it likely though, that it is indeed the working edge. However, it is unclear whether these traces are actually the result of the object having been used as a working tool or whether they are the result of shaping the object. If the artefact was used as a tool, it is probably also a rib spatula, but a very delicate one, which was not used for any work that would have exerted strong pressure on the object.

It cannot be excluded that the object is a purely decorative element in the sense of the bone sticks known from other LBK sites. If it was purely decorative, the traces observed could possibly also be the result of friction against the substrate on which the piece was sewn. In addition to its small size and thickness, which make it easily breakable, such an interpretation would also be supported by its very careful processing, even if the known pieces almost always consist of long bones and have a round profile. A piece that looks very similar to this one from Hilzingen 'Forsterbandried' was also classified by B. Fritsch (1998, Pl. 49.5) as a bone stick, since no working edge could be identified. At the same time, pieces that look very similar to the one at hand and to the one identified by B. Fritsch were identified by D. Fehlmann (2011, Pl. 23.5938) as narrow bone spatulas. A final classification of this and the following piece into one or the other category is not possible due to their fragmentary preservation.

5 Bone stick/rib spatula (Pl. 5.3.1,4)

Find no. S800301	
Max. length	59.7 mm
Max. width	9.6 mm
Max. thickness	2.5 mm

This object is very similar to the previous one in shape and colour, but slight differences indicate that it is not the second end of the same object. These variations include the preservation of the artefact, of which the surface is only partially preserved. But even this partial preservation cannot hide the strong smoothing and polishing of the object, which is the same as in the previous piece. In contrast to the previous find, however, in this case no possible traces of usage are discernible. The rectangular end with rounded corners is slightly damaged, but what remains is completely uniform and corresponds to the edges of the lateral sides in thickness and shape.

It is even more probable for this than for the previous object that is a kind of bone stick that was used decoratively and could, for example have been sewn onto clothing. It is similar to the items from other sites cited for object no. 4.

6 Bone spoon (Pl. 5.3.2,1)

Find no. S80376	
Max. length	108.7 mm
Max. width	19.5 mm
Max. thickness	3.9 mm

This item is also made from a split large mammal rib. The cancellous bone was not smoothed over in this artefact, and the general quality of the workmanship falls short of that of the two previously described objects. One of the lateral sides is significantly more uneven and rougher than the natural edge of a rib, which, in combination with the slightly converging shape, could indicate that it is an artificial edge for shaping the tool.

The artefacts most similar to the shape of this object are referred to as bone spoons and occur primarily in Eastern European sites of the Early Neolithic, with the settlement of Mezökövesd (Hungary), of the older Alföld-LBK, showing artefacts that could be similar to this one (cf. Kalicz and Koós 2002). Since ribs are generally poorly suited as a starting material for the production of points, which would be the alternative interpretation, the converging shape makes a spoon as the original shape of the object probable, even if this cannot be conclusively clarified due to the high degree of fragmentation (cf. Fig. 5.3.1).

7 Unfinished rib tool (Pl. 5.3.2,2)

Find no. F20109	
Max. length	48.3 mm
Max. width	14.2 mm
Max. thickness	7.1 mm

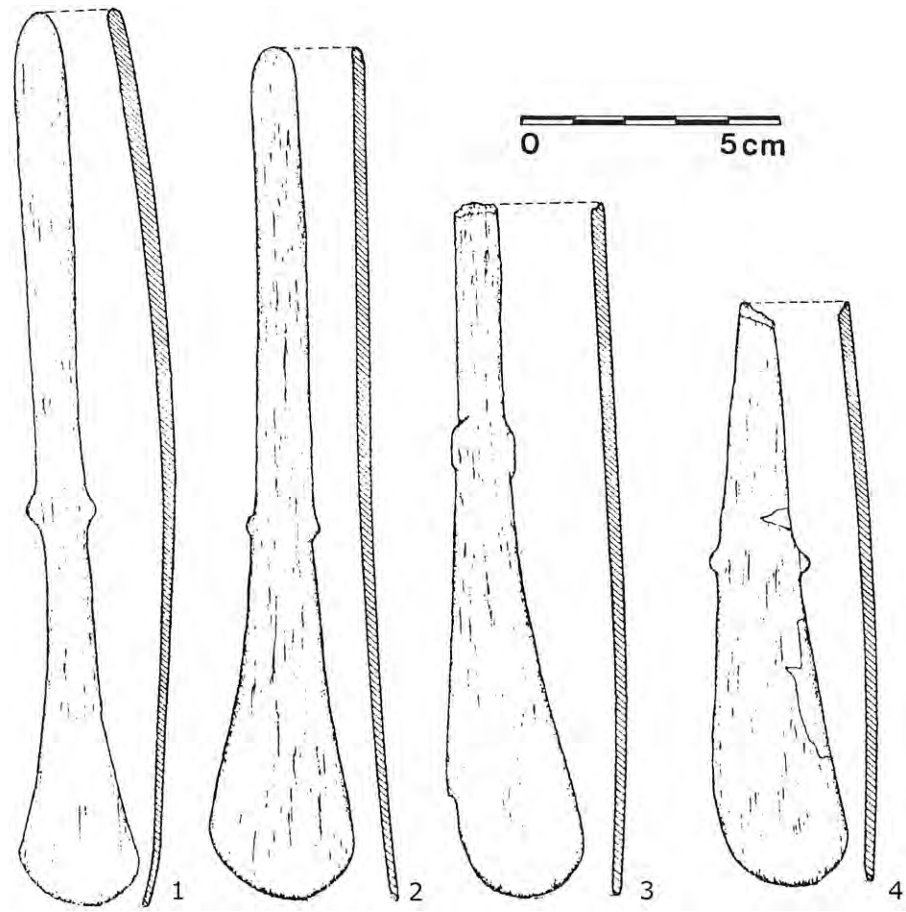

Figure 5.3.1. Various bone artefacts from Mezökövesd that resemble no. 6 at Vráble and are referred to as spoons (Laicz and Koós 2002, Fig. 16).

The object is a fragment of a rib tool that was probably not completed. The shape of the rib is still visible in the widest part, and there is no rounding of the edges, unlike seen in the other rib tools from Vráble. In addition, the surface is heavily eroded, although small scratches indicating perfunctory smoothing still remain. A working edge is not visible, which is also due to the fact that both short rib ends are broken off. Most rib objects are split lengthwise so that the cancellous bone is exposed (cf. Christidou 2001). Such a halving is also visible in this artefact, but it seems to have failed. Possibly it is a workpiece for which, after initial shaping, the halving of the rib failed, whereupon it was disposed of.

8 Rib object (Pl. 5.3.2,3)

Find no. F20146

Max. length	48.1 mm
Max. width	18.6 mm
Max. thickness	4.4 mm

The object presented is once again an artefact made from the longitudinally split rib of a large mammal, in which the exposed cancellous bone was largely smoothed over. Slight scratches running parallel to the lateral ends on the upper side may indicate polishing of the object. The lateral sides are only slightly rounded and retain a largely rectangular shape.

There are two possible 2 mm long chop marks running crosswise to the rib length. It is not possible to tell whether they occurred before or after the ends were smoothed. A working edge is not present due to the fracture, but it is nevertheless likely to be a piece stemming from a rib spatula.

Artefacts from long bones

Eight artefacts from Vráble were made from long bones, whereby the exact anatomical unit of origin could only be identified for three objects. Only three of the artefacts could be clearly identified as a device; two more are very likely to be pieces of jewellery.

9 Pestle-like object in the form of a horse's foot (Pl. 5.3.1,8)

Find no. S100064	
Max. length	146.4 mm
Max. width	86.4 mm
Max. thickness	63.5 mm

No comparative finds could be identified for this object, resembling in its form an over-stretched horse's foot. It was probably made from the proximal humerus of a cow. In comparison with some of the other pieces, the object has not been carefully reworked, despite its unusual shape, so the incision of the 'hoof' appears coarse. Various scratches and notches have not been smoothed over, and there is no polish. Traces of usage appear primarily on the underside of the 'hoof', in the form of long scratches running from the tip of the 'hoof' towards the shaft. The shape of the object, as well as the lack of further traces, suggest that the underside of the 'hoof' was actually the working surface of the device. Use as a hammer is unlikely due to the shape of the device as well as visible traces of usage. In difference to this using the object to rub or grind possibly relatively soft material seems nearly intuitive considering its shape. Very similar looking devices made of wood or stone are known as pestle variants from ethnological contexts, where they are mostly used for grinding rather than pounding (Covarrubias 1937) (Fig. 5.3.2). At the same time, the natural shape of the bone supports holding the object with the hand placed on the top, which could also indicate the device was used in a rubbing movement.

10 Strongly polished artefact/figurine fragment (Pl. 5.3.3,1)

Find no. F50025	
Max. length	66.0 mm
Max. width	21.3 mm
Max. thickness	7.1 mm

The original material of this object is probably the long bone of a large mammal, and the structure and thickness of the material suggests it stems from a metapodial. The piece has been very intensively smoothed and polished, resulting in most of its back being completely flattened. A deep incision in the centre of the object and two curves and smaller cuts suggest that the artefact was carved into shape, although it is not clear what exactly it could have been used for.

A clear resemblance to the abdomen of an anthropomorphic figurine with legs stretched out is visible. Its shape suggests the object could also have had other uses, such as straightening points, but bone is actually too soft as a material for such use. The clear shape of the main incision, which is not rounded by use, and the generally high quality of processing displayed are further arguments against such an interpretation. The object itself is too fragmentary to allow an unambiguous interpretation. It should be noted, however, that the known anthropomorphic representations from the LBK are very variable in shape and that a small number of these using bone as a source material have been recorded during recent years. These include one piece each from Berry-au-Bac (France) and Stráne pod Tatrami (Slovakia) interpreted as figurative representations, of which the lower half, especially in the case of the latter, shows clear parallels to the piece presented here (Fig. 5.3.3). Accordingly, an interpretation as an anthropomorphic representation of unknown function seems most reasonable.

Figure 5.3.2. Balinese Pengulakan pestle that resembles no. 9 at Vráble. Ethnographically, this tool is known both in stone and in wood.

11 Metapodial point (Pl. 5.3.4,1)

Find no. EF110135

Max. length	70.3 mm
Max. width	10.6 mm
Max. thickness	6.8 mm

This artefact is the working end of a point made from the metapodial of a small ruminant. The handle is not preserved and therefore it is not possible to say if it was made from the proximal or distal part of a metapodial. Distal metapodials including the condyle are, however, more common. Polishing is recognisable surrounding the tip but not on the upper shaft area. This could indicate a reworking of the point, as has been proven for other sites (Fehlmann 2008). However, since no traces of grinding or sharpening could be detected, this interpretation is not unambiguous. The side edges have been rounded off. Metapodial points are present in most LBK bone artifact assemblages. In Slovakia, examples exist from Štúrovo, which is contemporaneous with Vráble, and from the burial site at Nitra (Pavúk 1994, Fig. 52; 1972, Fig. 24-25).

12 Bone tool/metapodial point

Find no. EF13243

This find most probably represents a shaft fragment of a metapodial point, which should largely correspond in base material and form with the one described above. Due to the high degree of fragmentation, however, a clear identification is no longer possible.

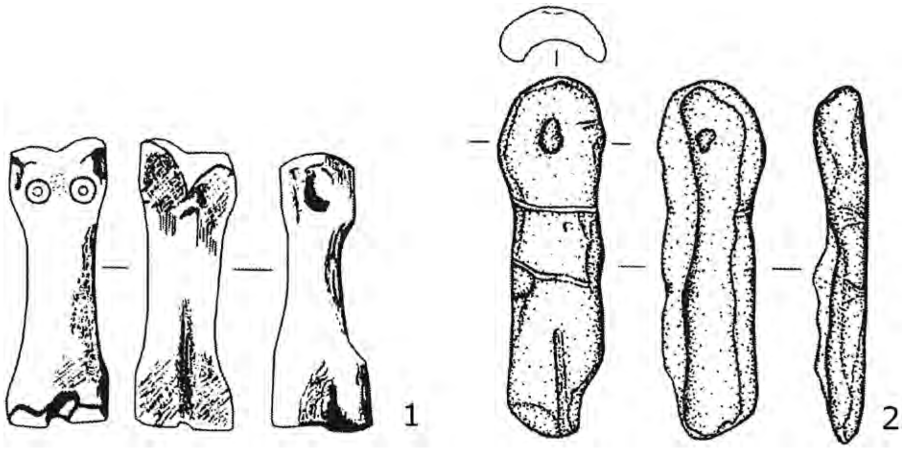

Figure 5.3.3. Two anthropomorphic figurines of the LBK from Berry-au-Bac and Stráne pod Tatrami that resemble no. 11 in the leg section (the latter in particular). Scale 1 : 2 (Becker 2011, Pl. 111, 3-4).

13 Bone tool/point (Pl. 5.3.4,2)

Find no. FS40125	
Max. length	74.1 mm
Max. width	11.8 mm
Max. thickness	3.2 mm

The object is in very poor condition: there is almost nothing left of the original surface, and the shape is also strongly changed by fragmentation It is likely that the bone was already broken at the time of use, which gives the impression of a spontaneously used or recycled tool. The tip itself has polish from usage and is slightly rounded. Points have been used for many purposes, but since this is made from a very thin bone, it may not have been used to work very hard materials. Ad hoc points are also known from Bad Nauheim-Nieder-Mörlen (Hüser 2005, Pl. 13) and Rosenheim (Haack 2002, Pl. 19).

14 Bone adze (Pl. 5.3.4,3)

Find no. S80306	
Max. length	59.2 mm
Max. width	17.3 mm
Max. thickness	9.2 mm

This object was made from the long bone of a large mammal and is covered with scratches of various orientations. The more recent ones seem to overlap the older ones and indicate a usage of the V-shaped working edge, which exerts pressure parallel to the long sides of the tool. In profile, the object has the shape of a stone adze. So-called bone adzes or bone chisels are also known from other LBK sites and have already been experimentally examined for their use (cf. Lobisser 1998). Differences in the shape to that of a stone adze are mainly due to the medullary cavity of the long bone. However, it is also this difference in form which, according to the experiments, makes this type of device especially suitable for hollowing out and working wood. Although bone adzes never occur in larger quantities at one site, they are geographically widespread, with the emphasis on the western distribution area of the LBK. Finds have previously been documented *e.g.* at Herxheim, Rosenheim, Berry-au-Bac and Hilzingen (Haack 2002, Pl. 30-31, 146-149; Fritsch 1998, Pl. 1, 19; 10, 16; 47, 14; Sidéra 2000, Fig. 6).

15 Bone pendant (Pl. 5.3.4,4)

Find no. EF14252

Max. length	43.1 mm
Max. width	13.8 mm
Max. thickness	6.4 mm

This object consists of two fragments made from what appears to be long bone from a large mammal. The two most likely belong to the same artefact and are therefore described together. The artefact has a drop-like shape, which is extended to the rear by the natural cavity of the long bone, leading to a U-shaped cross-section. The narrower side contains a drilled hole which probably served to hang the artefact on a thread or thong. The exact type of drilling can no longer be determined due to the poor surface preservation.

Generally, there is a large variety of bone pendants known from the LBK. The piece from Vráble cannot be clearly identified due to its fragmentation. Similar finds, interpreted as trophy imitations (*Hirschgrandel*, literally a canine tooth of a male deer), have been found at Asparn-Schletz (Fehlmann 2008, Pl. 30).

16 Bone artefact/bone pendant (Pl. 5.3.4,5)

Find no. EF13214

Max. length	74.3 mm
Max. width	21.1 mm
Max. thickness	4.1 mm

This object was only available as a photograph. It was made from the compacta of a long bone and has the approximate shape of an isosceles acute triangle with one long side bent outwards. The object is probably present in its full length, as there are remains of the smoothed original surface at both longitudinal ends. Traces of smoothing are clearly visible, as are traces of parallel running marks of processing on the lateral sides. In addition, there is an indentation in the area of the acute angle. Whether this is natural or was subsequently incorporated is not visible. It is not a perforation, but could be a failed attempt at one. If this is the case, the object is probably a pendant, similar to the previous one.

Discussion

The majority of the artefacts found are rib tools, in particular the rib spatulas, two of which have been clearly identified, and another four objects that may belong to this category. Rib spatulas are generally known in two different sizes, over the full or half width of the rib, the original material commonly being bovine bone (Sidéra 2001). Usually only the ends of the rib spatulas can be identified in the inventory. Complete specimens only exist in isolated cases, but these show that originally both rib ends were worked as partly differently shaped working edges. They were probably produced by cutting off the side edges and then splitting the rib along the cancellous bone (Christidou 2001). At Vráble, it is very likely that the unfinished rib object (no. 7) is part of this process.

The use of these spatulas continues to be controversial. It is probable they had a role in leather processing, in the stretching and scraping of hides, and as spatulas to aid the shaping and decoration of ceramics. Another option, which is more disputed, proposes a use as cutlery (Hüser 2005).

In general, rib spatulas are the second most common form of bone tool in most LBK find contexts, surpassed only by metapodial points (Rulf 1984). One securely identified and one probable point were present at Vráble. Based on widespread finds of semi-finished products of this form, a largely standardized method of production is assumed, in which the metapodials were split longitudinally along the natural sulcus, allowing the epicondyles to serve as a handle. Metapodial points are also referred to as (bone) awls and can be found far into the metal ages (cf. Pavúk 1994; Fehlmann 2008). They were probably used multifunctionally, but an association with leather and textile processing is assumed (Schibler 1997). No artefacts of antler or tooth have been found at Vráble so far, which is probably due to the fact that their occurrence is consistently rarer than that of bone objects and that the total number of bone artefacts at Vráble is low.

Overall, few general statements can be made about the use of bone artefacts at Vráble on the basis of the found objects. Find no. 7, which is very probably a semi-finished product, suggests that bone artefacts were produced at Vráble. The same local origin probably applies to most of the finds, since there are no clearly identifiable foreign forms. Processing techniques that have been identified on the objects include chopping to break up the ribs, smoothing, carving and polishing (although it is likely in some cases the visible polishing stems from use), and drilling. The traces of breakage present on all the objects studied were not created during the excavation, making it probable that the objects were disposed of after they broke.

Of the identified objects, only the spoon and the bone adze are known to have a regionally focused distribution. For this kind of spoon, the known focus lies within the Eastern European distribution area of the LBK, which makes its appearance at Vráble not unusual. Bone adzes are mainly known from the western distribution area of the LBK, and it was assumed that they occur only in the Stroke-ornamented ware culture sites in eastern Europe (Fehlmann 2008). The object found at Vráble could therefore be either an import or proof that this form also occurs to a lesser extent in the Eastern European LBK. For the other objects, there are either no comparative finds that would permit a spatial or chronological delimitation, or, as in the case of the spatulas they are forms whose distribution largely corresponds to that of the LBK in general and in some cases extends even farther (cf. Hüser 2005). Although according to Sídera (2013) rib spatulas are more typical for the older LBK than for the younger LBK, they do still occur during this time.

In general, it can be said that despite their small number the finds from Vráble reflect a diverse picture. While the high proportion of rib artefacts may indicate a uniformity of forms, there is at the same time great variance shown by the fact that nearly all other types of artifact are only present once within the assemblage and at least the pestle is up until now the only one of its kind. The quality of the objects is also diverse, ranging from a presumably reused, very coarsely worked point to the extremely carefully smoothed over and polished spatula/bone sticks. At the same time, the pestle in particular shows that everyday objects could still have an artistic component, because the conscious emphasis on the hoof form does not represent an improvement in use in the physical sense, but a purely aesthetic or possibly symbolic one.

Through this diversity, the finds at Vráble ultimately reflect not only aspects of bone processing, but also various impressions of human life in a settlement of the Early Neolithic, since both everyday working materials and elements serving ritual and adornment purposes are present. This multitude of shapes is not unusual for settlements from which bone artefacts have been published. Certain forms, such as the rib spatulas and metapodial points, appear again and again and often in large numbers, which speaks for their frequent and presumably diverse use. At the same time, there are also almost always unique pieces. This is probably, on the one hand, owed to human creativity and, on the other hand, to the fact that bone artefacts are usually far worse preserved than those made of stone and therefore many forms may have not survived in the archaeological record. As was already mentioned, sites with wet soil preservation show a significantly higher proportion of various bone artefacts, which suggests their not inconsiderable importance in people's lives. This in itself is not unexpected since bone is a relatively easily accessible and workable material (Hüser 2005).

Conclusions

Due to the small number of finds and the fragmentary existence of all 16 of them, it was not possible in many cases to clearly identify an artefact. The found spectrum of forms corresponds approximately to what is known from other sites and shows a larger number of rib artefacts, among them several rib spatulas, as well as some artefacts of different forms made of long bones. Of particular importance are a unique, pestle-like device in the shape of a hoof, as well as a fragment that could represent a figurine's leg section. The bone artefacts did not allow a temporal or chronological determination of the finds beyond the range assumed for Vráble on the basis of other investigations.

Bone artefacts were used and probably produced on site, they largely correspond to the canon of artefacts known from the LBK, and reflect technical skill. In the wider context of the LBK, despite the increasing importance of bone objects in research, many forms probably remain yet unknown. Accordingly, it remains an urgent necessity to keep paying attention to these artefacts in order to better understand the role bone played in the past as a raw material for tools and other uses.

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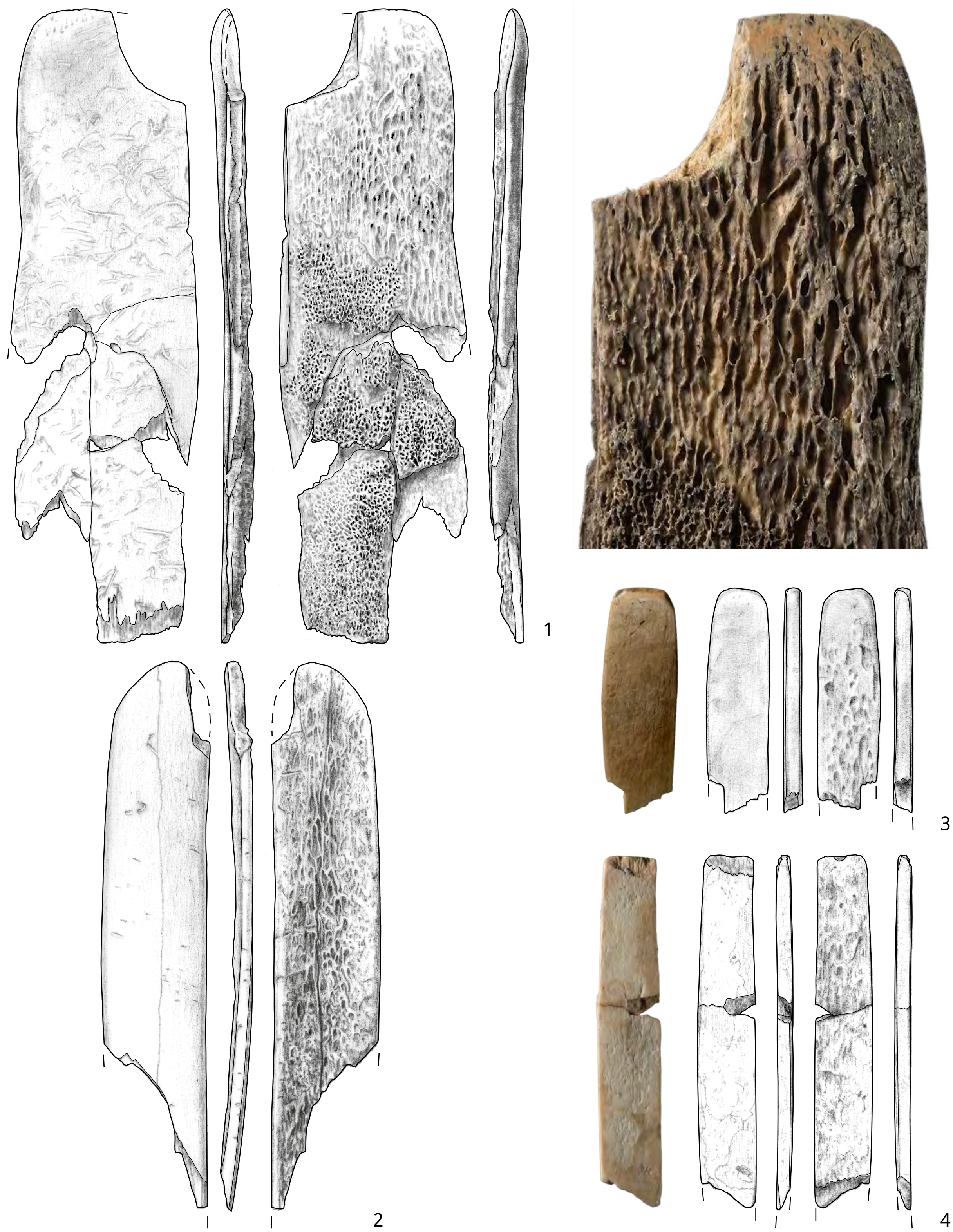

Plate 5.3.1. Bone tools. 1 and 2: Rib spatula; 3 and 4: Bone stick/rib spatula. Scale 1:1.

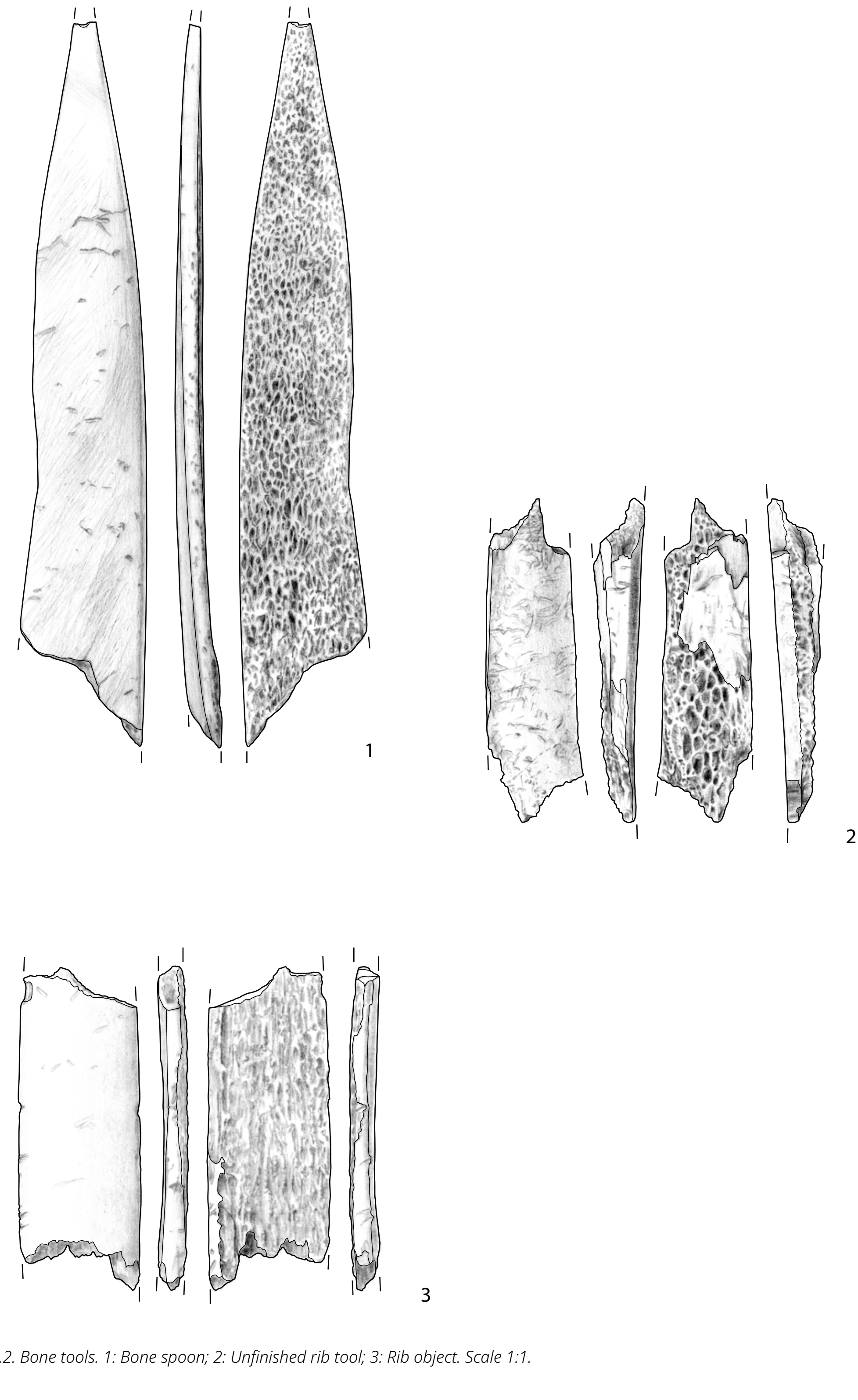

Plate 5.3.2. Bone tools. 1: Bone spoon; 2: Unfinished rib tool; 3: Rib object. Scale 1:1.

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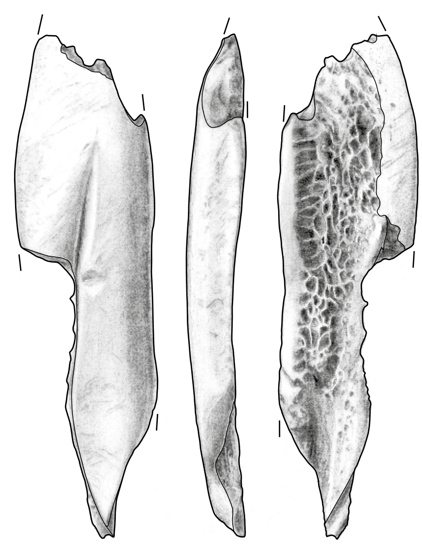

2

Plate 5.3.3. Bone tools. 1: Pestle-like object in the form of a horse foot; 2: Strongly polished artefact/figurine fragment. 1: scale 2:3; 2: scale 1:1.

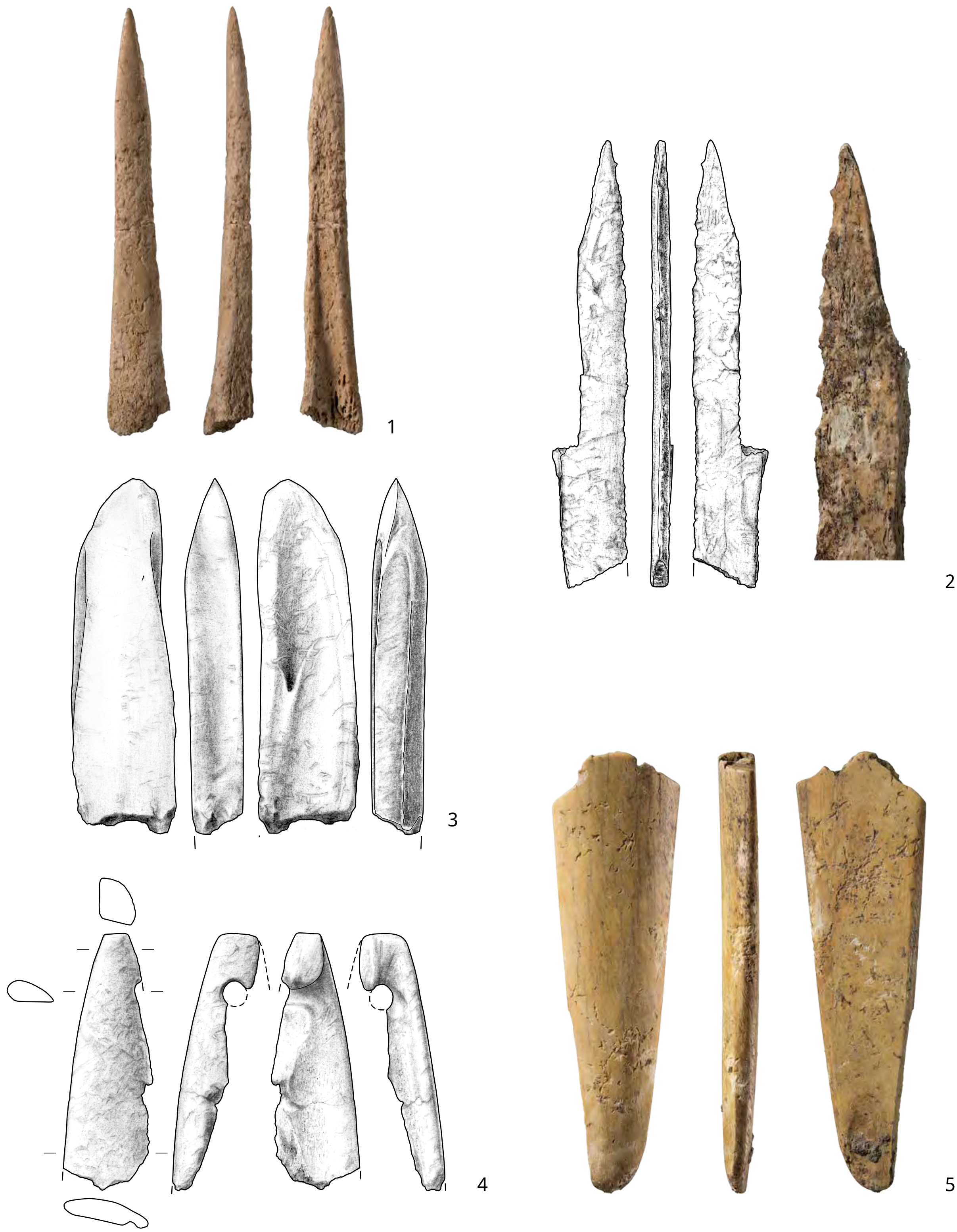

Plate 5.3.4. Bone tools. 1: Metapodial point; 2: Bone tool/tip; 3: Bone adze; 4: Bone pendant; 5: Bone artefact/bone pendant. Scale 1:1.

5.4. The animal remains from the LBK and Želiezovce settlement site of Vráble

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Abstract

Linearbandkeramik (LBK) communities across Central Europe exploited domesticated cattle, sheep, goats and pigs for household subsistence. Here, we explore animal exploitation strategies used by LBK farmers in south-western Slovakia, where the modes and types of animal husbandry are less well known. Zooarchaeological analyses of fauna recovered from Vráble 'Veľké Lehemby'/'Farské' (Nitriansky kraj, Slovakia) indicate a heavy focus on domesticated livestock, with only very occasional hunting of wild ungulates. Unlike at other LBK sites in Europe where cattle predominate, animal husbandry systems at Vráble focused on the exploitation of pigs. This may reflect the unusually concentrated settlement at this site, which might have encouraged rapid production of meat and removal of household refuse. Spatial differences in the frequency cattle, ovicaprids and pigs between three different neighbourhoods within the settlement may indicate variation in household or neighbourhood production strategies, but much larger sample sizes are needed in order to confirm these patterns.

Keywords Neolithic, LBK, Early Neolithic, Slovakia, zooarchaeology, archaeozoology, subsistence, social identity

Introduction

The spread of plant agriculture and animal husbandry into Central Europe during the sixth millennium BCE initiated a cascade of transformations in local subsistence strategies and landscape use. The first Linearbandkeramik (Linear Pottery Culture) groups established settlements on the Transdanubian plains around 5600/5500-5350 BCE (Oross and Bánffy 2009). While LBK settlement and subsistence is relatively well known in Central Germany and France, less is known about these communities in Central-Eastern Europe. However, recent research in this region exploring the initial arrival of the Neolithic in Central Europe is providing new insights into regional variation in LBK subsistence practices (*e.g.* Oross and Bánffy 2009; Furholt *et al.* 2014; Tóth *et al.* 2011; Bartosiewicz 2005). The Neolithic site of Vráble, which comprises three neighbourhoods (the southwestern: Vráble I, the southeastern: Vráble II, and the northern: Vráble III), offers the possibility to study a faunal assemblage from one of the largest LBK settlements located in Central Europe and to explore intra-site variation in animal exploitation practices.

Material and methods

Material

The faunal assemblage from 2012 through 2014 was recovered from excavation areas 2 through 10, which include eight distinct LBK longhouses and associated elongated pits. Two of these longhouses were situated in the south-eastern neighbourhood Vráble II, five in the northern neighbourhood Vráble III, and one in the south-western neighbourhood Vráble I. A total of 1,010 bone specimens were recovered from these three areas, of which 431 were identified to genus level. An additional 733 specimens were recovered during the 2016 and 2017 campaigns, of which 84 were identifiable to genus. This assemblage was recovered from the south-western and south-eastern neighbourhoods (I and II) and includes material from areas 11 to 14 as well as 21 to 23 (which include parts of a further seven LBK houses), as well as other features and pits.

Faunal remains from excavation areas 4 and 7 were recovered using a 1 cm^2 mesh sieve, while those from other areas were retrieved by hand-picking. Overall, bone preservation was poor, with specimens breaking after their removal from the sediment. This is not uncommon on LBK sites, which are generally situated on loess soil unfavourable to bone preservation (see Chapter 2.3) (Gordon and Buikstra 1981; Whittle 2005).

Faunal analysis

Faunal analysis of the material recovered from the 2012-2014 seasons was undertaken at the Zooarchaeology Laboratory at the University of Kiel, by Eckelmann (2017), while analysis of the material from the 2016 and 2017 seasons was undertaken at the Centre for Baltic and Scandinavian Archaeology in Schleswig, by Sarah Pleuger and Ulrich Schmölcke, respectively. Specimens were assigned a skeletal element and a taxon, to genus level where possible. The taxonomic categories 'large mammal' (i.e., cattle- or red deer-sized), 'medium mammal' (i.e., sheep-, goat-, or pig-sized) and 'small mammal' (i.e., rabbit- or fox-sized) were assigned to bone specimens bearing non-distinctive morphological traits. Symmetry, state of epiphyseal fusion, pathologies, and modifications were also recorded. In most cases, no distinction was made between sheep and goat due to poor preservation of morphological characteristics distinguishing each species. Microfauna, present as complete skeletons in deposits, most likely entered into the find context some time after initial deposition and are therefore not included in this analysis.

Metrical data were collected according to criteria established by von den Driesch (1976) and converted into log size index (LSI) values to enable size comparability between different anatomical elements (Meadow 1999). Standards used for LSI calculations are a Danish Mesolithic aurochs (Steppan 2001, remeasurement of the individual used in Degerbøl and Fredskild 1970) and a domesticated suid from the Neolithic site of Durrington Walls (Albarella and Payne 2005). Due to the small number of measurements available from Vráble, both length and width measurements, which respectively reflect height and weight, were used.

Age data were collected in order to construct survivorship curves and mortality profiles which provide information on animal production goals (Payne 1973; Gillis *et al.* 2017). Here, both eruption and wear stages of mandibular teeth as well as the state of epiphysial fusion of appendicular skeletal elements were recorded and analysed to estimate age at death and survivorship, respectively. Tooth wear was recorded using the methods developed by Grant (1982) and converted into age classes using methods developed for the aging of cattle by Legge (1992) and for pigs Lemoine and Zeder (2014). Sheep/goat tooth wear stages were recorded and converted into life stages according to Payne (1973). Age at epiphysial fusion was determined according to Silver (1969) for cattle and pig, and according to Zeder (2006) for sheep/goat. Additionally, bone specimens bearing underdeveloped cortical bone and bone structure indicative of infant or foetal individuals were also recorded according to these broad age categories.

Bone modifications, including cut marks, chopping, sawing, scraping, impact and burning were also recorded, as they are indicative of different processing and deposition practices. In order to also enable a better examination of the intensity of processing, taphonomic attributes, including fragment length and fracture patterns were also recorded. We used the fracture freshness index (FFI) by A. Outram (2001), which assigns points for the fracture angle, outline and edge texture of a bone fragment. A FFI score of 0 indicates a facture pattern associated with the breakage of fresh bone while a score of 6 indicates a pattern associated with the fracture of dry bone.

Different portions of an animal's body provide different types and quantities of meat, fats, hides and sinew. For the analysis of element distribution, the minimum number of each skeletal element (MNE) was calculated utilizing the method developed by Dobney and Rielly (1988) which is based on morphological zones. The results were divided into body part groups in order to identify variation in transport and processing practices between settlement parts.

The groups are as follows: the head and neck (skull, mandible, cervical vertebrae, axis, atlas); the axial skeleton below the neck (ribs, thoracic and lumbar vertebrae, sternum, sacrum and pelvis); the forelimb (scapula, humerus radius, ulna); the hindlimb (femur, patella tibia and fibula); and the distal extremities, including the metapodials, carpals, tarsals and phalanges. Isolated teeth were excluded from this grouping in order to limit bias in the calculation of body part distribution.

Results

Of the 1,743 bone specimens represented in the present study, 515 could be determined down to the genus level, and a further 366 specimens were only attributed to a size class (Table 5.4.1). Various remains of molluscs were also found during the excavations, but these were not included in this study (see Chapter 5.7). Pigs were the most commonly exploited taxon at Vráble (35%), followed by sheep/goat (30%) and cattle (29%). Fragments from medium-sized mammals were more abundant than those from large mammals. *Canis* sp. (n = 11; 2%), likely domesticates, were also identified, while wild animals, including roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), red fox (*Vulpes vulpes*), hare (*Lepus europaeus*) and grey partridge (*Perdix perdix*), comprised only 4% of specimens.

Body size distribution data indicate that pigs from Vráble were similar in size to domesticated pigs from the Late Neolithic site of Durrington Walls and comparable in size to animals from other LBK sites (Döhle 1994; Albarella and Payne 2005). Two very large-bodied individuals are likely wild boar (Fig. 5.4.1). For cattle, low LSI

	Bos sp.	*Sus sp.*	*Ovis aries/Capra hircus*	*Canis sp.*	*Cervus elaphus*	*Capreolus capreolus*	*Vulpes vulpes*	*Lepus europeana*	*Perdix perdix*	Large Mammal	Medium Mammal	Small Mammal	Microfauna	Unidentified	Total
Southwestern Neighbourhood	**55**	**38**	**39**	**0**	**2**	**2**	**0**	**4**	**0**	**31**	**80**	**2**	**5**	**494**	**752**
house 23	20	11	14					4		11	21			317	398
house 37	32	22	19		1	2				18	24	1	3	40	162
house 317	1		1							2				55	59
ditch		5	4		1						35	1	2	62	110
pits near ditch	2		1											20	23
Southeastern Neighbourhood	**61**	**70**	**73**	**1**	**1**	**1**	**1**	**0**	**1**	**36**	**52**	**4**	**10**	**206**	**517**
house 102	36	53	60		1	1	1		1	16	41	3	8	105	326
house 105	5	2	8							6	9	1	1	11	43
house 126	1													3	4
house 127	4									4				18	26
house 131	7	2	2							2				25	38
house 132	6	10	1							6			1	14	38
house 133	1	1	2	1						1	1			27	34
unattributable	1	2								1	1			3	8
Northern Neighbourhood	**35**	**73**	**42**	**10**	**1**	**4**	**1**			**43**	**94**	**9**		**162**	**474**
house 244		7	5							1	7	2		18	40
house 245	2	2	3	1						3	5			10	26
house 258	5	8	7							7	16	3		14	60
house 259	19	36	17	4		2	1			20	35	3		76	213
house 262	9	17	7			2				8	24			23	90
unattributable		3	3	5	1					4	7	1		21	45
Vráble	**151**	**181**	**154**	**11**	**4**	**7**	**2**	**4**	**1**	**110**	**226**	**15**	**15**	**862**	**1743**
% (n=515)	**29.3**	**35.2**	**29.9**	**2.1**	**0.8**	**1.4**	**0.4**	**0.8**	**0.2**						

Table 5.4.1. List of animal bones excavated 2012-2014 (identification by Rebekka Eckelmann) and 2017 (identification by Sarah Pleuger, Centre for Baltic and Scandinavian Archaeology) at the three neighbourhoods (I-III) in Vráble (NISP).

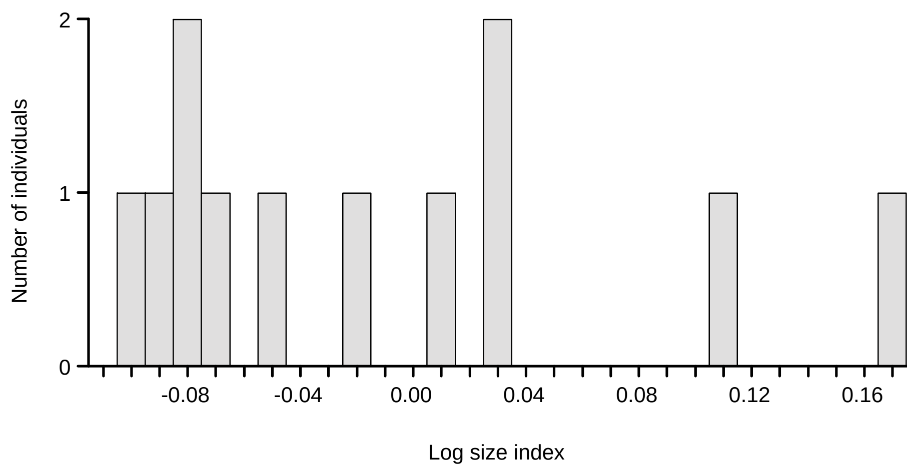


Figure 5.4.1. Log size index (LSI) distribution for pigs (n = 13; using Albarella and Payne 2005 as the standard).

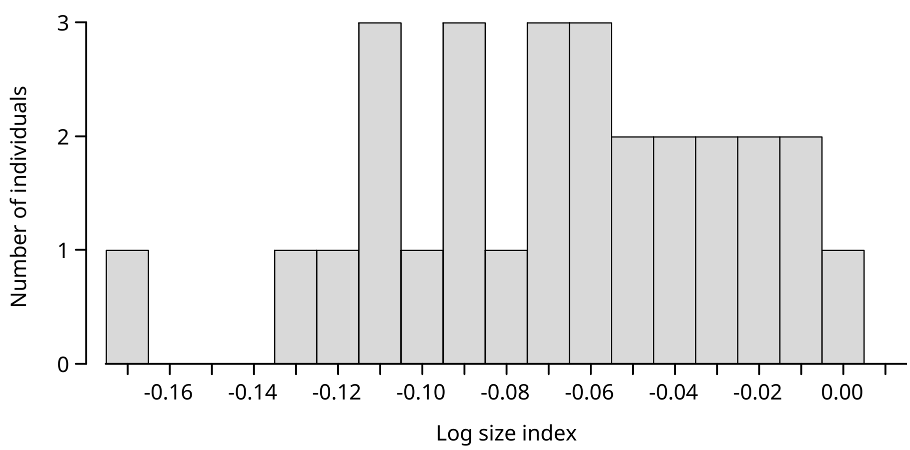


Figure 5.4.2. Log size index (LSI) distribution for cattle (n = 28; using Steppan 2001 as the standard).

values smaller than the range of values for female aurochsen indicate exploitation of domesticates at Vráble (Fig. 5.4.2).

Mortality profiles generated from a small sample of cattle tooth wear data indicate slaughter of young adult animals approximately from 3 years of age (Fig. 5.4.3) while epiphyseal fusion data indicates approximately 25% of animals survived beyond 4 years of age (Fig. 5.4.4). Kill-off of young adult animals is most consistent with a strategy geared towards meat production.

For pigs, mortality profiles indicate sustained harvesting starting from the end of the first year and continuing to the third year of life (Fig. 5.4.5). Epiphyseal fusion data indicates that only 10% of animals survived beyond 4 years of age (Fig. 5.4.6). Intensive harvesting of pigs before 3 years of age, when the costs of pig rearing begin to outweigh the gains, suggests intensive meat production. Caprine tooth wear indicates the slaughter of animals during the first and second years of life (Fig. 5.4.7), while epiphyseal fusion data indicate that 40% survived beyond 3 years of age (Fig. 5.4.8). This data suggest that most animals were slaughtered around two years in age when the investment-to-gain balance for meat production is at its peak (Payne 1973; Schmölcke *et al.* 2018). Similar harvesting practices are known from other LBK provinces (Bickle and Whittle 2013).

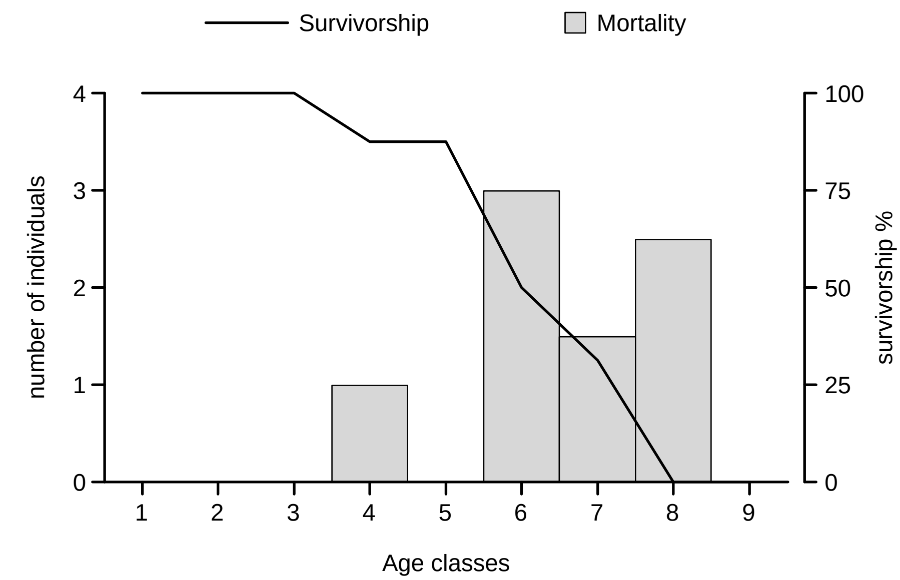


Figure 5.4.3. Cattle survivorship and mortality according to mandibular tooth wear (n = 8). Age classes refer to Legge (1992): 1= less then 1 months; 2=1-3 months; 3=3-6 months; 4=6-15 months; 5=15-26 months; 6= 26-36 months; 7=3-6 years; 8=6-8 years; 9=8-10 years.

Figure 5.4.4. Cattle survivorship according to epiphyseal fusion (n = 15). Age classes were assigned as A = up to 12 months; B = up to 24 months; C = up to 36 months; D = up to 48 months; E = older than 48 months. Bones in fusion were categorised as fused.

Figure 5.4.5. Pig survivorship and mortality according to mandibular tooth wear (n = 11). Age classes refer to Lemoine and Zeder (2014) but were pooled due to the small number of individuals, as follows: 0-1 = < 1 months; 2-4 = 3-12 months; 5-6 = 12-30 months; 7-8 = 30-52 months; 9-10 = > 72 months.

Figure 5.4.6. Pig survivorship according to epiphyseal fusion (n = 19). Age classes were assigned as A = up to 12 months; B = up to 24 months; C = up to 36 months; D = up to 48 months; E = older than 48 months. Bones in fusion were categorised as fused.

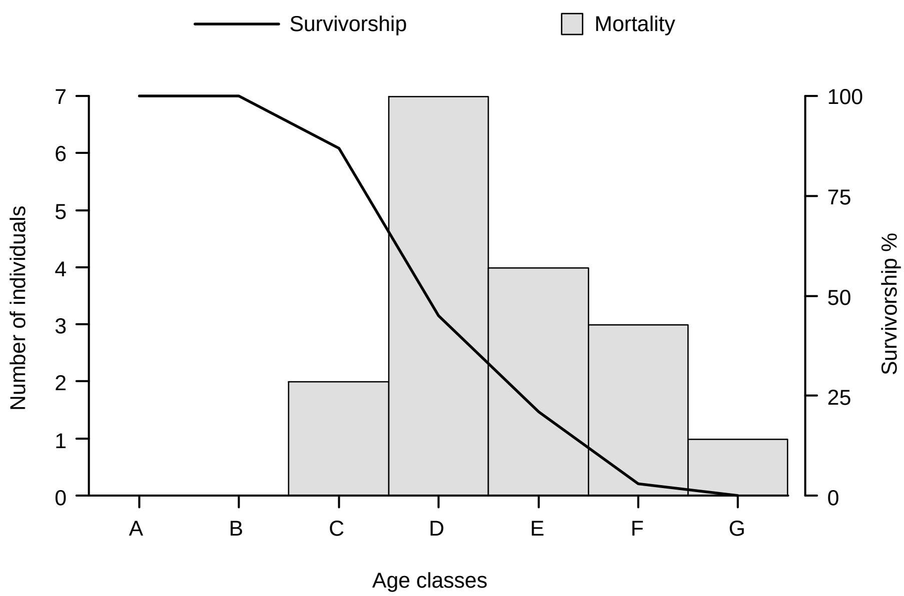


Figure 5.4.7. Sheep and goat survivorship and mortality according to mandibular tooth wear (n = 16). Age classes refer to Payne (1973): A = 0-2 months; B = 2-6 months; C = 6-12 months; D = 1-2 years; E = 2-3 years; F = 3-4 years; G = 4-6 years.

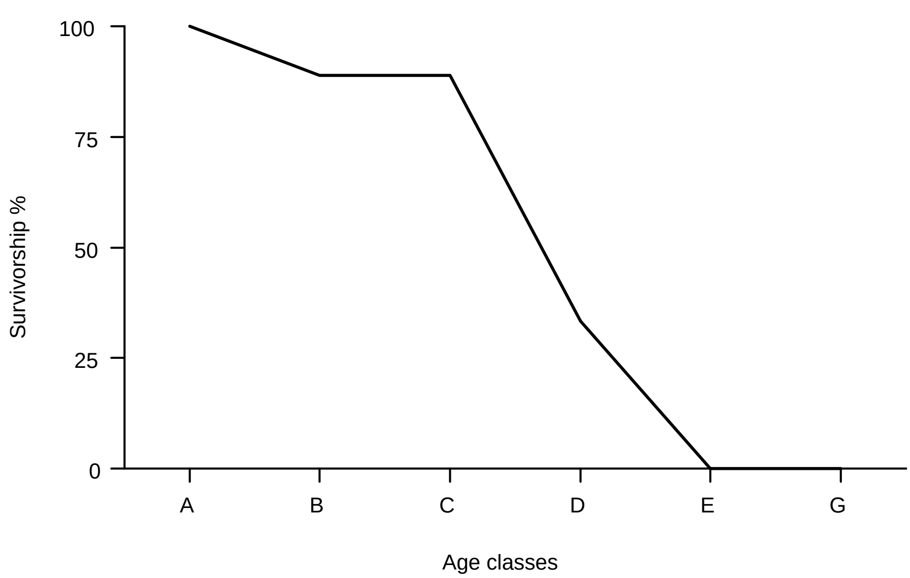


Figure 5.4.8. Sheep/Goat survivorship according to epiphyseal fusion (n = 18). Age classes refer to Zeder (2006): A = up to 6 months; B = up to 12 months; C = up to 18 months; D = up to 30 months; E = up to 48 months; G = older than 48 months. Bones in fusion were categorised as fused.

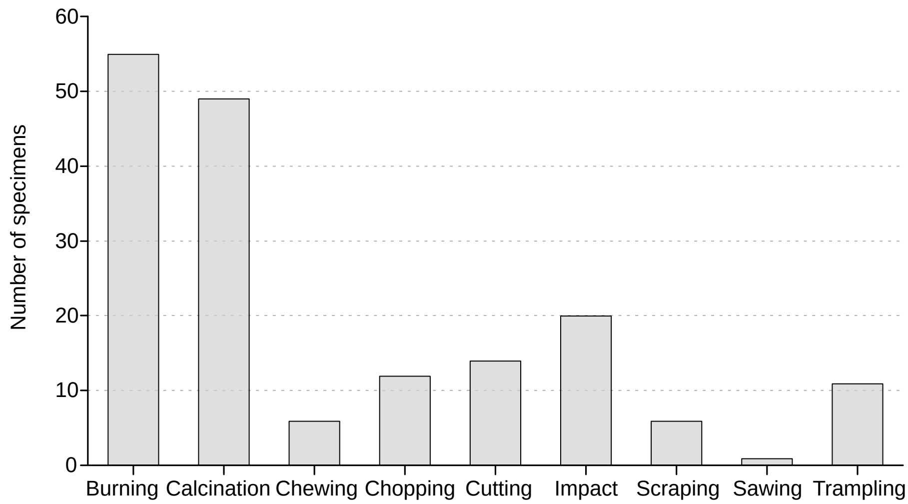


Figure 5.4.9. The number and distribution of elements with modifications indicative of either processing or waste management.

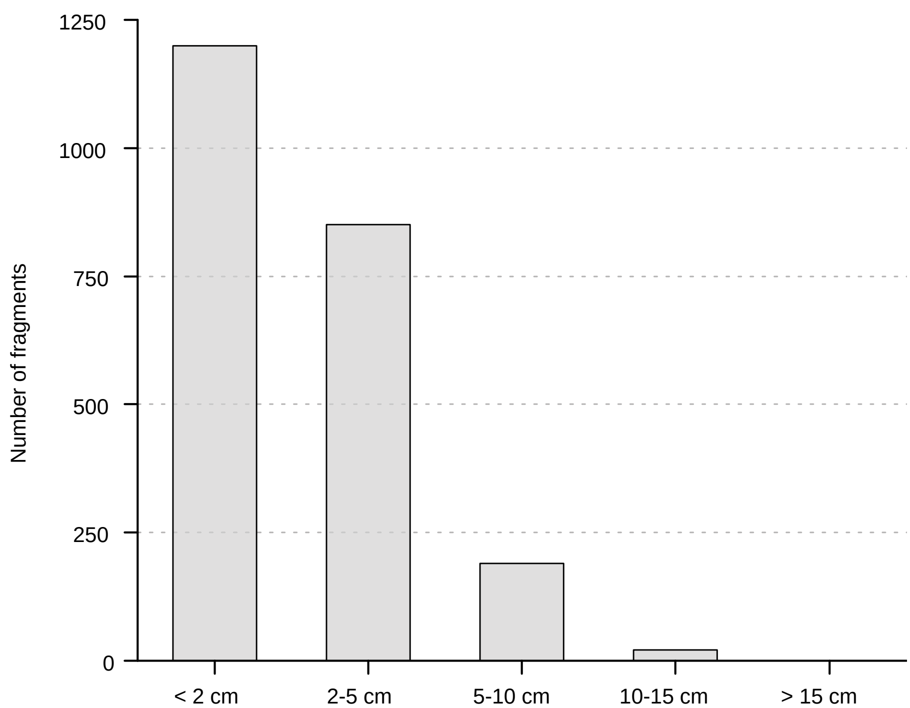
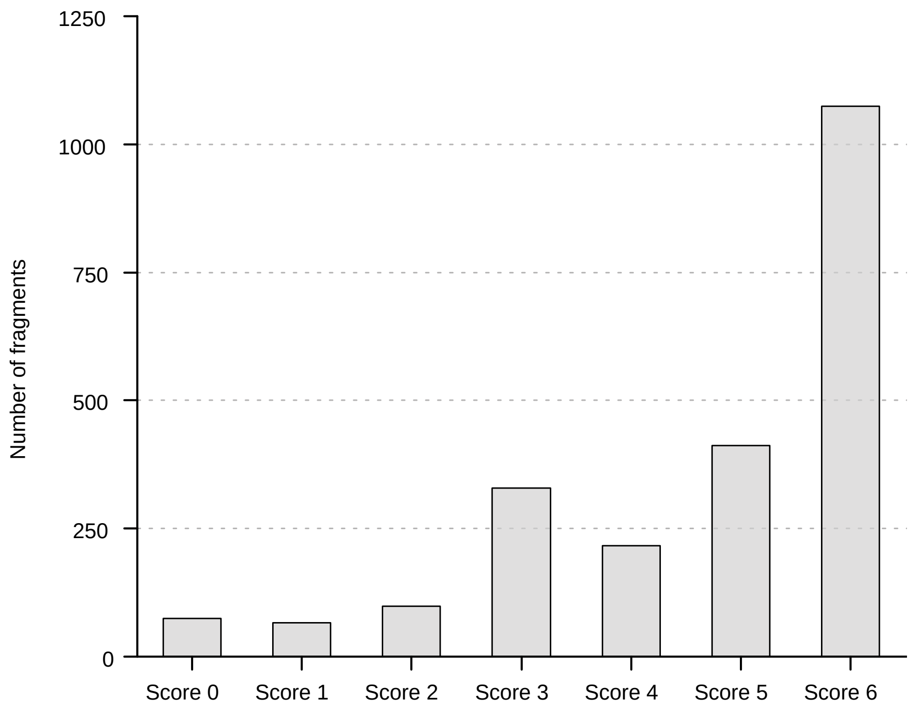


Figure 5.4.10. Size distribution of fragments with ancient breakage from the 2012-2014 seasons.

The faunal distribution within each individual neighbourhood varies slightly in terms of the taxonomic and skeletal element representation as well as degree of bone fragmentation. Pigs are most abundant in the northern neighbourhood (Table 5.4.1), sheep and goat in the south-eastern neighbourhood, and cattle in the south-western neighbourhood. Unfortunately, sample sizes are too small to confirm whether this variation is due to neighbourhood-specific animal use strategies or differences in disposal strategies.

Bone modification was largely limited to burning, with 6% of specimens exhibiting charring or calcination. Chop, cut, and impact marks caused by blows were visible on 1% of specimens (Fig. 5.4.9). Most chop marks occur near the long bone joints and on the dorsal rib area, in contrast to impact marks, which are mostly situated on the diaphysis of the long bones. No specific positioning of other marks could be identified. A number of bone specimens shaped into tools were made from the bones of medium-sized to large animals.



5.4.11. Fracture freshness index scores (following Outram 2001). Based on the assemblages from the 2012-2014 seasons exclusively.

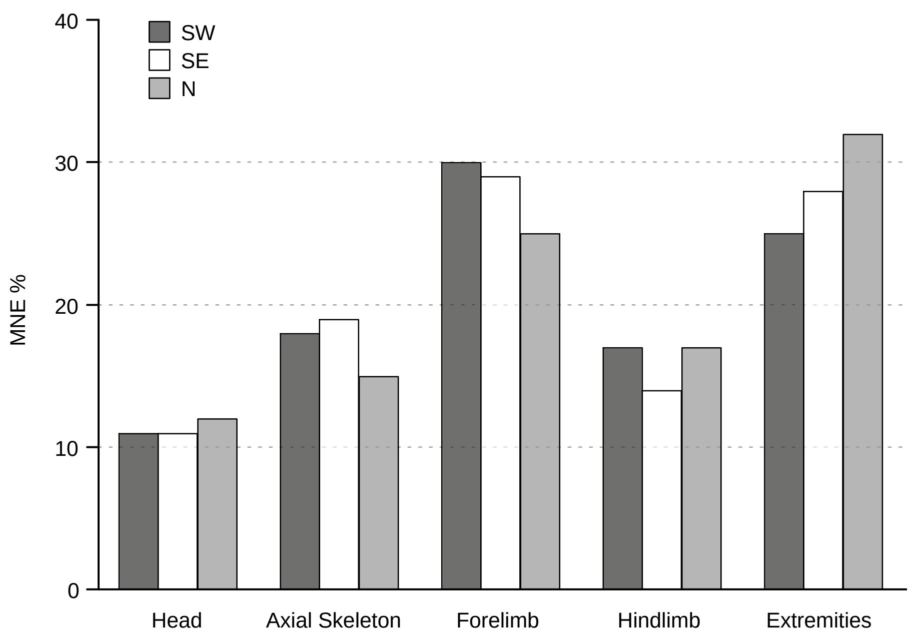


Figure 5.4.12. The abundance of different skeletal elements within the three different neighbourhoods at Vráble according to MNE. Isolated teeth are not included.

Fragmentation data were recorded only for the material excavated in 2012-2014. Over 50% of the fragments exhibiting ancient fractures are less than 2 cm in length (Fig. 5.4.10). Only 9% of the fragments are 5 cm or greater in length. Almost half of fragments (48%) exhibit characteristics of 'dry' or 'old' breakage, which is suggestive of trampling (Fig. 5.4.11); 42% exhibit ambiguous characteristics, and 10% exhibit characteristics of fresh breakage patterns.

Skeletal elements were evenly distributed with areas naturally consisting of more bones in one skeleton (*e.g.* the skull area in comparison to the hindlimb) showing a higher prevalence (Fig. 5.4.12). The distribution showed neither a conspicuous imbalance of epiphyses in comparison to shaft fragments nor a drastic predominance of a certain body part.

Special deposits

Most animal remains were recovered from the elongated pits running parallel to the side walls of the houses, but some material recovered from Areas 21 and 23 (both in the south-western neighbourhood) were recovered from different archaeological objects, namely, pits of undetermined function and a human burial. Object 21, a human burial containing the remains of a tightly flexed adult male, yielded an accumulation of sheep remains, presumably a grave good. The bones included a intact femur and tibia in articulation, a distal scapula exhibiting a fused epiphysis, two fused phalanx 2, a calcaneus, an ulna fragment, a fused radius, a metatarsal, an *os malleolare* (part of the ankle), an astragalus and half a pelvis. Fused distal and proximal ends on the femur indicate the animal was at least 4 years of age. All elements are from the left side of the body, presumably from the same individual. In addition, 15 very small, unidentifiable bone fragments were also recovered from the same context.

Object 18 is a small pit located in the elongation of the second, inner enclosure ditch in Area 21 – and possibly connected to that ditch – containing only two parts of a left and a right tibia each of an adult cattle, which had both been intentionally fractured during the Neolithic occupation. It is probable that these bones originate from the same individual. Apart from ten very small and unidentified fragments, the only other animal remain in this pit is a small part of a sheep/goat mandible.

Discussion

The range of animals exploited at Vráble is similar to that seen at other late LBK settlements in central Europe where cattle, sheep, goat and pig were exploited and game occasionally hunted, including red deer, roe deer and other, smaller species (Bickle and Whittle 2013). The molluscs, found in small numbers at Vráble and which include both freshwater and marine taxa, are also known from other sites (*ibid.*).

Economy

Wild animals

The low proportion of remains relating to hunting at Vráble is consistent with other LBK subsistence economies, where wild animals comprise only 3.5 to 5% of recovered faunal assemblages. Hunting of red deer, roe deer and possibly wild boar took place at Vráble, although it is unclear if this was carried out on an opportunistic basis or as part of intentional decisions to protect agricultural fields (see Benecke 2001; Lüning 2000). Hare, fox and grey partridge were also hunted.

Domestic animals

The overwhelming reliance on domesticated livestock at Vráble is consistent with animal exploitation systems employed by LBK communities elsewhere in central Europe (Bickle and Whittle 2013). However, while cattle herding typically served as the primary source of meat, milk, and manure at most LBK settlements (*e.g.* Bickle and Whittle 2013), pigs were more important at Vráble. High abundances of pigs and ovicaprids, similar to those at Vráble, have previously only been observed at the sites of Bruchenbrücken and Ammerbach-Pfäffingen, located in southern Germany (Lüning 2000). At some sites in southern Germany, pigs accounted for up to 40% of all domesticated animals, *e.g.* at Sallmannsberg and Wang (Bickle and Whittle 2013; Lüning 2000).

Sheep and goat occur less frequently in the Central European LBK sites than in the LBK sites in the Carpathian Basin, where, in contrast to the Central European LBK's cattle dominance, sheep and goats are more important (Bökönyi 1984). The higher frequency of ovicaprids at Vráble falls within the observed range for LBK sites in the middle Danube area (Knipper 2011).

The distribution of animal species shown in Table 5.4.1 represents an aggregation of bone and tooth specimens from all three settlements parts (neighbourhoods) and house units (cf. Table 5.4.1), which vary in species representation. For example, remains associated with house 259 and house 262, both located in the northern neighbourhood, the proportion of pig remains reaches nearly 50%, whereas in all other parts of the settlement and all other houses a more equal distribution of the three main domestic species is visible.

Different preferences in domestic species and variation in the proportion of wild animals exploited at various LBK may be due different local Mesolithic hunting traditions that persist into the Neolithic, variation in local ecologies that support different wild taxa, subsistence decisions, and what is referred to as 'cultural preferences' (Döhle 1993, Lüning 2000). Continued Mesolithic hunting traditions is often invoked for LBK sites in southern Germany which yield of both pigs and wild animals (Knipper 2011). For Vráble, however, this is an unlikely explanation as wild animal bones are as rare here as in most other LBK assemblages.

The overall shift to a dominance of cattle exploitation at in most LBK settlements in central Europe as opposed to sheep and goat herding prevalent in southeastern Europe, is usually attributed to different environmental conditions. The warmer and drier climates of the Balkan region may have encouraged a focus on the keeping of sheep and goat (Bökönyi 1974; Bartosiewicz 2005), practiced in earlier Near Eastern and Aegean traditions (Halstead 1996). It is possible that the earliest LBK farmers north of the Balkans employed similar practices in animal keeping and sought to continue sheep-based husbandry regardless of the different ecological conditions in their new environments (Pucher 1987; Stadler and Kotova, 2019). However, since relatively few grasslands were available in the newly settled regions of central Europe – in contrast to the areas formerly occupied in what is today southern Hungary – it is widely understood that early farmers in this region had to change their livestock economy. Accordingly, the economic importance of sheep husbandry decreased after the expansion of LBK into Central Europe (Bökönyi 1984). While the earliest LBK settlements in Austria heavily exploited sheep/goat at 5300 cal BCE, cattle-based animal exploitation increases until ca 4900 cal BCE when sheep and goats fell out of use, indicated by the rarity of their remains recovered from later LBK settlement sites located between the Alps and the Carpathians (Pucher 2001; Schmitzberger 2010). During the late LBK, around 4900 cal BCE, sheep remains are rare in archaeozoological assemblages and sometimes missing completely (Schmitzberger 2010).

Possible spatial differences in the faunal distribution at Vráble, could reflect different subsistence decisions by the households that comprise each neighbourhood may have been bound up in different intra-settlement social practices. As is discussed in chapters 6.1 and 6.3, Vráble is an agglomeration of independent farmsteads, which emerged and grew over time, most probably via relocation of farms previously more dispersed in the Žitava Valley and beyond. As emphasized by Bickle & Whittle (2013, 13-14), there is a marked regional variability of animal exploitation practices within the LBK area, the reasons for which are not yet well understood. The agglomeration of farms bringing potentially diverse traditions of subsistence practices into Vráble could account for variation in faunal composition across the site.

Although all three species were probably kept primarily for meat production, a simultaneous use of secondary products cannot be ruled out and is, in fact, likely. Manuring was a part of LBK small-scale, intensive horticultural cultivation (Bogaard *et al.* 2011; 2013; Saqualli 2014). This is also the case in Vráble, where $\delta^{15}N$

values of cereal grains suggest crop manuring (chapter 5.8.). Dairy products were also used within the LBK (Gillis et al. 2017). It seems that there was no intensive dairy economy but, rather, an extensive, small-scale use of dairy products (Gillis *et al.* 2017). For Vráble, milk production cannot be ruled out. It is possible that the presence of some older individuals, especially among the cattle reflects the of importance these animals as status indicators. Cattle may have played an important role in the emergence of social dependencies and the accumulation of prestige (Gillis *et al.* 2017). The amount of meat provided by a full-grown cow would be significantly greater than the amount that a single household could consume. As has been argued by Meadow (1984) and Russell (1998), storing meat is not always feasible. Sharing across households would have been a practical solution, while also serving to solidify social bonds within the community. Animals with additional expenditure investment, *e.g.* by raising them beyond the age of cost-efficient meat production, would be particularly suitable for such a social function (Russel 2011; Gillis *et al.* 2017). In such a situation, slaughtering cattle would not only highlight the owner's ability to afford the loss of an animal in their herd but would also sacrifice the labour put into rearing that animal to the community. The increased social value of cattle is indicated by their depiction in material culture demonstrated, for example, by LBK ceramic forms bearing decorations interpreted as cattle heads, which are also present at Vráble (see Chapter 5.1; Milisauskas 1976). An increase in social differentiation is often postulated for the late LBK period (*e.g.* Farruggia 2002; Golitko & Keeley 2007) and, cattle as a form of payment as well as a prestige object may have promoted this development (Russell 2011).

Beyond such social interpretations, differences in species distribution patterns could reflect a heterogeneous social composition of the inhabitants of Vráble, represented by an agglomeration of independent farms with roots in different regions. Differences in animal husbandry could also have served as a means to portray and consolidate identity relating to specific social subgroups, be they lineages, clans, or resident groups, such as neighbourhoods (Lüning 2000; Marciniak 2004; Hachem 2018).

According to evidence from stable isotope analysis, none of the domestic animals at Vráble were pastured within dense forest areas (see Chapter 5.8). As most of the wild animals found at Vráble prefer open land habitats to dense forests as well (Heptner *et al.* 1988), these results suggest an absence of densely forested landscape during the Early Neolithic. Recent botanical research as well as the isotopic results indicate the environment in south-eastern central Europe in general and in the Žitava Valley in particular consisted of various different types of landscape, including large forest-free zones and open forest areas (Kreuz 2008; see Chapter 5.8). Human clearing of forests and the associated emergence of larger open spaces appears to have been underway during the Neolithic (*ibid.*).

Carcass processing

Bone fragmentation, skeletal element distribution and traces of modification document processing and disposal of animal carcasses. At Vráble, the distribution of elements across the settlement shows that all body parts are equally represented (Fig. 5.4.12), indicating that domesticated animals were primarily slaughtered on-site, as otherwise the non-flesh-bearing elements would probably have been underrepresented (*e.g.* Bartram 1993).

In Vráble, the chop marks registered are largely found at the joints of the long bones and the dorsal rib area and demonstrate meat was broken into transportable and processable pieces (Lüning 2000; Marciniak 2005). Impact marks at Vráble were concentrated on the long bones, especially the humerus shaft, probably to access bone marrow. According to Marciniak (2005), this is a common practice for the LBK. Charred and calcined bones, which also occur in small quantities at Vráble, could indicate bones were roasted after meat removal. Such a technique would fit a number of fragments which show a semi-dry fracture pattern and are only slightly charred, which can also be achieved by heating (Outram 2001). For the fully calcined bones, it is more likely that they were disposed of in a fire and later taken out with the ash to be deposited in the longitudinal pits. This is also supported by charcoal particles still stuck on some bones.

Chewing and trampling marks are not related to the processing of meat, but to waste disposal. Chewing marks were identified in material from all three neighbourhoods, it is likely that dogs were more common at Vráble than the few dog bones found would suggest. Furthermore, both the crushed and chewed bones suggest that the material was left lying in the open for some time before being discarded in the longitudinal pits. This would be consistent with the results of the fragmentation analysis (Fig. 5.4.10; 5.4.11). Accordingly, the slightly elevated values of elements bearing semi-dry fracture pattern and the few fragments indicating fresh fractures, suggest freshly fractured bones were later broken again sometime after their disposal. For single specimens this process was directly visible, which would concur with Allard *et al.* (2013), who shows that the material from the longitudinal pits was mostly a secondary deposit. It is likely that the bone waste was initially left lying in or around the longhouses and was only later collected and thrown into the pits, further supported by the combined deposition of different waste materials (*ibid.*). Within such a scenario, secondary fragmentation by trampling, would explain the high number of small fragments, as well as the overabundance of elements with a dry fracture pattern.

The patterns of bone modification were largely consistent among the three neighbourhoods. A slightly higher proportion of large bone fragments and more fragments with fresh fractures in the south-western neighbourhood is possibly an indicator for prompt disposal of waste in the longitudinal pits. Another possibility are changes in the habits of processing of meat and bone marrow. Lower fragmentation rates could be an indication of a greater abundance of animal resources, which would reduce the need grease and marrow exploitation (Outram 2001). Nevertheless, in sum, the finds suggest that the processing of bones in the three neighbourhoods was, in general, rather uniform.

Summary and conclusions

The aim of this work has been to evaluate the animal bone material of the LBK settlement group of Vráble with special consideration of differences in animal use within different neighbourhood units. The patterns discussed at the level of the entire site show that hunting played only a marginal role in the whole settlement and that the domesticated species were mainly kept for meat production, with pig being the dominant species overall. Based on a small sample size, in the northern neighbourhood (Vráble III) pig dominates, while cattle is dominant in the southwestern neighbourhood (Vráble I). In the southeastern neighbourhood (Vráble II) NISP counts for the three main domestic species are equal. It may be that the agglomeration of independent farmsteads with potentially diverse regional origins and subsistence practices explains intra-site differences in faunal distribution, but much larger faunal assemblages are needed to explore this.

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5.5. Archaeobotanical remains from the LBK and Želiezovce settlement site of Vráble

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Abstract

This chapter combines the published and unpublished archaeobotanical data for Vráble, thus presenting the entire assemblage recovered in the course of the excavations. The collated data are used as a basis for the reconstruction of the plant-growing and -consumption habits of the Neolithic residents and for inferring the ways in which they used the surrounding landscape. The outcomes of the archaeobotanical analysis are also discussed in relation to the archaeological context in which the plant remains were present. The 'standard' LBK crop spectrum, characteristic of dry sites with charred plant preservation, was documented at Vráble, with einkorn and emmer as the most prominent components and likely the major cultivars. The lifecycle and growing habits of the potential arable weeds point towards high-intensity agricultural management, confirming the existing model of the nature and scale of farming at LBK sites. The agriculturally produced plant food was supplemented by fruit and nuts collected in the relatively open woodland surrounding the site. The scarcity of plant remains at Vráble is almost certainly a direct result of the taphonomic factors, of which re-deposition and re-location of the material probably had the greatest impact. Additionally, the variation in the quantities of the plant material across the site, especially between features of the same type and similar assumed purpose – *i.e.* the long pits – indicates that spatial distribution of plant-related activities, and perhaps also their nature, affected the quantities and rate of deposition of plant remains. In particular, the degree of use or discard of one or the other of the two main crops may have varied between the households.

Keywords: Neolithic, LBK, Želiezovce, Vráble, central Europe, crop production, plant discard

Introduction

Archaeobotanical investigations at Vráble began in 2012 and were conducted in the periods 2012-2014 and 2016-2017. The results of the 2012 excavation season were included in the first report on the archaeology of Vráble (Furholt *et al.* 2014), and those produced for the 2016 season were integrated in the extended site report for 2016 (Müller-Scheeßel *et al.* 2016). This chapter combines all of the data and considers the entire assemblage recovered in the course of the investigation. The data are used as a basis for the reconstruction of plant-growing and -consumption habits of the Neolithic residents of Vráble settlements and for the identification of the ways in which they used the surrounding landscape. In addition, the outcomes of the archaeobotanical analysis are discussed in relation to the archaeological context in which the plant remains were found, in order to better understand how the plant material was deposited and preserved.

Methodology

Sampling and recovery in the field

The sampling strategy developed over the course of the excavation seasons largely reflects an attempt to maximise recovery of plant remains. Given the dry conditions in the area in which the site is located, the expected method of preservation of plant remains was charring (carbonization). Therefore, in 2012, the archaeological contexts that exhibited a colour or consistency indicating potential inclusion of charred plant material (*e.g.* dark brown colour, relatively easily distinguishable from the distinctive yellowish colour of the loess-based matrix) were selected for sampling. The samples measured about 10 litres in volume and were processed by way of manual (bucket) flotation in the field, with the use of 0.3 mm sieve for capturing the floating material. The residue remaining at the bottom of the bucket (heavy fraction) was scanned for any charred remains, but none were noted and the fraction was discarded.

Since the analysis of the samples taken in 2012 demonstrated very low presence of plant material, the sampling method for the 2013-2014 and 2016 seasons was modified from judgmental sampling to a combination of systematic and random sampling (*e.g.* Jones, M.K. 1991). In these seasons, samples were taken from each excavated feature, often from different parts of the feature. For instance, in case of pits, the top and the bottom sections of the fill were sampled (for details on pit stratigraphy, see Chapter 3.1). In addition, arbitrary layers (*c.* 10 cm spits) were sampled within alternating squares of the (mainly 2 × 2 m) excavation grid. The targeted sample volume was, again, 10 litres. This sampling method remained generally unchanged in the 2017 season, with the exception that, in the case of pits, the samples were taken from the middle and the bottom sections of the fill (rather than the top and the bottom sections, as pre-2017). In addition to the flotation samples, a certain number of 'botanical samples' composed of charred material collected by hand in the field were taken and analysed. A selection of samples from geoarchaeological cores were also examined, as part of the search for plant remains suitable for AMS dating.

Recovery in the laboratory and identification and counting of the remains

The light fractions (*i.e.* the material retained on the 0.3 mm sieve) were not dried in the field. They were transferred into plastic bags and transported to the laboratory in Kiel, where they were rinsed, dried, and then fully sorted for charred seed/fruit and wood remains, molluscs and microfauna. In 2017, a small subset (eight in total) of the heavy fractions were brought to Kiel and were rinsed, dried and examined for plant remains. Apart from a few minute wood charcoal fragments, no other archaeological items were registered. This was taken as a confirmation that the discard of the heavy fractions in the field (after rapid scanning) does not have an effect on the number of the remains recovered.

A low-power stereo-microscope (10-40 ×) was used for sorting of the samples and for identification and counting of the seed/fruit remains. The data for each sample were entered into the ArboDat database (Kreuz and Schäfer 2012), and the taxonomic nomenclature used in the present report is the one offered by the database. In counting the remains, the following rules were applied:

- Each glume base has a score of one.
- For the 2012-2014 seasons, the number of fragments of cereal grains (both identified and indeterminate) recovered was converted to the number of whole grains based on the visual impression of the number and size of the fragments. For the 2016-2017 seasons, the apical and embryo ends of the grains were counted and the higher value was recorded in the database.
- The remains of 'food' and indeterminate vegetative matter were counted or their volume was measured (in ml); they are not included in the counts of the remains per context.
- The scores for hazelnut (*Corylus avellana*) and Cornelian cherry (*Cornus mas*) are based on the number of shell and fruit stone fragments, respectively, and are recorded as such (*i.e.* no conversion to 'minimum number of individuals' was attempted).
- Fragments of pods and culms were counted but are here not included in the totals per context.

The less well-preserved specimens of some of the taxa were noted as 'cf.' in the database. For the calculations and presentation, they were amalgamated with the corresponding definite taxonomic categories.

Numerical analysis

For the data analysis, archaeobotanical samples are grouped into analytical units, which are, following the instructions from the excavators, equivalent to archaeological 'contexts' – generally representing parts of archaeological features – though there are exceptions, such as arbitrary layers not assigned to a feature ('undefined'). These analytical units are considered as potentially representing individual behavioural episodes (Jones, G. 1991). There are 189 such units, and the information on their archaeological provenance and detailed botanical composition are given in the Appendix (online at: https://www.jma.uni-kiel.de/en/research-projects/data-exchange-platform).

The units are discussed and compared based on the abundance of the remains they yielded, as well as their botanical density, *i.e.* number of remains per litre of floated soil, which serves as a rough indicator of the rate of deposition and preservation of botanical material (cf. Jones, G. 1991; Bogaard 2011, 84). The degree of representation of individual taxa, or groups of taxa, is assessed using their abundance (number of the remains per context or site-wide) and their frequency (the percentage of analytical units in which they occur), and these two parameters are used as proxies for the inferences on importance/degree of use of different crops.

Variation in the spatial distribution of the plant remains is explored at the level of features and of structures (houses) or areas, rather than at the level of analytical units. For this purpose, the counts of the remains in individual units are summed up for features (Table 5.5.3) and structures (Table 5.5.4). The resulting higher totals of the remains provided a better-grounded insight into the representation of major crops in different (parts of the) settlement neighbourhoods.

TAXA		TOTAL	FREQUENCY (%)
CEREALS			
Triticum monococcum	glume base	146	19
Triticum monococcum	grain	864	40
Triticum dicoccum	glume base	190	21
Triticum dicoccum	grain	817	30
Triticum monococcum/dicoccum	glume base	25	7
Triticum monococcum/dicoccum	grain	130	15
Triticum cf. *spelta*	grain	1	1
Triticum aestivum/durum/turgidum	grain	2	1
Triticum sp.	grain	70	15
**Hordeum vulgare vulgare,* 6-row	grain	2	1
**Hordeum vulgare,* cf. 6-row	grain	4	2
**Hordeum vulgare*	grain	1	1
cf. **Hordeum vulgare vulgare*	grain	2	1
**Panicum miliaceum*	grain	7	4
Cerealia indeterminata	grain	1038	67
	TOTAL	**3299**	
LEGUMES			
Lens culinaris	seed	20	7
Pisum sativum	seed	3	1
Leguminosae sativae indeterminatae	seed	7	4
	TOTAL	**30**	
OTHER CROPS			
Linum usitatissimum	seed	2	1
Papaver somniferum	seed	1	1
	TOTAL	**3**	
FRUITS and NUTS			
Cornus mas	fragment of stone	3	2
Corylus avellana	fragment of shell	75	5
Fragaria vesca	seed	2	1
Physalis alkekengi	seed	2	1
Sambucus ebulus	seed	36	7
Sambucus sp.	seed	2	1
	TOTAL	**120**	
ARABLE WEEDS and/or RUDERALS			
Avena sp.	fragment of awn	2	1
Bromus arvensis	fruit	2	1
Bromus secalinus	fruit	3	2
Bromus sp.	fruit	3	2
Carex sp.	nutlet	1	1
Chenopodium album	seed	34	11
Chenopodium hybridum	seed	8	4
Coronilla sp.	seed	1	1
Echinochloa crus-galli	fruit	4	2
Galium aparine	seed	7	3
Galium spurium	seed	22	7
Galium sp.	seed	2	1
Lapsana communis	seed	1	1
Malva sp.	seed	1	1
**Panicum* sp.	grain	3	1

Table 5.5.1. Crop and wild taxa documented at Vráble, their quantity and frequency across the analytical units (– intrusion from later occupation layers).*

TAXA		TOTAL	FREQUENCY (%)
Plantago lanceolata	seed	1	1
Poa sp.	fruit	1	1
Polygonum convolvulus	nutlet	12	5
Polygonum lapathifolium agg.	nutlet	1	1
Rumex conglomeratus	nutlet	1	1
Solanum nigrum	seed	9	3
Thlaspi arvense	seed	2	1
Trifolium sp.	seed	6	3
cf. *Vaccaria*	seed	1	1
Vicia sp.	seed	3	2
Brassicaceae p.p.	seed	1	1
Caryophyllaceae	seed	1	1
Chenopodiaceae p.p.	seed	2	1
Cyperaceae p.p.	nutlet	1	1
Fabaceae p.p.	seed	1	1
Lamiaceae	seed	2	1
Liliaceae	seed	1	1
Poaceae p.p.	fruit	10	4
Polygonaceae p.p.	nutlet	3	1
Solanaceae p.p.	seed	5	2
	TOTAL	**158**	
OTHER and UNIDENTIFIED			
Indeterminate seed		54	18
Indeterminate awn fragment		2	1
Indeterminate stem/culm fragment		2	1
Indeterminate pod fragment		1	1
Indeterminate fruit flesh fragment		3	1
Indeterminate vegetal matter		11	4
„Food“ remains		25	4
Dung remains		4	1
Indeterminate mineralised seed		2	1

Table 5.5.1. Continued.

Results and discussion

A total of 596 flotation samples have been processed, amounting to 5,408 litres of soil. Of these, 211 samples (35%) did not contain any non-wood plant remains. The rest (385 samples, 65%) yielded a comparatively small assemblage of about 3,700 charred plant remains, extracted from *c.* 3740 litres of soil. The overall botanical density of the flotation samples is, thus, extremely low – about one charred remain per litre of soil. This, however, echoes the situation observed at a number of other Early-Middle Neolithic sites in central Europe, including Slovakia, where the preservation of macroscopic plant remains occurred solely by charring (*e.g.* Kreuz *et al.* 2005; Hajnalová 2007; Kreuz 2012). Nonetheless, even such a relatively small dataset offers important insights into the plant economy of the Vráble communities. Table 5.5.1 gives a list of all of the identified taxa and their absolute quantity in the assemblage. The Appendix gives counts for each taxon per analytical unit.

The state of preservation and taphonomy of the remains

As noted, the macroscopic plant remains from Vráble have been preserved through charring; only two of the recovered seeds are in a mineralised state (Table 5.5.1). It has been widely acknowledged that, due to their fire-contingent preservation, charred plant archives constitute only a fraction of the plant materials and species used by ancient communities (*e.g.* Willerding 1971; 1991). For LBK sites, this is particularly clear when charred and waterlogged macro-botanical assemblages are compared (Bogaard *et al.* 2017).

Charring is one of the key formation processes relevant to the Vráble assemblage. Another pertinent taphonomic factor is the non-primary nature of the analysed deposits (cf. Kreuz 1990). At Vráble, all of the plant material comes from 'secondary' contexts (cf. Miksicek 1987; class B or C *sensu* Hubbard and Clapham 1992) – in most cases pits into which the material was deposited after being charred elsewhere. Pits could also represent 'tertiary' contexts if their fills were quarried for use as, for instance, building material (*e.g.* for repairing walls or as floor packing). Such re-use of accumulated household material was noted at some large, long-lasting Neolithic sites (*e.g.* Farid 2007). Plant remains would have been lost or destroyed in the transport and re-location of the deposits (Fuller *et al.* 2014, 180).

As described below, the crop assemblage is mostly composed of grains and seeds, but it also contains the remains of chaff – glume wheat glume bases. In the same deposits, glume wheat chaff is much less visible than the grain, perhaps because most of the grain represents a cleaned product (*i.e.* dehusked and freed from chaff and weeds) ready to be transformed into a meal. However, experiments have shown that cereal chaff is much less likely to survive in the charring conditions in which the grains can be preserved (Boardman and Jones 1990). Further, the grain may have been less affected in the process of re-deposition of charred material from primary to secondary context. Thus, the lower presence of glume wheat glume bases compared with the grain may, in part, be a result of unfavourable circumstances of charring and deposition.

Certain plant-related practices may also have resulted in the low representation of chaff in the assemblage. One such practice may have been the usage of chaff and other cereal by-products for tempering daub. Without burning, this potential 'chaff evidence' in daub remains largely invisible in the archaeobotanical record, unless the examination of impressions in the daub (and pottery) is conducted, such as done for some LBK and Želiezovce sites in Slovakia, where the imprints of einkorn and emmer chaff have been detected in daub and ceramics (Hajnalová 2007, 301). The daub remains from Vráble have not been analysed, but the few observed fragments hint that some plant material was added to the clayey matrix.

Another possible reason for the relatively low presence of crop processing by-products in the Vráble dataset could be their re-use in the practice of middening – the spreading of household detritus on cultivated land (Bogaard 2012). Direct deposition of manure could have been achieved by the penning of animals on arable fields at Vráble, according to the nitrogen stable isotope values in plant and animal remains (Chapter 5.8; Gillis *et al.* 2020). Farmyard animal manure and domestic waste could have been accumulated, and perhaps applied selectively, *e.g.* on areas producing lower yields or on plots on which particular crops were grown.

In sum, plant use, re-use, and depositional history contributed to the low amount and ubiquity of plant remains at Vráble. Additionally, the continuous modern-day use of the area for agricultural production has likely affected the (upper portion of the) cultural layers.

Insights into crop production at Neolithic Vráble

The Vráble dataset conforms to the general pattern of composition of charred plant assemblages (Knörzer 1971; Jones, M.K. 1988, 44), since, as shown below, it contains harvested crops and their associated impurities. Additionally, it includes remains of wild edible fruit and nuts that were potentially gathered and consumed.

Crop spectrum and quantities

Cereal remains constitute the greatest portion of the assemblage. These are chiefly einkorn (*Triticum monococcum*) and emmer (*T. dicoccum*) grains and glume bases (Fig. 5.5.1; 5.5.2). Einkorn and emmer are also the most frequently occurring taxa in the archaeological deposits (see Table 5.5.1). The presence of two other wheat types – spelt (cf. *T. spelta*) and a free-threshing wheat (*T. aestivum/durum/turgidum*) – is questionable since it is based on (altogether only three) grains rather than chaff, which was absent. There is a possibility that some of the grains identified as einkorn/emmer (*T. monococcum/diccocum)* and spelt wheat belong to the 'new type' glume wheat belonging to the *T. timpoheevii* group (Czajkowska et al. 2020). However, no 'new type' glume wheat glume bases were recognised among the chaff, which would have confirmed the presence of this taxon. On the other hand, only a portion of the recorded chaff was available for a re-assessment,[1] and so the presence of this wheat type at Vráble remains a possibility.

All of the barley grains are most likely intrusive. Two directly dated yielded post-LBK dates (KIA-54864, 2492±23, 772–541 cal BCE at 95.4%; KIA-54865, 5377±27, 4331-4061 cal BCE at 95.4%). The status of barley as an LBK crop is generally unclear (e.g. Kreuz et al. 2005; Kirleis and Willerding 2008; Bogaard 2011). The few grains of broomcorn millet (*Panicum miliaceum*) are also intrusive, that is, of a (much) younger age. Two of them, both extracted from samples taken from long pits, were directly dated using AMS; one grain gave a modern date, and the other returned a date indicating that it derived from the Middle/Late Bronze Age (Poz-106228, 3115±35 BP, 1451-1281 cal BCE at 95.1%). Two leguminous crops were documented in small quantities – lentil (*Lens culinaris*) and common pea (*Pisum sativum*). Flax/linseed (*Linum usitatissimum*) and opium poppy (*Papaver somniferum*) were also found in minor amounts.

Einkorn and emmer are the major components of LBK (and Želiezovce) plant assemblages, especially at dry sites, whereas other cereals and pulses occur occasionally and in much smaller quantities. By analogy with other analysed LBK sites, lentil and common pea would also have been grown at Vráble, along with flax/linseed. Some or all of the other rarely encountered crop species may have been cultivated, but may also (or instead) have represented random inclusions in the fields sown with the two major crops (Bogaard 2004; Kreuz *et al*. 2005; Hajnalová 2007; Kreuz 2007; 2012).

Vráble replicates this general pattern of the LBK crop spectrum; it is, therefore, reasonable to expect that the character of agricultural land use strategies employed at Vráble is comparable to that associated with LBK settlements in general, or at least those situated in the loess belt of central Europe. These include maintenance of long-lived arable plots at a small, household scale, with significant effort invested, in the form of thorough tilling and hand-weeding, and with variable levels of manuring (Bogaard 2004; Bogaard *et al*. 2013).

Crop production and storage

Crop growing and harvesting at Vráble are further documented by the presence of a wide range of potential arable weeds (Table 5.5.1; Fig. 5.5.2). The most numerous here are those that are most frequent at a number of other LBK sites in central Europe

1 This reassessment was done by D. Filipović.

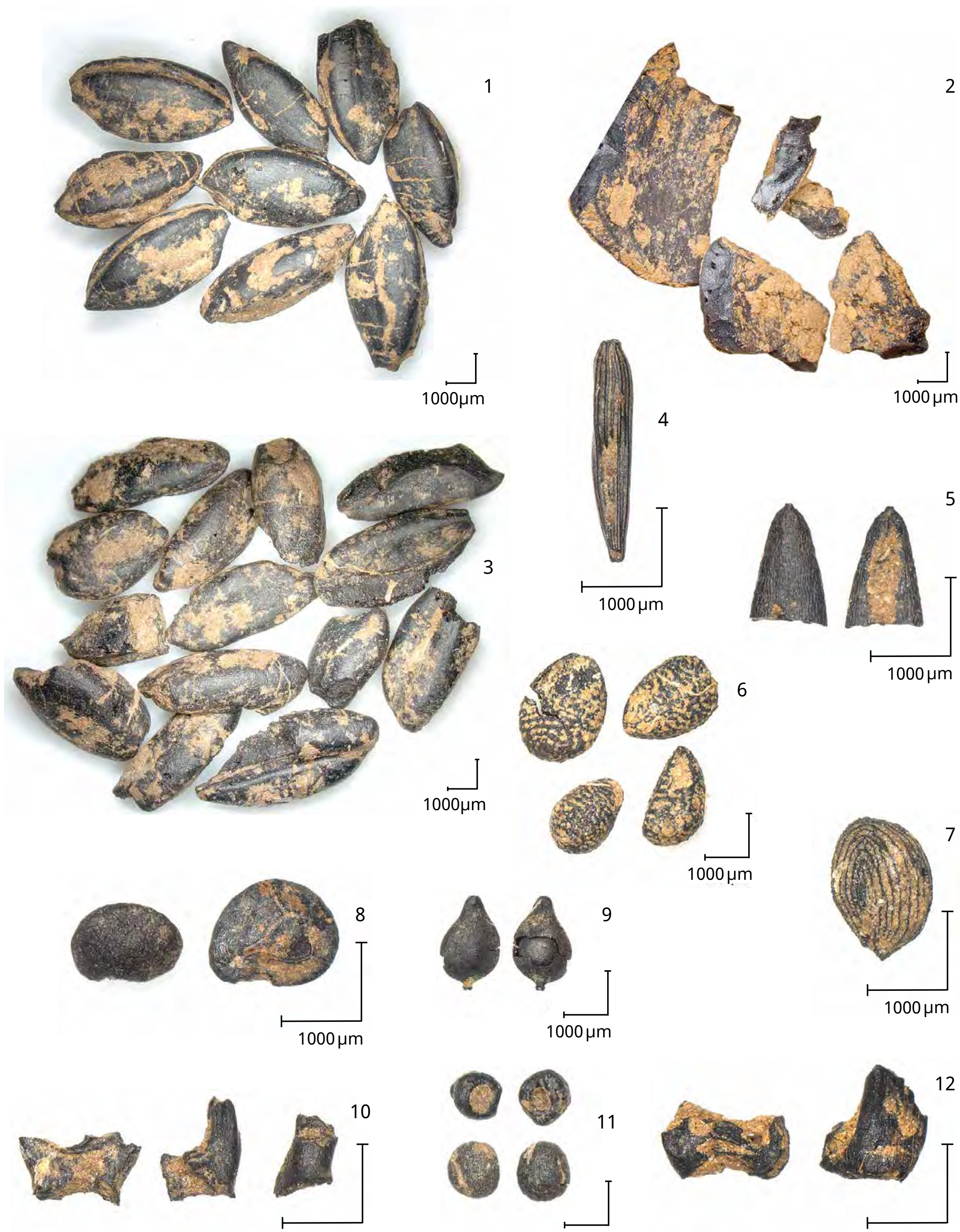

Figure 5.5.1. Selected remains of crop and wild plant types from Vráble: 1 Triticum monococcum *grain; 2* Corylus avellana *nutshell; 3* Triticum dicoccum *grain; 4* Lapsana communis; *5* Bromus arvensis; *6* Sambucus ebulus; *7* Thlaspi arvense; *8* Solanaceae; *9* Carex *sp; 10* Triticum monococcum *glume bases; 11* Galium spurium; *12* Triticum dicoccum *glume bases.*

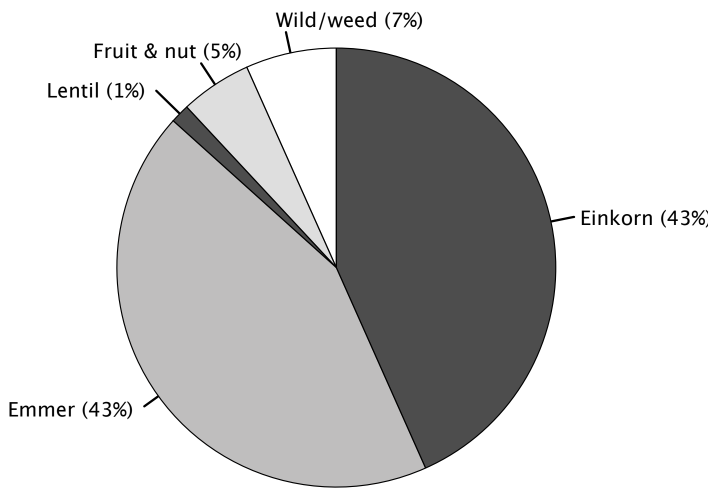

Figure 5.5.2. Proportions of the main plant taxa and groups in the Vráble assemblage (n = 2325).

(Bogaard 2004, Table 4.4; Kreuz *et al.* 2005, Table 7). The 'weed evidence' from LBK sites has been used to infer the presence/absence and intensity of certain agricultural practices (*e.g.* tilling, weeding). One of the aspects of the crop growing regime that has been investigated is the sowing time (autumn or summer), and the views on this are contrasting (Bogaard 2004; 2011; Kreuz *et al.* 2005; Kreuz 2007). The crop sowing season has implications not just for the annual cycle of activities involved in food production and the organisation of labour (*e.g.* Bogaard 2004, 163-164), but also for livestock management. Most directly, spring/summer sowing would have required access to and protection of arable land during a shorter period, leaving the fields available for animal grazing between the harvest (in late summer) and the following year's spring sowing. Autumn sowing would have ensured a longer growing period and thus higher yields (Bogaard 2004) and, presumably, more cereal fodder available for winter months.

The record of potential arable weeds from Vráble is too limited to allow detailed insights into the crop growing practices or for a quantitative assessment of the growing habits and ecology of these plants. Nonetheless, it is worth considering some characteristics of the few relatively abundant taxa, namely, fat hen (*Chenopodium album*), false cleavers (*Galium spurium*) and black bindweed (*Polygonum convolvulus*). These are summer annuals and could thus suggest spring sowing (cf. Kreuz *et al.* 2005), but they can accompany autumn-sown crops too. Being able to survive disturbance through (heavy) anthropogenic influence (*e.g.* weeding), they are found in intensively cultivated plots. Their long flowering period is advantageous in highly disturbed fields and means they can produce multiple generations and be in seed at the time of crop harvest (Bogaard 2004, 83). It is thus possible that autumn sowing was practiced at Vráble, probably in the case of einkorn and emmer, whereas pulses and perhaps flax/linseed may have been sown in spring (Bogaard 2011, 47). The three weed species that are most prominent in the assemblage are successful in highly disturbed environments (cf. Ellenberg *et al.* 1992), such as thoroughly tilled cultivation plots would have been, and they can be taken as reflecting high-intensity maintenance of arable land.

As observed ethnographically, glume wheats are stored in a semi-cleaned state, *i.e.* in spikelets (Hillman 1981; Filipović 2012; Alonso *et al.* 2014), from which quantities for *e.g.* daily use are taken out and processed for meals (Hillman 1984). Although much less common than the grain, glume wheat chaff is present at Vráble, documenting that glume wheats were brought to the settlements (and houses) in semi-processed form and were probably stored as such. This may have also been true for legumes and flax, but their pods and capsules are seldom found in charred assemblages (Jones, G. 1984).

Ethnographic accounts of traditional glume wheat processing describe a series of steps taken after the harvest and before the storage of the crop, including threshing, winnowing, raking, sieving and so on (Hillman 1981, 1984; D'Andrea and Mitiku 2002). These steps tend to take place near the fields or at the edge of the settlement – away from the domestic compound (*ibid.*; Alonso *et al.* 2014). Perhaps the apparently free space between the houses at Vráble was used for carrying out these stages in crop processing.

Ethnographic records also reveal a multitude of traditional methods of storage of harvested crops – from air-tight and lined underground silos near or in the houses; to clay bins; to baskets and containers made of (un)fired clay, dung, or vegetal material; to storage structures, such as wooden granaries or silos carved into soft rock (*e.g.* Sigaut 1981; Ertuğ-Yaraş 1997; Gronenborn 1997; Peña-Chocarro *et al.* 2015). It is possible that some similar strategies were employed at the study site. The beehive-shaped pits registered in relation to the excavated houses at Vráble (Chapter 3.1), and similar features discovered at some other sites in this region (Gašpar 2017), may have been storage facilities, perhaps used for keeping the bulk of the cereal harvest. Or perhaps they were not intended for storing plant food for humans, but for keeping animal fodder for the lean winter months. If so, maybe the semi-cleaned product (*e.g.* einkorn and emmer spikelets) was taken from the threshing floor to indoor storage spaces/containers, whereas the by-products (straw, large weed heads, light chaff) were swept up and compressed into the underground space.

If the pits were indeed meant for storing food and if, for instance, einkorn and emmer spikelets were to be placed directly in the pit, they would have needed thorough drying prior to storage, and the pits would have had hermetic seals preventing the inflow of oxygen and thus food spoilage (cf. Sigaut 1981, 11). Once the seal had been removed, the entire content would have had to be removed from the pit to avoid fungal growth on the grain and insect infestation (*ibid.*). It is, therefore, unlikely, that underground grain silos would have been intended for short-term storage, and unlikely that they would have been opened on a daily or weekly basis to extract small amounts for imminent use.

If the pits held crop product, this was perhaps seed corn kept for the next sowing season. It may have also been food kept for sharing and exchange, especially if it was not the entire community that was involved in crop production. It is not implausible that, during the period of co-existence of all three settlements at Vráble, not all three communities, or not every household, engaged in the cultivation of glume wheats (or crops in general). In other words, there could have been glume wheat 'producers' and 'consumers', and the chaff remains would have been left behind by both, because of the state in which einkorn and emmer were stored (Hillman 1981, 142). The presence/absence of certain remains, such as cereal culm nodes and culm bases, could also point towards production and producers (*ibid.*). No such material was recovered from Vráble, but this may largely be due to the poor preservation and low density of the botanical material in general; therefore, the absence of cereal straw evidence cannot be taken as indicative. What could, potentially, be significant is that, as noted above, the daub remains encountered at Vráble seem to have included very little plant temper. Assuming that cereal straw and other by-products of the harvest could have served as tempering material, which is, for example, seen at Early Neolithic sites in the eastern Carpathian Basin and the central Balkans (*e.g.* Stevanović 1997; Carneiro and Mateiciucová 2007), this could imply that this resource was not produced by, or available to, every household. On the other hand, not much daub was found at Vráble (Chapter 3.1), and only a few fragments of it have been examined, which precludes any conclusions on the choice of plant temper and the degree of its use. What may shed some light here are the results of nitrogen stable isotope analysis of plant and animal remains from Vráble, which suggest that the livestock feeding regimes included grazing on crop stubble (Chapter 5.8;

Potential weed taxa	Height category
Avena sp.	tall
Chenopodium album	tall
Galium aparine	tall, climbing
Galium spurium	tall, climbing
Lapsana communis	tall
Bromus arvensis	medium
Bromus secalinus	medium
Bromus sp.	medium
Carex sp.	medium
Chenopodium hybridum	medium
Echinochloa crus-galli	medium
Polygonum convolvulus	medium, climbing
Polygonum lapathifolium agg.	medium
Rumex conglomeratus	medium
Solanum nigrum	medium
Vicia sp.	short to medium
Plantago lanceolata	short
Thlaspi arvense	short
Trifolium sp.	short

Table 5.5.2. Classification of the potential weeds recorded at Vráble into categories based on their maximum height, following Kreuz et al. (2005, Table 7) and Bogaard (2011, Table 6.6) (short: < 40 cm; medium: 40-80 cm; tall: > 80 cm).

Gillis *et al.* 2020). Perhaps cereal straw was left in the field. For this purpose, the cereals would have been harvested higher on the stalk, leaving the mass of the by-products for stubble-grazing animals.

If harvesting had been done high on the stem, *e.g.* by stripping or plucking by hand or with the aid of a tool, or by sickle harvesting (Hillman and Davies 1999; Schlichtherle 2005; Anderson 2013), then this could also have been a strategy for avoiding some of the arable weeds and may represent one of the reasons for the low presence of potential crop weeds in the seed assemblage (Jones, M.K. 1998). The three most abundant arable weeds (mentioned above) can be considered tall because they can grow to over 80 cm in height (Kreuz *et al.* 2005, Table 7; Bogaard 2011, Table 6.6); therefore, their seeds would have been collected by harvesting either low or high on the stem, as well as by ear-plucking. The majority of the other potential arable weeds from Vráble can be considered 'medium' or 'short' (Table 5.5.2), and this signals that cereal stems were cut at medium height – that is, about 40 cm or less above the ground. That sickle-harvesting of cereals was practiced is perhaps supported by the presence of flint pieces at Vráble that bear a characteristic gloss along the edges (silica sheen) that identifies them as sickle blades. Some of them also show the kind of wear pattern along the edge that could indicate their use for cutting cereal straw (Chapter 5.2).

Table 5.5.3 (overleaf). Total amounts of the main and summarised classes of plant remains within different feature types in the three Vráble neighbourhoods.

Settlement neighbourhood	Structure (house) or area	Feature ('Objekt')	Feature ('Objekt') type	Unit of analysis (Context)	Sample volume (L)	Einkorn glume base	Einkorn grain
N	244	2014/1	long pit	S7 B001	10	1	
N	244	2014/1	long pit	S7 B002	10		
N	244	2014/1	long pit	S7 B006	10		
N	244	2014/1	long pit	S7 B015	20	9	1
N	244	2014/1	long pit	S7 B022	10	1	
N	244	2014/1	long pit	S7 B023	10		
N	244	2014/1	long pit	S7 B027	18		
N	244	2014/1	long pit	So7 B10	5	2	
N	244	2014/1	long pit	So7 B12	10	1	1
N	244	2014/1	long pit	So7 B14	10	2	
N	244	2014/1	long pit	So7 B20	10	1	
N	244	2014/1	long pit	So7 B21	10		
N	244	2014/1	long pit	So7 B25	10		
N	244	2014/1	long pit	So7 B26	10		
N	244	2014/1	long pit	So7 B3	30	6	1
N	244	2014/1	long pit	So7 B4	10		
N	244	2014/1	long pit	So7 B5	18		
N	244	2014/1	long pit	So7 B8	4		
N	245	2014/2	long pit	S8 B012	10	1	2
N	245	2014/3	long pit	So8 B011	10		1
N	258	2014/6	long pit	S8 B003	10	1	15
N	259	2014/4	long pit	So8 B013	10		1
N	259	2014/5	long pit	So8 B006	10		1
N	262	2014/8	long pit	S10 B001	20	1	
N	262	2014/8	long pit	S10 B002	10		
N	262	2014/8	long pit	S10 B006	7		
N	262	2014/8	long pit	So10 B003	50		1
N	262	H262/1	long pit	S10 B003			
SE	102	2013/1	long pit	So4 B001	30	1	3
SE	102	2013/1	long pit	So4 B002	160	11	29
SE	102	2013/1	long pit	So4 B005	10	1	
SE	102	2013/1	long pit	So4 B015	30		2
SE	102	2013/1	long pit	So4 B018	10		
SE	102	2013/1	long pit	So5 B001	60	3	4
SE	102	2013/1	long pit	So5 B002	20		4
SE	102	2013/1	long pit	So5 B003	10		
SE	102	2013/1	long pit	So6 B001	80	9	1
SE	102	2013/1	long pit	So6 B003	10		1
SE	102	2013/2	long pit	So4 B009	70	13	131
SE	102	2013/2	long pit	So4 B011	10	9	83
SE	102	2013/2	long pit	So4 B012	30	24	346
SE	102	2013/2	long pit	So4 B013	10	2	5
SE	102	2013/2	long pit	So5 B009	90	19	40
SE	102	2013/2	long pit	So5 B016	50	1	2
SE	102	2013/2	long pit	So5 B017	50		10
SE	102	2013/2	long pit	So5 B018	20	5	14
SE	102	2013/2	long pit	So5 B019	30	2	9
SE	102	2013/2	long pit	So5 B020	10	1	2
SE	102	2013/2	long pit	So6 B009	40	1	6
SE	102	2013/2	long pit	So6 B030	10		
SE	102	H102/4	long pit	S6 B000	40	2	3
SE	105	2013/3	long pit	So6 B004	20	1	2
SE	105	2013/4	long pit	So6 B010	90	4	1
SE	126	Objekt 123	long pit	S14 B035	10		
SE	126	Objekt 123	long pit	S14 B036	10		
SE	126	Objekt 123	long pit	S14 B042	10		
SE	126	Objekt 124	long pit	S14 B016	8		4
SE	126	Objekt 124	long pit	S14 B044	10		
SE	127	Objekt 143	long pit	S14 B060	10		

Emmer glume base	Emmer grain	Einkorn/ emmer glume base	Einkorn/ emmer grain	All other crops grain/ seed	Fruits and nuts seed/ stone/ shell	Arable weeds and ruderals seed/ fruit	All included items
2							3
1				2			3
						1	1
24				6		4	44
							1
1				1			2
2				1			3
							2
5		1					8
1				2			5
1							2
				1			1
1							1
				1			1
2				2			11
			1	1			2
				3			3
				1			1
1	1						5
	1						2
	7			31			54
				1		1	3
1	1						3
				2			3
				1			1
							0
1	2			5			9
				1		2	3
	4			9	1	3	21
11	28	1		23		9	112
				2			3
2				3		2	9
							0
2	9		27	22	1	2	70
2	5		31	14		2	58
				6			6
10		1		15		4	40
1			4	1			7
27	99	7	16	4		3	300
26	112					6	236
11	175			80		11	647
				13			20
30	82		1	152		6	330
	3			7			13
1	34			97	1	1	144
2	28		3	56			108
2	14	2		51		1	81
	5			19			27
	2			31		1	41
				6			6
	2	1		9	1	2	20
	2		3	4		1	13
3	4	3	2	25	1	7	50
				1		1	2
				1			1
				1			1
	1		2	3			10
				1			1
				1		1	2

Settlement neighbourhood	Structure (house) or area	Feature ('Objekt')	Feature ('Objekt') type	Unit of analysis (Context)	Sample volume (L)	Einkorn glume base	Einkorn grain
SE	127	Objekt 144	long pit	S14 B057	20		1
SE	127	Objekt 157	long pit	S14 B069	10		
SE	131	Objekt 2	long pit	S11 B012	10		
SE	131	Objekt 57	long pit	S12 B078	10		
SE	131	Objekt 57	long pit	S12 B084	18		6
SE	131	Objekt 57	long pit	S12 B108	10		
SE	131	Objekt 57	long pit	S12 B120	10		1
SE	131	Objekt 65	long pit	S12 B012	10		
SE	131	Objekt 65	long pit	S12 B013	10		1
SE	131	Objekt 65	long pit	S12 B014	10		4
SE	131	Objekt 65	long pit	S12 B015	10		2
SE	131	Objekt 65	long pit	S12 B017	58		4
SE	131	Objekt 65	long pit	S12 B042	10		7
SE	131	Objekt 65	long pit	S12 B045	10		3
SE	131	Objekt 65	long pit	S12 B053	10		
SE	131	Objekt 65	long pit	S12 B064	10		
SE	132	Objekt 10	long pit	S11 B046	20		
SE	132	Objekt 113	long pit	S13 B001	20		
SE	132	Objekt 113	long pit	S13 B002	9		
SE	132	Objekt 113	long pit	S13 B033	6		1
SE	132	Objekt 24	long pit	S13 B083	10		
SE	132	Objekt 24	long pit	So11 B051	30		1
SE	132	Objekt 9	long pit	S11 B044			
SE	132	Objekt 9	long pit	S12 B072	10		
SE	132	Objekt 9	long pit	S12 B080	10		1
SE	132	Objekt 9	long pit	S12 B095	8		1
SE	132	Objekt 9	long pit	S12 B130	10		
SE	132	Objekt 9	long pit	S12 B140	10		
SE	132	Objekt 9	long pit	So12 B157			
SE	132	Objekt 9	long pit	So12 B159	10		
SE	133	H133/26	long pit	S11 B046	10		1
SE	133	Objekt 26	long pit	S11 B053	40		1
SE	133	Objekt 26	long pit	S13 B004	20		
SE	133	Objekt 26	long pit	S13 B081	8		
SE	133	Objekt 37	long pit	S11 B075	30		
SE	133	Objekt 37	long pit	S11 B133	10		
SE	133	Objekt 37	long pit	S11 B150	10		
SE	133	Objekt 37	long pit	S11 B502	10		
SE	133	Objekt 37	long pit	S11 B512	10		
SE	133	Objekt 37	long pit	S11 B600	10		
SE	133	Objekt 37	long pit	S13 B012	10		
SE	133	Objekt 37	long pit	S13 B072	10		1
SW	23	2017/102	long pit	S22 B101	10		1
SW	23	2017/102	long pit	So22 B008	23		1
SW	23	2017/103	long pit	S22 B165	12		
SW	39	2012/1	long pit	S2 B004	60		10
SW	39	2012/1	long pit	S2 B005	40		4
SW	39	2012/1	long pit	S2 B006	40		1
SW	39	2012/1	long pit	S2 B028	10		1
SW	39	2012/1	long pit	S3 B003	10		
SW	39	2012/1	long pit	S3 B004	50		1
SW	39	2012/1	long pit	S3 B031	10		
SW	39	2012/1	long pit	S3 B034	70	1	
SW	39	2012/1	long pit	So2 B002	20		
SW	39	2012/1	long pit	So2 B003	10		
SW	39	2012/1	long pit	So2 B007	10		
SW	39	2012/1	long pit	So2 B46	10		1

Table 5.5.3 (continued).

Emmer glume base	Emmer grain	Einkorn/ emmer glume base	Einkorn/ emmer grain	All other crops grain/ seed	Fruits and nuts seed/ stone/ shell	Arable weeds and ruderals seed/ fruit	All included items
			1	5			7
				1	2	1	4
				1			1
				1			1
	3			2		2	13
				1			1
				1			2
						1	1
				1			2
2				5		2	13
			1	4			7
	1	1	3	10	1	3	23
			1	2			10
			3	3			9
				1			1
			1				1
				1			1
				1		1	2
				1			1
		1		5			7
				1			1
			2	1	16	2	22
							0
						1	1
	5			4		3	13
			1	1			3
					11	2	13
					42		42
					1		1
						1	1
							1
			1	4		1	7
			1	1			2
			1	2			3
			1	2			3
1		2		3		1	7
			1	3			4
							0
					1		1
							0
				1			1
				2			3
				1			2
				2		2	5
						1	1
1	9			20	1		41
	5			10	1	3	23
1	6			7	1	1	17
							1
				1		1	2
	3			11		10	25
				1			1
	5			7	5	3	21
				2	1		3
	2						2
				1			1
							1

Settlement neighbourhood	Structure (house) or area	Feature ('Objekt')	Feature ('Objekt') type	Unit of analysis (Context)	Sample volume (L)	Einkorn glume base	Einkorn grain
SW	39	2012/1	long pit	So3 B035	160	1	1
SW	39	2012/1	long pit	So3 B036	80		1
SW	39	2012/2	long pit	S2 B040	20		
SW	39	2012/2	long pit	S3 B032	40	1	
SW	39	2012/2	long pit	S3 B037	10		
SW	39	2012/2	long pit	S3 B039	10		
SW	39	2012/2	long pit	So3 B033	10		
SW	39	2102/2	long pit	So2 B041	50		
SW	39	H39/26	long pit	S3 B016	10		
SW	317	2017/100	long pit	S22 B003	9		
SW	317	2017/101	long pit	S22 B004	8		
SW	317	2017/101	long pit	S22 B006	12		
SE	132	Objekt 11	long pit	S11 B047	20		
SE	east of 132	2013/114	storage pit	S13 B025	10		
SE	east of 132	2013/114	storage pit	S13 B028	10		8
SE	east of 132	2013/114	storage pit	S13 B045	10		8
SE	in the area of 131	Objekt 101	storage pit	S12 B074	20		2
SE	in the area of 131	Objekt 101	storage pit	S12 B077	6		
SE	in the area of 131	Objekt 101	storage pit	S12 B081	16		4
SE	in the area of 131	Objekt 101	storage pit	S12 B097	8		3
SE	west and north of 126	Objekt 120	storage pit	S13 B035	10		
SE	west and north of 126	Objekt 120	storage pit	S13 B049	10		1
N	between 258 and 259	2014/10	miscellaneous pit	So8 B004	10		9
N	in the area of 262	2014/12	miscellaneous pit	S9 B020	20	1	3
N	in the area of 262	2014/12	miscellaneous pit	S9 B021	30		1
N	in the area of 262	2014/12	miscellaneous pit	S9 B023	10		1
N	in the area of 262	2014/12	miscellaneous pit	S9 B024			
N	in the area of 262	2014/12	miscellaneous pit	S9 B025	10		
N	in the area of 262	2014/12	miscellaneous pit	S9 B027	10		1
N	in the area of 262	2014/12	miscellaneous pit	So9 B018	10		1
N	in the area of 262	2014/12	miscellaneous pit	So9 B019	238	4	29
SW	Trench 24	S24/150	miscellaneous pit		36		1
SE	133	Objekt 71	miscellaneous pit	S11 B079	10		
SE	west and north of 126	Objekt 121	miscelleanous pit	S13 B041	8		
SE	west and north of 126	Objekt 122	sunken dwelling	S13 B042	10		
SE	west and north of 126	Objekt 122	sunken dwelling	S13 B065	10		1
SE	west and north of 126	Objekt 122	sunken dwelling	S13 B074	10		1
SW	39	Objekt 12	posthole	S2 B009	10		1
SW	39	H39/20	posthole	S3 B013	10		
SW	39	H39/29	posthole	S3 B015	10		
SW	39	H39/27	posthole	S3 B019	10		
SW	39	H39/23	posthole	S3 B028	10		
SW	39	H39/16	posthole	S3 B040	10		
SW	39	Objekt 24	posthole	S3 B047	10		
SW	39	H39/26	posthole	S3 B048	10		
SW	39	H39/27	posthole	S3 B050	10		
SW	39	H39/05	posthole	So2 B48	10		
SE	102	H102/5	posthole	So4 B007	10		
SE	102	H102/12	posthole	So5 B005	10		
SE	133	Objekt 73	undefined	S11 B081	10		
SW	in the area of 39	S2/67	undefined	S2 B010	10		1
SW	in the area of 39	S2/66	undefined	S2 B011	10		
SW	in the area of 39	S2/65	undefined	S2 B012	10		
SW	in the area of 39	S2/64	undefined	S2 B013	10		
SW	in the area of 39	S3/40	undefined	S3 B001	10		
SW	in the area of 39	S3/44	undefined	S3 B006	10	2	
SW	in the area of 39	S3/43	undefined	S3 B007	10		

Table 5.5.3 (continued).

Emmer glume base	Emmer grain	Einkorn/ emmer glume base	Einkorn/ emmer grain	All other crops grain/ seed	Fruits and nuts seed/ stone/ shell	Arable weeds and ruderals seed/ fruit	All included items
1	23			30	16	4	76
	5			10	2		18
	1			3			4
1	1			9	2	4	18
						2	2
				1		1	2
				2		2	4
1	3			11	4	4	23
				2			2
	1		1				2
				1		1	2
		2					2
						3	3
				2			2
	2		8	14		1	33
	2		9	30			49
			2	4		1	9
			1	1			2
				3		1	8
	2			1			6
				1			1
			1	2			4
	3			10			22
1	19			9	2		35
	2	1		2			6
1	1			1			4
				5			5
				1			1
				1			2
	5			6			12
3	70	2		84	2	5	199
				5			6
				1			1
2				2			4
				1			1
				1			2
							1
	1						2
							0
				2		1	3
				1		1	2
				2			2
				2			2
				1		2	3
				1	1		2
				1		1	2
				1			1
				1			1
1	1						2
				1	1		2
	1						2
	1			1			2
	3			3			6
	3						3
				1		1	2
1	2			2			7
	3			1			4

Settlement neighbourhood	Structure (house) or area	Feature ('Objekt')	Feature ('Objekt') type	Unit of analysis (Context)	Sample volume (L)	Einkorn glume base	Einkorn grain
SW	in the area of 39	S3/42	undefined	S3 B008	10		
SW	in the area of 39	S3/47	undefined	S3 B011	10		
SW	in the area of 39	S3/49	undefined	S3 B017	10		
SW	in the area of 39	S3/48	undefined	S3 B021	10		
SW	in the area of 39	S3/53	undefined	S3 B023	10		
SW	in the area of 39	S3/55	undefined	S3 B026	10		
SW	in the area of 39	S3/57	undefined	S3 B029	10		
SW	in the area of 39	S3/58	undefined	S3 B030	10		
SE	127	Objekt 145	around human skeleton	S14 B048	10		
SW	ditch	2017/14	around human skeleton	S21 B315	10		
SW	ditch	2017/2	slit-shaped pit	S21 B002	10		
SW	ditch	2017/11	miscellaneous pit	S21 B297	8		1
SW	ditch	2017/13	miscellaneous pit	So21 B265	8		
SW	ditch	2017/1	ditch	S21 B001	37		
SW	ditch	2017/3	ditch	S21 B003	6		
SW	ditch	2017/209	ditch	S23 B009	19	1	

Table 5.5.3 (continued).

Traces of wild plant gathering

The taxa classified as 'fruits and nuts' produce edible fruit that were probably collected and consumed as food. Some of the arable/ruderal taxa also have edible parts, such as seeds or leaves (fat hen, black bindweed) (see Bogaard 2011, Table 5.19). The recorded spectrum of gathered plant resources is narrow, which is typical for charred assemblages, where non-crop material is largely under-represented (van der Veen 2007; Colledge and Connoly 2014). It is, therefore, difficult to assess whether or not there was a preference for any particular source of wild plant food and how wide the spectrum was. The wood charcoal evidence from Vráble provides some clues.

Two of the taxa registered in the wood charcoal record – hazel (*Corylus*) and cornel (*Cornus*) (Chapter 5.6) – are perhaps the species noted in the fruits/nuts assemblage, common hazel (*Corylus avellana*) and Cornelian cherry (*Cornus mas*), suggesting that these plants were exploited for both fruit and wood. There are other taxa in the wood charcoal dataset which would have also offered edible fruit, such as oak (*Quercus*), wild cherry (*Prunus*), and beech (*Fagus*). The traces of woodland vegetation at Vráble show that wild food and fuel were potentially sourced from the same areas covered with this type of vegetation – mixed oak forests, characterised by more-or-less open canopy, with small trees of hazel and cornel type growing along the edges and in openings, as well as forest berries, such as wild strawberry. Deciduous oak forests probably occupied dry areas beyond the arable zone, whereas the moist area along the river banks and the flood-prone zone would have been occupied by taxa such as ash (*Fraxinus*), alder (*Alnus*) and poplar (*Populus*) – all documented in the wood charcoal archive from Vráble (*ibid.*). The riparian zone would have offered further edible fruit, as well as wood for fuel and timber, but the availability of these resources may have been less reliable due to the potentially seasonally fluctuating extent of the wet zone in the wider area of the Žitava river (Chapter 2.3).

Emmer glume base	Emmer grain	Einkorn/ emmer glume base	Einkorn/ emmer grain	All other crops grain/ seed	Fruits and nuts seed/ stone/ shell	Arable weeds and ruderals seed/ fruit	All included items
				2		4	6
				1			1
	1						1
						1	1
				1			1
				1			1
				1			1
				2		2	4
				2			2
							0
							0
							1
						1	1
	1			3	1	1	6
						1	1
							1

Spatial distribution of plant remains

Feature-level distribution

It is of interest to examine how the plant remains are distributed across the three neighbourhoods of the Early-Middle Neolithic settlement, as this may help identify potential variations in procurement/use/discard within the site. This is done by looking at the composition of different archaeologically defined features, of which the most prominent are the long pits, followed by other variously shaped pits (*e.g.* postholes, storage pits). Table 5.5.3 shows the quantities of the main and summarised classes of the remains in different feature types in the three neighbourhoods. The majority of the features have a 'standardised' composition and include traces of a range of crops, small amounts of seeds of arable/ruderal plants, and occasional remains of gathered fruit.

There are some exceptions to this general pattern; for instance, postholes are almost devoid of plant remains, especially of the remains of einkorn and emmer, whereas they contain very small amounts of the remains of other crops and few wild/weed seeds. They seem to have received little charred plant material, which is in line with their proposed function. The majority of the analysed postholes have been associated with House 39, which yielded very low amounts of material, as visible in the undefined contexts excavated in the area of this house. The ditch around the south-western neighbourhood is, likewise, botanically poor. Perhaps these parts of the settlement were not commonly used for plant-related activities, or not those that would leave behind significant quantities of charred remains. This impression is supported by the very low presence of the remains of major crops – einkorn and emmer – which would, presumably, have been processed and their by-products discarded on a regular basis. It is also possible that (post-)depositional processes here were even less favourable for the preservation of plant remains than in the other investigated zones of the site. Another feature that contained just a few remains is the sunken dwelling in the south-eastern neighbourhood.

Relative to the contexts described above, miscellaneous non-long pits, including storage pits, yielded moderate quantities of plant remains. Particularly noteworthy is one of the pits detected in the area of House 262, in the northern neighbourhood, which yielded more than 200 remains. The remains were, however, extracted from

Settlement area	Structure (house) or area	Number of amalgamated units of analysis	Soil volume	Density	Einkorn glume base	Einkorn grain
N	259	2	20	0.30		2
N	245	2	20	0.35	1	3
N	between 258 and 259	1	10	2.20		9
N	258	1	10	5.40	1	15
N	244	18	215	0.44	23	3
N	262	13	415	0.67	6	37
			TOTAL		**31**	**69**
SE	127	4	50	0.30		1
SE	126	11	106	0.26		7
SE	133	14	198	0.18		3
SE	105	2	110	0.57	5	3
SE	131	18	246	0.45		37
SE	132	18	203	0.96		20
SE	102	25	900	2.56	104	695
			TOTAL		**109**	**766**
SW	317	3	29	0.21		
SW	Trench 24	1	36	0.17		1
SW	23	3	45	0.18		2
SW	ditch	7	98	0.10	1	1
SW	39	46	980	0.36	5	22
			TOTAL		**6**	**26**

more than 230 litres of sediment. This is a good illustration of the very low botanical density, but also a signal that multiple and/or larger samples from individual features have the potential to offer more material (*e.g.* 24 samples were taken from this particular pit). The assemblage from non-long pits is quite diverse, with major crops being more visible than in most of the long pits. In the storage pits, einkorn and emmer (and other crops) are represented by grains (or seeds). According to the archaeological observations, there was no burning in these pits, and they are evidently not the primary location of origin of the charred material. Perhaps the grain, derived from cereal stores located elsewhere, became charred in the process of food preparation. In some of the other non-long pits, glume bases are also present (although in very small numbers), along with the grain, perhaps pointing towards the deposition of unprocessed spikelets, or chaff and grains lost or discarded during processing. In both storage and other non-long pits, the combination of different crops (einkorn and emmer, and some barley – see Appendix) with wild fruit/nut remains and seeds of arable weeds suggests that these features received residues from different plant-related activities, perhaps mixed together in fireplaces into which they would have been thrown as 'casual fuel' (van der Veen 2007).

Emmer glume base	Emmer grain	Einkorn/emmer glume base	Einkorn/emmer grain	All other crop grain/seed	Fruit/nut seed/stone/ shell	Wild/weed seed/fruit	All included items
1	1			1		1	6
1	2						7
	3			10			22
	7			31			54
40		1	1	21		5	94
6	99	3		118	4	7	280
48	**112**	**4**	**1**	**181**	**4**	**13**	**463**
			1	9	2	2	15
2	1		3	14		1	28
1		2	5	20	2	2	35
3	6	3	5	29	1	8	63
2	6	1	12	41	1	10	110
	9	1	20	61	70	14	195
128	603	12	82	621	4	53	2302
136	**625**	**19**	**128**	**795**	**80**	**90**	**2748**
	1	2	1	1		1	6
				5			6
				3		3	8
	1			3	1	3	10
6	78			155	34	48	348
6	**80**	**2**	**1**	**167**	**35**	**55**	**378**

Table 5.5.4. Total amounts of the main and summarised classes of plant remains extracted from different houses and neighbourhoods at Vráble.

The observation above also applies to the majority of the long pits, which typically contain mixtures of einkorn and emmer grain and chaff, sometimes also wild/weed seeds, and rarely traces of other crops (*e.g.* pulses) and fragments of nutshell/fruit stone. The low density indicates slow deposition, or filling of the pits with deposits containing little charred material. However, from some of the deposits in the long pits flanking House 102, relatively high quantities of remains were extracted (see Table 5.5.3). As was the case with the pit associated with House 262 (described above), in the case of House 102, the abundant remains derived from large sediment volumes (*e.g.* 70 litres or more) and multiple samples. There were, however, several relatively small deposits (*i.e.* up to 30 litres) in the House 102 pits that displayed higher botanical density than the site-wide average of ≤ 1, and two of them contained around 20 items per litre of soil (contexts So4 B011 and So4 B012). They may reflect episodes of the disposal of large amounts of concentrated charred remains, such as spent fuel from fireplaces. In both of these contexts, grains and glume bases of einkorn and emmer were found, along with some indeterminate cereal grains and weed seeds. These may have been spikelets taken from the store and (accidentally) charred. The combination of emmer and einkorn parts in the

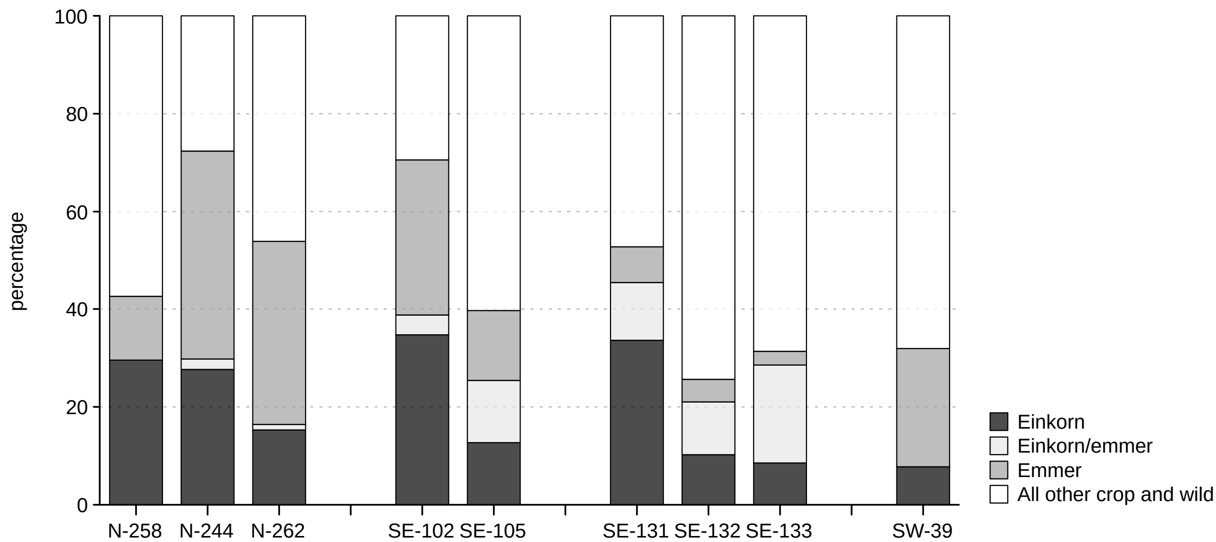

Figure 5.5.3. Proportions of the different plant taxa and groups in the assemblages from the different houses at Vráble (N = northern neighbourhood; SE = south-eastern neighbourhood; SW = south-western neighbourhood ; see Table 5.5.4. for the counts of the remains per house).

same deposit could point towards the combined processing, storage and, moreover, growing of the two cereals, perhaps as a maslin that acted as a buffer against the risk of crop failure (cf. Jones, G. and Halstead 1995).

Comparison between houses and neighbourhoods

Further patterns in the spatial distribution of plant material at Vráble can be observed at the level of houses and neighbourhoods, based on the different quantities of major crops and summary plant categories, as shown in Table 5.5.4 and Figure 5.5.3. Whereas both einkorn and emmer are found in all examined house areas, their representation is varied, perhaps reflecting changeable degree of production or use. However, the apparent pattern is in all likelihood spurious in the cases where very little plant material was recovered, for instance fewer than 50 remains, such as in the case of House 133, with only 35 remains (Table 5.5.4; Fig. 5.5.3 – the structures with fewer than 50 items are not shown in the figure). Where the assemblage includes 100 or more items, perhaps the proportional representation of emmer and einkorn can be taken as 'genuinely' reflecting the degree of their use. Hence, it would appear that the inhabitants of House 262 consumed more emmer than einkorn, unlike, for instance, those of houses 131 and 102, but similar to those of House 39. On the other hand, if the two cereals were grown as a mixed crop, this could be evidence of their varied contribution to the yields rather than potential preferences in consumption.

The dataset from House 244 perhaps also indicates combined growing of the two main crops. It contains similar proportions of einkorn and emmer, and both components are composed almost entirely of glume bases (Table 5.5.4). This could signal that einkorn and emmer were processed together, although it is equally possible that the mixing occurred at the time of deposition (*e.g.* by-products from separate harvests thrown into the same fires).

When the proportions of einkorn and emmer are examined only for the house areas that yielded more than 100 einkorn+emmer remains each, the differences in the representation of the two staples become more obvious (Fig. 5.5.4). One such 'large' einkorn+emmer dataset is available from each neighbourhood: House 262 in the north, House 102 in the south-east and House 39 in the south-

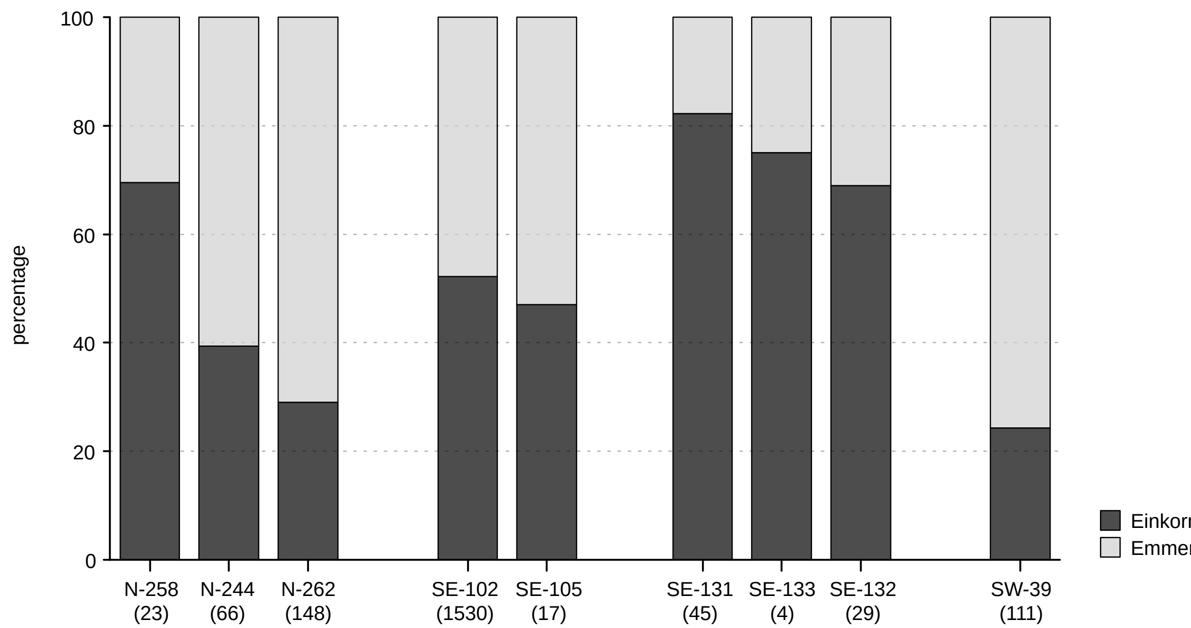

Figure 5.5.4. Proportions of the remains of einkorn and emmer retrieved from the different houses at Vráble (the sum of einkorn and emmer remains is stated in parentheses).

west. They illustrate potential differences in the rate of production or use of einkorn *vs*. emmer within and between the neighbourhoods – perhaps due to the varied presence of einkorn and emmer within a mixed (maslin) crop or, if they were grown separately, due to the consumption of different quantities by different households.

House 102 is the earlier in the sequence of House 102-House 105, whereby the two buildings are seen as manifesting the development over time of the same house group (farmstead) (Chapter 3.1; 4.2). From this perspective, it is interesting that the proportions of einkorn and emmer remains found in the area of House 105 are similar to those in House 102; however, only 17 einkorn+emmer remains were discovered in House 105 and they cannot be taken as representative. Houses 131, 132 and 133 are spatially close or overlapping and succeed each other chronologically, perhaps also offering a picture of the diachronic development of a single farmstead (*ibid.*). The greater presence of einkorn compared to emmer in the assemblages from these houses is, maybe, a consequence of the preference for einkorn. Note, however, that the number of einkorn+emmer remains is also low.

Perhaps the number of crop remains in the House 102 long pits, which is larger by far than in any other examined section of the settlement, demonstrates higher and/or more regular consumption of plant food here than elsewhere. Or perhaps this household deposited plant refuse close to the house, whilst others discarded it away from the living space, entailing that there may have been different attitudes towards disposal of waste (*e.g.* Valamoti 2005). Further, the 'plant-rich' House 102 may have (also) stored more crops than the others, perhaps as surplus products meant for sharing and exchange (*e.g.* Halstead 1989). There are a number of possible explanations for the differences between the houses and neighbourhoods in the representation of the staple crops in the archaeobotanical assemblages, and they may or may not have something to do with the plant-related behaviour and practices involved in plant consumption and discard.

Conclusions

The archaeobotanical assemblage from Neolithic Vráble is composed of the 'standard' LBK-Želiezovce crop spectrum characteristic of dry sites with charred plant preservation, in which einkorn and emmer are the most prominent components and thus likely the major cultivars. The collected fruits and nuts supplemented the plant food produced through cultivation. The scarcity of plant remains at Vráble is almost certainly a direct result of a series of taphonomic factors, of which re-deposition and re-location of the material probably had the greatest impact. Despite the limited number of remains, it is possible to discern a pattern of varying presence of einkorn and emmer in some of the houses, perhaps reflecting variety in the degree of their production and/or use.

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5.6. Little but worth it: Anthracological data and thoughts on forestation in the surroundings of the LBK and Želiezovce settlement site of Vráble

Tim M. Schroedter

Abstract

Within the framework of the excavation of the Linearbandkeramik settlement of Vráble 'Veľké Lehemby' (Slovakia), wood charcoal was used to get insight into the wood vegetation in the vicinity of the site. Despite the relatively large overall sample size of more than 1,000 identified charcoal fragments, only a low number of taxa were documented at the site. Low diversity in the charcoal assemblage indicates a high degree of selection in the fuel wood economy. The rare types represent valuable additional indicators for the character of the exploited forest landscape during the Linearbandkeramik at Vráble.

Keywords: Charcoal analysis, human impact, wood economy

Introduction

The anthracological investigation presented in this chapter provides insight into the exploited forest vegetation in the surroundings of the Neolithic settlement site of Vráble 'Veľké Lehemby' (Nitriansky kraj, Slovakia) during Linearbandkeramik (LBK) and Želiezovce. All available charcoal fragments from the archaeobotanical samples were used as a basis for the investigation. The samples were collected from archaeological features, mainly different types of pit and postholes. Their infilling took place at least over a certain time span and they thus can be interpreted as synthetic deposits in the sense of Théry-Parisot *et al.* (2010, 143). Such deposits display a long-term vegetation signal for a site and thus are regularly implemented for anthracological studies (*e.g.* Masi *et al*. 2018; Moskal-del Hoyo *et al.* 2015; Marston 2009).

Material and methods

A total of 85 of the archaeobotanical samples contained charcoal fragments. Of the 1,131 fragments, 1,053 were determined. 9 distinct taxa were proven, and 78 fragments were indeterminate. The small size of the individual fragments did not allow for the documentation of further dendrological features, such as growth ring width or minimum diameter, or for the detection of fungal hyphae.

The identification was conducted using a stereo lens and a reflected light microscope. The anatomical features allowed for identification to the genus level. The aim was to reach 30 identifications per sample or, failing that, as many as possible. This number of charcoal fragments is assumed to contain the majority of taxa present in a given sample (see O'Carroll and Mitchell 2012). Despite the low number of detected wood taxa, a range of insights into natural vegetation and wood use could be gained.

Results

The number of identified fragments is within the range that is expected to be sufficient to get insight into the exploited woodland vegetation (see Heinz 1991, fig. 2; Moskal-del Hoyo *et al.* 2015, fig. VI-8). The results are presented in Table 5.6.1[1]. A total of 9 taxa have been identified, reflecting a undiverse assemblage.

The dominant taxon was deciduous oak (*Quercus*), followed by ash (*Fraxinus*). These two taxa sum up to 96% of all identified fragments. Further taxa occurred only as single finds. Beech (*Fagus*) was documented, as well as several light demanding species, namely, hazel (*Corylus*), pine (*Pinus*), some cherry (*Prunus*), pomaceous fruits (Maloideae) and cornelian cherry/dogwood (*Cornus*), and a small range of taxa which can be located in moist stands, namely, alder (*Alnus*), poplar (*Populus*) and elm (*Ulmus*). Coniferous wood was also present as a single find.

Comparable investigations in the wider region of south-eastern Europe regularly yield 20 or more taxa (*e.g.* Marinova and Ntinou 2018; Schroedter *et al.* 2012). Nevertheless, the documented assemblage fits the Atlantic period, with its more or less open mixed deciduous oak forest and riverine vegetation (*e.g.* Marinova and Ntinou 2018; Moskal-del Hoyo 2013; Magyari *et al.* 2010).

The limited range of taxa can be explained by one or both of the following factors: the low find density of, on average, 13 fragments per sample of 10 litres, which can also be observed within the carpological record (see Chapter 5.5), and the very selective wood exploitation by the Neolithic population.

Discussion

The charcoal assemblage reflects several distinct forest stand characteristics. The oaks (*Quercus*) comprise several species, all of which reflect mixed deciduous forests with a more or less open canopy, while beech (*Fagus*) belongs to forests with a closed canopy. A discussion on the distinct characteristics of beech and oak forests has been presented in the work by A. Kreuz (2008) on the issue of the openness of woods. These two taxa thus indicate more or less dense forests in the vicinity of Vráble. The scarce occurrence of taxa connected with bright stands does not allow for a statistically valid estimation on the degree of anthropogenic impact on the vegetation. The finds of hazel, cornelian cherry/dogwood and prunus nevertheless indicate the presence of bright stands in the surroundings of the site, at least in open canopy forests with a rich understorey. This kind of forest has also been traced at other

1 Online available at https://www.jma.uni-kiel.de/en/research-projects/data-exchange-platform.

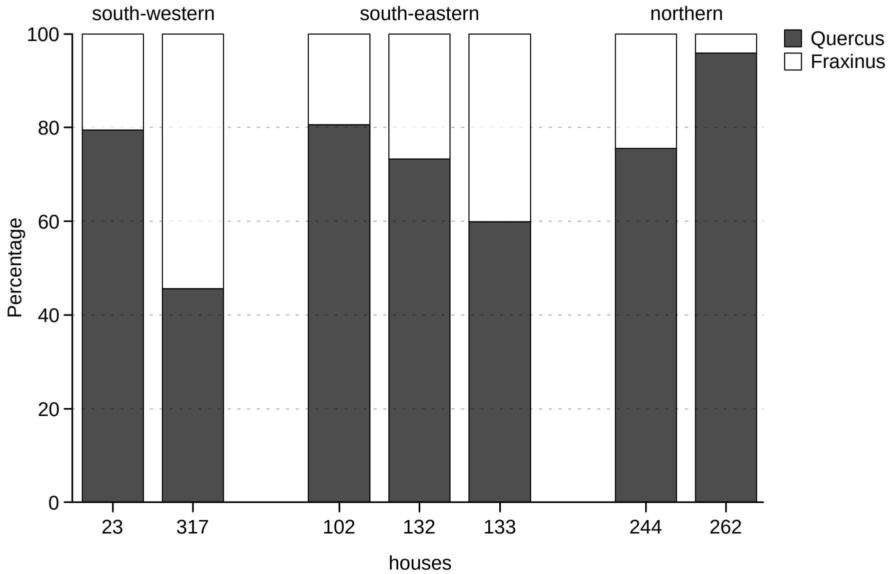

Figure 5.6.1. Oak : ash ratio from houses at Vráble with $n_{Total} > 50$.

sites at the regional level (*e.g.* Pokorny *et al.* 2015; Jamrichová *et al.* 2014). The postulated open character of the vegetation in the vicinity of the site is also indicated by the stable isotope analyses, in that the nitrogen values of the animal bones suggest manuring in open grassland in contrast to forest pasture (see Chapter 5.8).

Small-scale vegetation patterns are postulated at other Neolithic sites around 250 km east, with regional variations (Moskal-del Hoyo 2013), displaying distinct stand conditions reflecting different moisture levels. Similar assumptions can be made for the surroundings of Vráble. Although the low number of taxa per sample does not allow for any estimation of the extensions of such vegetation types, the presence of different hydrological situations can be seen in the overall charcoal assemblage. Hazel nutshells and kernel fragments of cornelian cherry as single finds in the carpological material (see Chapter 5.5) document the presence of these taxa and their exploitation as food resources. Ash, alder, poplar and elm suggest the presence and exploitation of a moist stand, probably floodplains or oxbow lakes nearby. Again, no estimations concerning their extent can be made.

Another aspect reflected in the charcoal assemblage is a possible diachronic shift in wood use from oak to ash. This shift is demonstrated in Figure 5.6.1. In two cases pairs of neighbouring houses belong to different phases (Chapter 4.2). The long pits of house 132 (south-eastern neighbourhood) are dominated by oak, while the long pits of the later house 133 contain higher proportions of ash. This shift towards lower percentages of oak can also be seen in the south-western part of the settlement, in houses 317 and 23. The long pits of the younger house 317 again display lower percentages of oak. In the northern settlement, similar percentages as in the houses 23 and 132 are found in the more or less contemporaneous house 244. However, in this case, the younger house 262 contains even higher proportions of oak. Other houses are either not directly dated (house 102) or contain too few charcoals (see Table 5.6.1).

The variation in wood use can be explained in several ways: Either a change in wood choice due to cultural or technological reasons led to the shift in the charcoal assemblage or an actual change in the availability of suitable oak occurred. The former seems less likely, since no relevant cultural or technological changes occur during this phase. The latter could be explained by an over-exploitation of oak or by hydrological changes (increasing precipitation or changes in the fluvial activities) causing a change in the vegetation.

	Neighbourhood	Quercus	Fraxinus	Alnus	Prunus	Corylus	Ulmus	Pomoideae	Ostrya/ Carpinus	Fagus	Cornus	Populus	indet	Total
23	SW	62	16				1						10	89
317	SW	36	43		3								8	90
102	SE	245	61			1		1					18	326
103	SE	24											1	25
127	SE	3												3
131	SE	10								1	2			13
132	SE	85	31	1	2				1				2	122
133	SE	100	67		1								3	171
244	N	18	15										3	36
245	N	24	14										3	41
258	N	9	1											10
259	N	8				1							4	13
262	N	47	2							1		1	6	57
Total		**671**	**250**	**1**	**6**	**2**	**1**	**1**	**1**	**2**	**2**	**1**	**58**	**996**

Table 5.6.1. The different plant taxa represented as wood charcoal in the long pits of houses of Vráble.

Conclusion

The study on wood charcoal at Vráble thus displays information on the Neolithic vegetation in the surroundings. The integration of related disciplines provides further support on the character of the forested surroundings of Vráble. The data collected reflect a manifold landscape, with patches of distinct woodland vegetation with a wide range of micro-climatic conditions. New issues have been raised concerning the diachronic change in taxonomic composition and the openness of the surroundings.

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5.7 Snail shells from the LBK and Želiezovce settlement site of Vráble

Frank Schlütz

Abstract

The analysis of snail shells, which mainly derive from the excavations in 2016, point towards a landscape of open grasslands around Vráble. With the dominating species being represented by *Pupilla muscorum, Succinea oblonga* and *Columella columella*, environmental conditions can be reconstructed and the understanding of the shaping of the landscape by the settlement community enhanced.

Keywords: Neolithic; molluscs; on-site; local conditions; long pits

This chapter discusses the analysis of snails from the Linearbandkeramik (LBK) and Želiezovce settlement of Vráble (Nitriansky kraj, Slovakia). Snails can be useful palaeoecological indicators. A total of 54 soil samples were taken during two excavation campaigns, most of them in 2016, three in 2013. Altogether, 1135 shells were sifted out from the sampled material (using a mesh size of 0.35 mm or smaller). These were identified to the species level where feasible. Sub-adult and broken shells were added to the relevant species of the same sample; a single apex of *Cochlicopa* could not be identified below the genus level. All numbers in this chapter relate to minimum number of individuals (MNI).

The archaeological material mostly come from the infill of the long pits situated along the longer sides of the excavated Neolithic houses. Some of them come from storage pits and post holes. The samples contained as many as 102 shells; 3 contained none. All 15 species identified (following the nomenclature of Welter-Schultes 2012; Kerney *et al.* 1983) still live in Slovakia today (Horsák *et al.* 2010). As the samples contained no typical Pleistocene loess taxa, it is likely that most of the shells originate from Neolithic sediments rather than from older sediments. An exception are finds of *Cecilioides acicula* whose shells were transparent and, in some cases, even contained the organic remains of the snail body. All of the 51 finds of this soil-dwelling species were treated as recent and excluded from the palaeoecological

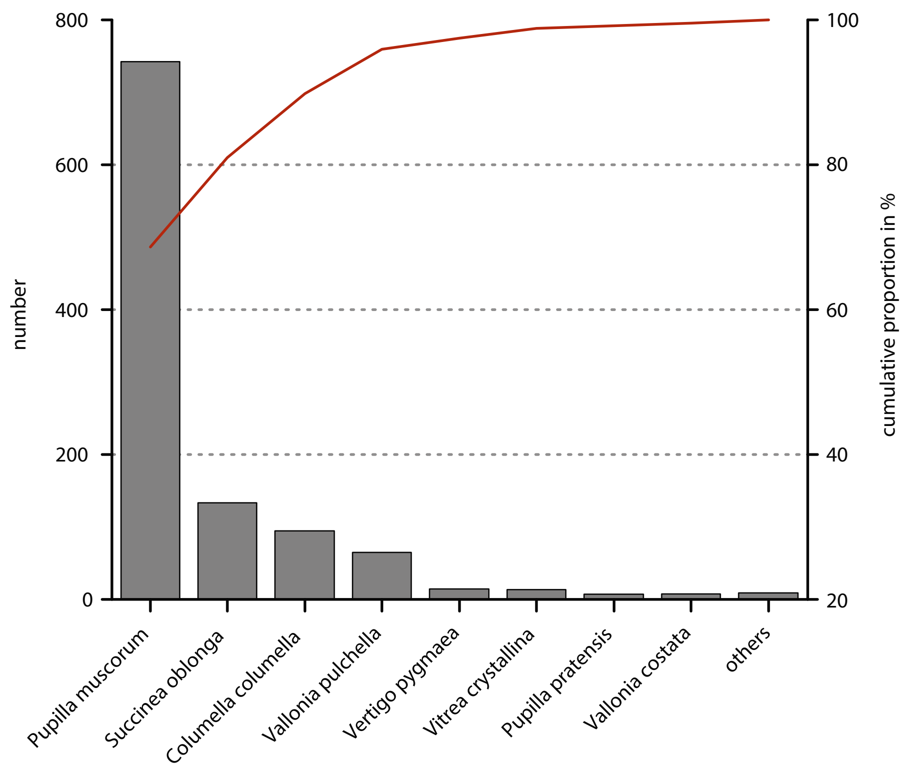

Figure 5.7.1. A Estimated minimum number of individuals (bars) and summed percentages (graph) of fossil shells. 'Others' includes species represented only by a single find (cf. Table 5.7.1).

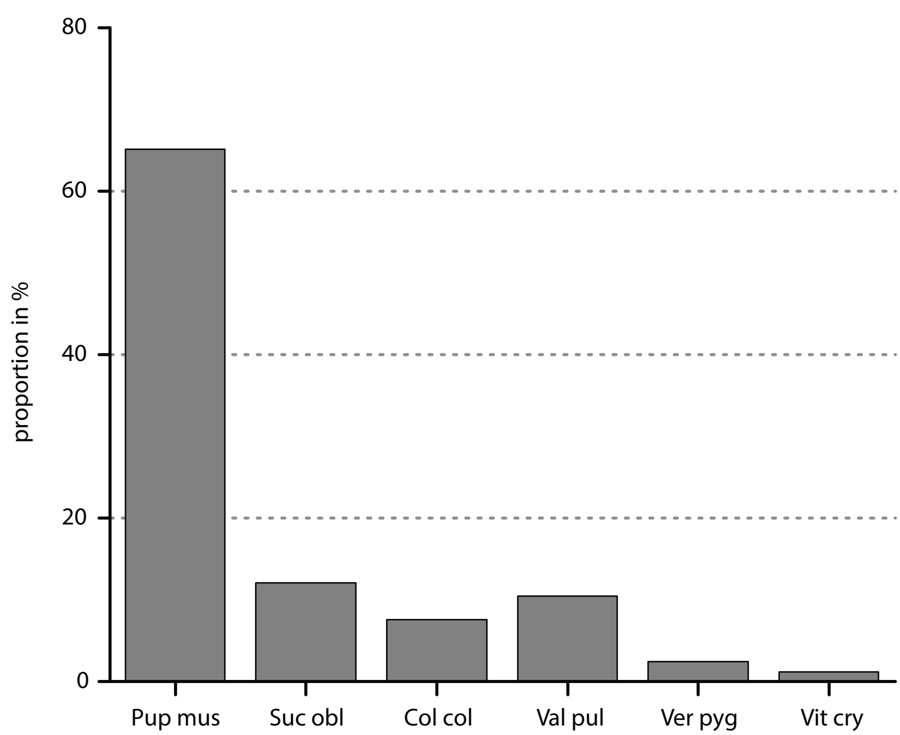

Figure 5.7.1. B1 Fossil finds from long pits from the sides of houses grouped by their relative position in relation to the corresponding house with results from long pits west of the houses..

interpretation (Willerding 1966). The ecological groups given in Table 5.7.1 follow Horáčková *et al.* (2015). In order to provide a spatial overview, the MNI estimates of all samples from the same archaeological feature were summed.

The dominant fossil species by far is *Pupilla muscorum,* with 743 shells, followed by *Succinea oblonga* and *Columella columella* with 134 and 96 finds, respective-

Species	Minimum number of individuals	%	% summed	Ecological group
Pupilla muscorum	743	68.61	68.61	B5
Columella columella	96	8.86	77.47	B5
Vallonia pulchella	66	6.09	83.56	B5
Vertigo pygmaea	16	1.48	85.04	B5
Vallonia costata	4	0.37	85.41	B5
Truncatellina cylindrica	1	0.09	85.50	B5
Vallonia excentrica	1	0.09	85.60	B5
Succinea oblonga	134	12.37	97.97	C8
Carychium tridentatum	1	0.09	98.06	C8
Chondrula tridens	1	0.09	98.15	B4
Vitrea crystallina	15	1.39	99.54	A2
Pupilla pratensis	4	0.37	99.91	C9
Vitrea contracta	1	0.09	100.00	C7

Table 5.7.1. Fossil species represented in the samples grouped by abundance of represented ecological groups (adapted from Horáčková et al. 2015). A2 woodland to semi-open habitats; B4 warm and dry open habitats; B5 open habitats in general; C7 mesic or various; C8 damp; C9 wet sites.

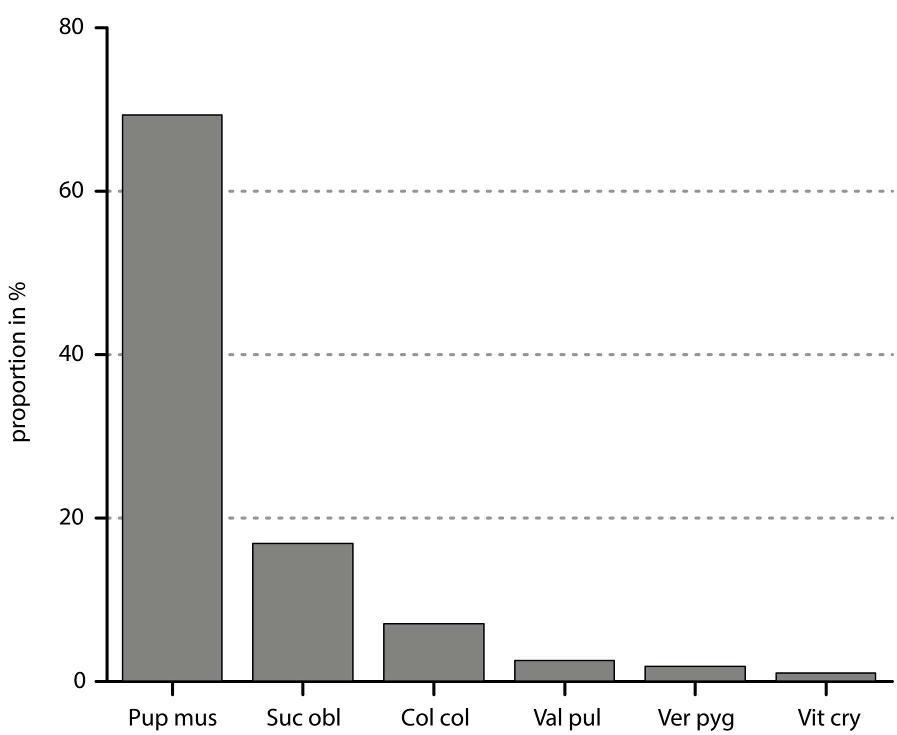

Figure 5.7.1. B2 Fossil finds from long pits from the sides of houses grouped by their relative position in relation to the corresponding house with results from long pits west of the houses.

ly (Table 5.7.1). These three species together make up more than 90% of the total number of individuals (Figure 5.7.1A).

Pupilla muscorum belongs to a group of snails living in open grassy habitats without trees or shrubs (Table 5.7.1, group B5). Such species are often found as pioneer species on clearings in the vegetation. The overwhelming dominance of a

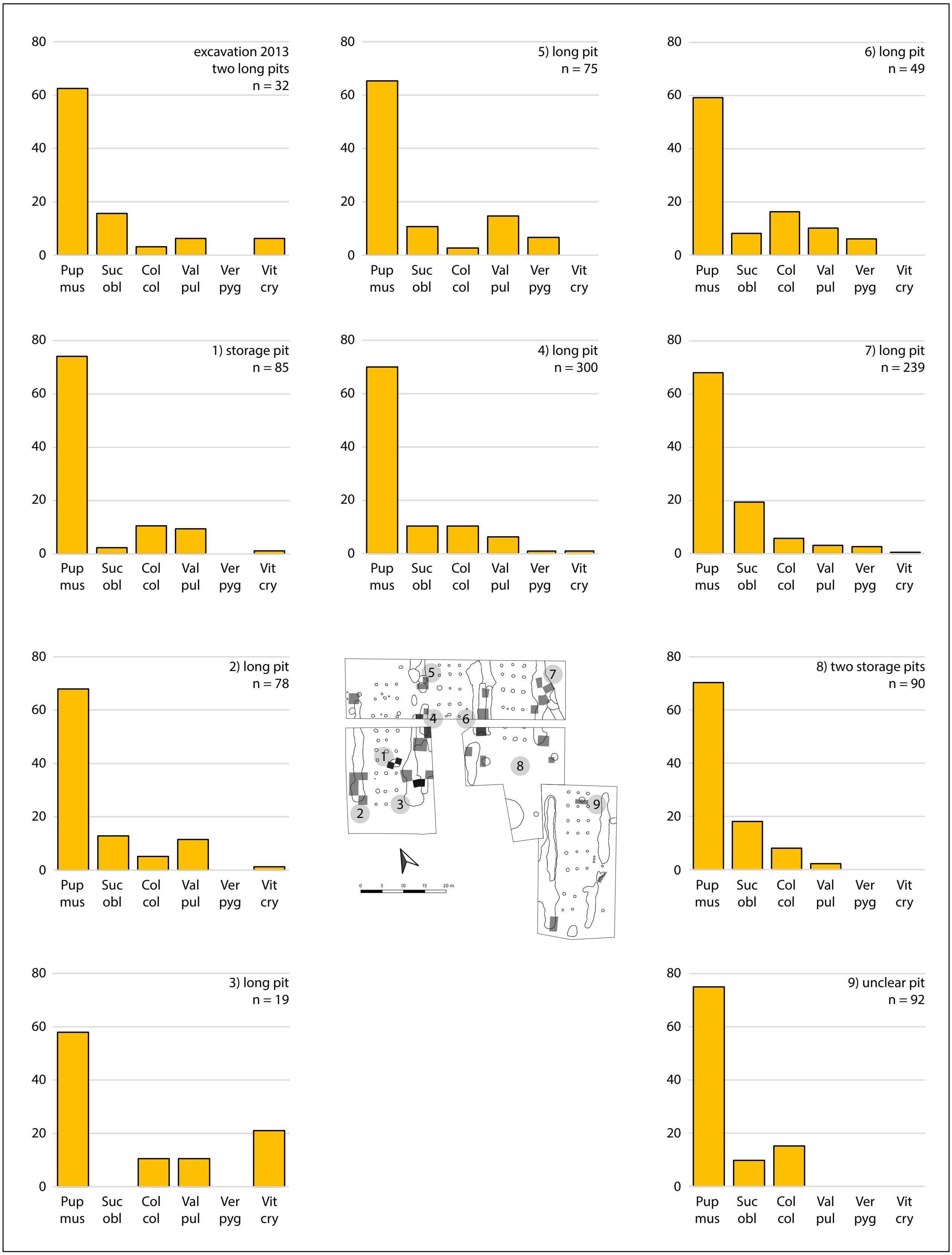

Figure 5.7.2. Archaeological features from the 2013 (top left) and 2016 (1-9) excavations. The area excavated in 2013 is about 120 m north from that excavated in 2016. Only spectra with at least 19 fossil snail shells are given; rare species are not depicted.

single species may point either to an early stage of snail succession or to lasting disturbances. As indicated by *Columella columella,* the humidity conditions tended to be damp or even wet. *Succisa oblonga* is found on barren soils, which are at least temporarily muddy (Schlütz and Bittmann 2015). Species from mainly dry habitats are very rare (*Truncatellina cylindrica, Chondrula tridens*) in the samples. The higher share of *Succisa oblonga* in the eastern long pits may point to somewhat muddier conditions east of the Neolithic houses (Fig. 5.7.B2).

In general, the ground of the Neolithic settlement was very likely covered by short grass, with some patches of naked soil. This holds true for both excavated areas (Fig. 5.7.2). Some samples from inside house 131 (Fig. 5.7.2,1) also contained blackened shells, possibly indicating infill from a fireplace inside the house into the sampled pit.

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5.8. Stable isotopic perspectives on animal and human diet at the LBK and Želiezovce settlement site of Vráble

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Abstract

Stable isotopic analyses of samples of bone, seeds and food residues or crusts have opened new avenues for researching the evolution of stock rearing and farming during prehistory and have provided in-depth perspectives into human diet. Here we present results from stable isotopic analyses of human and animal bones and of cereal grains from the Linearbandkeramik (LBK) site of Vráble, Nitriansky kraj, Slovakia. These provide an insight into animal fodder and pasturing, and cultivation practices. Livestock at Vráble appear to have been kept within the vicinity of the site and may have been reared on cereal by-products. From the animal and plant data, we calculated that animal products played a small role in the diet of LBK farmers at Vráble.

Keywords: Carbon isotopes, Nitrogen Isotopes, animal stable isotope values, human stable isotope values, pasturing and fodder practices

Introduction

Stable carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and oxygen ($\delta^{18}O$) isotope analyses of animal and plant remains recovered from LBK settlements have provided new insights into the animal husbandry and plant management strategies practised by the first farmers of central and northern Europe (Knipper 2011; Oelze *et al.* 2011; Kovačiková *et al.* 2012; Bogaard *et al.* 2013; Fraser *et al.* 2013; Whittle and Bickle 2013; Berthon *et al.* 2018; Gillis *et al.* submitted). Isotopic analyses of livestock bone collagen and dental bioapatite have revealed aspects of animal husbandry strategies during the LBK, such as the timing of cattle breeding (Kovačiková *et al.* 2012; Gillis *et al.* submitted); pasture and foddering provisioning (Oelze *et al.* 2011; Kovačiková *et al.* 2012; Fraser *et al.* 2013; Gillis *et al.* submitted); seasonality of fodder (Berthon *et al.* 2018; Gillis *et al.* submitted); and mobility among pastures (Knipper 2011). Livestock herds produce a key ingredient for crop cultivation: manure, which may have been deliberately collected or introduced by animals being penned on cultivation plots during fallow years or post-harvest. Although limited in number, stable isotopic analyses of carbonised seed remains are revealing plant management strategies practised by LBK farmers concerned with fertilisation of crops in order to ensure production and possibly to increased yields (Fraser *et al.* 2013; Styring *et al.* 2017).

The diet of prehistoric communities has long been a focus of archaeological research, as food procurement and consumption practices can reflect human management of plant and animal resources and may provide insight into social organisation and inequality. Reconstructions of human diet using faunal and plant remains are hampered by preservation conditions, taphonomic pathways and recovery methodologies. These remains are not a direct reflection of human diets; rather, they are a residue of feasts and accidents. The advent of stable isotope analyses of bone and plant material has allowed us to directly reconstruct human and animal diets based on the principal that 'you are what you eat +/–ppm' (after Fuller *et al.* 2004: 2889). For humans, nitrogen stable isotopes have the primary the focus, as these directly reflect protein consumption (DeNiro and Epstein 1981) and therefore indicate whether the diet was meat based or plant based. In several case studies, stable isotope analyses of cereals and pulses have shown that prehistoric human diets were more plant-based than previously thought (Fraser *et al.* 2011; Styring *et al.* 2012; Styring *et al.* 2015).

In this chapter, we examine animal husbandry strategies, particularly foddering and pasturing, and their impact on agricultural activities at Vráble 'Veľké Lehemby' through stable carbon and nitrogen isotope analyses of remains of animal bones and cereal grains. The results of this study, together with those of previous studies, builds a picture of livestock pasturing/foddering practices and their articulation with agricultural activities at Vráble, and how this may have been different from or similar to other LBK settlements. Finally, we use our results to examine human diets, in particular the proportion of animal protein.

Stable isotope research and reconstructing prehistoric farming practices

Carbon isotopes

The carbon isotope ratio composition of animal tissues reflects dietary intake, which in herbivores is a direct reflection of ingested plants (Ambrose and Norr 1993; Jim *et al.* 2004). The main source of variation in plant $\delta^{13}C$ values are from the different photosynthetic pathways (C_3 [Calvin cycle] and C_4 [Hatch Slack] [Vogel 1978; O'Leary 1988]). C^3 and C^4 plants exhibit a global range of between −26.5±2‰ (range: −38‰ to −22‰: Smith and Epstein 1971; Vogel 1978; O'Leary 1988; Tieszen 1991) and −12.5±1‰ (range: −19‰ to −6‰: Smith and Epstein 1971; O'Leary 1988; Tieszen 1991), respectively. The landscape of the western Carpathians during the LBK occupation consisted of a range of environments containing largely C^3 plants, but possibly some C^4 plants as well. Vegetation communities situated at lower altitudes consisted primarily of C^3 mixed broad-leaf and pine forests (Chytrý 2012; Kuneš *et al.* 2015), while open forest-grassland would have supported C^3 flora as well as possibly some C^4 plants, such as sedges (*Carex* sp.) and eudicots (Chenopodiaceae and Amaranthaceae) (Collins and Jones 1986; Ehleringer *et al.* 1987; Kadereit *et al.* 2003).

The $\delta^{13}C$ herbivores values are influenced by the $\delta^{13}C$ of atmospheric CO_2 at the time of plant growth. The burning of fossil fuels and, to a lesser extent, the removal of large stretches of forests has led to changes in the carbon isotope composition of atmospheric CO_2. The $\delta^{13}C$ value of CO_2 during the Vráble occupation has been estimated at −6.3‰ based on interpolating data from Antarctic ice cores (Ferrio *et al.* 2005). Given that the current $\delta^{13}C$ of atmospheric CO_2 is −8‰, the correction will be 2.3‰. This correction is important to bear in mind when comparing modern plant and animal values with those from prehistoric samples.

In C^3 plants, the isotope fractionation of stable carbon isotopes takes place during the carboxylation process, which is directly affected by low light intensity and its role on stomata conductance (Farquhar *et al.* 1989; Van der Merwe and Medina 1991; Arens *et al.* 2000). In European forested temperate environments, canopy density substantially influences the carbon isotope ratio composition of understory floral growth (Vogel 1978; Van der Merwe and Medina 1991), with understory plants exhibiting $\delta^{13}C$ values of *c.* −31.5‰. These values increase moving up through the canopy (−31.2‰ to −27.9‰). This is the result of two main factors: first, atmospheric CO_2 under the canopy is ^{13}C depleted relative to the atmosphere, caused by the uptake of CO_2 respired by organic matter with low delta ^{13}C values (Tieszen 1991) and, second, light intensity increases as the canopy opens, improving the efficiency of photosynthesis and thus favouring the transfer of ^{13}C (Farquhar *et al.* 1989; Van der Merwe and Medina 1991). The net result is the reduction of $\delta^{13}C$ values, which can be between 1‰ and 6‰ depending on the density of the canopy.

Animals browsing and grazing under forest canopies exhibit low carbon isotope values in their skeletal tissues. Contemporary wild herbivores feeding in minimally managed mixed deciduous forest in temperate environments in Poland and France exhibit bone collagen $\delta^{13}C$ values ranging from −26.1‰ to −21.7 ‰ (Drucker *et al.* 2008). Differences in feeding strategies may be change depending on the local forested environment, for example, red deer *(Cervus elaphus)* from mixed-deciduous English woodlands have been found to exhibit dietary values of −23.9‰ (range 2.2‰), whereas those from a coniferous plantation where browse maybe limited to forest edges exhibit values of −22.8‰ (range 1.3‰) (Stevens *et al.* 2006). Red deer and roe deer *(Capreolus capreolus)* from LBK sites from across central and northern Europe exhibit bone collagen $\delta^{13}C$ values of −26.8‰ to −22.9‰, adjusted for the Suess effect for comparison(Fraser *et al.* 2013; Hedges *et al.* 2013; Gillis *et al.* submitted). Cattle forest pasturing is evident at several LBK sites, such as Bischoffsheim (Gillis *et al.* submitted) and Vaihingen (Fraser *et al.* 2013), with animals exhibiting bone collagen values of −26.3‰ to −23.3‰ adjusted for the Suess effect.

Carbon isotope fractionation also occurs during CO_2 transfer and liquid transportation. In periods of water stress and low humidity, plant stomata will close to conserve water and will be less likely to discriminate against ^{13}C, leading to an enrichment of plant $\delta^{13}C$ values. In temperate European environments, seasonal variation in soil moisture conditions may cause 1‰ difference in $\delta^{13}C$ hair values of herbivores from winter to summer (for example, summer and winter values for cattle pastured in Germany are −26‰ and −25‰, respectively; Schnyder *et al.* 2006). In continental European environments, where there are greater differences between summer and winter temperatures, we would expect the magnitude of this effect to be greater (Tieszen 1991). In contrast, in water-rich areas, such as swamps and banks of rivers, plants readily up take CO_2 and discriminate against ^{13}C, leading to depleted $\delta^{13}C$ values (Fan *et al.* 2018). Cattle have a tendency to prefer boggy areas, and this has been proposed as an alternative explanation for the depleted values seen in British aurochs (*Bos primigenius*) (−24‰ to −22.2‰) rather than a reflection of browsing within a forested environment (Lynch *et al.* 2008).

Nitrogen isotopes

Stable nitrogen isotope composition of livestock bones and teeth provides insights into management strategies, such as weaning (Balasse and Tresset 2002; Gillis *et al.*

2013) and winter foddering (Makarewicz 2014; 2015), while δ^{15}N values of cereal grains and pulses has been used to investigate prehistoric manuring practices (Bogaard *et al.* 2013; Fraser *et al.* 2013; Styring *et al.* 2014). Nitrogen isotope values in producers and consumers exhibit a *c.* 3‰ stepwise enrichment between trophic levels, with terrestrial animals exhibiting a 2.7‰ enrichment (Schoeninger and DeNiro 1984) or, in the case of pigs, 2.5‰, as shown in a recent controlled feeding experiment (Webb *et al.* 2017). δ^{15}N values of suckling mammals can be up to 3‰ to 5‰ higher than that of adults due to the consumption of milk protein.

Stable nitrogen isotope values of herbivore bone collagen are directly related to plant and soil conditions. Soil nitrogen isotope compositions are the result of fractionation that occurs during the physical and biological processing of organic and inorganic N compounds (Knoepp *et al.* 2015). Compounds with ^{14}N lost through leaching, denitrification and volatilisation, resulting in the enrichment of the remaining matter with ^{15}N (Knoepp *et al.* 2015). European temperate forests soils undisturbed by deforestation or farming activity, such as grazing and tillage, which are similar to those encountered by LBK farmers, have been shown to have low δ^{15}N soil values (–6 to 0.6‰). This is due to the wet and cool conditions, where little ^{14}N is lost through denitrification (Handley *et al.* 1999; Martinelli *et al.* 1999). The age of the soil can also affect the total soil δ^{15}N value and, in turn, the plant δ^{15}N value, whereby younger soils will have low δ^{15}N values due to the nett balance of accumulating N from the atmosphere with little loss of ^{14}N in contrast to older soils, which have lost ^{14}N through leaching, denitrification and volatilisation, leading to the enriched δ^{15}N values (Martinelli *et al.* 1999).

Nitrogen is fixed in plants from the atmosphere directly by N_2-fixing plants, such as legumes, that convert atmospheric N_2 to ammonia; these plants in general exhibit δ^{15}N values around 0‰, reflecting atmospheric N_2 (Ambrose and DeNiro 1989). In contrast, non-fixing plants, which include cereals and most tree species, rely solely on sources of fixed N derived from decomposed plant and animal matter and from activity of nitrogen-fixing microorganisms (Handley *et al.* 1999). Within these plants, δ^{15}N values vary widely between and within species, reflecting physiological differences that impact the degree of N assimilation by plant roots or shoots and subsequent translocation and reduction processes, local differences in soil N, and abiotic factors, including aridity and salinity (Amundson *et al.* 2003; Liu *et al.* 2014; Nitsch *et al.* 2015). These latter abiotic factors can lead to the enrichment of δ^{15}N values by an increase in denitrification, favouring the loss of ^{14}N (Ambrose and DeNiro 1989; Handley *et al.* 1999). Nitrogen from animal origin *e.g.* manure, is enriched in ^{15}N due to the loss of ^{14}N by the animal during digestion and excretion (Robbins *et al.* 2005).

The incorporation of manure into the soil N cycle can lead to an increase of between 4‰ and 9‰ in plant δ^{15}N values. There is a clear link with manure and enriched δ^{15}N values in cereals, and the magnitude of this effect is relative to the quantity of manure (Bogaard *et al.* 2007; Fraser *et al.* 2011). For example, crops grown without manure have values of around 2.5‰, whereas those under a long-term manuring regime of *c.* 35-37 tonnes per hectare, applied annually, have values of around 6‰. Crops grown under low levels of manure, *i.e.* 20-30 tonnes per hectare, or after a period of intensive manuring will have delta ^{15}N values between 2.5‰ and 6‰ (Fraser *et al.* 2011). Therefore, plant remains have the potential to be used as an indication of quality of agricultural soils and manuring practices during prehistory (Fraser *et al.* 2011; Bogaard *et al.* 2013; Fiorentino *et al.* 2014).

Material and methods

To investigate livestock pasturing and foddering and crop cultivation practices at Vráble, samples were taken from a total of 45 domesticated animal bones (*Bos taurus,* n = 20; *Ovis aries/Capra hircus*, n = 13; *Sus scrofa* sp., n = 12) from the three settlement areas (Table 5.8.1). We are primarily interested in the pasturing and foddering of adult herds. We therefore selected fused elements for sampling, as the isotopic signature acquired in early bone formation will be considerable attenuated in adult bone. Alongside this, 10 samples of emmer (*Triticum dicoccum*) and einkorn (*T. monococcum*) wheat grains were collected from contexts where there was a large sample of well-preserved cereal grains (here defined as >5; Table 5.8.2). Human remains were analysed for carbon and nitrogen stable isotopes as part of the quality control protocol during radiocarbon analysis, conducted at the Poznań Radiocarbon Laboratory.

Bone collagen was extracted from the animal bone samples following Tuross *et al.* (1988), using an EDTA (0.5M; pH7.5) solution. Small fragments of bone were soaked in 10ml EDTA until complete decalcification. The samples were rinsed in ultra-pure distilled water several times, and then they were rinsed in 0.1M NaOH. Extracted collagen was left to soak in distilled water overnight, at 10°C, and then rinsed again, five times, in ultra-pure distilled water. Then the samples were freeze dried. Bone collagen samples (800-1200 µg) were analysed for carbon and nitrogen isotopes on GVI Iso Prime and a Eurovector elemental analyser at Boston University. For $^{13}C_{V\text{-}PDB}$, the CO_2 gas was calibrated against NBS 20 (Solenhofen Limestone), NBS 21 (Spectrographic Graphite), and NBS 22 (Hydrocarbon Oil). For $^{15}N_{air}$, the gas was calibrated against atmospheric N_2 and IAEA standards N-1, N-2, and N-3 (all of which are ammonium sulphate standards). Two internal lab standards were used, namely, peptone and glycine, which gave a mean analytical precision estimated (based on 3 peptone and 5 glycine standards) for ^{15}N analyses of 0.08‰ and for ^{13}C analyses of 0.02‰. Cereal grain samples were analysed at the Service de Spectrométrie de Masse isotopique du MNHN (SSMIM, Paris) using an elementary analyser (Flash 2000) interfaced with a mass spectrometer (Delta V Advantage). The mean analytical precision, estimated based on 13 alanine standards, is 0.06‰ for $\delta^{15}N$ analyses and 0.07‰ for $\delta^{13}C$ analyses.

A number of different pre-treatment protocols exist for stable isotopic analysis of carbonised seeds, following either acid-base-acid or acid alone protocols at a variety of temperatures. A recent comparison found little difference between stable isotope results, although acid-base-acid protocols lead to considerable sample loss (Brinkkemper *et al.* 2018). We chose a gentle acid protocol to remove exogenous carbonates, as the grains had no observable contaminates, such as sediment. Bulk samples of more five samples each were prepared by first soaking in aqueous 0.5 M HCl for 30 min or until effervescence ceased at room temperature. This was followed by three rinses in ultra-pure distilled water and then crushing using a pestle to grind each bulk sample into a homogenised powder. Stable isotope composition, particularly nitrogen, can vary up to 3‰ within a single ear. Therefore, using bulk samples of several grains is advantageous, as such analysis characterises the mean value and reduces the effect of a single high value (Nitsch *et al.* 2015).

Carbonisation causes loss and breakdown of proteins, lipids and carbohydrates (cellulose and starch) and leads to changes in the original bulk $\delta^{15}N$ and $\delta^{13}C$ values. Charring experiments have proposed several offset values for $\delta^{15}N$ values, from 1.1±0.4‰ (Fraser *et al.* 2011) to, more recently, 0.3±0.5‰ (Nitsch *et al.* 2015). This discrepancy is due to the variation in temperature and charring time. We will use the most recent calculated offset value of 0.3‰, as it considers different possible variations in temperature and time, and its impact on $\delta^{15}N$ values. We will use an offset value of 0.1±0.1‰ for $\delta^{13}C$ values (Nitsch *et al.* 2015). The offset between grain and rachis $\delta^{15}N$ values is 2.4±0.8‰ (Fraser *et al.* 2011), and between grain and rachis $\delta^{13}C$ values it is 2.0‰ (Wallace *et al.* 2013).

The difference, or enrichment, between diet and animal or human $\delta^{13}C$ values has been shown to be dependent on the tissue studied (*e.g.* bone collagen, bioapatite [Sponheimer *et al.* 2003a; Jim *et al.* 2004]), digestion physiology, the ratio between C4 and C3 plants in the diet (Codron *et al.* 2011), and the ratio of marine versus terrestrial

ASIL number	Settlement area	Taxon	Element
7153	N	Bos taurus	mandible
7154	N	Bos taurus	tibia
7155	N	Bos taurus	metatarsus
7156	N	Bos taurus	phalanx 3
7157	N	Bos taurus	phalanx 1
7165	N	Bos taurus	metacarpus
7152	SE	Bos taurus	phalanx 1
7158	SE	Bos taurus	phalanx 1
7160	SE	Bos taurus	tibia
7161	SE	Bos taurus	ulna
7162	SE	Bos taurus	mandible
7163	SE	Bos taurus	humerus
7164	SE	Bos taurus	phalanx 1
7145	SW	Bos taurus	phalanx 1
7146	SW	Bos taurus	humerus
7147	SW	Bos taurus	radius
7148	SW	Bos taurus	humerus
7149	SW	Bos taurus	humerus
7150	SW	Bos taurus	metacarpus
7151	SW	Bos taurus	phalanx 1
7169	N	Ovis aries/Capra hircus	humerus
7170	N	Ovis aries/Capra hircus	mandible
7171	N	Ovis aries/Capra hircus	mandible
7178	N	Ovis aries/Capra hircus	metacarpus
7172	SE	Ovis aries/Capra hircus	radius
7173	SE	Ovis aries/Capra hircus	humerus
7174	SE	Ovis aries/Capra hircus	radius
7175	SE	Ovis aries/Capra hircus	humerus
7176	SE	Ovis aries/Capra hircus	humerus
7177	SE	Ovis aries/Capra hircus	phalanx 1
7166	SW	Ovis aries/Capra hircus	tibia
7167	SW	Ovis aries/Capra hircus	mandible
7168	SW	Ovis aries/Capra hircus	mandible
7181	N	*Sus scrofa* sp.	scapula
7182	N	*Sus scrofa* sp.	femur
7183	N	*Sus scrofa* sp.	metacarpus 3
7189	N	*Sus scrofa* sp.	scapula
7190	N	*Sus scrofa* sp.	humerus
7184	SE	*Sus scrofa* sp.	scapula
7185	SE	*Sus scrofa* sp.	scapula
7186	SE	*Sus scrofa* sp.	femur
7187	SE	*Sus scrofa* sp.	pelvis
7188	SE	*Sus scrofa* sp.	femur
7179	SW	*Sus scrofa* sp.	radius
7180	SW	*Sus scrofa* sp.	tibia

Table 5.8.1. Sample list for bone collagen samples. ASIL = Archaeological stable isotope lab, Kiel.

ASIL number	Species	House number	Settlement area
8218	T. dicoccum	102	SE
8219	T. monococcum	102	SE
8220	T. dicoccum	262	N
8221	T. monococcum	262	N
8222	T. dicoccum	39	SW
8223	T. monococcum	39	SW
8224	T. dicoccum	131	SE
8225	T. monococcum	131	SE
8226	T. dicoccum	258	N
8227	T. monococcum	258	N

Table 5.8.2. Sample list for cereal samples. ASIL = Archaeological stable isotope lab, Kiel.

protein (Schoeninger and DeNiro 1984). In general, the enrichment between dietary $\delta^{13}C$ values and herbivore bone collagen $\delta^{13}C$ values has been proposed to be between 5.1‰ and 5.3‰ (Ambrose and Norr 1993; Sponheimer *et al.* 2003a; Jim *et al.* 2004). Here we will use 5.1‰, in order for our results to be comparable to previous stable isotope studies of LBK faunal material (Berthon *et al.* 2018). We will use an enrichment factor between diet $\delta^{15}N$ and animal $\delta^{15}N$ values of 3‰ (following Schoeninger and DeNiro 1984; Sponheimer *et al.* 2003b; Vanderklift and Ponsard 2003).

To calculate the percentage of animal protein within human diets we used the equations 'Standard method' and 'Standard method plus plants' as described by Styring *et al.* (2015). The first method assumes that humans eating a plant-based diet will have the same $\delta^{15}N$ values as the local herbivores, whereas humans eating only animal protein will have a bone collagen $\delta^{15}N$ value one trophic level higher than the local herbivores. The second assumes that humans eating only plants will have a bone collagen $\delta^{15}N$ value one trophic level higher than the cereal grain values and that humans eating only animal protein will have a bone collagen $\delta^{15}N$ value one trophic level higher than that of local herbivores.

Statistical analyses were carried out using PAST (Hammer *et al.* 2001), and non-parametric analysis was carried out in cases where the sample size is less than 30 (Dytham 2003). All standard deviations are to 1σ.

Results

Animal stable isotope values

The percentage collagen extracted from the bone samples ranges between 2.0 and 12.0. All samples with the exception of one sample (7154) yielded well-preserved collagen, as indicated by C:N ratios ranging from 3.1 to 3.2 and %C values ranging from 39.7 to 45.9 (Ambrose 1990; van Klinken 1999). The %N values, ranging from 14.9 to 17.4, are slightly higher than the recognised standard (Table 5.8.3), although they are within ranges seen in previous studies (Sealy *et al.* 2014). The $\delta^{13}C$ values for all sampled animals range from –21.8‰ to –16.0‰, and the $\delta^{15}N$ values range from 6.8‰ to 11.7‰.

ASIL number	Taxon	δ^{13}C (‰)	δ^{15}N (‰)	%C	%N	C:N
7153	Bos taurus	-20.1	8.4	43.6	16.6	3.1
7154	Bos taurus	-19.5	10.6	40.9	13.3	3.6
7155	Bos taurus	-19.9	8.0	43.1	16.3	3.1
7156	Bos taurus	-18.9	11.3	43.1	16.4	3.1
7157	Bos taurus	-20.3	9.5	43.4	16.3	3.1
7165	Bos taurus	-20.1	9.8	43.8	16.7	3.1
7152	Bos taurus	-20.5	9.5	44.2	17.4	3.0
7158	Bos taurus	-20.5	8.4	44.5	16.9	3.1
7160	Bos taurus	-20.2	8.2	39.7	15.0	3.1
7161	Bos taurus	-20.3	7.9	44.5	16.9	3.1
7162	Bos taurus	-19.7	9.0	45.9	17.4	3.1
7163	Bos taurus	-19.6	10.1	43.1	16.5	3.0
7164	Bos taurus	-19.7	8.8	44.7	17.1	3.1
7145	Bos taurus	-20.1	6.9	42.6	15.8	3.1
7146	Bos taurus	-20.0	7.9	43.6	16.1	3.2
7147	Bos taurus	-20.7	10.1	44.0	16.6	3.1
7148	Bos taurus	-16.0	8.5	44.2	16.3	3.2
7149	Bos taurus	-20.5	7.1	43.7	16.2	3.2
7150	Bos taurus	-20.0	10.3	43.0	16.1	3.1
7151	Bos taurus	-20.7	9.6	42.9	16.2	3.1
7169	Ovis aries/Capra hircus	-20.0	9.2	43.8	16.2	3.2
7170	Ovis aries/Capra hircus	-19.6	10.2	45.2	17.0	3.1
7171	Ovis aries/Capra hircus	-21.3	9.1	44.0	16.4	3.1
7178	Ovis aries/Capra hircus	-20.1	8.1	45.3	17.1	3.1
7172	Ovis aries/Capra hircus	-20.4	8.8	44.1	16.1	3.2
7173	Ovis aries/Capra hircus	-20.7	9.6	43.5	15.8	3.2
7174	Ovis aries/Capra hircus	-20.2	9.6	45.1	16.6	3.2
7175	Ovis aries/Capra hircus	-19.3	11.7	43.9	15.9	3.2
7176	Ovis aries/Capra hircus	-20.3	9.9	44.3	16.3	3.2
7177	Ovis aries/Capra hircus	-20.2	10.8	44.3	16.6	3.1
7166	Ovis aries/Capra hircus	-20.8	9.0	43.6	16.3	3.1
7167	Ovis aries/Capra hircus	-20.6	8.7	43.6	16.1	3.2
7168	Ovis aries/Capra hircus	-20.4	8.5	43.5	15.9	3.2
7181	*Sus scrofa* sp.	-20.3	9.7	44.5	16.7	3.1
7182	*Sus scrofa* sp.	-20.7	10.0	41.2	15.2	3.2
7183	*Sus scrofa* sp.	-20.4	9.0	43.8	16.4	3.1
7189	*Sus scrofa* sp.	-20.9	10.0	44.2	16.4	3.1
7190	*Sus scrofa* sp.	-21.5	8.9	44.8	16.7	3.1
7184	*Sus scrofa* sp.	-20.2	8.8	43.9	16.1	3.2
7185	*Sus scrofa* sp.	-20.7	9.0	44.0	16.4	3.1
7186	*Sus scrofa* sp.	-20.5	10.0	43.9	16.4	3.1
7187	*Sus scrofa* sp.	-20.5	8.8	45.4	16.7	3.2
7188	*Sus scrofa* sp.	-20.8	9.2	45.2	16.8	3.1
7179	*Sus scrofa* sp.	-21.6	8.9	43.9	15.9	3.2
7180	*Sus scrofa* sp.	-19.8	9.5	43.3	16.2	3.1

Table 5.8.3. Bone collagen results from faunal samples.

Cattle (*Bos taurus*)

Figure 5.8.1 shows the cattle results for each settlement. The overall mean for $\delta^{13}C$ for the cattle samples is −19.9±4.4‰ (1σ; range: −20.7‰ to −16‰). Removing the outlier sample of 7148 (−16.0‰) gives $\delta^{13}C$ values ranging from −20.7‰ to −18.9‰. There is no significant difference between the three settlement areas for $\delta^{13}C$ (Kruskal-Wallis, H = 4.01, p = 0.13). The range of dietary $\delta^{13}C$ values is between −25.8‰ to −24‰. The mean $\delta^{15}N$ value is 9.0±1.2‰ (1σ; range: 6.9‰ to 11.3‰) based on 21 samples. There is a large range for $\delta^{15}N$ values within each of the settlement areas, particularly in the south-western one (~3‰). However, there is no significant difference among the three settlement areas (Kruskal-Wallis, H = 1.97, p = 0.37). The range of dietary $\delta^{15}N$ values is between 3.8‰ to 8.3‰.

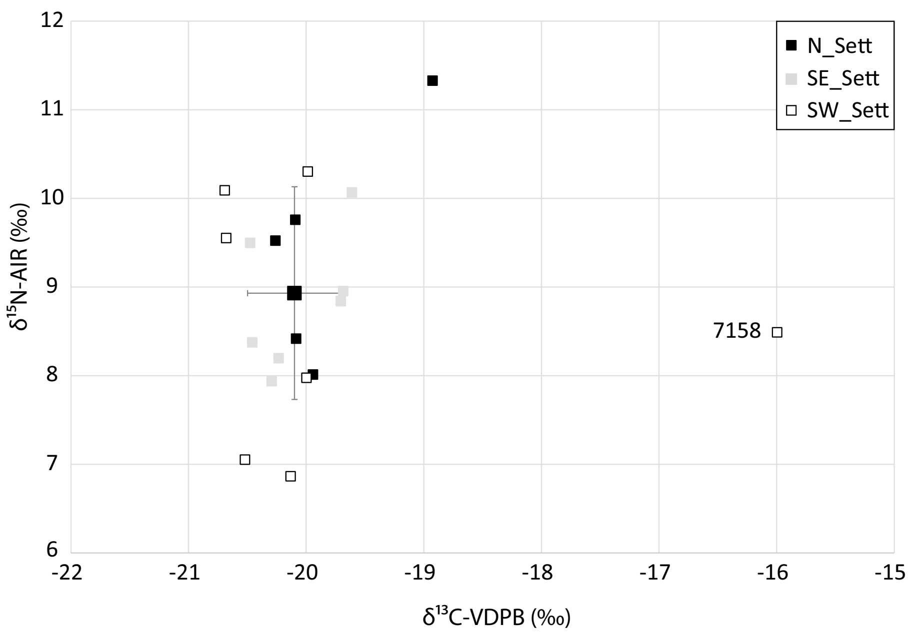

Figure 5.8.1. Bos taurus results from the three LBK settlement area at Vráble. Sett = settlement area.

Sheep/goat (*Ovis aries/Capra hircus*)

Figure 5.8.2 shows the $\delta^{13}C$ and $\delta^{15}N$ values for sheep/goat from the individual settlement areas. The overall mean for $\delta^{13}C$ values is −20.3±0.5‰ (1σ; range: −21.3‰ to −19.3‰) based on 13 samples. There is no significant difference between each of the settlement areas for $\delta^{13}C$ (Kruskal-Wallis, H = 2.5, p = 0.29) nor with other species. The range of dietary $\delta^{13}C$ values is between −26.4‰ and −24.4‰. The $\delta^{15}N$ values mean is 9.5±1‰ (1σ; range: 11.7‰ to 8.1‰). There is no significant difference between settlement areas (Kruskal-Wallis, H = 4.96, p = 0.08) and with other species. The range of dietary $\delta^{15}N$ values is between 3.0‰ to 8.7‰.

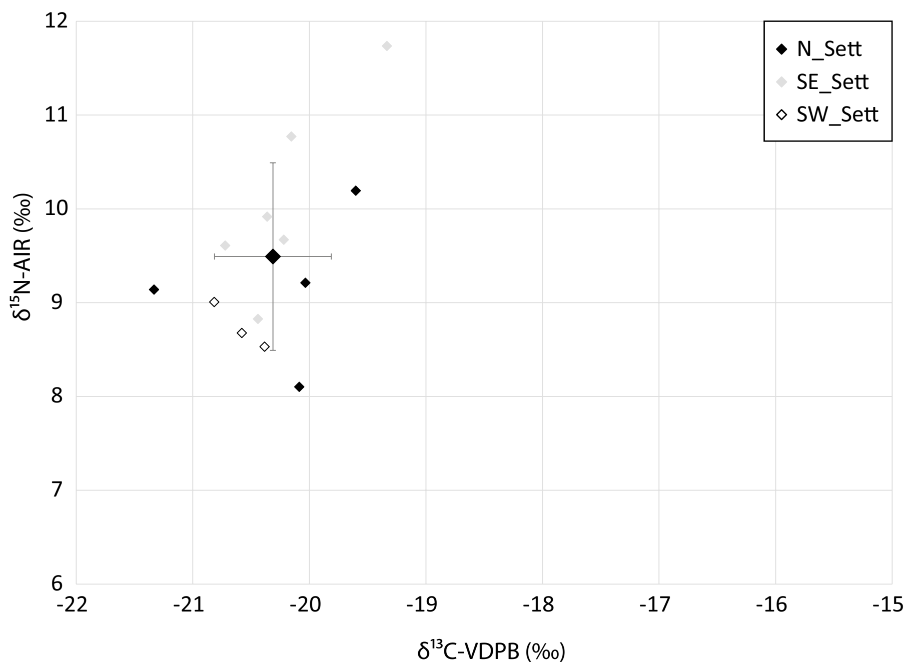

Figure 5.8.2. Ovis aries/Capra hircus results from the three LBK settlement areas at Vráble. Sett = settlement area.

Pig (*Sus scrofa* sp.)

The mean $\delta^{13}C$ value for pigs is −20.6±0.5‰ (1σ; range: −21.6‰ to −19.8‰), based on 12 samples (Fig. 5.8.3). As was the case with the cattle and sheep samples, there is no difference among the stable isotope results from the three settlement areas (Kruskal-Wallis, H=0.19, $\delta^{13}C$ values p = 0.9). There is also no difference between pig and sheep $\delta^{13}C$ values. However, there is a significant difference between pig and cattle values (Mann-Whitney, p = 0.002). The pig samples are slightly more depleted, by −0.6‰, in comparison to those from cattle, which may suggest pigs had access to fodder depleted in ^{13}C. The range of dietary $\delta^{13}C$ values is between −26.7‰ to −24.9‰.

Pig $\delta^{15}N$ values are on average 9.3±0.5‰ (1σ; range: 8.8‰ to 9.9‰). There is no significant difference among the three settlement areas or with other species. The range of dietary $\delta^{15}N$ values is between 3.7‰ to 4.8‰.

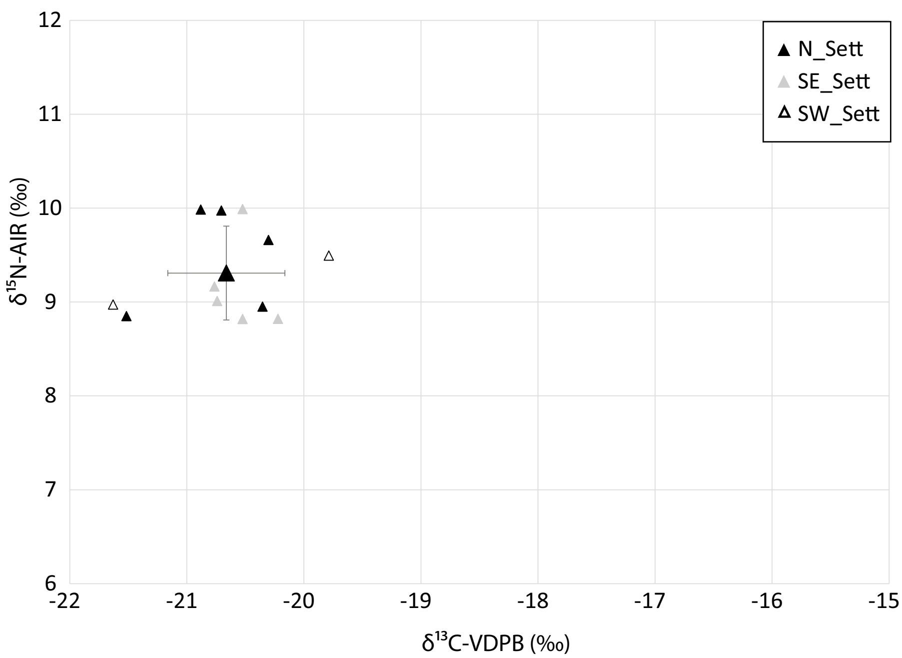

Figure 5.8.3. Sus scrofa sp. results from the three LBK settlement areas at Vráble. Sett = settlement area.

Cereal stable isotope results

The C:N ratios (24.1 to 18.2), %C values (59.7 to 52.6), and the %N values (3.6 to 2.8) (Table 5.8.4) are consistent with previously reported values from carbonised archaeological cereal grains (Fraser *et al.* 2013; Vaiglova *et al.* 2014). The average $\delta^{13}C$ value for the emmer samples is −23.5±0.5‰ (N: −23.1±0.2‰ [n = 2]; SE: −23.9±0.4‰ [n = 2]; SW: −23.3‰). For the einkorn samples it is −23.6±0.3‰ (N: −23.3±0.1‰ [n = 2]; SE: −23.7±0.4‰ [n = 2]; SW: −23.9‰). There is little difference between settlement areas or between species except in the standard deviation, which is greatest in emmer samples and for the south-eastern samples in general. The estimated $\delta^{13}C$ values for chaff for emmer are between −22.2‰ to −21.0‰. Those for einkorn are between −22.0‰ to −21.2‰.

The average $\delta^{15}N$ value overall, taking into account the charring offset, is 6.6±1‰ for emmer (N: 6.7±0.8‰ [n = 2]; SE: 7±1.4‰ [n = 2]; SW: 5.7‰) and 6.9±1‰ for einkorn (N: 7.9±0.1‰ [n = 2]; SE: 6.4±0.3‰ [n = 2]; SW: 5.8‰). There is little difference between einkorn and emmer except for the SE settlement, where emmer has a greater value (Table 5.8.4). The standard deviation is greater in emmer than in einkorn grains. The estimated $\delta^{15}N$ value for chaff is on average 4.3±1‰ for emmer (N: 4.3±0.7‰; SE: 4.9±1.4‰; SW: 3.3‰) and 4.6±0.9‰ for einkorn (N: 5.5±0.1‰; SE: 4.3±0.3‰; SW: 3.4‰).

ASIL number	Species	$\delta^{13}C$ (‰)	%C	$\delta^{15}N$ (‰)	%N	C:N
8218	T. dicoccum	−24.2	55.4	8.0	2.7	22.3
8219	T. monococcum	−24.1	56.0	6.6	3.6	18.2
8220	T. dicoccum	−23.4	55.5	6.1	2.9	23.0
8221	T. monococcum	−23.1	56.8	8.0	3.3	19.7
8222	T. dicoccum	−23.4	56.1	5.7	2.8	24.1
8223	T. monococcum	−24.0	52.6	5.8	2.8	23.1
8224	T. dicoccum	−23.8	58.8	6.0	3.1	20.0
8225	T. monococcum	−23.5	59.7	6.2	3.2	21.6
8226	T. dicoccum	−23.1	54.6	7.2	3.1	22.3
8227	T. monococcum	−23.4	56.1	7.8	3.0	21.4

Table 5.8.4. Cereal $\delta^{15}N$ (adjusted for charring with offset of 0.3‰) and $\delta^{13}C$ results (adjusted for charring with offset of 0.1‰).

Human stable isotope results

Stable carbon and nitrogen isotopic compositions were generated during the radiocarbon analysis of human material from Vráble (Fig. 5.8.4, reported in Chapters 3.2 and 4.2). The quality indicators were variable, with only C:N ratios (range: 3.3 to 2.9) falling with the recommended range proposed by Ambrose (1990) and van Klinken (1999) (Table 5.8.5). The average percentage of collagen extracted is below the recommended 3.5% (2.3±1%; range: 0.7 to 4) proposed by Ambrose (1990), indicating that collagen is poorly preserved. The %C values (47.1±3%; range: 52 to 37) are higher than recommended (34.8±8.8), as are the %N values, which are on average 17.1±1.2% (expected: 12 to 16) (van Klinken 1999). Unlike in radiocarbon analysis where these values are important for detecting contamination, in palaeodietary reconstruction poor quality as indicated by these values rarely has an impact on the final isotopic compositions (van Klinken 1999).

Sample number	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	%Collagen	%C	%N	C:N	Sex	Age
Poz-98342	−20.3	10.2	0.7	52	14.8	3.3	u	15-22
Poz-98344	−20.1	10.5	3	49.4	18.1	3.2	m?	15-20
Poz-98345	−20.3	10.7	3.3	49.3	18	3.2	u	18+
Poz-98346	−20.7	9.5	3	42.4	16.8	2.9	m?	15-25
Poz-98347	−19.7	10.5	2.1	45.7	16.9	3.2	m?	15-25
Poz-98348	−20.0	10.4	1.4	48.5	17.6	3.2	m?	25-35
Poz-98349	−20.0	10.5	1.4	49.9	18.2	3.2	u	18+
Poz-98350	−19.8	10.9	1.5	48.8	17.9	3.2	m?	15-25
Poz-98352	−20.1	10.4	1.5	46.3	16.9	3.2	f	40-50
Poz-98357	−19.8	10.9	1	45.8	16.7	3.2	u	15+
Poz-98358	−19.7	11	3.7	46.9	17.1	3.2	m	25-35
Poz-98359	−20.4	10.9	2.8	48.2	17.7	3.2	u	3 to 5
Poz-98360	−20.4	6.4	2.9	48.7	17.8	3.2	m	20-30
Poz-98361	−20.1	9.8	2	50.3	18.3	3.2		
Poz-98364	−20.2	10.5	2.8	46.8	17	3.2	m	30-45
Poz-98366	−19.9	10	2.8	44.8	16.3	3.2		
Poz-98369	−19.6	10.7	4.8	47.5	17.5	3.2	m	35-40
Poz-98444	−19.8	10.6	3.6	46.6	17.6	3.2	f?	20-25
Poz-98445	−20.0	11	1.3	37	12.9	3.3	u	18+
Poz-98446	−20.1	11.1	1.8	47	17.2	3.2	u	18+
Poz-98447	−19.9	11	2.2	47.2	17.2	3.2	u	18+
Poz-98448	−20.0	10.8	2.2	46.8	16.9	3.2	u	18+
Poz-98449	−19.7	10.6	3.6	50.3	18.5	3.2	u	18+
Poz-87473	−20.9	11	0.9	45	16.4	3.2		

Table 5.8.5. $\delta^{13}C$ and $\delta^{15}N$ values of human bone collagen samples with the sex and age range detailed for individual samples. m = male; f = female; u = unidentified.

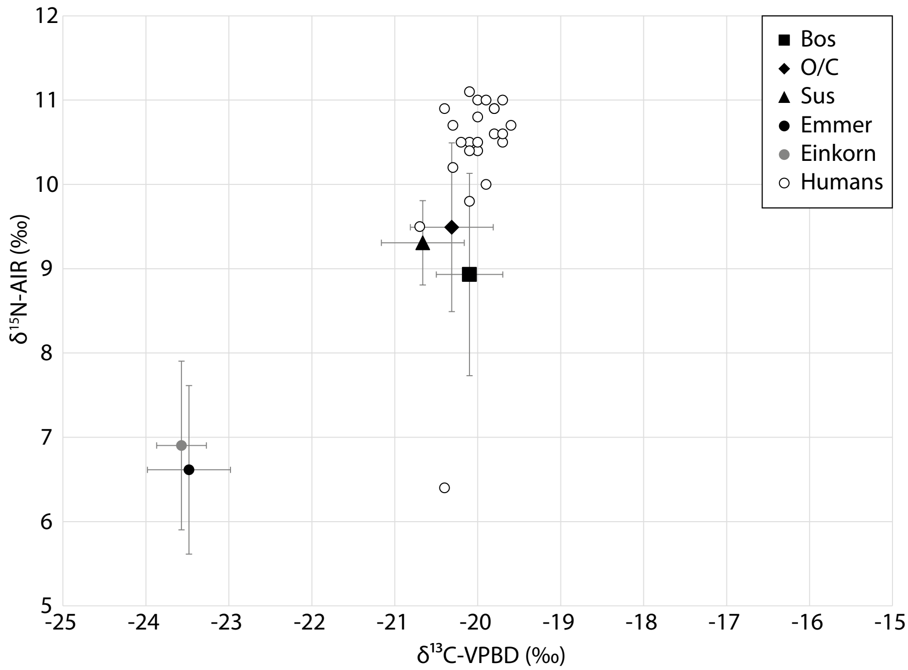

Figure 5.8.4. Human δ13C and δ15N values together with the average values for cereals and livestock.

The overall average for δ13C values is –20.1±0.3‰ (range: –19.6‰ to –20.9‰). There is no difference between identified males (–20‰, n = 9) and females (–20‰, n = 2) or among age groups (15-25: –20.1‰; 25-35: –20‰; 35-60: –20‰). For δ15N values, the average value is 10.4±0.9‰ (range: 6.4‰ to 11.1‰), including outlier Poz-98360, who has a value of 6.4‰. There is little difference between male and female individuals (male: 10‰; female: 10.5‰), and again no difference between mean values from each age group after removal of the outlier (15-25: 10.3‰; 25-35: 9.6‰; 35-60: 10.5‰). One infant was sampled. This individual has a value of 10.9‰, which is similar to the adult and sub-adult values, so little can said about its weaning status, nor about weaning practices at the sites.

Discussion

Vráble pasturing and fodder practices

The results provide an insight into pasturing practices, as well as the regional environments across the LBK cultural zone. The δ13C values for cattle from Vráble are statically significantly different from those from sites situated elsewhere in central Europe (Czech Republic, Austria; ANOVA, $p > 0.05$) and north-western Europe (southern Germany, western France; ANOVA, $p > 0.05$). However, δ13C results from cattle are similar to those from the Carpathian region, signifying that they were foddered and/or pastured on plants with similar a range of δ13C values. There are no significant differences between δ13C values of sheep/goat from Vráble and other LBK sites from north-eastern and central Europe and the Carpathian basin. This indicates there was low variability in sheep/goat diets across LBK regions and that the diet of these species from Vráble was similar to animals in other regions. Given the small difference between *Ovis/Capra* and the other livestock at Vráble, this lack of difference among species suggests that all species fed a similar diet.

We compared the pig δ13C results with those from other LBK settlements. The Vráble pig samples are significantly different from those from north-western LBK settlements (ANOVA, $p = 0.01$). Both cattle and pigs from Vráble have significantly higher $\delta^{13}C$ values in comparison with animals from north-western Europe. The use of forest resources, such as leafy hay, and grazing under forest canopies can be identified using stable isotope analysis. Comparison with modern reference datasets from wild forest fauna, it appears unlikely that the domesticate animals were pastured within local forests or on forest resources. Furthermore, little species-specific livestock pasturing and foddering was practiced. This is unlike the sites of Bischoffsheim and Vaihingen (Fraser *et al.* 2013; Gillis *et al.* submitted) where sheep may have been kept within the settlements, while cattle were allowed to roam free (*sensu* Bogucki 2013).

At Vráble, the estimated fodder values suggest that animals had access to plants with high delta 15N values. Enriched $\delta^{15}N$ values in pigs are often interpreted as the result of the animals being free to roam settlement areas, allowing them access to $\delta^{15}N$- enriched food sources, such as midden discard or human waste (Hedges *et al.* 2013; Balasse *et al.* 2016). Unusually, at Vráble, herbivores have higher values than pigs, and given that these animals had a herbivore diet, these high values are directly related to the plants they consumed. High d15N values have only been observed in LBK domesticated animals from Heibronn-Neckargartach (Baden-Württemberg, Cattle 8.7±1‰, sheep/goat 8.5±0.5‰ and pigs 8.1±0.7‰; Hedges *et al.* 2013), albeit in a much smaller pig sample ($n = 2$). All species have similarly relatively high $\delta^{15}N$ values, which are significantly different compared to results from other regions (ANOVA, $F = 17.9$ Tukey *post-hoc* tests; Vráble ~ central Europe $p < 0.05$; Vráble ~ north-eastern Europe $p < 0.05$; Vráble ~ Carpathian basin $p < 0.05$), with values at Vráble being higher than at any other LBK site.

Animals consuming plants within forests or natural occurring grasslands will have $\delta^{15}N$ values reflecting these environments. Forest soils prior to clearance would have been undisturbed and would have had a low $\delta^{15}N$ value. Wild ruminants, such as deer, can be used as an analogue for an undisturbed system. Livestock who are pastured on natural occurring grass pastures within woodlands would have similar values to deer. Since we have no values from wild species to provide a reference for the local nitrogen $\delta^{15}N$ signal at Vráble we use reference from Balatonszárszó (northern Carpathian Basin; Hedges *et al.* 2013; 5.2‰ to 6.8‰). The $\delta^{15}N$ values for the Vráble livestock (6.8‰ to 11.7‰) diet are higher than this wild reference from Balatonszárszó, which suggests they were fed on plants with high $\delta^{15}N$ values, perhaps grown in continuously used pasture or cultivation plots.

Manure and cultivation

Cereal crops from Vráble were found to have the highest reported values for any LBK site analysed so far (emmer: 6.6‰ ± 1 and einkorn: 6.9‰ ± 1). Cereal grain samples from the site of Vaihingen exhibited $\delta^{15}N$ values of 4.6±0.4‰ for einkorn and 4.2±0.6‰ for emmer (Fraser *et al.* 2013), and those from Viesenhäuser Hof exhibited values of 5.9±0.4‰ for einkorn and 6.4‰ for emmer (Styring *et al.* 2017). Cereals from long-term experiments (> 100 years), where manured plots received 20 tonnes per hectare of animal manure biennially, have been found to have a range of $\delta^{15}N$ values between 2.7‰ to 5.7‰ (Bogaard et al. 2013), suggesting that $\delta^{15}N$ values greater than 6‰ indicate cereals received a high level of manure 35 tonnes per hectare. Consequently, Vaihingen cereals are calculated to have received a medium amount (10-15 tonnes per hectare) of manure (Fraser *et al.* 2013), while Viesenhäuser Hof cereals received a higher level of manure. Analysis of livestock from these sites implies their diet consisted mainly of wild plants. However, the high values evident in the Vráble livestock suggest crops and/or by-products were used as fodder. It is also clear that cultivation plots received livestock manure.

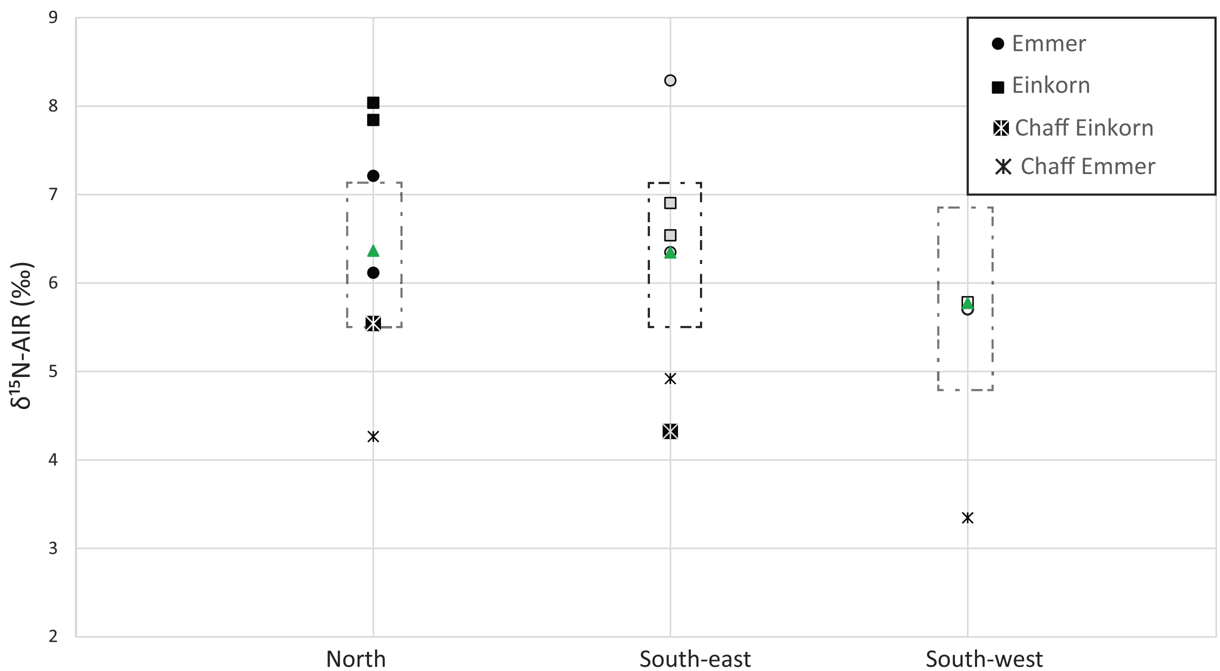

Figure 5.8.5. $\delta^{15}N$ results for emmer and einkorn samples from the three settlement areas, with estimated chaff results (average –2.4‰; Fraser et al. 2011). The chaff value for the south-western settlement area was based on both emmer and einkorn. $\delta^{15}N$ values have been adjusted for charring (–0.3‰; Nitsch et al. 2015). The green triangle represents fodder values estimated from animals based on the overall mean value from bone collagen samples (–3‰). The dotted box represents the standard deviation (Ambrose and Norr 1993).

Cereal by-products as animal fodder?

The high level of manuring at Vráble suggested by the $\delta^{15}N$ cereal values may be a reflection of animals being penned on plots post-harvest. All animal species also have high $\delta^{15}N$ values, suggesting that they were pastured and foddered on manured cereal by-products or crops. We estimated the chaff $\delta^{15}N$ values and plotted these together with those from emmer and einkorn grains and then estimated the livestock fodder value based on the average for all species within each settlement (Fig. 5.8.5). The predicted fodder for livestock corresponds to the cereal grains and, to a lesser extent, by-products, strongly supporting the conclusion that cereal by-products and crops contributed to the livestock diet at Vráble. Intensive management involving penning animals on cultivation plots would reduce the need for fodder and manure collection. The result suggests a close articulation between livestock husbandry and crop cultivation.

Human palaeodietary reconstruction

Comparing the stable isotopic compositions of livestock and cereals with those from humans provides a unique opportunity to examine the protein content of LBK farmers' diet at Vráble. The percentage of animal protein was calculated using the equations 'Standard method' and 'Standard method plus plants' as described by Styring *et al.* (2015), and this produced estimates of 40 per cent (95% confidence interval: 30% to 50%) and 30 per cent (95% confidence interval: 10% to 50%), respectively. These values are comparable with estimates from Vaihingen (Styring *et al.* 2015) of 58 per cent and 26 per cent, although trophic difference value between consumer and diet used in the Vaihingen study was 4‰. At both sites it would appear that LBK farmers' diet may have been considerably lower in animal protein than previously believed. Meat may have been consumed primarily at communal feasts or celebrations (Marciniak 2005), and animal protein may have come from other sources that were seasonally available, such as dairy.

Conclusions

Stable isotope analysis provides an insight into the diet of livestock and the possible inter-connectivity between stock rearing and cultivation practices during the LBK. Previous comprehensive stable isotopic analyses have been concentrated in the western parts of the LBK cultural zone, where forests were considerable denser and were used as cattle pasture. However, in comparison with other studied LBK sites, cereal grains have been under-analysed, which restricts our understanding of the relationship between animal husbandry and plant cultivation practices. Here we have uncovered that at Vráble, unlike at other LBK sites, livestock were foddered and/or pastured on cereal crops and by-products. The resulting high $\delta^{15}N$ values within cereal grains appeared to have been passed on to humans. Furthermore, it appears that cereals made up a larger proportion of human diets than animal protein. Compound-specific analysis of human bones may further illuminate the composition of human diet and sources of dietary protein; therefore, further samples of cereal grains are needed to create a significant sample. Overall, the analysis has shown similarities and differences compared with previous LBK stable isotope studies. The building blocks of LBK subsistence practices were relatively similar (cattle, sheep, pigs, cereal crops), but the practices, such as foddering and pasturing animals and manuring, may have varied across central and northern Europe.

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Section 6: Synthesis

6.1. On the demographic development of the LBK and Želiezovce settlement sites of Vráble and the Upper Žitava Valley

Johannes Müller, Nils Müller-Scheeßel, Ivan Cheben, Maria Wunderlich, Martin Furholt

Abstract

Demography is a central factor to understand the social and economic development of a settlement as large as Vráble. Using the magnetic plans of the entire site, combined with targeted excavations and extensive coring programs, we develop a chronological model. This is based on ^{14}C dates and the orientation of houses, which show a strong correlation, indicating a gradual change in orientation towards the left of 13° per 100 years. The internal use of space and the number of houses in the different periods of the settlement are combined with anthropological information on the mean number of inhabitants per ground floor area of houses to estimate the number of inhabitants of the settlement and change in this number over time. The reconstruction of population numbers in different parts of the settlement improves our understanding of social and economic processes and strategies during the settlement history of Vráble (Nitriansky kraj, Slovakia). Including the regional context of the Upper Žitava Valley, we find a possible over-exploitation of arable land, and inter-site mobility and agglomeration processes at Vráble are to be seen in this light. The increasing population density of the northern neighbourhood of the settlement is interpreted as reflecting its increasing economic dominance at the cost of the others. We interpret the construction of the enclosure in the south-western neighbourhood as an attempt to counter this dominance. While this attempt was moderately successful for a few generations, the entire settlement eventually went into decline.

Keywords: LBK house orientation, agglomeration, dispersion, 14C modelling

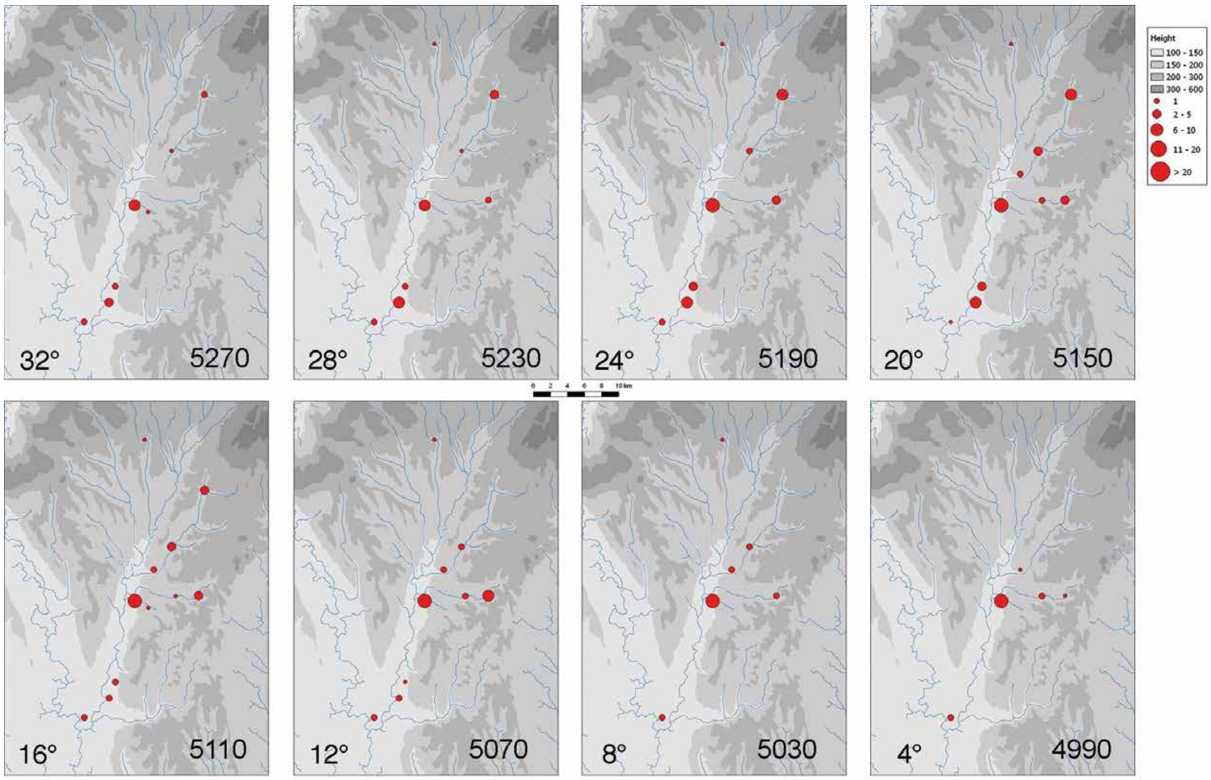

Figure 6.1.1. Settlements of the Early Neolithic in the Upper Žitava Valley, showing the number of houses per prospected settlement according to the results of magnetic prospections. The approximate chronological information is based on the chronological relevance of the orientation of the houses (see text).

Introduction

Due to the magnetic prospections, excavations and data analysis, we are quite well informed about the regional settlement process in the Upper Žitava Valley (Fig. 6.1.1). Furthermore, we are very well informed about the 50 ha Neolithic settlement at Vráble. Together, these are good preconditions for reconstructing population densities in both the Žitava Valley and the settlement of Vráble.

Number of houses at Vráble

The basis for the overall interpretation of the population densities is a chronological ordering of the house plans, which is based on the established relationship between local house orientations and ^{14}C dating (Müller-Scheeßel *et al.* 2020). Based on a regression analysis of the house orientations in connection with the ^{14}C dates from Vráble, we can expect a change in the orientation of the houses of 13° per 100 years. Assuming 31 years per house generation, an average change of 4° per house generation is calculated (Müller-Scheeßel *et al.* 2020). Therefore, we can approximate four longhouses around 5275 BCE, 20 around 5200 BCE, 66 around 5150 BCE, and almost 70 around 5075 BCE (Fig. 6.1.2). Afterwards, an abrupt reduction of the number of houses can be observed: 55 longhouses by 5050 BCE, 32 by 5000 BCE and only about four by 4950 BCE.

Transferring the selective ^{14}C dates of the longhouses to their orientation and, finally, to the magnetic settlement plan, a spatial-temporal pattern of rise and decline within the settlement area becomes visible (cf. Fig. 6.1.3 and Table 6.1.1). Initially, individual courtyards can be detected in three spatial areas of the unenclosed area (approx. 5270-5230 BCE). Later on (approx. 5230-5110 BCE), an increasing agglomeration of up to 28 longhouses can be seen in these three separate spatial areas, which can now be understood as neighbourhoods. Finally,

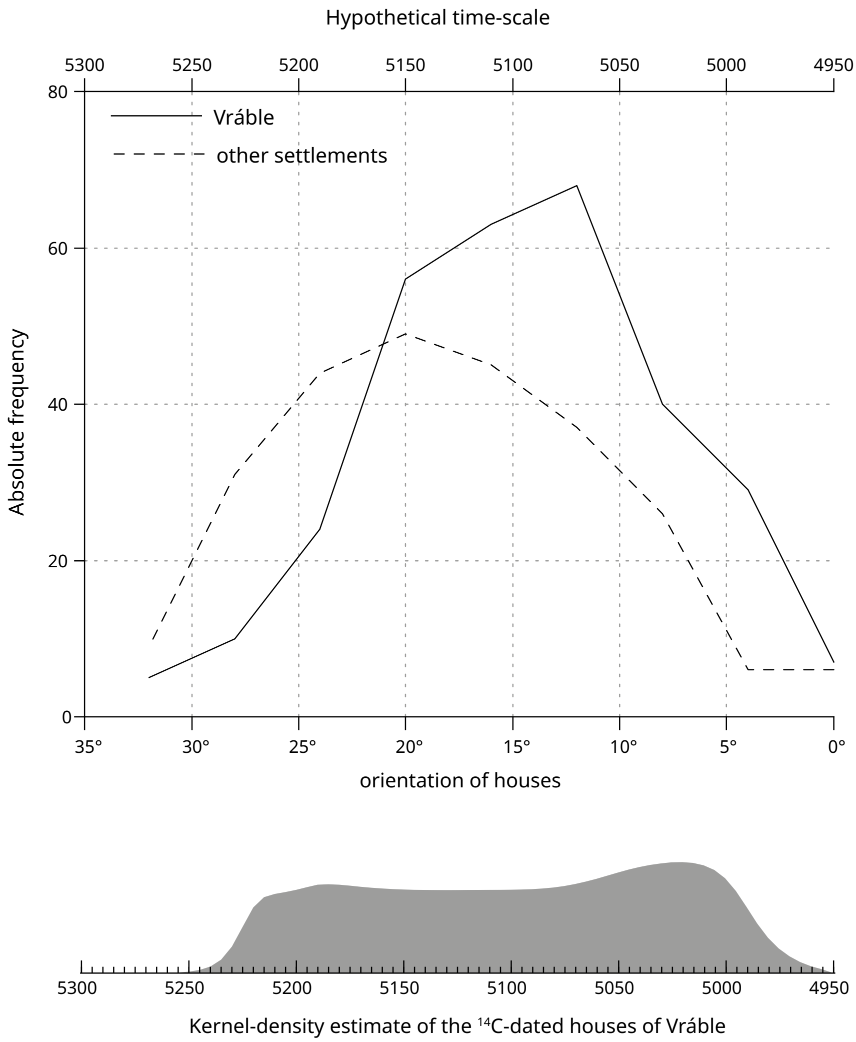

Figure 6.1.2. Early Neolithic Vráble. The approximate chronological information is based on the chronological relevance of the orientation of houses.

an enclosure is built around one of the house agglomerations (approx. 5070 BCE), consisting of a 1.4 km long double ditch and palisade. It is very likely that this enclosure occurred after the entire neighbourhood had reached its maximum number of houses (cf. Fig. 6.1.3 and Table 6.1.1). The enclosing of one of the agglomerations is connected with the rapid and continuous reduction in the number of longhouses in all three neighbourhoods. Before the actual desertion of the settlement, the enclosure was abandoned around 4990 BCE.

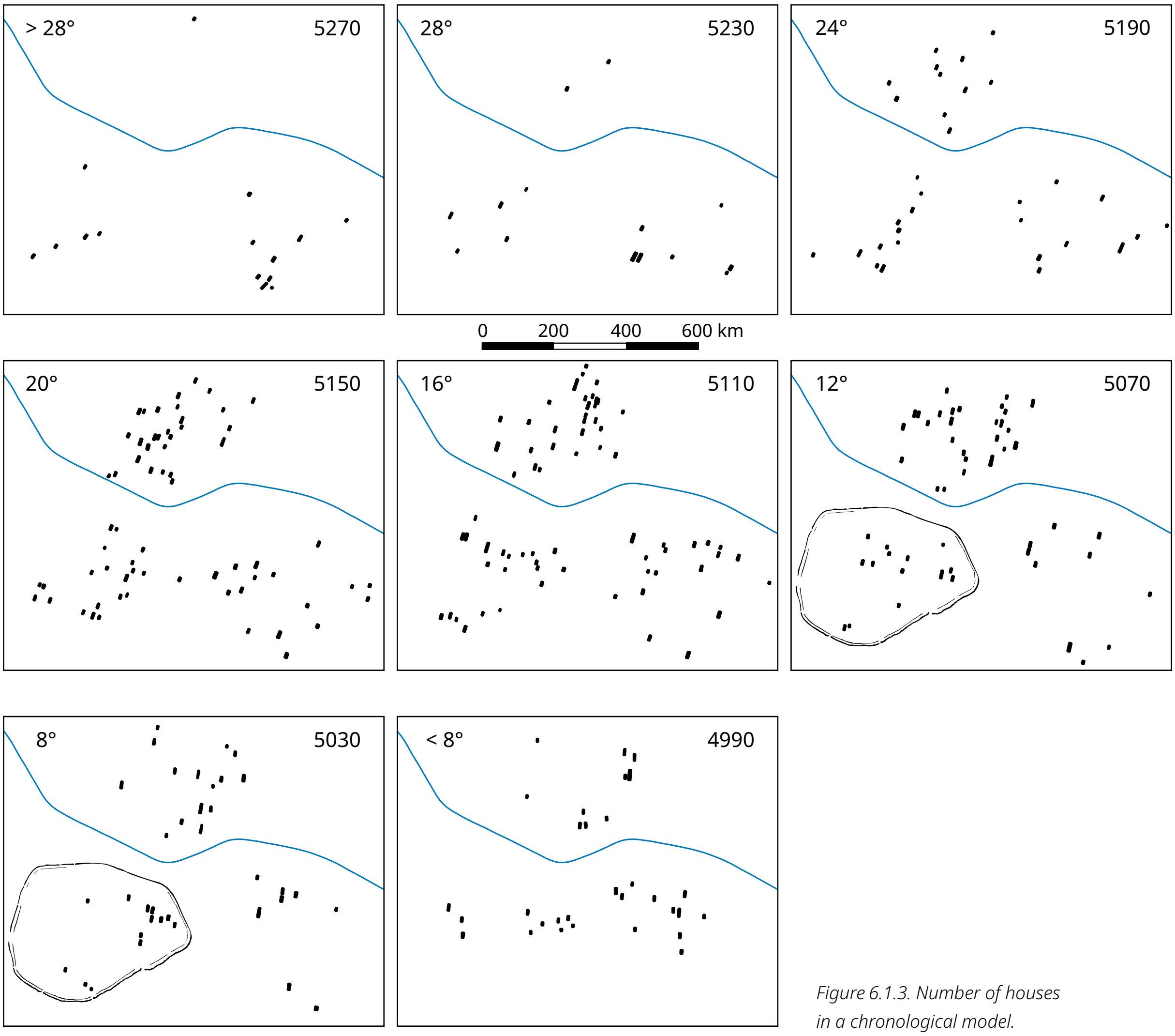

Figure 6.1.3. Number of houses in a chronological model.

Year BCE	N houses	SW houses	SE houses	Sum houses	N population	SW population	SE population	Sum population	Population min	Population max
> 5270	0	0	4	4	0	0	34	34	20	100
5270	1	5	5	11	8	42	42	94	55	275
5230	2	5	7	14	17	42	60	119	70	350
5190	11	11	10	32	94	94	85	272	160	800
5150	28	21	16	65	238	178	136	552	325	1625
5110	30	21	18	69	255	178	153	586	345	1725
5070	27	14	10	51	230	119	85	434	255	1275
5030	15	13	8	36	128	110	68	306	180	900
4990	7	7	9	23	60	60	76	196	115	575
4950	3	3	2	8	26	26	17	68	40	200

Table 6.1.1. House numbers and population estimates in Vráble. The phase with the enclosure around the south-western neighbourhood is highlighted (generally, arbitrary 40-year bins; data before about 5270 BCE are merged, so the earliest phase covers a longer time interval). For the population estimates, minimum and maximum numbers are given along with a sound average (see text).

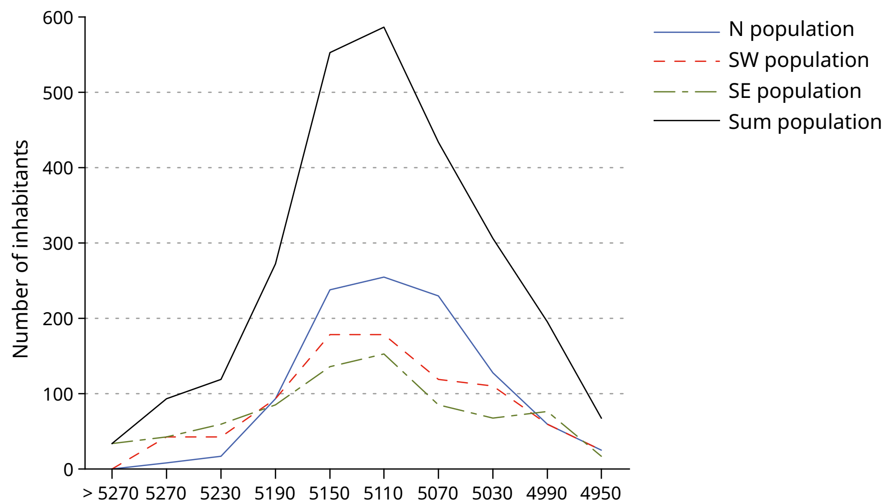

Figure 6.1.4. Population estimates for the three neighbourhoods in Vráble (based on an average per house, see Table 6.1.1 and text).

The population of Vráble

We assume that most of the LBK longhouses of the settlement of Vráble are visible in the magnetic map and that therefore the number of houses is known with considerable accuracy. If the number of inhabitants per house is known, the population size of Vráble can be calculated. But in fact, the exact number of inhabitants of an LBK longhouse is unknown. In order to get closer to the determination of the size of the household, research has pursued different approaches, leading to different results. Therefore, the estimates for the size of a household range from 5 to 25 persons (cf. Kreuz 2010, 114-115). Andreas Zimmermann *et al.* (2009, 368) suggest the use of an average value of 8.5 inhabitants per household, for what in our opinion are good reasons. Our calculations are based on the range proposed by Kreuz (2010) and on the average proposed by Zimmermann *et al.* (2009) (given in parentheses) (Table 6.1.1). Accordingly, for Vráble we assume a population of 55-275 (94) people at the beginning of the settlement, 345-1725 (586) around 5110 BCE and 115-575 (196) around 4990 BCE. Shortly after 4950 BCE, the settlement was abandoned. If we compare the numbers for the different time periods scenario by scenario, we see that between 5270 and 5150 BCE the population grows by approximately 1.5 per cent per year, between 5150 and 5110 BCE it is stable, and between 5110 and 4950 BCE it decreases by approximately 1.3 per cent per year. This allows us to identify phases of demographic change.

Interestingly, the diachronic evolution of the distribution of houses in the three neighbourhoods of Vráble shows differences that can also be interpreted as different demographic processes. Table 6.1.1 and Figure 6.1.4 highlight a constant 'growth' of the three quarter-centuries between approximately 5230 and 5150 BCE, with the northern quarter showing the strongest population growth and the south-eastern quarter the weakest. While an average of 240 people lived in the northern neighbourhood, about 180 inhabited the south-western neighbourhood and about 150 the south-eastern neighbourhood. Whereas in the northern neighbourhood this population size was maintained until about 5070 BCE, in the south-western neighbourhood it was reduced to almost half by that time. In the south-eastern neighbourhood, the population rose initially, to about 170 inhabitants by around 5110 BCE, and then declined, to approximately 90 inhabitants by around 5070 BCE.

The reduction in population in the south-western neighbourhood stopped more or less at 5070 BCE, *i.e.* when the south-western enclosure was constructed. At the same time, the number of inhabitants in the northern neighbourhood strongly decreased – from 230 inhabitants by 5070 BCE to around 130 inhabitants by 5030 BCE. By 4990 BCE, the population figures of the three neighbourhoods with approximately 60-70 inhabitants each, were once again balanced.

We assume that the strong population increase in the northern neighbourhood and the considerable population reduction in the south-western neighbourhood indicate a demographic dominance of the northern neighbourhood, and hence also a labour force dominance. We see the enclosure around the south-western neighbourhood as a reaction to this development in order to strengthen the group identity in this neighbourhood and to prevent a further loss of its significance. This strategy obviously succeeded: After a balance had been re-established among the neighbourhoods, at least demographically and thus probably also economically, the ditch-system had served its purpose and was abandoned.

Interestingly, the south-western neighbourhood, which was obviously able to mobilize the labour required for the construction of the 1.4 km long double ditch and palisade that constituted the enclosure structure itself, was not the most populous neighbourhood at the time the enclosure was erected. In order to counteract the demographic and labour dominance of the northern neighbourhood, the enclosure seems to have been all the more necessary.

A comparison of the development of the population figures in the neighbourhoods with that in the entire village shows that the obviously temporary antagonistic development of the neighbourhoods also had consequences for the attractiveness of the entire settlement (Fig. 6.1.4). Up to about 5100 BCE, the total population increased or remained at a level of just under 600 inhabitants, while after that the population rapidly decreased as the differences between the neighbourhoods increased. This process only slowed down again when a political response to the divergences between the neighbourhoods was found, with the help of the enclosure. Which causes were responsible for the final settlement abandonment by 4950 BCE remains to be determined.

Population development in the Upper Žitava Valley

In Vráble, because the magnetic survey achieved complete coverage, we can assume near-complete discovery of all LBK longhouses that once stood there. This is not the case elsewhere in the Upper Žitava Valley, where complete coverage was not reached. The magnetically documented houses outside Vráble therefore certainly do not correspond to the original total number of houses in the valley.

Still, the population development can be derived at least approximately from the number of longhouses present in the magnetic data and from their dating (Müller-Scheeßel *et al.* 2020; Fig. 6.1.2). In the Upper Žitava Valley, a population increase can be observed up to around 5150 BCE (from 10 known houses around 5275 BCE to 46 known houses around 5150 BCE). Subsequently, the number of houses decreased until about 5000 BCE. The population reduction thus started about 175 years earlier than in Vráble. Accordingly, it can be suggested that, due to centralisation processes, part of the population of the Žitava Valley was concentrated in Vráble. In the spatial representation of the settlement process, it can be seen that especially from the 5100s BCE onwards, primarily the central area of the Upper Žitava Valley still had settlements, while the remaining areas were hardly occupied (Fig. 6.1.1).

Due to the limited magnetic mapping of the valley, we could only attempt to approximate the original number of inhabitants of the rest of the Žitava Valley, and we had to rely on additional methods. We combined the approach of Andreas Zimmermann and his working group (2009), who determine the size of the core settlement area, with that of Siegmund (1992), who calculated of the standard distance between settlements. On this basis, results are transferred from better documented areas

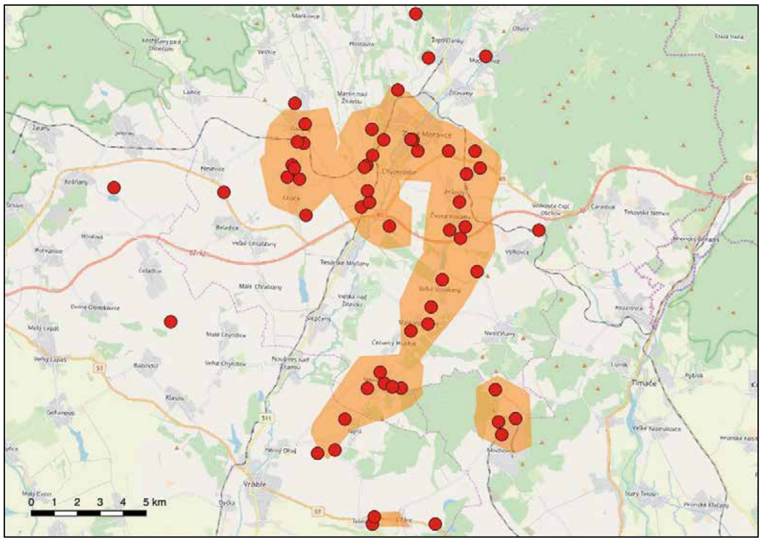

Figure 6.1.5. TThe northern part of the Upper Žitava Valley, the area covered by Gabulová (2015) and the core region of LBK settlements. Orange polygon core area.

(„Schlüsselgebiete" according to Zimmermann *et al.* 2009) to less well documented ones in order to draw conclusions about the whole.

Following the methodology of Zimmermann *et al.* (2009, 360), an area of 80.2 km² (1400 m isoline of greatest empty circles; Fig. 6.1.5) emerges as the core region of LBK settlement in the northern Upper Žitava Valley, the area where we have the best coverage, thanks to the work by M. Gabulová (2015, 114 Fig. 14). Standard distances between settlements are 550 m and 800 m; these repeat at 1100 m, respectively 1600 m. If we conservatively assume a distance of 800 m and we further assume an area-wide, hexagon-like settlement system, each individual settlement would have covered an area of 55.4 ha. However, it must be taken into account that the known LBK settlements in the Upper Žitava Valley are only a maximum of 815 m and an average of 200 m away from the next watercourse (Gabulová 2015, 106 Table 4) and that 50 per cent are located at a distance of about 150 to 320 m from water (Gabulová 2015, 106 Fig. 6). Assuming 800 m distance to the next watercourse, the core area of the potential settlement area is reduced to 57.9 km². By dividing this area of this highest settlement density by the assumed area of 55.4 ha covered by each individual settlement, we arrive at an expect number of 105 settlements. However, we only know of 47 settlements, *i.e.* less than half of all settlements predicted. Extrapolating this ratio of predicted and known sites (47/105 = 0.45) to the entire northern Upper Žitava Valley, with its 57 sites (Gabulová 2015), we would assume to find 127 settlements (57/0.45 = 126.7) within the area of 260 km².

On the basis of the magnetic prospections, the house density for each settlement can be determined relatively reliably, even if only a partial section of the settlement area could be prospected (Table 6.1.2). Our prospections yielded a density of 0.07 to 0.32 ha per house. Based on the probable size of the Vráble house yard of 0.49 ha, a settlement length of 1.6 to 6.7 generations can be assumed. On arithmetic average, the settlements would have been inhabited by 3.6 generations of houses. Assuming a length of 25 years per house generation, an absolute average settlement length of 91 years is calculated. In contrast, assuming 40 years per house generation (Meadows *et al.* 2019), an average settlement length of 145 years is calculated.

More difficult to determine is the number of house yards per settlement. The former settlement size can only be determined with relative certainty for five settlements; therefore the total number of formerly existing house yards can only be calculated for these settlements. For these five, the number of house yards per settlement lies between 9 and 18, with an arithmetic mean of 13.0. This number is considerably higher than supposed by Milo *et al.* (2004), for example.

Settlement	Magnetic survey in ha	Area of settlement covered	Percentage of settlement covered	Number of houses (at least two experts agreed)	Density per house	Generations per house
Čierne Kľačany 'Pri mlyne'	11.50	7.40		49	0.15	3.24
Čifáre 'Kapustniská'	15.70	8.10	92	41	0.20	2.48
Horný Ohaj 'Dolne siatie'	1.60	0.80		11	0.07	6.74
Maňa 'Za hlbokou cestou'	27.90	5.70	97	29	0.20	2.49
Nevidzany 'Konopiská'	5.50	2.70		22	0.12	3.99
Sľažany 'Domovina'	0.84	0.84		6	0.14	3.50
Telince 'Horné lúky'	8.00	4.10	98	13	0.32	1.55
Úľany nad Zitavou 'Dolné diely'	8.20	3.00	68	34	0.09	5.55
Vlkas 'Do hulského chotára'	17.70	8.50	98	61	0.14	3.52
Vráble 'Drakovo'	1.40	0.30		2	0.15	3.27
Mean						

Table 6.1.2. Population estimates for individual settlements of the Upper Žitava Valley based on magnetic prospection.

If we assume that the LBK in the Upper Žitava Valley lasted from about 5300 to 4950 BCE, the total duration is 350 years. Out of 127 settlements, 33 (assuming a house lifespan of 25 years) or 53 (assuming a house lifespan of 40 years) would then have been inhabited simultaneously. With 13 houses per settlement, a total number of 429 or 689 simultaneous households is calculated for the Upper Žitava Valley. Assuming an average of 8.5 inhabitants per longhouse, as proposed by Zimmermann *et al.* (2009), this corresponds to 3,650-5,900 inhabitants, equivalent to a population density of 14-23 inhabitants/km² at 260 km².

The maximum number of 70 houses that we suppose for Vráble's heyday would represent 10-16 per cent of the total population of the northern Upper Žitava Valley. Assuming that the growth of Vráble was at the expense of the entire Upper Žitava Valley and not only at that of its northern part (Gabulova's working area) alone, it becomes clear that the decline in the number of houses in settlements outside Vráble shown in Figure 6.1.2 cannot be entirely explained by the move of their inhabitants to Vráble. Nevertheless, it can be assumed that the decline in the other settlements and the increase in Vráble were causally related.

There are various approaches for calculating the land requirements of LBK settlements on the basis of population size (for examples of overviews, see Ebersbach and Schade 2005, 265 Fig. 7; Milo *et al.* 2004, 149 Fig. 15). Most authors assume a requirement of 0.5-1 ha of farming area per person. Not to be neglected is the need for grazing land for the LBK's preferred animal, cattle. The grazing area of the cattle is given by Ebersbach and Schade (2005, 265 Fig. 7) as 10 ha per animal. According to ethnographic parallels, a maximum of 0.5 cattle per person can probably be assumed for herds with community care (Ebersbach and Schade, 2004, CD-ROM 7), which would correspond to a requirement of 5 ha per person. This results in a total demand of *c.* 5.5-6 ha per person in the vicinity of the settlement. In addition, there is the actual settlement area, which, as we calculated above as having been 0.49ha.

Thus, the area required by the inhabitants of the Upper Žitava Valley was probably 18.3-59.0 km² of cultivated area and 182.5-295.0 km² of forest area, plus 2.1-3.4 km² of settlement area, adding up to 202.9-357.4 km². These calculations suggest that the Upper Žitava Valley, with its area of 260 km², was close to overexploitation, if not already overexploited.

Mean generations per house	Number of concurrent houses	Number of houses	Mean number of houses	Population estimate for settlement duration 25 years	Population estimate for settlement duration 40 years	Mean population estimate for settlement duration 25 years	Mean population estimate for settlement duration 40 years
	15.10			81.11	129.78		
	16.53	17.97		62.01	99.21		
	1.63			168.44	269.50		
	11.63	11.99		62.32	99.72		
	5.51			99.81	159.70		
	1.71			87.50	140.00		
	8.37	8.54		38.84	62.15		
	6.12	9.00		138.83	222.13		
	17.35	17.70		87.91	140.66		
	0.61			81.75	130.67		
3.63			**13.04**			**90.85**	**145.35**

Conclusions

The following scenario is conceivable: The intensive settlement of the Upper Žitava Valley, with a population density of 14-23 inhabitants per km², reaches a critical mass, with regard to overuse of the soil. This led to two different developments: first, the abandonment of some of the settlements in the Žitava Valley, perhaps connected with the movement to new, previously unsettled regions, and second, further concentration in the settlement of Vráble. The settlement of Vráble probably offered advantages, enabling better exploitation and distribution of resources. For example, the larger population could have enabled a wider spread of economic risk through sharing systems. Perhaps, there were more fertile soils around Vráble (although we have no empirical evidence for this). Subsistence involving pasturing cattle on the harvested grain fields, as practised in Vráble, and the resulting fertilising effect (cf. Chapter 5.8) could have resulted in higher overall crop yields, which gave the settlement group in Vráble advantages in food security, and therefore attracted people. The changes in Vráble itself, however, from about 5150 BCE onwards lead to internal conflict, in part due to the strong increase in population, and certainly also in part due to the increase in importance of one of the three neighbourhoods. The conflict lead to a population reduction. Only the construction of a ditch structure within the settlement reduced the downward demographic trend and led to a regaining of equal rights for the neighbourhood – with a considerably reduced number of inhabitants. Here, as well, increasingly scarce resources could have been a factor.

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6.2. Patterns of subsistence at the LBK and Želiezovce settlement site of Vráble

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Abstract

We summarise and contextualise the results of zooarchaeological, archaeobotanical and stable isotope analyses as well as the demographic patterns discussed in earlier chapters in order to reconstruct the subsistence strategies at Vráble (Nitriansky kraj, Slovakia) and discuss their social implications. While there are differences in preferences for animal species and crop species between the farmsteads, there seems to be an overall system of strong spatial integration of animal husbandry and plant cultivation, in which cultivation plots were used intensively as pasture areas, providing manure and thus enhancing crop yields. Such a spatially concentrated subsistence regime corresponds to the concentrated settlement pattern at Vráble, as opposed to the rest of the Upper Žitava Valley. The higher productivity of the fields at Vráble, which, we argue, could, in part, have been a consequence of this specific subsistence regime, may have been an important pull factor explaining the phenomenon of settlement concentration at Vráble. The concentration may, in turn, have further reinforced crop yields. The partial switch from productive subsistence-related activities to large-scale investment into economically unproductive, socially antagonistic enclosure construction activities may have been a factor driving the eventual decline of the settlement.

Keywords: Subsistence practices, productivity, social organisation

Introduction

The preceding chapters have presented and discussed the evidence for subsistence practices at Vráble, providing us with a number of vital aspects concerning the subsistence economy. These warrant some additional discussion concerning site-specific aspects, as compared to other Neolithic communities on the Balkans and in central Europe, which we provide here. In addition, we discusses the social consequences of the means and organisation of production; the datasets relating to animal bones and botanical macro-remains; the isotopic studies of plants, animals and humans; and the nature, presence and spatial distribution of storage facilities. This will be combined with our previous considerations of population numbers and their temporal dynamics, in order to provide the basis for a more comprehensive synthesis of the political economy and social organisation at Vráble (Chapter 6.3).

The Vráble data in context

At first glance, the overall pattern of the subsistence economy at Vráble is what one is tempted to call a typical LBK economy, that is, a mixed economy of horticulture, dominated by emmer and einkorn and domesticated animals, with wild resources playing only a minor role. While in most LBK settlements cattle husbandry dominates, with sheep, goat and pig only playing secondary roles (Bickle and Whittle 2013, fig. 1.5; Lüning 2000), many LBK sites show deviations from the supposed norm. For example, in the settlement of Brunn am Gebirge, in Austria, there is a development from a dominance of sheep and goat in the earlier phases to one of cattle in the later phases. Stadler and Kotova (2019) argue for a general temporal trend, as their early phase, starting around 5600/5500 BCE, is attributed to the formative phase of the LBK, associated with late Starčevo materials. As sheep and goat are dominant in the Balkan region, and as the LBK is seen as a social and cultural phenomenon that developed out of this Balkan tradition, the shift in animal species is seen as an expression of the successive establishment of LBK practices. Beside this possible temporal gradient, there are regional patterns. As discussed by, among others, Lüning (2000, 109ff.) and Bickle and Whittle (2013, 13ff.), there seems to be a more dominant role of cattle in relation to the other domestic species in the northern and western parts of the LBK settlement areas, especially modern-day Poland and the Paris Basin, while cattle proportions are lower along the Danube. In southern Germany and eastern France, there are a number of sites with higher ratios of pig. In general, the number of identified specimens (NISP) numbers for domestic species is a coarse indicator for subsistence strategies, especially as the total numbers of identifiable bones are usually rather low, due to bone preservation conditions. There also seem to be significant spatial and chronological variations. Spatial variations are seen not only between different areas of the LBK complex, but also within sites (*e.g.* at Cuiry-lès-Chaudardes: Hachem and Hamon 2014; or at Mold: Lenneis 2011). The NISP numbers therefore, in general, mask differences and variability, and it is thus even more significant that they still point to considerable variation. The most striking patterns of intra-site variation are found at the settlement of Cuiry-lès-Chaudardes, in the Paris basin, where some houses are associated with larger amounts of wild animal bones, and others are more clearly relying on domesticated animals (Gomart *et al.* 2015; Hachem and Hamon 2014). This difference appears to be stable over several generations and accompanies differences in house type and pottery manufacturing traditions (Gomart 2014). This striking pattern only became visible because at this site the authors can rely on a large assemblage of more than 17,000 identifiable animal bones. This is far from the situation in most LBK sites, including Vráble, but it indicates that intra-site variability in subsistence practices is a phenomenon that is probably undervalued in most reports on LBK sites.

Domesticated animals

With this in mind, our finding of differential NISP patterns in the different neighbourhoods of Vráble is, despite the small sample size, at least not something out of the ordinary. A dominance of cattle was found only in the south-western neighbourhood, while the south-eastern and northern ones showed a dominance of pig and sheep/goat, respectively. It probably reflects an even more complicated situation than the one described in Chapter 5.3. The 15 houses we have excavated can be assigned to six different farmsteads, with two found in each of the three neighbourhoods. The proportion of animal species is similar when we compare houses from the same neighbourhood, and distinct when we compare between them. In the northern neighbourhood, trenches 7 and 8, which represent one farmstead with a temporal depth, showed a stable spectrum of animal species, sheep/goat being the most frequent. The two farmsteads excavated in the south-eastern neighbourhood both show a high proportion of pig bones.

Domesticated plants

Concerning domesticated plants, the situation is slightly different (see Chapter 5.5). Again, we are dealing with a small sample size. The overall pattern is very much in line with other LBK sites, with a heavy reliance on emmer and einkorn. Yet the ratio of these two main crops shows clear differences between the farmsteads, while being stable within a farmstead across the generations (Müller-Scheeßel *et al*. 2016).

Stable isotope analyses

The stable isotope analyses (SIA), namely, carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$), have shown results that point towards a system in which manure is being used in crop production, a system not well known within the LBK context except at the sites of Vaihingen an der Enz (Baden-Württemberg (Fraser *et al*. 2013)) and Viesenhäuser Hof (Baden-Württemberg (Styring *et al*. 2017); see also Chapter 5.7). As Gillis and Makarewicz (Chapter 5.7) point out, the current state of zooarchaeological analysis for the Early Neolithic in central Europe has revealed that while the main components of LBK subsistence are rather uniform – cattle, sheep and goat, pig, cereal grains – the actual husbandry strategies in terms of pasturing and foddering are quite variable, as revealed by SIA. This means that our view of LBK uniformity is obviously undervaluing the degree to which cultural, social and economic practices were subject to local variability and adjustment (Bickle and Whittle 2013). If one sees 'the LBK' broadly speaking as a package of practices, probably better adjusted to the central European climate and environment (Banffy 2019) than to the Balkan climate and environment, from which it partly derives, one main feature of this package may have been its flexibility to adjust to different environmental surroundings, or to incorporate different traditions.

What Gillis and Makarewicz (Chapter 5.7) found via $\delta^{13}C$ and $\delta^{15}N$ stable isotope analyses is a strong spatial and practical integration of crop cultivation and animal husbandry. They make a compelling argument for a system in which all the domestic animal species were kept close to the site, and at least for part of the year may have grazed on the crop fields, where they were eating straw, weeds, chaff and grains (missed or lost by the harvesters), at the same time providing manure. They may also have been foddered grain and chaff. It is significant that the $\delta^{15}N$ values for the cereals are the highest measured so far in an LBK context, indicating a high intensity – which suggests either that a large number of animals were penned on cultivation plots or that cultivation plots were used intensively as pasture areas. The $\delta^{13}C$ values negate a larger role of forest pasture or leaf fodder, and as the $\delta^{15}N$ values for all animals are basically the same, we have to assume that they were penned in during some parts of the year or kept close to the settlement. They were probably not kept close to the houses, as in that case we would expect pigs as omnivores to have higher $\delta^{15}N$ values. For example, in the south-western neighbourhood, between 5070 and 4990 BCE (Fig. 6.1.3), large parts of the enclosed area was free of houses, and those open areas may have been used for crop cultivation and grazing.

The same may be true for the large open areas in the centres of the northern and south-eastern neighbourhoods during this late settlement period.

The isotopic values of the humans are, as observed in most LBK contexts, relatively homogeneous, with no clear differences between the sexes or among age groups. The ratio of meat in the human diet at Vráble was probably low, as the percentage of 30-40% calculated by Gillis and Makarewicz may also include dairy products.

Reconstructing the subsistence economies at Vráble

The patterns we describe for the distribution of animal and plant species primarily refer to patterns of consumption and deposition, rather than to subsistence strategies, which are more directly reflected by the isotopic data. Nevertheless, the difference in animal species composition between the neighbourhoods, as well as the consistency of consumption patterns within the neighbourhoods and across different farmsteads, can be interpreted as an expression of different preferences for specific domesticated animal species, despite the fact that there seems to be a uniform system of animal management, partly on the agricultural fields, as evident from the stable isotopic values. Within this overall Vráble-specific pattern of subsistence, different preferences for animal or crop species are visible, and they could derive from different traditions, could be influenced by the quality of fields available, or could have developed through mutual learning within the neighbourhoods. The latter possibility is one basis for our argument of neighbourhood social cohesion (Chapter 6.3). In addition, sharing of food was very likely an important factor, most obviously in the case of cattle (Russell 1998) but probably also in the case of to sheep, goat and pigs. The small amount of meat in the diet has been interpreted to mean that meat consumption was largely restricted to feasting events (Marciniak 2005), a possible carrier of communal sharing and the maintenance of social ties and communality. This significance of animal herds for communality and social exchange may have been of even more importance if we assume that animals were collectively herded (Ebersbach and Schade 2004). Although we do not have any direct evidence for this, it seems likely that such a collective herding was organised at the level of the neighbourhood, at least in the later phases of settlement. As soon as the enclosure around the south-western neighbourhood was in place, a common herding of animals between that and the other neighbourhoods was impeded. If we assume that the animals were partly held within the enclosure, as indicated by the large open areas, the animals were probably regularly moved in and out of the enclosed space. The fact that all seven entrances face away from the other neighbourhoods speaks for a spatial separation of the herds of the three neighbourhoods.

Storage and sharing

Grains and other foodstuffs were probably mostly stored within the individual houses. No special, centralised or communal storage facilities have ever been convincingly identified in LBK contexts, and the size of the longhouses as well as their dispersed placement within the settlement make them the most logical place to store the day-to-day food. In addition, we have the beehive-shaped pits, which are interpreted as a specific type of container for long-term storage of a large volume of grain (see discussion in Chapter 6.3). They constitute an efficient technology to store grain surplus for more dire times. These pits are distributed spatially in a way that indicates that they were associated with individual houses (Mueller-Scheessel *et al.*

2016). This would support our idea that plant cultivation was organised by the individual farmsteads. However, when such a large cache of grain is opened, sharing of its contents among several houses is more or less a necessity, as the content, cannot be consumed by one farmstead alone before it spoils. As sharing-practices are a means to provide social security and strengthen communal frameworks within communities, there would be a social significance behind this implication. This sharing, in addition to the communal organisation of herding practices, would, then, reinforce social bonds, again maybe mainly within the neighbourhoods, but possibly also beyond.

The social implications of the Vráble subsistence patterns

The social organisation of subsistence practices is thus to be characterised as a tight, integrated and spatially circumscribed one, whereby most activities took place in or close to the settlement. This spatial concentration of economic activities is probably part of, or a factor influencing, the agglomeration process we are seeing at Vráble. While the wider radius of herding practices practiced elsewhere probably served as an important vehicle of inter-settlement communication and interaction in a situation of more dispersed settlement, Vráble constitutes a very different model. When subsistence practices do not create and reinforce inter-settlement communication, then a closer, more concentrated co-habitation would be an alternative strategy to maintain social ties.

Carrying capacity and resource stress

As was argued in Chapter 6.1, the Early Neolithic population of the Upper Žitava Valley probably came close to reaching the limits of the carrying capacity of its agricultural fields somewhere between 5250 and 5100 BCE. This is the time when people started to concentrate at Vráble or, possibly, leave the valley for other regions. While it seems counter-intuitive for populations to concentrate in a situation of resource stress, the reason why farmers were attracted to the site of Vráble may lie in their system of integrated crop cultivation and animal husbandry, which, through its high intensity of manuring, would have provided more consistent crop yields. This is a system that works better in a situation of settlement concentration, where animals are intensively manged *i.e.* kept within the vicinity of the site. Even if the inhabitants of the smaller settlements practiced a similar strategy, it may have been less effective due to lower concentrations of both domestic animals and humans. This is a question that will need further investigations. Our point here is that Vráble may have looked attractive due to higher crop yields. Maybe the soils around Vráble were more fertile to begin with, and the ongoing concentration of more population and animals would have intensified the manuring regime, further increasing crop yields. Whatever the starting point, at the time when arable land appears to have become scarcer and soils may have become nutrient poor, people may have realised that joining large communities was a better option than living in smaller, less connected settlements. The increase in the human population at Vráble enlarged the available workforce, and this would have led to the intensification of crop production. Keeping animals within the settlement or close to them inadvertently led to increased availability of manure, which either intentionally or unintentionally arrived at the cultivation plots, leading to improved crop productivity and thereby reinforcing the positive effects of living together in large groups.

In the three neighbourhoods at Vráble, the number of farmsteads developed differently. The enclosure around the south-western neighbourhood was constructed at a time when there was a decline in the number of farmsteads, while especially the northern neighbourhood was thriving, probably attracting more newcomers. The cost-intensive construction of this 1.4 km long double-ditch system is a visible sign of the development of rising competition between these increasingly antagonistic communities. It may have been an attempt to secure fields and pastures, and also a strategy to increase the attractive nature of the south-western community (as discussed in Chapter 6.1). In the long run, this strategy did not work, as the number of farmsteads did not rise in the south-western neighbourhood. Overall there is a decline in the number of farmsteads in all of Vráble after 5050 BCE. We can speculate that the re-direction of the workforce from food production to monumental building activities, to activities reinforcing social discord, instead of communality, could have had a negative effect on the communities' subsistence productivity and overall prosperity. As argued in Chapter 6.3, the increasing antagonism and tensions between social groups at Vráble may have been the main reason for the decline of the population at Vráble – and for the end of LBK type settlement in the Upper Žitava Valley.

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6.3. The political economy of the LBK and Želiezovce settlement site of Vráble

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Abstract

We present a synthesis of the socio-political developments of the communities at the Neolithic site of Vráble 'Veľké Lehemby' (Nitriansky kraj, Slovakia), discussing subsistence strategies, the use of space and the built environment, as well as material culture and integrate these into a model of the political economy. A characteristic of the site is the simultaneous existence of both exclusionary and communal strategies, which were influenced by and were influencing different social spheres of the settlement community. While we can trace differentiated subsistence strategies at the level of individual farms, as well as at the level of neighbourhoods, we can also see strong indicators for the importance of collective and communal mechanisms, as well as practices of sharing. These are indicated by the presence of specific storage pits and the communal building of an enclosure. We interpret these communal activities not only as indicators for structures of social security and solidarity, but also as indicators of growing social tensions and possibly conflicts over the course of the settlement history. We argue that the settlement was abandoned as a result of an intensification of these tensions, leading towards the deliberate separation of one of the neighbourhoods and the development of social inequality, expressed through differentiated burial rites. The social and political structure of Vráble dissolved at the beginning of the 5th mil. BCE and was followed by a decentralised and dispersed system of sites during the subsequent period of Lengyel communities.

Keywords: neighbourhoods, economic differentiation, sharing practices, communal frameworks, cooperation, social tension

Introduction

The site of Vráble represents one of the largest settlement concentrations known from the context of the central European 'Linearbandkeramik' (LBK) (cf. Petrasch

2012). The investigation of the economic and social preconditions and consequences of this social agglomeration and its implications for social and political forms of organisation are the main objective of our research at this site (see Chapter 1). Based on the results of the preceding chapters, and in the context of the discussions about the Early Neolithic period in Europe in general and about the LBK societies in particular, we here present a discussion about the political economy of the settlement concentration at Vráble. We want to clarify the relationship between social institutions at the levels of the settlement community or intermediate units, such as the neighbourhood.

Within the German-speaking archaeological research tradition, the extensive excavations of LBK settlements in connection with Rhineland lignite mining have heavily dominated the discourse on Neolithic social organisation (cf. *e.g.* Boelicke *et al.* 1988; Lüning 1997). Yet, the availability of both settlement and burial remains across different regions of central Europe allows for a wider range of research questions to be addressed.

Social-archaeological questions that are of particular importance for this chapter were discussed and answered in a variety of ways. While early research in particular pictured LBK communities as strongly egalitarian or acephalous (cf. Lüning, 1988 [1991]), in recent years, notions of more marked social differentiation processes have become more prominent (*e.g.* Jeunesse 1997; van der Velde 2008). On the basis of comprehensive analyses of stable isotopes in burials, researchers have suggested patrilocal residence structures as an LBK-wide pattern, in which women exhibit a higher degree of mobility than men and in which local men may have a more elevated social position than non-locals, which may also have led to the development of social differentiation (cf. *e.g.* Bentley *et al.* 2012; Hedges *et al.* 2013, 267-269). This confirms the conclusions from analyses of epigenetic traits that were carried out some time ago and that also suggested patrilocality (Eisenhauer, 2003). While the LBK phenomenon was originally regarded as a relatively uniform socio-cultural unit, at least in the older phases, followed by increasing regionalisation in the younger periods (Lüning, 1988 (1991)), in recent years, the notion of a high degree of regional, but also local diversity of cultural practices has gained popularity, which requires a focus on individual case studies (cf. Bickle and Whittle 2013, 25).

Against this background, our first important question to discuss is the reason for the increasing settlement concentration at Vráble. The site itself has no visible ecological or natural features that would set it apart from other sites populated at the same time. The three parts of the settlement lie on the eastern Žitava terrace, on both sides of a small creek that, a few hundred metres farther west, flows into the Žitava River. This creek flows through an east-west valley, of which there are two more to the north, both of which also have LBK settlements. South of Vráble, the LBK settlements are lined up like beads on a string along the first terrace east of the Žitava River. Soil conditions and hydrology are, as far as we are able to judge, not significantly better or different around Vráble than in the rest of the Upper Žitava Valley. Thus, we assume that there were no ecological or natural causes for the settlement concentration at Vráble. The choice of location for the settlement concentration is thus most likely due to human agency or historical events. One possible explanation for the attractiveness or Vráble is the specific subsistence regime, which shows a strong integration of cereal farming and animal grazing (see Chapter 6.2). This resulted in high levels of manure brought to the fields and most likely provided better returns on cereal crops. However, for such a regime to have this effect, a critical mass of animals would have needed to be present, so one could argue that it would be a consequence of settlement concentration rather than its reason. It is also possible that settlement concentration and the integrated cultivation-grazing regime had a mutually reinforcing effect on each other. In any case, the concentration of animals close to the site and partly on the cereal fields of Vráble corresponds to the concentration of people at that place (see Chapter 6.2).

Various social or psychological pull factors can also be considered as initial reasons for the phenomenon of settlement concentration: greater security through living together in a large group – even if there is no archaeologically demonstrable threat situation; greater economic security through an increased involvement in local communal structures, such as sharing; and the psychological aspect of the attractiveness of a more intensive and varied social community, of feasts, ritual ceremonies and the like, which a large settlement has compared with smaller hamlets. All these reasons can be summarised as social and economic pull factors, and they seem, at the current state of research, to be the most plausible explanation for the settlement concentration at Vráble.

Taking into account the different aspects of the settlement of Vráble described in the previous chapters, we can further explore the social and political organisation of the communities living there. Since social and political organisation in general tends to be characterised by complexity and opposing interests or influences, a suitable theoretical background must capture and interpret this complexity. Of particular importance here are theoretical concepts that can link basic forms of action and organisation of communities with one another regardless of their complexity or degree of hierarchisation (*e.g.* cooperative action: Carballo *et al.* 2014; sharing economies: Widlock 2016; political-economic strategies: *e.g.* Blanton *et al.* 1996; and anarchist theories: *e.g.* Angelbeck and Grier 2012; Furholt et al. 2020a).

We summarise the diversity of theoretical approaches referred to here under the term 'political economy' because this emphasizes the connection between social production and intra-societal power relations, as well as the negotiation processes of different social interests within the framework of social practice. We do not want to restrict this term to its classical version, *i.e.* one strongly oriented towards Marxism, but, rather, to extend it to include approaches based on a broader cultural anthropological basis (as proposed in Furholt *et al.* 2020a).

The spatial division of Vráble into three settlement parts, which is clearly visible on the settlement plan, reflects a horizontal social differentiation of the settlement community into residence groups, and this requires an analytical separation of at least three social scales: the settlement community, the neighbourhood and the household. As a first step we here describe the socio-economic organisation within the neighbourhoods, *i.e.* the relationships between households in the neighbourhoods. As the second step, we explore how the three neighbourhoods are linked. Whether these neighbourhoods represent kinship groups or independently formed residence groups (Steuer 1982) is not clear at this point.

The political economy within the neighbourhoods

The largest significant social unit within the settlement of Vráble are the different neighbourhoods, which formed spatially independent units during the agglomeration process. In Neolithic research, a particularly concise description of neighbourhoods was given by Bleda Düring (2006, 2011) for the Pre-Pottery Neolithic and early pottery Neolithic central Anatolian settlements. These comprise densely built-up settlement areas that are clearly separated from each other by gaps of unbuilt areas. They were inhabited by about 150-250 people and represent social groups that are characterised by direct social interactions practiced in everyday life. In the field of LBK research, Czerniak (2016), D. Hofmann (2016) and Bogaard *et al.* (2011) have discussed the existence of such neighbourhoods at Targowisko, Poland, and Vaihingen an der Enz, south-western Germany.

At Vráble, neighbourhoods of the form defined by Düring are easily discernible on the settlement plan. Like in the central Anatolian case, within these three neighbourhoods, households represent the most important archaeological reference level, which has also received special attention within the LBK research traditions (cf. *e.g.* Czerniak 2016). These households were and are often seen as autonomous economic units (cf. Bogucki 1988; Lüning 1982), which represent the basic social grouping within the village units. Whether these were systems of extended families or units inhabited by people of different origins is a matter of dispute. Most studies assume that the individual longhouses can be assigned to core families or extended families and that the number of occupants does not exceed 10 persons per house (cf. *e.g.* Lüning and Stehli 1989; Rück 2009; Strien 2010; with higher population numbers and a different interpretation: Kreuz 2010). In any case, the houses were probably the most important everyday social unit at Vráble due to their spatial dispersion, probably emphasizing their independence. This idea is at the basis of the historically dominant 'farmstead model' (from the German *Hofplatzmodell*; *e.g.* Zimmermann 2012), which is partly disputed by the 'house row model' (from the German *Hauszeilenmodell*; Rück 2009) and other models (Stäuble 2005). As shown elsewhere (Müller-Scheeßel *et al.* 2020), given the results of our excavations and dating programs, the farmstead model offers the most plausible model of spatial organisation within the neighbourhoods of Vráble. These farmsteads are composed of economic areas with an average size of about 0.5 ha, within which at any given time only one or two houses were contemporaneously in use. Each farmstead thus represents one household spanning several generations. This means that the concentration of settlement in the neighbourhoods at Vráble represents a very special form of social agglomeration, which we call low-density agglomeration. Very different from Düring's central Anatolian case, low-density agglomeration refers to a system which features the combination of strong settlement- and neighbourhood-wide institutions, as well as strong autonomy of the households (or farmsteads). This is a combination which holds high potential to create social tension, as the interests of autonomous units and communal institutions may have diverged. In the case of Vráble, we argue, we can see a process where social tensions strongly increased during the history of the settlement.

Economic differentiation of individual households?

Within Vráble, there are indications of a certain degree of economic differentiation among the individual farmsteads, which supports the idea of independence and autonomy of these basic socio-economic units. The autonomy of the individual farmsteads, which is an integral component of the farmstead model, is demonstrated by the differential access to raw materials, reflected by the frequencies of obsidian and flint artefacts (see Chapter 5.2; Müller-Scheeßel *et al.*, 2016), different proportions in cereal species used (see Chapter 5.5) and unique properties in the pottery decoration style (see Chapters 4.1 and 5.1).

The density of stone artefacts and the proportion of obsidian artefacts among the six investigated farmsteads show clear, significant differences. In addition to the high number of obsidian artefacts, the farmstead investigated in 2016 also contained Bükk-style pottery (see Chapter 5.1), which indicates that the access of this farmstead to eastern Slovakian obsidian is an expression of close social relations to this region, which may also have manifested itself in the exchange of (potting) individuals. A large number of obsidian artefacts were found in the earliest phase (house 132) of the farmstead excavated in 2016 (see Chapter 5.2). In the following phase, during which possibly two houses were in use at the same time (houses 131 and 133), clear differences were found. House 131 shows a clear preference for obsidian (> 50%) and has a very extensive inventory of tools (n=76). In contrast, house 133 shows a much smaller inventory of both obsidian and tools (n=30). We interpret this as the division of labour between two buildings belonging to one household. In the youngest house (126/127) a considerably lower density of stone tools was found – and an obsidian proportion (19%) that is no longer so clearly distinguishable from that of the other farmsteads. The production of pottery also seems to be organised on a farmstead-specific basis. While the ornamental patterns can be assigned to the Želiezovce style (with some Notenkopf elements in the early phase) (see Chapter 4.1), the analysis of the non-Želiezovce patterns shows that they are clearly farmstead-specific.

While emmer and einkorn are the dominant species in the cultivated plant spectrum at Vráble (see Chapter 5.5), there are also clear differences within the individual neighbourhoods in the preference for these two crops. Within the individual houses to be assigned to a farmstead, however, these emmer: einkorn ratios are much more similar, and thus we capture generation-spanning, farmstead-specific cultivation traditions. These divergent economic strategies can be reconciled with a differentiated role of individual farmyards in the overall economic concept of the settlement, and they also indicate the existence of network-based strategies and particularistic tendencies (cf. Blanton *et al.* 1996; Feinman 2000) of individual households, which could ultimately lead to social tensions.

Differential subsistence strategies between households and varying preference for different raw materials for the manufacture as well as the shape of tools are not an unknown phenomenon in the LBK area and are also not limited to certain phases of the LBK. Differences in the spatial distribution of specific types of flint as well as basic forms such as blades and flakes have already been documented in other LBK settlements (cf. *e.g.* Fischer 2011; Strien 2005). Different subsistence strategies have been described, for example, for Cuiry-Les Chaudardes, France (Hachem and Hamon 2014).

A potentially detrimental aspect of a concentrated settlement mode with simultaneous economic autonomy of farmsteads – low density agglomeration – as we reconstruct it at Vráble, is that this inevitably results in a differentiation of cultivation and grazing areas close to and farther away from settlements. Such differentiation is not as important in the smaller, scattered settlements of the Žitava Valley. There is no empirical evidence for conflicts over the use rights of certain areas. But since we assume that the 0.5 hectare areas assigned to each farmstead within the settlement were not sufficient to satisfy the needs of these social units (see Chapter 6.1), we could further assume that conflicts may have arisen over the use of different areas of different accessibility or fertility. This may have been reinforced by the importance of animal manure in the integrated crop cultivation-animal grazing regime of Vráble. In addition, as shown in Chapter 6.1, the growth in the number of contemporary farmsteads was not uniform across all three neighbourhoods at Vráble. Around 5100 BCE, especially the northern neighbourhood was thriving, while the south-western neighbourhood was in decline. This decline could be stopped for a few generations following the construction of the enclosure system. But this was eventually followed by the abandonment of the entire settlement.

Sharing economies: Storage pits and domestic animals

There are explicit indications of communal, cooperative strategies, which should also be seen in the context of the overall structure of the neighbourhood community. For one, there are signs of a sharing economy, which is indicated by the existence of beehive-shaped storage pits (also known as truncated cone pits). Within the LBK research, beehive-shaped storage pits represent a differentiated class of features, which were already discussed as potential storage pits in the early excavations of Köln-Lindenthal (Butler and Haberey 1936). Beehive-shaped storage pits are not restricted to LBK settlements, but they have been documented in particularly large numbers in the LBK settlement of Štúrovo (Nové Zámky, Slovakia; cf. Pavúk 1994). At Štúrovo, it was observed that the beehive-shaped pits were partially filled with burnt clay, which may have been deposited in the course of the abandonment of houses. Artefacts or other waste, on the other hand, were found in only a very few cases. The spatial distribution and allocation of the individual pits to specific buildings differs considerably between the individual settlements and thus hampers a uniform interpretation of the social function of these pits (cf. Pavúk 1994).

The characterisation of the beehive-shaped pits as storage pits results from their lack of artefacts and from ethnographic analogies (cf. Kriegler 1929). A special characteristic of beehive-shaped storage pits is that their contents had to be consumed very quickly once they had opened due to changes in the conditions of preservation within the pit. During the excavations in 2016, four of these pits were documented (see Chapter 3.1). The evaluation of the magnetic surveys (see Chapter 2.1) also indicates that such truncated cone pits are evenly distributed over the settlement, meaning that probably a large proportion or even all of the houses documented at Vráble can be assigned such a pit. The social significance associated with the pits touches several of the basic organisational units within the overall social and economic system of the neighbourhoods. As already mentioned, LBK farmsteads and settlements as a whole have been widely associated with kinship systems. Whether the population of a house is actually to be equated with a biologically related core or extended family, or whether it is a residential community, must remain an open question. It can be assumed that the social and political organisation of the neighbourhoods, and also of the settlement as such, was characterised by kinship-defined groups, such as families and lineages, which, nevertheless, can be socially defined (Sahlins 2013). In such comprehensive kinship systems, we are primarily considering not only structures that were defined along a perceived biological kinship, but also those that were repeatedly expanded or actively shaped by specific modes of action and organisation, as the example of Karsdorf shows, where individuals assigned to individual houses did not show a mitochondrial (maternal) kinship (Brandt *et al.* 2014).

In this context, aspects of a sharing economy are of particular importance (cf. Widlok 2016). In the course of the reinterpretation of the mechanisms leading to the formation of complex kinship systems, performative and negotiated aspects were increasingly brought to the fore within cultural anthropological research (cf. Godelier 2012; Sahlins 2013). The importance of sharing of specific spatial reference systems and of food, which can and in many cases does contribute to the formation and strengthening of social reference and kinship systems, was repeatedly described (cf. *e.g.* Holland 2012). Also, cattle in particular have been described as important animals in this context, whose shared exploitation (especially in the case of slaughter) can also be used as a balancing factor to maintain social cohesion and reduce potential tensions (cf. Gillis *et al.* 2017; Russell 1998, 45).

Outside the social and kinship reference systems, sharing economies were associated with different, sometimes divergent social incentives. For example, storage of resources in particular was associated with the emergence of social complexity and social inequality. Particularly in the context of anthropological and archaeological studies, this link is often made on the assumption that social competition (between individuals and groups) is in many cases closely related to an unequal distribution of or access to resources. In the case of such a linkage, storage systems can intensify processes of social differentiation and lead to the formation of dependencies and, ultimately, hierarchies (cf. *e.g.* Hayden 1994; Earle 2002). But these same sharing systems can also serve a completely different purpose, as a levelling mechanism. They can perform this purpose in addition to having potential control over resources and aspects of social and economic security. The potential or actually performed sharing of previously stored goods or resources can be used as a social institution to maintain or reinforce social cohesion, to balance existing economic inequalities and, ultimately, to avoid the formation of reinforced hierarchies (Widlok 2016; Müller 2017). Apart from the obsidian artefacts, which are perhaps more likely to be part of the realm of prestige objects, the evidence at Vráble does not indicate an obviously unequal or centralised and differentially restricted access to basic resources. Although there are indications of different preferences and unequal use, *e.g.* of specific grain species, it can be assumed on the basis of the excavation results that most, maybe even every house can be assigned a storage pit. The participation in specifically pronounced sharing mechanisms thus encompassed all households of the neighbourhoods and therefore points to a system strongly designed for communal, potentially socially balancing, mechanisms.

This pattern clearly contradicts later developments in the same micro-region. Within the Bronze Age settlement of Vráble Fidvár, for example, storage pits were also documented, a large proportion of which, however, were centrally concentrated within a certain area of the village (Rassmann *et al.* 2017). In this case, a centralised system of storage pits can be associated with a control of resources and represents a clear counter-model to the social strategies in the Early Neolithic settlement at Vráble.

The importance of collective strategies and cooperation: The large houses and the enclosure

An especially important institution within LBK settlements are the long houses, which have been documented in different contexts and which take different shapes (cf. Hofmann 2013, 41; Czerniak 2013). Extra-long houses occur in the entire central European distribution area of the LBK and are defined, for example, by Pechtl (2009) as having a length of more than 33 m. The coexistence of ditched enclosure systems and extra-long houses at the same site, as observed at Vráble, is rare. Both large houses and ditched enclosure systems can be seen as expressions of a monumental reference system, and they find their temporal focus in the youngest phases of the LBK (Pechtl 2009, 25). A kernel-density curve of the house sizes following Pechtl (2009), as well as the house lengths documented by the magnetic plans of Vráble, shows a multi-peaked distribution with a clear centre of gravity at a maximum length of between 10 and 20 m. Both curves show smaller maxima at a maximum length of about 25 m, 30 m, and 40 m.

On this premise, in the case of Vráble, houses with a length of about 30 m or more can be defined as extra-large. These houses can only be found in the northern neighbourhood (n=24) and the south-western neighbourhood (n=14), which has a ditch during the youngest settlement phase.

A clear interpretation of the extra-large houses is made difficult for the entire range of distribution of the LBK by the lack of clearly assignable inventories and a lack of documented internal installations due to poor preservation conditions (cf. Pavúk 1994, 245). The idea of large houses as an expression of a specific social function thus rests on the documented differences in size, varying and partly added construction elements in the large buildings of the LBK, as well as partly documented differences in zoological and archaeological material (cf. Lenneis and Hofmann 2017), but would have to be verified by further, external indicators. However, there are further possible interpretations of this house form, which is closely linked to its rarity, but also to the general architectural similarity between normal and the large LBK houses. At Vráble, the magnetic investigations do not reveal any architectural features of these houses that could be characterised as unusual. During the 2014 campaign, one of the houses defined as large was partly excavated. A human skull fragment was discovered in its western long pit, which could suggest a special ritual significance of this feature, especially given the role of human heads, as evidenced by the headless burials in the enclosure ditch (see Chapter 3.2). Of great interest, however, is a potential function of the extra-long houses as communal buildings.

Cultural anthropological studies show that, although such communal houses sometimes contain specific furnishings and architectural elements, they can also be of a design that is completely in conformity with the rest of the settlement. Examples of collectively used communal houses are known from north-eastern India, for example. These houses do not necessarily have special material equipment, but in many cases, they are much larger than normal residential houses (Nienu 2015, 214). Although the character of large LBK houses must therefore remain unconfirmed, they may very well be communal houses even in the absence of special equipment. If such an interpretation is accepted, they can be seen as a connecting institution between the relatively autonomous house units.

Ultimately, an agglomerated settlement pattern always points to a certain need of the social groups concerned to live within a common social space. However, the interpretation presented here is difficult to reconstruct from the archaeological dataset. The repeatedly documented above-average density of finds (cf. Lenneis 2013), in connection with large houses can, however, easily be reconciled with a communal interpretation. Since these houses in their communal function would also have been used by a correspondingly larger collective than would have been the case with a normal house, a certain over-equipping is to be expected. A different interpretation, however, is the idea that some large houses are economically differentiated domestic buildings, like was argued for Cuiry-les-Chaudardes (cf. Hachem and Hamon 2014), which in this form may well point to the existence of social inequality.

The Vráble enclosure is an indicator of tension between the neighbourhoods and the entire settlement. The spatially excluding function of the ditch system refers to the isolation of one neighbourhood from the other two. At the same time, however, the trench work in itself also most probably represents a collectively organised endeavour of the neighbourhood that it eventually enclosed. The available ^{14}C dates from the enclosure originate from burials that were at the bottom of the ditch and alongside the ditch. The ones at the bottom date to 5050 cal BCE and represent the *terminus ante quem* for the excavation of the ditch system. Thus, the enclosure can probably be dated to the last settlement phase. The outer ditch of the south-western neighbourhood encloses a total area of 14.7 ha; it is 1.4 km long and has a width of 2.5-3.5 m and a depth of 1.5 m below today's surface. LBK ditch systems have repeatedly been the subject of workload calculations, one of the purposes of which is to allow for conclusions to be drawn about the social organisation of such construction projects. The values of the work performance collected for different ditch systems usually range between 10 000 and 14 000 person work hours (ph), depending on the volume of the excavation, the calculation of palisade facilities, as well as the distance the backfill was moved between the ditch excavation and the ramparts (cf. Haack 2014, 347-349). Even though non-LBK trench and pit systems of very different sizes are included in the various calculations, the calculated output rarely falls below 10 000 ph (*e.g.* Hofmann *et al.* 2006; Hage 2016; Kerig 2003; Pechtl 2009). Due to the high number of hours to be worked, in these contexts it is usually assumed that different working groups cooperate, groups that may well consist of different social groups or settlement contexts (cf. Haack 2014, 351). In view of the fact that the enclosure at Vráble comprises only the south-western neighbourhood and that the orientation of the five entrances make it clear that this is a delineation from the other two neighbourhoods, the involvement of the other neighbourhoods in the work process seems unlikely. Accordingly, 'work' output of this magnitude can only be embedded in the collective framework of action of the south-western neighbourhood. The enclosure of the south-western settlement area can thus, analogous to the large houses of the northern neighbourhood, have fulfilled important functions within the social fabric through its communal and cooperative frame of reference. In particular, cooperative practices have repeatedly been associated with aspects of reciprocity and their potential for preserving social cohesion (cf. Carballo *et al.* 2014; Müller, 2010).

Within the analytical realm of the individual neighbourhoods, there are indications of economic differentiations (cf. types of grain, pottery styles and access to supra-regional networks and raw materials) and differential population growth rates, but these exclusive strategies are in tension with neighbourhood-internal communal and cooperative strategies from the outset and thus correspond to a basic pattern described by Marshall Sahlins (1972). In the course of time, however, there are increasing indications of a shift in the tensions to the level of antagonism, or even competitive behaviour, between the neighbourhoods, as opposed to between the farmsteads within a neighbourhood.

An increase in social tensions and conflicts towards the end of the LBK phenomenon has been postulated in various regions of Europe (cf. Eisenhauer 1999), although very different social solutions can be observed. These include clear acts of violence, such as assaults (cf. Talheim; *e.g.* Wahl und Trautmann 2012; Strien *et al.* 2014), massacres (Asparn/Schletz; cf. Teschler-Nicola 2012), torture (Schöneck-Kilianstädten; cf. Meyer *et al.* 2015) and mass executions (Halberstadt-Sonntagsfeld, Meyer *et al.* 2018), as well as clearly ritually motivated irregular depositions and burials in enclosures (cf. Herxheim; *e.g.* Zeeb-Lanz *et al.* 2016) and the demolition of settlement systems (Eisenhauer 1999).

Both regular and irregular burials, as well as the termination of a settlement that had existed for several centuries and thus the abandonment of the social experiment of population agglomeration, are phenomena we find at the end of the LBK settlement history of Vráble, although these phenomena lack the clear indications of excessive violence or the extent of ritual elaboration found in the above-mentioned sites. However, changes are clearly visible in the relationship between the different neighbourhoods of Vráble, which in the following represent the second essential level of reference for the interpretation of Vráble's political economy.

The political economy of Vráble

Economic differentiation: The neighbourhoods

Overall, the economic system of LBK settlements can be described relatively uniformly as agropastoral, although there are regional differences. In general, evidence of a greater importance of wild animals as a supplement to the spectrum of farm animals is rather low (<10%), although exceptions (38-43%) are observed in southern Germany (cf. Bickle and Whittle 2013). Vráble fits into the usual picture presented by the faunal spectrum of LBK sites, with a small proportion of hunted game, and also with the general composition of the farm animal spectrum. As shown in the previous chapters, what is special about the economic system at Vráble is the strong spatial integration of cereal cultivation and animal farming. Animals were kept close to the site, partly on the cereal fields, thus providing a high degree of manuring – visible in the unusually high $\delta^{15}N$ values of cereals – and overall probably creating a higher crop yield than in other places.

The exact composition of domesticated animal species varies regionally within the range of the LBK and partly also within individual settlement sites (cf. Bickle and Whittle 2013). References to a differentiated use of the different livestock species between individual households of a settlement were documented, for example, for Cuiry-lès-Chaudardes (Hachem and Hamon 2014, 166-167) and Mold (Lenneis 2011), and we thus know that such differentiation does not represent an unusual phenomenon within the LBK. At Vráble, pigs are the most common farm animals, accounting for 35% of all identifiable animal bones. Sheep/goat (30%) and cattle (29%) are almost tied for second place if all neighbourhoods are combined (see Chapter 5.4). Vráble provides an interesting case study with regard to the frequently raised question of economic independence and differentiation between parts of settlements and potential farmsteads. Although there is no clear differentiation in the use of livestock within the neighbourhoods, there might be between the neighbourhoods. Thus, cattle represent the dominant share of livestock only in the south-western settlement area, while in the northern neighbourhood it is pig; in the south-eastern neighbourhood all main species are more evenly distributed This pattern can be interpreted as an expression of different cultural preferences or, alternatively, as an expression of an immanent particularistic and exclusive economic practice. Of particular interest here is the dominance of cattle in the south-western settlement area. The slaughter of a cow exceeds the dietary demands of a single household and can thus be viewed in the context of sharing economies, as discussed above, as well as a specific presentation of prestige (cf. Bogaard 2011; Gillis *et al.* 2017).

Although the importance of sharing economies is suggested by the presence of the beehive-shaped storage pits and large houses in all settlement areas, the enclosure undoubtedly represents the most pronounced materialisation of cooperative action in the context of Vráble. The fact that the houses with the highest proportion of cattle bones are also located in this settlement area could indicate a close connection between the economic orientation of individual households, the separation of an entire settlement area and the emphasis on cooperative action within this neighbourhood.

In summary, from an economic point of view, represented by the specific preference for livestock and cereals, clear differentiation processes within households and neighbourhoods at Vráble are discernible. Although there is obviously a strong need for a close neighbourhood community and although a shared ideological superstructure is evident in the spatial design of the three neighbourhoods (see Chapter 1), there are also strong particularistic tendencies in each of the neighbourhoods.

The enclosure as an expression of spatial and ideological separation of the different neighbourhoods?

Enclosures are a well-known phenomenon in LBK contexts, especially in the later phases, which manifests itself in very diverse ways. For example, enclosures are mostly found in the context of regular settlement sites (*e.g.* Langweiler 9; cf. Stehli 1994; cf. also Saile and Posselt 2004; Jürgens 2019), but also as supra-regional centres in connection with irregular burial customs (*e.g.* Herxheim, cf. Orschied and Haidle 2012). The settlement of Herxheim, in particular, with a minimum number of 500 individuals deposited in the ditch systems dating to the most recent settlement phase, represents a special feature that has been interpreted as a ritual expression, due to an absence of signs of violence and a presence of signs of cannibalism (Boulestin *et al.* 2009), both of which are now strongly disputed (cf. Orschied and Haidle 2012; Zeeb-Lanz 2019). On the other hand, at a site which is undoubtedly related to violent acts, namely, the settlement of Asparn/Schletz, a total of at least 67 individuals was recovered from the enclosure ditch system associated with the settlement, many of whom showed traces of violence, which is interpreted as a massacre of the entire settlement community (Teschler-Nicola 2012). What these different findings have in common is that they date to the younger phase of the LBK, around 5100-4900 cal BCE. On the basis of these sites, a narrative was developed that presumes an increase in violence in a phase of upheaval (Golitko and Keeley 2007), which is often described as a crisis situation (cf. Zeeb-Lanz *et al.* 2016, 187). At least for some of the features, however, the possibility must be taken into consideration that irregular burials and an open type of burial within ditch systems, as evidenced by traces of animal gnawing, were part of complex burial or deposition customs. Whether all skeletons date simultaneously to the younger LBK or whether this type of irregular death

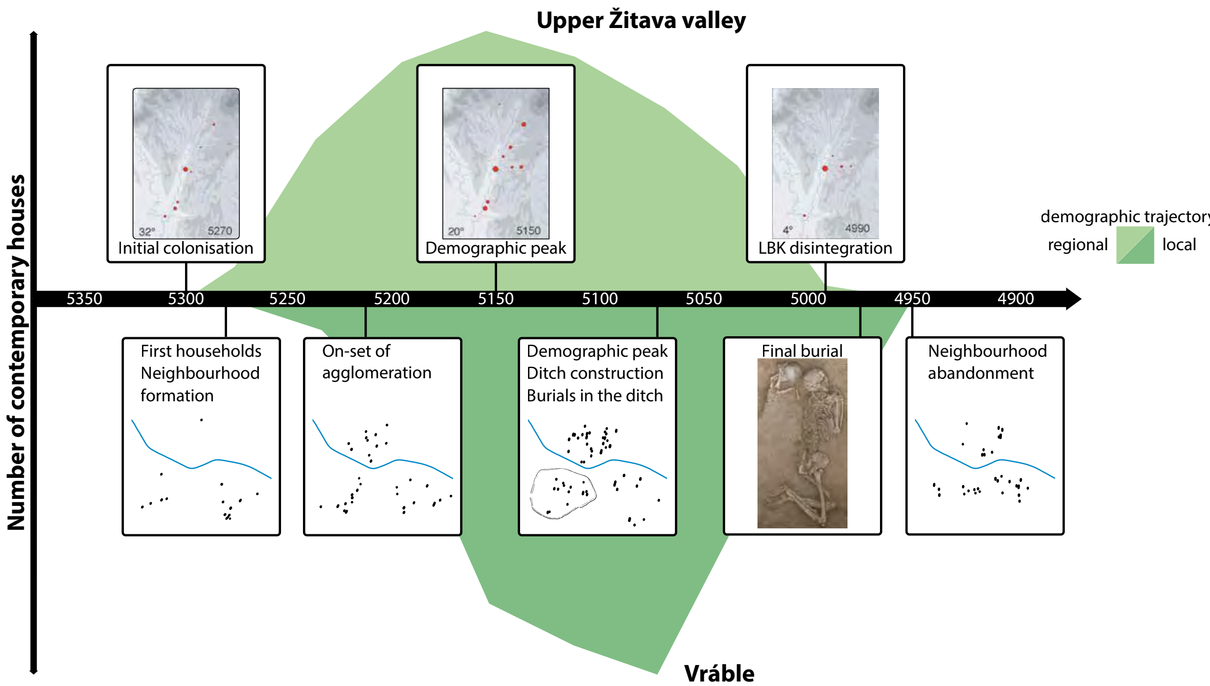

Figure 6.3.1. The chronological framework of the socio-spatial development of Vráble with consideration of the demographic development.

treatment actually took place over a longer period has not yet been determined conclusively (Link 2014, 277-279).

The finds from Vráble show both parallels to and differences from this framework. At Vráble, too, the ditch system and related burials, as described above, can be dated to the late phase of the settlement (Fig. 6.3.1). It was constructed in a period when the south-western neighbourhood was in decline in terms of farmstead numbers, while the other neighbourhoods were thriving. We suggest that this project was an attempt to counter this trend, either by raising the attractiveness of the south-western neighbourhood or by antagonising the others.

The burial rites associated with the individuals buried in and alongside the ditch system also show deviations from the usual norm. Such deviations are not unusual in late LBK contexts. Four of the individuals at the bottom of the ditch were laid down headless and without grave goods. In addition, there are isolated bones in refuse pits within the neighbourhoods, as well as further disarticulated burials along the edge of the ditch system. Both the headless individuals and the regular burials have a prominent position within the mortuary rituals, due to their location at or in the gateway of the ditch system.

These features show that, towards the end of the settlement phase, the creation of the ditch system was associated with a complex and differential treatment of different groups of people – a phenomenon that can be associated with intensified social conflict and a possible reaction to an impending crisis situation. However, it should be stressed that there is no clear evidence of lethal violence related to the deposited individuals. Thus, Vráble differs from the above-mentioned situations in which the use of lethal violence or, as in the case of Herxheim, much more complex ritual actions are evident. Altogether, however, the installation of the enclosure in itself represents an act that is to be connected with a separation of the neighbourhood in question from the rest of the settlement complex. This is very clearly illustrated by the fact that the five entrances are all to be found in the southern and western sections of the enclosure and that there is also not a single entrance from or towards the south-western neighbourhood from the direction of the other two neighbourhoods, which were both being inhabited simultaneously with the south-western one. The positioning of the entrances thus considerably facilitated access to the south-western neighbourhood from outside the settlement. The spatial separation, which had been present since the beginning of the settlement, was intensified in this late settlement phase and can only be reconciled with an ideological division of the community. The Vráble ditch is therefore not an outward demarcation of the settlement community, but, rather, an inward demarcation of one neighbourhood directed against the other two.

Furthermore, it is remarkable that the depositions of dead human bodies along and in the ditch document the presence of people ritually treated in different ways, *i.e.* the division of people into different social groups. At the very least we can make a distinction between the four headless individuals, who were each laid down in pairs in the terminal end of the western ditch (in both entrances excavated so far), and the regular burials next to the ditch and in the entrance area. We think it is possible that isolated human bones in the ditch fill and burials in the long pits of houses represent further social categories. The findings of spinal anomalies or malformations in three of the four headless individuals, including a possible case of Klippel-Feil syndrome (Chapter 3.2), suggest that this differential definition of social groups may have been based on a different physical appearance. We should point out, however, that nothing is known about any different values ascribed to these groups. Although the headless individuals have no grave goods, they were probably part of much more complex ritual ceremonies than the regular burials.

Discussion

The LBK settlement features of Vráble allow for a number of interpretations concerning the social and economic organisation of the local communities at different levels. First, the reason for the population concentration at Vráble may have to do with its economic attractiveness due to higher crop yields, caused by the integrated crop cultivation and animal husbandry system. This system may have been reinforced by the population concentration process itself, providing even more animals for manure. Vráble seems to have been made up of a number of different social groups, which in some aspects act completely independently of each other, but are closely linked by an ideological superstructure. Vráble's neighbourhoods, which are spatially clearly delimited, can probably be associated with distinct social systems, such as lineages, although lineage overlap between the delimited settlement areas should not be ruled out. There could also have been different social groups within the neighbourhoods, as mentioned above.

The emphasis on a spatially delimited settlement area assigned to specific social groups could, from a cultural anthropological point of view, be understood as reflecting shared claims to specific land areas and resources, which are often of great importance, especially for social units, such as clans or lineages (cf. Leach 2003; Godelier 2012; Strathern and Stewart 2018, 121). Such a connection between kinship and social systems and the spatial design of LBK settlements has repeatedly been discussed in different contexts (cf. *e.g.* Frirdich 2005; Strien 2005, 195).

By contrast, the individual households within the neighbourhoods show a high degree of self-sufficiency and autonomous economic strategies. Accordingly, it can be argued that a high degree of socio-economic autonomy played an important role within the LBK social fabric (cf. van der Velde 2008). This independence is also emphasised at Vráble by the spatial autonomy of the individual farmsteads, which, according to our chronological model (Meadows *et al.* 2019; Müller-Scheeßel *et al.* 2020) were on average 70-150 m apart (Furholt *et al.* 2020b), *i.e.* had 0.5 to 1 ha of space available. As a counterpoint to the overemphasis on the autonomy of households as fundamental social and economic units within the neighbourhoods, there are clear indications of a communal superstructure that could have served to provide social security for the individual households and, at the same time, to establish a collective frame of reference.

Within this sphere, both the beehive-shaped storage pits, the large houses and the enclosure can be linked to specific sharing economies and cooperative strategies. Cultural anthropological studies have particularly highlighted sharing as a specific social strategy that often takes on the fundamental function of securing livelihood and social cohesion (cf. Widlok 2016). These aspects of social action, which are easily recognisable in the archaeological dataset, can therefore be regarded as an important link between different levels of social organisation. In particular, groups that place a high value on economic autonomy, as is customary in the LBK, and that thus potentially stand divided in a certain area of conflict, must resort to balancing mechanisms in order to maintain social cohesion (cf. Mac Sweeney 2011, 37-38).

Similar structures can also be traced at the settlement level, *i.e.* within the field of interaction of the different neighbourhoods. The very similar design of the individual neighbourhoods in form, size and orientation suggests a shared ideological superstructure, which seems to have been maintained throughout the entire settlement period. The trapezoid as the basic form of settlement is widespread in LBK contexts (cf. Saile and Posselt 2004). Overall, the stable isotope analyses (see Chapter 5.7) have revealed rather uniform subsistence strategies all over Vráble, the only differences existing in the animal species composition between the neighbourhoods and in farmstead-specific preferences towards cereal species.

Ultimately, at Vráble we can roughly differentiate between two different phases of social organisation. As the kernel density modelling of the 99 ^{14}C dates indicates (see Chapter 4.2), during the first phase, 5250-5050 cal BCE, after settlement formation, we see a slowly intensifying agglomeration process, which takes place in the context of the shared ideology of spatial organisation of neighbourhoods. In this phase, within a uniform subsistence regime, differentiated economic strategies of individual households, but above all of neighbourhoods, seem to demonstrate strong particularist interests of individual social groups. The mentioned potential conflicts over the use rights of certain areas may also have played a role here.

At the same time, there is a strong emphasis on sharing economies, which serve to promote social cohesion among social groups. Relationships between these groups are documented by shared economic strategies between individual houses in the neighbourhoods. It is conceivable – albeit not empirically proven – that in such a situation of low-density agglomeration, in which there are both a strong household autonomy and strong collective social imperatives of cooperation and sharing within the settlement community or the neighbourhood, social tensions can arise that stem from conflicting goals of particular household and collective community interests (Halstead 2006; Leppard 2014). During the later phase of settlement development, however, the tensions between the neighbourhoods clearly intensify, even to the point of a rupture. The different neighbourhoods were able to attract different numbers of newcomers, and the tensions that were already indicated by the strongly autonomously oriented households and neighbourhoods apparently take over in this phase after 5100 cal BCE. The division of people within the neighbourhood into different social burial or body deposition groups can also be interpreted as a strategy of conflict resolution. Nevertheless, even in this phase a relatively strong communal frame of reference within the neighbourhood can still be assumed, which for the south-western neighbourhood is expressed by the collective construction of the ditched enclosure system. This rough temporal and social description of the process largely coincides with the dynamics presented by Erich Claßen (2009) for the Aldenhovener and the Titzer Platte.

The tensions that can be discerned at Vráble, which may have been associated with violent conflicts, as traumata on the human skeletons suggest (see Chapter 3.2), ultimately led to the spatial symbolic separation of a neighbourhood. The enclosure around the south-western settlement does not represent an uncrossable barrier, but is to be seen as a clear demarcation and separation of the groups living there. The orientation of all entrances away from the other two neighbourhoods is a clear sign of this evolving antagonism. The simultaneously evolving complex burial practice along and in the ditch also points to the necessity of a ritual reaction to the changing circumstances. As already mentioned, such an overall crisis-like situation is not a singular phenomenon during the late phases of the LBK; indeed, it can be found in different forms over a wide geographical area (cf. Link 2014, 279-280). However, indications of a lethally violent or even war-like situation at the end of the settlement history are not found at Vráble. Vráble's enclosure thus enriches the overall picture of late LBK enclosure trenches and associated human depositions to the extent that we can clearly state that we are not dealing with a dichotomy between violence (seen at Schletz, Kilianstädten) and ritual (seen at Herxheim), but with a much more multi-faceted spectrum, which contains various forms of treatment of human bodies in LBK enclosures. The explanation of an increase in 'warlike' conflict as the cause of these phenomena (Golitko and Keeley 2007) does not satisfyingly explain this variability, especially since the enclosure system at Vráble is not a fortification directed outwards, but a symbolically loaded demarcation directed inwards. Although it is plausible to see the phenomena discussed here at Vráble and at such places as Schletz, Herxheim or Kilianstädten as an expression of increasing social tensions, they are tensions of very different natures. These tensions can occur both between communities and within settlement communities, in the context of which – possibly as an attempt to overcome them – different ritual or violent actions were carried out on human bodies in connection with the settlement enclosure.

At Vráble, in contrast to some other LBK areas (*e.g.* the Mittelelbe-Saale area; see Link 2012) there is no continuity of place into the subsequent Lengyel period. The agglomerative settlement structures at Vráble that existed for centuries completely dissolved and were replaced by a dispersed settlement mode in the region. In the magnetic plan, individual houses can be found 500 m south of Vráble (see Chapter 2.1). Accordingly, there seems to be a fundamental disintegration of the previously existing collective reference systems, which are not re-established in this form in the Lengyel period. In this respect, regional developments such as the erection of a circular enclosure in Žitavce, 6 km south of the LBK site of Vráble (Kuzma and Tirpák 2012, 254-256), seem to be significant.

Summary: A sociopolitical narrative

Overall, the low-density agglomeration at Vráble – the combination of household autonomy and strong, village-wide institutions – represents a significant case study demonstrating the complex interplay of particularistic/exclusive as well as communal and cooperative and socially safeguarding strategies. This includes the very phenomenon of settlement concentration, the presence of a uniform subsistence regime, and the existence of three similarly shaped neighbourhoods. This striking division of the settlement community into three neighbourhoods provides a level of social identification that lies – on a spatial and social scale – between the household and the village community. At this level, phenomena of social cohesion develop, for example by the alignment of animal husbandry strategies. However, during the late phase of settlement, approx. 5050-4950 cal BCE, the downside of this neighbourhood-based social cohesion and identification also becomes apparent, namely, increasing antagonism between the settlement parts, which is most clearly expressed in the elaborate construction of an enclosure directed against the other neighbourhoods. But even within these units, despite all the cohesion phenomena that are present, social contrasts seem to persist or even grow. This can be seen

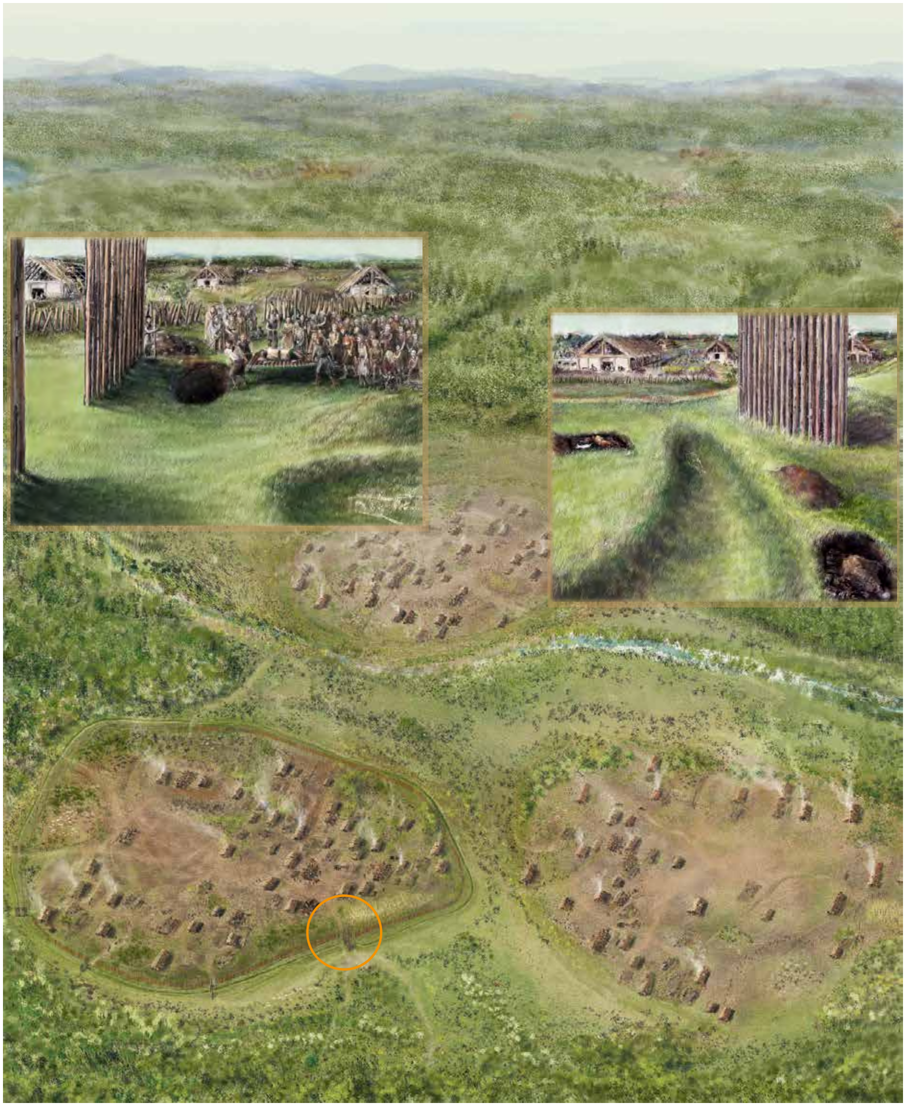

Figure 6.3.2. A reconstruction of the neighbourhoods within Vráble at the later phase of the settlement. The distinct burial rites occurring at this phase are depicted in detail (illustration: K. Winter).

in the monopolisation of certain supraregional networks and the associated access to special resources (obsidian, spondylus) by individual farmsteads, although we cannot empirically prove that such phenomena intensify in the late phase. We also assume there would have been conflicts with regard to access to favourable cultivation and grazing areas closer to the settlement. In the late phase, the different social categorisation of different groups of people in the burial rite can be interpreted as an indicator of increasing social inequality (Fig. 6.3.2).

These phenomena are to be seen in the context of the Early Neolithic, in which cohabitation in a village community is essentially voluntary. We should assume that Neolithic people are integrated into communities by strong social ties and by an internalised set of social norms, in a way probably similar to those described for modern acephalous societies (Clastres 1989; Amborn 2018; 2019). Additionally, an essential structural feature of the Early Neolithic is its expansive nature, in which the development of new settlement areas, the foundation of new settlements by smaller social groups, as well as social mobility between settlement communities are common experiences (cf. Leppard 2014; Furholt *et al.* 2020b). Therefore, an increase in conflict and social inequality is a great danger for the existence of the village community as a whole, especially if this conflict and inequality runs contrary to traditional incorporated social norms. The advantages of a concentrated settlement as practiced at Vráble – a richer community life, closer and more regular social contacts with a larger group of people, greater economic security through sharing practices, and an effective, integrated subsistence system with high crop yields due to high levels of manure – will eventually be outweighed by the negative consequences of intra-societal conflicts. The abandonment of the settlement by one group after the other – a scenario in which those at the losing end of the social conflicts were the first to leave the community might be conceivable – apparently quickly led to a complete abandonment of the village, at the latest by 4950 cal BCE.

Certainly, other factors may also have caused or influenced the abandonment of the concentrated mode of settlement. Nor should it be argued that the socio-political scenario that we are developing here, based on the available data, can also be applied to other LBK sites. Certain structural parameters that become visible at Vráble, however, are also valid for other contexts, such as the tension between the possibility of monopolising resources as well as cultivated and grazing land, and the need for communal solidarity and the practice of sharing, acted out on the level of households, neighbourhoods and the village community. Finally, Vráble makes an important contribution to the understanding of the larger phenomenon of late LBK enclosures and the treatment of human remains, as it shows, by broadening the spectrum of these manipulations of human bodies observed, the inadequateness of the simplistic explanation of an increase in warlike conflicts between communities.

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ARCHAEOLOGY IN THE ŽITAVA VALLEY I

The LBK and Želiezovce settlement site of Vráble

The early Neolithic site of Vráble (5250-4950 cal BCE) is among the largest LBK settlement agglomerations in Central Europe, and exceptional within the southwest Slovakian area. Geophysical surveys revealed more than 300 houses, grouped into three contemporary neighbourhoods, one of which is delineated by a complex ditched enclosure system. This enclosure is associated with a large number of human remains, which reveal new patterns of burial and deposition practices. This volume presents the first part of the results of an international research project that was started in 2012 and aims to explore the social implications of settlement concentration in the context of early farming communities, on the background of subsistence patterns and landscape use.

This is the first volume of "Archaeology in the Žitava valley", and it presents the finds, features and data uncovered and synthesised from our archaeological, pedological, geophysical, archaeobotanical, anthropological, zoo-archaeological and stable isotope studies on the site of Vráble "Veľké Lehemby" and "Fárske" in southwest Slovakia. These data are used to reconstruct the social and economic patterns and social processes, highlighting a growing tension between incentives of cooperation and sharing vs. monopolisation of resources and individual interests, driving the 300-year history of this site until its total abandonment. While the history of Vráble is unique, it holds clues for a better understanding of the overall, central European phenomenon of large, enclosed settlements of the later LBK, their association with rituals and violence involving human bodies, and the end of the LBK social world.

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